CONTRACT SPECIFICATION

POS-SPEC-000139

FOR

PHOTOVOLTAIC SOLAR POWER INSTALLATION
AT

Belleau Substation

Prepared by POS

for

Ameren MISSOURI

Rev	*Date*	*Revisions*	*Originator*	*Reviewer*	*Approver*
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I N D E X

SECTION 1A - SUPPLEMENTAL GENERAL CONDITIONS

FOR AMEREN MISSOURI POWER OPERATIONS

EFFECTIVE DATE: OCTOBER 2011

Reason for Change: Revision

Responsible Department: Ameren Missouri Power Operations Services Project Engineering

Approved By: Robert W. Ferguson Date: October 2012

Robert J. Schweppe

This document contains: Pages: 9 Attachments: none

This document supersedes and makes void: Supplemental General Conditions 8/1/08

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1.0 GENERAL

1.1 This section of the specification clarifies and supplements the Ameren General Conditions of Contract ("GCC") and other Contract documents. Specific duties set forth herein do not constitute an exclusive list of requirements, but complement the Ameren General Conditions of the Contract. In the event of a conflict between this specification and the Ameren General Conditions of Contract, this specification shall be controlling.

1.2 Contractor shall assure that all tiers of Subcontractors comply with all requirements of Contract documents.

1.3 For any work performed for Ameren Missouri Power Operations, Contractor agrees to comply with Ameren's Supplemental Terms and Conditions, commonly referred to as Section 1A-Supplemental General Conditions for Ameren Missouri Power Operations.

2.0 DEFINITIONS

2.1 Accident/Incident An incident is defined as a near miss, vehicle accident, or property damage to Company-owned/leased equipment or facilities. Refer to OSHA 29CFR1904 for definitions of reportable incidents and injuries.

2.2 Asbestos Containing Material (ACM) Material that contains asbestos that may become airborne and must be handled according to Ameren procedures and Federal and State regulations.

2.3 Competent Person An individual, who is trained and certified in applicable standards, is capable of identifying workplace hazards relating to specific operations, performs inspections of industrial and construction jobsite equipment, and has authority to take corrective actions when needed.

2.4 Computer Based Training (CBT) Computer Based Training is used for safety and job work rules orientation of new employees before they are permitted unescorted access to Company property.

2.5 Confined Space An enclosed area that may require a permit, specialized training, and/or special equipment to enter because of atmospheric or physical entrapment hazards. See OSHA 29CFR1910.146 and Ameren Management Instruction ES-REG-209.

2.6 Hot Work Work that will generate sparks, such as; cutting, grinding, welding, and brazing. A permit may be required for hot work that is hazardous due to location or other factors.

2.7 Environmental, Safety and Health Ameren's ES&H Department sets standards for environmental, safety and health issues and monitors compliance with Ameren policies, as well as with Federal, State and Local regulations.

2.8 Extra Work is defined in Article 1 of the GCCs.

2.9 Extra Work Order (EWO) is defined in Article 1 of the GCCs.

2.10 Job Working Rules Rules of conduct for Contractors working at Ameren facilities that include various types of prohibited behavior: off-limit areas, driving and parking instructions, and safety information that may be specific for the plant, such as fire alarms and evacuation procedures.

2.11 Single Point of Contact (SPOC) is defined in Article 1 of the GCCs.

2.12 Specifications are defined in Article 1 of the GCCs.

2.13 Work is defined in Article 1 of the GCCs.

2.14 Worker's Protection Assurance (WPA) or Hold Card Procedure Ameren's equipment lock-out procedure that ensures equipment and systems are in a safe state prior to service or testing. Employees must have WPA training and adhere to WPA procedures. Contractor supervisors must have plant-specific training prior to starting jobs requiring WPA protection.

3.0 INTENT OF SPECIFICATIONS AND DRAWINGS

3.1 The Contract Documents shall be interpreted as being complementary, requiring a complete Project. Any requirement occurring in any one of the Contract Documents is as binding as though occurring in all Contract Documents. Generally, Specifications address quality, types of materials and Contract conditions, while Plans show placement, sizes, and fabrication details of materials. Reference Article 2.01 of the GCCs.

4.0 BENCH MARKS

4.1 Company will furnish one site bench mark with its assigned elevation. Contractor shall furnish field layouts and shall be responsible for the use of field dimensions and elevations. All such Work shall be subject to approval at the discretion of the SPOC.

5.0 DRAWINGS, DETAILS & INSTRUCTIONS PROVIDED BY CONTRACTOR

5.1 Contractor shall submit to the Company copies of shop drawings, equipment details, installation, operating, and maintenance instructions, wiring diagrams, parts lists, cable termination sign-off sheets, etc. Reference Article 3.02 of the GCCs.

5.1.1 These submittals shall cause no delay in the performance of work. The minimum turn-around time for design changes shall be incorporated on drawings and shall not delay the performance of work. As-built drawings shall be submitted in accordance with Company's schedule.

5.1.2 Contractor shall submit five (5) copies of the above information, four (4) of which Company will retain. One (1) copy will be returned.

5.1.3 In addition to the copies listed above, Contractor shall submit drawings electronically in an approved CAD format. Ameren typically uses Bentley Microstation V7 or V8 (.dgn files).

5.1.4 Company will review submittals for general design features. Contractor is responsible for dimensions, quantities, accuracy, fit, adequacy of details, and coordination with other trades. Contractor must request deviations from contract documents in writing and receive written approval from Company.

5.1.5 Contractor must request field changes in writing and receive written approval from Company. Contractor shall promptly submit as-built drawings to Company.

6.0 LABOR CONDITIONS

6.1 Contractor's Work shall be performed under the National Maintenance Agreement (NMA), unless an exception is agreed upon in writing by the Construction Project Lead or his management, Contractor must furnish a copy of the site extension approval(s) granted by the International Union(s). Site extension requests for the NMA may be filed online at www.nmapc.org.

6.2 There shall be no limit on the work output of any employee, and no restrictions on what tools or equipment may safely be used to increase productivity. There shall be no minimum, other than what may be required by safety regulations, on the number of employees assigned to any crew or to any service.

6.3 Featherbedding practices of any kind will not be tolerated.

6.4 Actual work hours will be agreed upon during pre-job conferences; lunch breaks will be an unpaid one-half hour. No additional organized breaks are allowed. There shall be no non-working stewards. If a steward is included in the labor force, the steward must be a qualified worker and shall exercise no supervisory functions.

6.5 Contractors must conform to Construction Users Round Table (CURT) Tripartite Initiative report, dated June 2004, with respect to absenteeism, excessive overtime and work disruptions.

6.6 Contractor employees must be rested and fit for duty when they report to the Company's site. Contractor employees must not work in excess of 16 consecutive hours without prior approval of Contractor's Superintendent and Company, and then only when additional steps have been taken to ensure worker safety.

6.7 Contractor shall provide break/lunch facilities at a location in close proximity to the majority of the Work such locations to be approved by the SPOC or other Ameren Management personnel.

6.8 There shall be no slowdowns, illegal strikes, or unauthorized work stoppages of any kind. Contractor understands that its work must be completed in a timely fashion notwithstanding the presence of a labor strike or any pickets at or around the job site.

6.9 In the event that Company's employees, another contractor's or subcontractor's employees or Contractor's employees engage in a strike or established pickets, Contractor is expected to continue to meet its obligations under the terms of the contract and/or obligations with Company. Any such picketing activity is not an excuse for non-performance or delay in completing the project

6.10 Medical Services provided by Ameren:

On specified projects, contractors are not to include costs within bids associated with the following medical services:

- Initial, random, and for-cause substance abuse (SA) testing,
- First-aid expenses that can be addressed by an onsite nurse, if onsite nurse is provided.

7.0 CONTRACTOR MANAGEMENT REQUIREMENTS

7.1 Prior to mobilization, Contractor shall submit an organizational chart and resumes for the entire management team that will utilize, on or offsite, for the project.

7.2 Contractor should adhere to the Job Working Rules, Appendix B.

7.3 Contractor will be responsible to comply with the training and implementation requirements of the FERC Affiliate Restrictions procedure, GEN-ADM-5476 (see Appendix H).

7.4 Contractor supervisory employees who will be responsible for requesting and signing the WPA must receive site-specific training before working onsite. The SPOC will arrange for the required WPA supervisor training.

7.5 Contractor supervisor shall comply with the specific plant's WPA procedure which is included as Appendix B of this specification. WPA procedure provides details of program and outlines responsibilities for supervisors.

CAUTION: The presence of WPA process does not relieve workers of the responsibility to verify that equipment is actually de-energized or in the designated state. Instruct employees to walk down the job, check energy sources and isolation points such as: voltages, temperatures, pressures, etc. to confirm status.

7.6 Contractor Site Representative should read, understand, and sign the Contractor Agreement of Understanding Form – Attachment A18, prior to beginning work onsite.

7.7 Contractor supervisors shall instruct employees to observe WPA rules and comply with WPA tags at all times.

7.8 Contractor shall participate in individual Construction Progress meetings. The meetings are typically held weekly, but the SPOC may specify another frequency during the course of the Contract.

7.8.1 A Contractor representative with sufficient authority to make binding work and schedule commitments shall attend these meetings.

7.8.2 The individual progress meeting will typically concentrate on safety and housekeeping, schedule and work progress, job related problems, and site coordination.

7.8.3 Contractor should come to the progress meeting with an updated schedule showing actual progress and the critical path of the work. See Appendix D for additional schedule requirements.

7.8.4 Contractor shall take and distribute meeting minutes within 2 working days of the meeting.

7.9 A Contractor representative with sufficient authority to make binding commitments may also be required to attend a weekly Outage Coordination Meeting.

7.10 Contractor personnel, Business agents, Vendor/Sales representatives, etc., should use the entrance designated for their Contractor, park in the Construction parking lot, and be escorted onsite unless they have a Contractor badge. Construction badge holders may use Contractor entrance or Ameren employee entrance, and park in the Construction parking lot or main parking lot depending on purpose of visit.

8.0 DELIVERY AND STORAGE

8.1 Contractor shall be responsible for receiving, unloading, inspecting and hauling materials unless otherwise stated in the Contract documents.

8.2 Contractor and the project must be indicated on materials delivered to the site.

8.3 Contractor shall provide facilities to store materials and equipment on the jobsite. The SPOC will designate storage locations that will not interfere with Company's personnel or operations.

8.4 Payment for material or equipment stored onsite will not be made to Contractor until the material or equipment is installed. Contractor may apply for early payment only if early delivery and storage of the material or equipment will benefit Ameren.

8.5 A carrier that is compliant with the Depart of Transportation's (DOT's) Hazardous Materials Security Plan must be used for deliveries to Ameren. For a list of approved carriers visit: www.ameren.com/sites/aue/source/business/pages/spcarriers. Any vehicle carrying hazardous materials onto Company facilities will be refused entry until proof of compliance is provided.

8.6 If materials are provided by Ameren, they will be stored by Ameren until Contractor is onsite. Contractor will be responsible for loss or damage after acceptance of equipment or material provided by Company. Contractor shall inventory and haul excess material retained by Company to designated Company storage location(s) after completion of Work.

8.7 Contractor shall restore construction storage areas to a reasonable condition that satisfies the SPOC.

8.8 Material Receipt

8.8.1 Contractor must resolve all issues with contractor-procured material.

8.8.2 Contractor must identify, inspect, test and store material to purchase order requirements.

8.8.3 Contractor must ensure all receiving quality documentation is supplied to Ameren's SPOC upon receipt.

8.8.4 Contractor must have a program in place to ensure receipted critical plant material and equipment is not relocated or improperly stored without proper authorization from Ameren's SPOC.

8.8.5 Contractor will be provided a list of critical materials and equipment during Pre-Construction Meetings.

8.8.6 Contractor must handle, store, and identify Critical Material in accordance with the paragraph below:

MATERIAL HANDLING, STORAGE, AND IDENTIFICATION INSTRUCTIONS FOR CONTRACTORS
AUE-ADM-4203, Receiving Storage, and Handling of Critical Materials

All Ameren purchased critical material received by a contractor or sub-contractor has specific requirements that must be met to comply with Ameren's Quality Management Program in accordance with AUE-ADM-4203. Contractor requirements contained in AUE-ADM-4203 are provided below. Contractors will be evaluated on their quality control and material management. A list of critical materials shall be provided to the contractor during Pre-Construction Meetings.

1) Notify Responsible Engineer (RE) of Ameren material received and the PO number. Ensure receiving documentation remains with the material until clear direction is provided by RE.

NOTE: Steps 2-5 shall be directed by Responsible Engineer (RE)

2) Receiving documentation, number of containers, and intended storage location shall be taken to Storeroom personnel.

3) Storeroom shall create a Receipt Order (RO) number for traceability and provide identification labels for attachment to each container. Information will always include the RO tracking# and may include PO #, Job #, RE, PM, Storage Level, and intended location.

4) The RO number shall be clearly marked on all boxes, containers, equipment, and packing slip(s).

5) An Ameren Material Receipt Inspection Report (MRIR) shall be printed with the inspection requirements and shall be used to document inspection results. Contractors may perform additional inspections as directed by RE.

6) After successful acceptance, MRIR Inspector(s) shall sign the MRIR and each traceable barcode label; and shall attach labels to containers.

7) Hold tags shall be attached to any materials not accepted.

WARNING: Contact Responsible Engineer or Ameren Designee immediately if unidentified material is discovered, labels become unreadable, material needs to be relocated, or if material location or storage level differs from label.

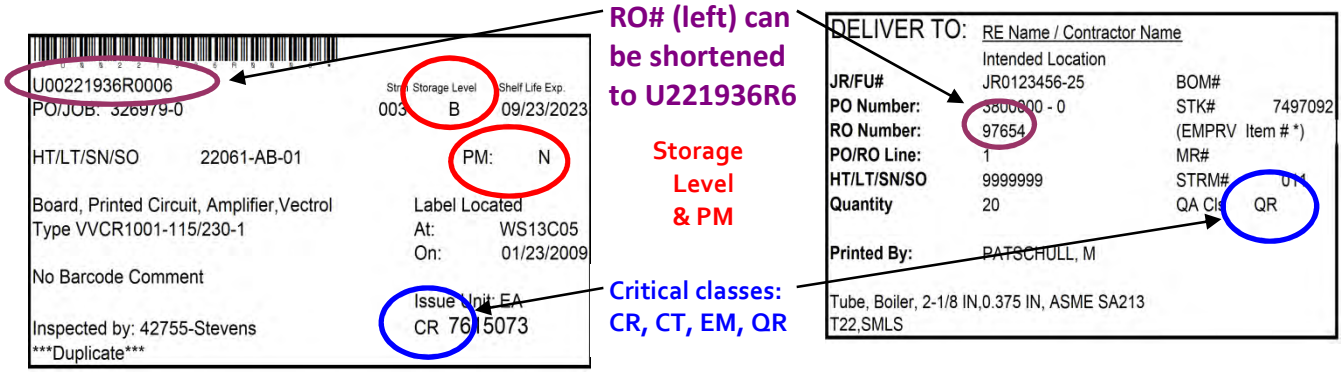
If during staging, prep work, etc., the material is repackaged or removed from labeled containers and the potential for identification or material loss exists, transfer the RO or barcode number, at a minimum, to the materials.

Storage Level B- Indoor storage. Temperatures controlled between 40°F and 140°F. This level includes the storeroom, turbine floor, or any other location inside the plant.

Storage Level C- Covered storage. Temperature control not required. These locations include secondary storerooms, covered parking areas, etc.

Storage Level D- Outside storage. Store in well drained areas in a manner allowing air circulation to minimize trapped water.

CRITICAL MATERIAL BARCODE **DELIVERY MATERIAL TAG**



9.0 REMOVALS AND PREPARATORY WORK

9.1 Contractor shall cooperate with the SPOC in scheduling removal work so there is no disruption to Company's personnel or operations.

9.2 Contractor shall provide protective enclosures, covers, water stops, etc. to prevent water or other weather-related damage to facilities during construction.

9.3 Materials authorized to be removed become the property of Contractor, unless otherwise specified in the Contract documents, and shall be promptly removed from the worksite. An inventory of materials being removed must be submitted to the SPOC. If materials are retained, the SPOC will designate where materials shall be stored. Retained materials shall be neatly stored and protected from the elements.

9.4 Before mobilizing tools, material and equipment, Contractor shall install protection on both sides of all walkways in work area from top rail to toe board. This protection may include, but not limited to, orange

fencing, plywood and sheet metal. However, openings in fencing shall be no larger than one inch square. Contractor shall install decking on open floor work areas, seal decking along edges and install toe boards, and install debris nets to further contain fallings objects. All wood subject to ignition sources shall have fire retardant cloth or tarps installed over the wood. Cloth shall be secured to avoid tripping hazards. All safety barriers shall be removed after the completion of the project.

10.0 CUTTING & PATCHING AND TEMPORARY BUILDINGS, ETC.

10.1 Contractor shall do all cutting, fitting, or patching that may be necessary to make the several parts come together properly and fit to receive the Work of other Contractors and Subcontractors.

10.2 All temporary buildings/structures such as tool rooms, break rooms, lunch rooms, etc., shall be constructed with non-combustible materials.

10.3 Before mobilizing tools, material and equipment, Contractor will install appropriate trash cans, cigarette butt receptacles, and dumpsters in designated areas.

11.0 TEMPORARY HEAT

11.1 Contractor shall provide temporary heat to protect Work materials against damage from dampness and cold to the satisfaction of the SPOC.

12.0 QUALITY REQUIREMENTS

12.1 The Quality Management System document (QMS) provides the basis for Ameren Missouri Power Operations quality management program and provides assurances that processes are in place to achieve our business objectives. The QMS Performance Standards and Performance Criteria provide requirements to achieve a controlled and systematic approach to quality activities and promote continuous improvement.

12.2 The QMS Performance Standards and Performance Criteria specified in this document are applicable to Ameren Missouri Power Operations processes, programs and activities commensurate with their importance to quality.

12.3 Contractor and subcontractors agree to comply to Ameren's Quality Management Process requirements per Procedure AUE-MAN-QMS-1001, or the Contractor's and subcontractor's internal policy that meets or exceeds Ameren's requirements for construction services, materials, design basis, design documents or calculations required as part of the work scope included in this Ameren Contract. Contractor and subcontractor can obtain the full Quality Management System Procedure, AUE-MAN-QMS-1001, from http://www.ameren.com/BusinessPartners/Suppliers/Pages/VendorForms.aspx.

12.4 Contractor and subcontractors shall adhere to an internal quality management plan and supportive procedures. The Engineer's quality management plan and supportive procedures are all subject to Ameren review and audit. Should a gap be identified between Ameren's Quality Management System (QMS) and the Engineer's quality management plan and supportive procedures, Engineer will be required to comply with Ameren's QMS and all applicable Ameren procedures. In the case where an Engineer lacks an internal quality management plan and/or supportive procedures, the Engineer shall follow the requirements outlined in Ameren's QMS and all applicable Ameren procedures.

12.5 Design Basis, Design Documents and Calculations

12.5.1 Contractor and subcontractors shall meet design basis and technical requirements in accordance with Section 1D and Section 1E of this specification.

12.5.2 All design documents and calculations shall be approved by a qualified Approver. The responsibility of the Approver is to ensure that all design documents and calculations are prepared, independently reviewed, and processed in accordance with all applicable procedures (AUE-ADM-3201, AUE-ADM-3203 and GEN-ADM-3205). The Ameren engineer shall ensure compliance with these procedures. The Contractor shall request a copy of these procedures if they are applicable to his scope of work. It is not acceptable for the Approver to be the preparer of the design documents.

12.6 Ameren will be allowed to make quality inspections during equipment fabrication at Contractor's and subcontractor's facilities at no cost to Ameren. Ameren will be allowed to view Contractors quality procedures and deviation reports.

12.7 Material handling, traceability and storage are to be compliant to the requirements of AUE-ADM-4203

12.8 Material handling requirements for contractors contained in AUE-ADM-4203 are provided in Section 8.8.6 of this section.

13.0 OWNER APPROVAL OF PROCEDURE

13.1 Ameren must consent to deviations from the procedures, methods and materials agreed to in the Contract. Reference Articles 2.01 and 4.01 of the GCCs.

13.2 Ameren reserves the right of approval over all procedures, methods, and materials to be employed by Contractor or its Subcontractors for this Work. Reference Articles 2.01 and 4.01 of the GCCs.

14.0 CONFIDENTIALITY

14.1 Contractor shall hold Ameren's Confidential Information confidential and shall not use or disclose to others during or subsequent to the performance of the Work (except as is necessary to perform the Work). Reference Article 9.02 of the GCCs.

14.2 Publication or advertising of information directly derived from the Project or Work or data obtained in connection with services rendered under the Contract must first be approved in writing by Ameren (Ameren personnel need approval from Ameren Corporate Communications). Contractor shall not release any information for publication or advertising purposes relative to the material, equipment and/or services furnished under the Contract Documents without the prior written consent of Ameren. Ameren reserves the right to release all advertising or publicity concerning the Project or Work. Except as to signs required by building department regulations or any other governmental requirements, Contractor shall not display or permit any signs or advertisements to be displayed about the Project site nor publicize in any manner its performance of the Work without the express written permission of Ameren. Reference Article 9.02 of the GCCs.

14.3 Contractor shall restrict the knowledge of all confidential information regarding the Work to as few as possible of its employees who are directly connected with performance of the Work and have a definite need for such knowledge. Upon request by Ameren's Representative, Contractor shall cause such persons or groups of persons involved in the Work on Contractor's behalf as Ameren may designate to sign individual secrecy agreements in a form satisfactory to Ameren. Reference Article 9.02 of the GCCs.

15.0 ACCOUNTING / INVOICING REQUIREMENTS / ACIP

15.1 Contractor shall furnish complete accounting information and cooperate with Ameren’s accounting practices.

15.2 For Time and Material contracts prior to commencing work, Contractor shall furnish Company with a written estimate for Company approval. Once approved, Contractor shall promptly notify Company of any facts and circumstances that may adversely impact the estimate. Further, Contractor shall not exceed ninety percent (90%) of the time and materials estimate without Company approval. All overtime for Time and Material contracts shall be approved by Company in advance of working. Reference Articles 6 and 8 of the GCCs.

15.3 Company reserves the right not to honor charges associated with timesheets that are not provided daily.

15.4 Material invoices must be submitted as Work progresses. Total cost updates will be provided on a weekly basis.

15.5 If Work indicated or specified in Contract Documents is increased, Company may have Contractor perform Extra Work.

15.5.1 Contractor must obtain written approval from the SPOC prior to performing any Extra Work. Each Extra Work Order (EWO) shall be invoiced separately and shall reference the EWO number and Purchase Order (PO) number.

15.5.2 If work is performed on a time and material basis, then work shall be charged at the rates indicated on the Labor Rate Sheets in the Contract.

15.5.3 Ameren will pay Contractor the cost of extra work as follows:

NOTE: Subcontractor labor and material charges shall be subject to the provisions of sections 15.5.3.1 and 15.5.3.2.

15.5.3.1 Labor:

- Direct cost of payroll labor, including first line foreman, excluding job Superintendent and General Foreman
- Fringe benefits including welfare and pension
- Insurance
- Taxes including FICA, Federal, State and Local tax
- Overhead, including costs for home office, field office, consumables, and small tools with an original value under $1,200, as agreed by Company and Contractor at the award of Contract
- Profit, as agreed by Company and Contractor at the award of Contract

15.5.3.2 Material and third party rental equipment:

- Direct cost of material or rental equipment

Subcontractors:

- Direct cost of Subcontractor

Contractor-Owned Rental Equipment (excluding third party rental equipment):

- Contractor shall submit for approval an equipment rental rate schedule including all equipment, tools, and supplies required to perform the Work specified. These equipment rental rates will be used for extra work.
- If the project is part of the Ameren Coordinated Insurance Program (ACIP) all contractors of all tiers will be required to provide completed enrollment and monthly reporting forms for duration of their work on project. All prime contractors will be responsible for their subcontractors of all tiers with respect to compliance of enrollment and reporting requirements.
- If the project is part of the (ACIP), contractors of all tiers must be enrolled and have a copy of ACIP certificate of insurance prior to mobilization onsite. Ameren will not allow non-enrolled contractors to access site prior to enrollment in ACIP.

END OF SECTION 1A

SECTION 1B – SUMMARY OF WORK

1.0 INTRODUCTION

1.1 Definitions

1.1.1 The term "Company" means the entity identified in the Company's Purchase Order, its agents, employees, representatives, successors, and assigns. The terms "Purchaser," "Owner," and "Buyer," if used in the Contract Documents, are considered synonymous and refer to the Company.

1.1.2 The term "Engineer" means the Engineer duly appointed to represent the Company as specified from time to time by the Company who may be employed by the Company or who may be employed by others.

1.1.3 The term "Contractor" means the entity identified in the Company's Purchase Order, and its agents, employees and authorized representatives undertaking the performance of the Work as defined in this Specification. The terms "vendor," "supplier," "manufacturer," or “fabricator” if used in the Contract Documents, are considered synonymous and refer to Contractor.

1.1.4 The term "Sub Contractor" means any individual, partnership, firm, corporation or business entity, other than an employee of Contractor, who contracts or agrees with Contractor (or another Sub Contractor or any tier thereof) to furnish any services, labor, materials or equipment for, or in connection with, the performance of the Work.

1.1.5 The term “Construction Project Lead” means the Company’s representative as specified from time to time and located at job site.

1.2 Location

Ameren Missouri Belleau Substation Property
Between Hwy 79 and TR Hughes Blvd
Site access is from Hwy 79

1.3 Contacts

mcrosby@ameren.com

1.3.1 All questions regarding this contract shall be directed to:

Scott Wibbenmeyer
Renewables Project Manager
1901 Chouteau Ave
P.O. Box 66149, MC-611
St. Louis, MO 63166-6149
Phone: (314) 554-6635
SWibbenmeyer@ameren.com

2.0 SUMMARY OF WORK

Contractor shall develop, permit, design, engineer, procure, construct, interconnect to electric utility system, commission, startup and test performance of a fixed axis solar photovoltaic facility to fit the specified plot of land adjacent to the Belleau substation in O’Fallon MO. The Company’s design requirements are outlined in section 1-D and the divisions of this specification to guide concepts and requirements. Technical Section of this specification establishes the minimum high level requirements for the design basis, design, materials, fabrication, startup, commissioning, testing, delivery and construction of a complete solar facility. The technical section of the specification shall not be considered a complete encompassing design or construction specification, but rather be utilized to support the deliverables required at various stages of the project. Contractor will be responsible for utilizing the requirements of this specification to develop all design, engineering and construction specification along with all other documents for this project

2.1 Scope of Work

2.1.1 Contractor's Scope of Work includes developing, permitting, engineering, project and construction management, procurement, quality assurance, interconnect to electric utility system, testing, training, commissioning, startup, testing performance and records management of a PV solar facility with a thirty (30) year service life as the basis for the design in accordance with this specification, the Schedule of Contract Submittals, Drawings, Division of Responsibilities, Schedule and other Contract Documents. The Work also includes furnishing all labor, materials, equipment, tools, and other items and services necessary for engineering, procurement, construction and completion of the facility.

2.2 Engineering and Planning

2.2.1 The contractor's engineering scope of services will include the design and engineering of a "ready for construction" design and construction specification package for a fixed axis photovoltaic solar facility that optimizes the energy output and land use provided at the Site. The standard of care for all such services performed or furnished under this specification will be the care and skill ordinarily used by members of the engineering profession practicing under similar conditions at the same time and locality.

2.2.2 The main goal of the engineering scope is to work with Ameren Missouri to complete the design inputs, design basis, preliminary design, final design, engineering, permitting, site evaluation, specifications and procurement activities to a level which will deliver a 100% completed design/construction package.

2.2.3 Under this specification the contractor will be required to obtain input and approval from Ameren Missouri regarding the design basis, design, engineering and procurement of materials for the project. With respect to each discreet portion of Facility design, Supplier shall submit all design drawings, data and documents upon substantial completion of the same, but in any event prior to commencing construction of, or the procurement of Equipment for, such portion of the Facility. Supplier shall incorporate design changes reasonably requested by Company as a result of Company Review to the extent they are consistent with this specification and divisions. Any incorporation of Company's comments shall not alter or impair any of Supplier's obligations hereunder with respect to such design. To the extent that Supplier relies upon this specification or any portion thereof in the preparation of any drawings, plans, bills of material, schedules and estimates, Supplier shall independently verify any such specifications for the completion of the Project and achievement of the intended results. Notwithstanding the definition of Company Review, in the event that Company Review, with respect to design drawings, data and documents as described herein, is not complete within the referenced ten (10) Business Day period, Supplier shall be entitled to proceed with the Work and shall remain bound by all of its obligations under the contract.

2.2.4 Contractor shall deliver those items listed in this specification and in Appendix M, Schedule of Contract Submittals, and Appendix N, List of Drawings, in the format and per the requirements approved by Ameren Missouri.

2.2.5 Prepare design documents consisting of final design criteria, drawings, specifications for the project

2.2.6 Assemble Design Basis document per requirements and format of Section 1-E of this specification prior to start of construction with update upon final acceptance to include all design changes through construction, commissioning, startup and testing.

2.2.7 Complete value engineering report showing various methods and model outputs to provide justification for equipment selected for final design and overall output and efficiency options evaluated for the facility.

2.2.8 Prepare detailed equipment list and justification for the selection.

2.2.9 Prepare final drawings showing the scope, extent, and character of the construction to be performed and furnished by contractor and specifications.

2.2.10 Provide technical criteria, written descriptions and design data required for obtaining approvals of such governmental authorities as have jurisdiction to review or approve the final design of the project, and assist Company in consultations with appropriate authorities.

2.2.11 Obtain all bids and other information necessary to confirm the Total Cost Estimate provided in the Contract, is valid to complete procurement, supply, construction, and commissioning of the Project.

Contractor shall provide to Owner a detailed breakdown of all components of the Total Cost Estimate.

2.2.12 Contractor shall complete all engineering and planning. Engineering shall include but is not limited to the following:

2.2.12.1 Conduct initial project kick-off meeting with Owner to review project plan and gather initial design information. Consult with Company to understand owner's requirements for the project and review available data in order to develop the design basis document.

2.2.12.2 Conduct 50% Design Review with Owner to review all design details, drawings and plans completed. Meeting shall include Contractor's engineering and construction team along with Ameren's project team. Meeting will be held at an Ameren Missouri office.

2.2.12.3 Conduct 100% Design Review with Owner to review all design details, drawings and plans completed. Meeting shall include Contractor's engineering and construction team along with Ameren's project team. Meeting will be held at an Ameren Missouri office.

2.2.12.4 Contractor shall meet with Ameren scheduling, all subcontractors, vendors and others to review and baseline the Level III project schedule.

2.2.12.5 Shall deliver project plan, construction plan, transportation plan, procurement plan, rigging and lifting plan, site specific safety plan, Quality assurance/control plan, laydown plan, commissioning plan, startup plan, and training plan.

2.2.12.6 Identify and analyze requirements of governmental authorities having jurisdiction to approve portions of the project designed or specified by contractor with whom consultation is to be undertaken in connection with the project. A list of all required permits or permits that may need modifying (operating and building) shall be submitted to owner. All permits will be the responsibility of Contractor.

2.2.12.7 Obtain such additional geotechnical and related information which contractor deems necessary for performance of work.

2.2.12.8 Perform environmental evaluation, permitting and project site development. Including but not limited to site soil/geotechnical study, site resistivity, site corrosion effects, topographical review, environmental mitigation plan, noise and vibration impacts, water quality and hydrology, archaeology reviews, ecology reviews, landscape character and visual survey including ambient light and location to dusty environments and combined effects or other items which may alter or impact the surrounding environment during and following construction. Deliverables shall include:

1. Environmental and Permitting Plan. Supplier shall submit an Environmental and Permitting Plan which shall contain:

   a. Dust Control. Supplier shall provide a comprehensive plan to address dust compliance. Supplier shall maintain dust compliance in accordance with federal, state or local requirements, until Final Acceptance is achieved.

   b. Spill and Contamination Response. Supplier shall provide procedures for clean-up of spills or contamination that may occur on Project Site.

   c. Spill Contingency plan. Supplier shall prepare a written Spill Contingency plan per the EPA's Spill Prevention, Control and Countermeasure (SPCC) program focusing on the procedures to prevent and control oil spills. The plan shall be certified by a Professional Engineer and prepared following good industry practice.

   d. Archaeology and Ecology. Supplier shall evaluate and report historic preservation and ecology impacts of the project per the procedures and process of the Missouri Department of Natural Resources or other enforcement bodies.

   e. Lighting and Sound. Supplier shall evaluate site lighting and sound both pre and post construction to allow for the design to have no adverse impacts on surrounding area following this project.

f. Permits. Supplier shall identify, plan and execute all permitting required for the project. The list shall provide a detailed description and estimated timeline of all Applicable Permits. Permitting shall be reviewed and approved by Owner prior to submittal. Permitting requirements shall include but are not limited to:

i. Project Information Form – Historic Preservation MDNR
ii. O'Fallon zoning, special use permits and variances
iii. County, State and Local road alteration permit
iv. Storm Water discharge permit
v. Water supply connection permit
vi. MDNR land disturbance permit
vii. County/City grading and building permits
viii. Fire district permits
ix. Public Service Commission Certificate of Convenience (will be completed by Ameren Missouri)
x. NPDES permit and reporting

2. Project Site Development Plan. Supplier shall submit a Project Site Development Plan The Project Site Development Plan shall include the following:

a. Geotechnical Report. Supplier shall perform or cause to be performed a geotechnical report for the Project Site, including soil conditions, and recommendations. The geotechnical report shall include, but not be limited to:

i. Client, project location, project title, and contract number
ii. Project Site conditions
iii. Geological setting
iv. General subsurface conditions, including the following
    a) Subsoil description
    b) Soil classification
    c) Physical/strength properties of soil
    d) Ground surface and groundwater elevations

v. Representative soil profiles (cross-sections)
vi. Geological hazards and considerations
    a) Fault surface rupture
    b) Seismic shaking
    c) Seismic zone site class and related seismic parameters
    d) Liquefaction potential and related impacts
    e) Lateral spreading
    f) Erosion
    g) Expansive soil
    h) Bearing capacities
    i) Settlement – gross and differential
    j) Corrosion – corrosivity of soil and resistivity
    k) Scouring
    l) Thermal Conductivity

vii. Earthwork
    a) Clearing and Site preparation
    b) Subgrade preparation
    c) Material for structural and non-structural fill
    d) Compaction requirements
    e) Wet weather construction conditions and considerations
    f) Trench backfill
    g) Trench excavations
    h) Surface drainage considerations
        1. Temporary – during construction
        2. Permanent
    i) Construction observation and testing requirements.

viii. Conclusions and Recommendations
    a) Seismic design

b) Foundation design recommendations including, but not limited to, allowable bearing pressure, settlement, friction coefficient, soil skin friction, soil passive pressure, depths, pier or pile types and sizes, uplift and lateral loads and recommended insitu field tests for verification of design parameters
c) Geotechnical recommendations for vehicle access and road design
d) Limitations
e) Soil resistivity and corrosion potential of anticipated foundation systems and underground utility materials used on Project

ix. Exhibits
a) Site location map
b) Boring location map
c) Soil classification chart
d) Rock classification chart
e) Boring logs

b. Hydrology Report. Supplier shall perform or cause to be performed a detailed hydrology study and shall provide a report for the same which shall include, but not be limited to:

i. Details of Project Site conditions, such as:
a) Hydrological setting
b) Site drainage information, including tributary areas, drainage culverts, blue line streams, and major channels and swales
c) Existing Flood Data
d) Review of existing soil information
e) Regression analysis to determine 10, 25, and 100 year flows and elevations
f) Historical drainage information
g) Water inundation levels
h) On-site storm water runoff management plans

c. Topographical Survey. Supplier shall perform or cause to be performed a topographical survey of the Project Site. Topographical survey shall include contour mapping with one (1) foot minimum contour intervals.

i. Company shall perform or cause to be performed an ALTA survey and/or a boundary survey of the Project Site. Supplier shall perform or cause to be performed any additional surveys as necessary.

d. Project Site Improvement Plan. Supplier shall provide details of Project Site improvements, which shall include but not be limited to the following information:

i. Clearing, grubbing, and preparation requirements to the Project Site as necessary to accommodate and complete the Project.

ii. Road features to be designed and constructed to allow for delivery, maintenance, ingress/egress access of all Project components and construction Equipment to their respective design and working locations, including lay down areas and temporary construction facilities.

2.2.12.9 Contractor shall perform structural and corrosion engineering. Supplier shall be responsible for all structural and corrosion engineering. The Supplier shall design all structural systems required for the Facility, including but not limited to the PV arrays, mounting systems and foundation systems. The design shall be based upon standard utility practice, including the requirement of applicable codes and standards and permits, as well as the information and specifications provided by the module, inverter, transformer, switchgear, racking and all

other suppliers. As a minimum foundation designs shall include:

1. The theoretical calculated load design values for the foundations plus the recommended factor of safety which shall be field verified in accordance with the geotechnical recommendations and as noted below.

    a. Cast in place, buried or driven foundations such as piers, caissons and piles shall be field verified per the latest version of ASTM D3689, ASTM D3966 and ASTM D1143M or Owner approved equivalent. The number of tests and distribution of these test locations throughout the site shall be as determined by the geotechnical engineer of record to ensure that the minimum design loads are met for all the pile foundations.

    b. A foundation corrosion study shall be performed by a NACE certified corrosion engineer experienced in designing for Missouri soils. The study shall use the results of the geotechnical evaluation report to ensure a minimum design life of 30 years for all foundations. Pitting corrosion shall be assumed to be concentrated in the top 12 inches below the final soil elevation. Coatings, cathodic protection or a sacrificial allowance of the foundation are examples of acceptable corrosion mitigation methods. The final structural design shall take into account any loss of the foundation due to corrosion.

2.2.12.10 Supplier shall be responsible for all civil engineering. Supplier shall design all systems in accordance with local codes and standards. Supplier shall design necessary road improvements to meet MODOT or local codes, standards, Special/Conditional Use Permit stipulations and conditions, and requirements presented by construction equipment, delivery vehicles and operation and maintenance traffic. The design will include vehicle access roads to provide maintenance/cleaning access with the appropriate surfacing material, which shall comply with MODOT or local county/city surface material requirements.

1. Erosion Control. Supplier shall be responsible for constructing and maintaining erosion control in accordance with the conditions set forth in its NPDES permit, including arranging for the required inspections. Supplier shall plan and execute construction of earthwork methods to control surface drainage from cuts and fills and prevent erosion and sedimentation. Supplier shall pay for all fines and damages resulting including any and all NPDES permit violations.

2. Weed Control. Supplier shall provide a plan to prevent the transportation of noxious and invasive weeds to the Project Site from vehicles and materials entering the Project Site. The plan shall be implemented and in effect before any materials will be allowed to be transported to the Project Site and shall comply with all local and permitting requirements throughout the term of this Agreement. The Supplier shall also provide a soil treatment plan to prevent weed growth on the Project Site for Company Review. The plan shall include the application of a pre- emergent in areas to be disturbed and in those areas required for operation and maintenance of the Facility. The weed control plan shall comply with local and permit requirements.

3. Grading and Drainage. Supplier shall develop a grading and drainage plan for Company Review, which shall be designed and installed in accordance with local code and permit requirements. All structure required for such grading and drainage plan shall comply with applicable MODOT standard specifications for drainage facilities.

4. Minimum Elevations of Equipment and Structures if the site is within a Floodplain. The elevation of all electrical Equipment (including combiner boxes) and mechanical Equipment and foundations, shall be set as required by local, state and federal code requirements, but at a minimum shall be set twelve (12) inches above a 100 year floodplain level, if applicable, as defined by FEMA; Any exceptions to this shall be specifically noted as an exception and submitted to Company for Company Review prior to implementation.

5. Fire Prevention and Protection. As part of its Health and Safety Plan, Supplier shall include a fire prevention and response plan. Supplier shall perform all Work in a fire-safe manner and supply and maintain adequate fire-fighting equipment capable of extinguishing incident fires at the Project Site. Supplier shall comply with all state,

federal and local fire prevention regulations.

6. Construction Facilities. Prior to moving onto the Project Site, Supplier shall prepare a construction facility plan showing the location and layout of the intended staging areas, storage areas, security fence, office areas, workshops and other temporary facilities.

7. Final Stabilization. The Supplier shall prepare a finish grade final soil stabilization plan.

8. Roads and Construction Access.

   i. Construction Access. Supplier shall abide by all load limits established by MODOT and the government entity having jurisdiction over the Project Site. Supplier shall be responsible for providing, operating and maintaining at its sole cost equipment services and personnel with traffic control signage and protective devices, which meet the requirements of the MUTCD as required to allow traffic to flow on haul routes and on-Site access roads in a safe manner. Supplier shall be responsible for the construction of any temporary access around areas of excavation and other construction activity, as required. Temporary construction roads and staging areas shall be coordinated with Company, and shall be completely removed in their entirety after Final Acceptance and restored in strict accordance with all permit requirements. Supplier shall be responsible for making all necessary improvements to state, county and other roads outside of the Project Site, as required, to allow for delivery of Equipment in order to complete the Work.

   ii. On-Project Site Roads. Supplier shall provide on-Project Site interior roads for operations, maintenance and emergency traffic. Roads shall be constructed per the technical divisions of this specification.

2.2.12.11 Contractor shall be responsible for all electrical engineering. Supplier shall be responsible for all electrical engineering design. Electrical engineering design shall meet applicable codes and standards and the requirements of the Agreement, as applicable.

1. Supplier shall prepare one-line and key electrical drawings including protection and control schemes and key equipment specifications.

2. Electrical engineering shall be completed per the requirements and scope of the technical section 1D and divisions of this specification.

3. All electrical design shall meet NEC requirements for all devices and qualifications.

4. All protection Equipment used throughout the Facility shall be sized and specified to reduce damage to all components and to the interconnection point in the event of electrical failure.

5. The above ground portion of the electrical systems shall be neatly routed to facilitate access, troubleshooting, maintenance, etc.

6. The electrical design shall include the design of equipment grounding and lightning and surge protection for the entire Facility.

7. Supplier shall design and specify all communications hardware and software required for system protection and remote monitoring and control. All monitoring and communication supplemental equipment and cabling shall be designed and specified. Company reserves the right to specify certain manufacturers and models.

8. Supplier shall design and specify any necessary power and communications required for Facility operation, control and security system.

9. Supplier shall provide a comprehensive statement on the overall power factor control strategy for the entire field from inverter output to MV system to Interconnection Point. The power delivered to the Interconnection Point must at all times meet the provisions of the Interconnection Agreement for power factor. A one-line drawing is required to illustrate the power factor control strategy.

10. Supplier shall provide provisions to isolate equipment to facilitate panel/inverter maintenance and minimize impact to Facility production.

11. All grounding and bonding design shall be prepared in accordance with technical section and divisions of this specifications.

2.3 Health and Safety Planning

2.3.1 Contractor Design shall use the Design for Safety Checklist (Appendix A, Attachment A9).

2.3.2 Contractor shall comply with the Safety and Housekeeping procedures stated in Section 1A, Item 7.8.2.

2.3.3 The Company has computerized the WPA request process. All organizations working on plant site shall be required to use the WPA computers to request WPA tags to be hung for equipment turned over, controlled and operated by company. The Company will provide training to one or two individuals per organization.

2.3.4 Supplier shall provide a project-specific safety plant/ ES&H Action Plan, including an Emergency Response Action Plan that is in accordance with Ameren, Federal, State & Local requirements and meets or exceeds Good Industry Practices. Supplier's Health and Safety Plan shall include a Project safety risk assessment. Supplier's Health and Safety Plan shall define Supplier's proposed efforts to initiate and maintain reasonable safety precautions and programs to conform with Applicable Laws, Good Industry Practices designed to prevent injury to persons, including members of the public and the employees, agents, contractors, consultants and representatives of Company, Supplier and its Subcontractors while performing work on the Project Site. Supplier shall erect and maintain reasonable safeguards for the protection of workers and the public. Supplier shall exercise reasonable efforts to eliminate or abate all reasonably foreseeable safety hazards created by or otherwise resulting from performance of the Work. Supplier shall cause all of its employees, agents and Subcontractors to follow all safety measures and procedures set forth in the Health and Safety Plan. Supplier shall furnish and maintain all necessary safety equipment such as barriers, signs, warning lights and guards as required, providing adequate protection to persons and property in connection with its performance of the Work at the Project Site. In addition, Supplier shall give reasonable Notice to Company in the event that any public or private property or utilities are susceptible to injury or damage through the performance of the Work and shall make all necessary arrangements with Company relative to the removal and replacement or protection of such property or utilities. Supplier plan shall include the following information:

1. In its Health and Safety Plan, Supplier shall provide a summary of its safety program which shall include the following: (a) a safety & environmental policy; (b) hazard communication; (c) safety rule enforcement; (d) alcohol and drug policy; (e) employee rights and responsibilities; (f) housekeeping; (g) accident reporting and investigation; (h) machine guarding; (i) respiratory protection; (j) material handling; (k) unsafe act/condition reporting; (l) driving safety; (m) parking lot safety; (n) electrical safety; (o) personal protective equipment; (p) emergency procedures fall prevention; (q) ergonomics; (r) lockout/tagout; (s) confined spaces; (t) hearing conservation; (u) industrial truck operations; (v) electrical safety Work-related practices.

2. Plan shall incorporate safety requirements of the Appendix A and all other requirements of this specification and agreement.

3. Plan shall include description and procedure for lock-out/tag-out program to be used for the project.

2.4 Owner Review of Documents

2.4.2 The documents and drawings listed in Appendix M and Appendix N shall be submitted to the Company for review per the mutually agreed upon delivery/progress schedule. At a minimum the

documents shall be reviewed at the completion of the Preliminary Design, 50% design, 100% design (for construction) and As-builts following construction.

2.4.3 The Company's comments will be forwarded to the Engineer within 10 working days of the date documents are received in Company's offices.

2.4.4 The Company's review of the listed documents will normally be limited to ensuring the Engineer's design complies with the intent of the Contract Documents. In the event Contractor believes the Company's comments extend beyond the scope of the Contract, he shall promptly notify the company using the change control procedure agreed upon in the Contract. Engineer shall not incorporate such changes into the design pending final resolution of the scope change request.

2.4.5 Except as noted above, the Engineer shall submit all design documents, including vendor drawings, upon initial issue and at each subsequent revision, to the Company for information. The vendor drawings submitted to the Owner shall reflect the Engineer's comments. The intent of this request is to enable the Company to be cognizant of the engineering progress and to validate the intent of the scope of the Contract. In general, the Engineer should not expect to receive comments to these types of drawings, unless there is a conflict with the scope of the Contract.

2.5 General Requirements and Design Basis

2.5.2 Contractor shall prepare all documents and deliverables per the requirements and format per the design basis Section 1E, and the technical Section 1D and Technical Divisions of this specification. In addition all deliverables shall meet the requirements listed in the technical divisions.

2.5.3 Contractor and subcontractors shall provide FME plan in accordance with Appendix X prior to start of work.

2.5.4 Contractor and subcontractors shall submit a Quality Plan which is in compliance with the Quality Requirement in Section1A – Supplemental General Conditions, Section 12, and specification division prior to start of work.

2.5.5 Contractor shall be responsible for independent review of design documents, calculations and drawings. Engineer shall provide proof of documentation for independent reviews such as documents being initialed or other similar verification. The purpose of the independent review is to 1) provide an unbiased review of the work, including an in-depth review and evaluation of all inputs, design changes and outputs, 2) ensure the design basis is maintained, and 3) minimize the potential risk of undesirable results. The Independent Reviewer is not involved in the development of the design and has the educational and professional experience to perform an independent review. The Independent Reviewer may be either internal or external to the Contractor's organization.

2.5.6 Notwithstanding any review or comments by Ameren, Contractor shall remain solely responsible for all design and engineering included within Contractor's scope of services.

2.5.7 All activities related to this project shall be fully transparent. Under the transparency policy the Company shall be involved with and approve all procurement activities and vendors. Correspondence, meetings, prices and quotes between contractor and a vendor/sub-contractor shall be made available in the original form to the Company.

2.5.8 Contractor shall be responsible for furnishing all material (except those items of material specifically stated to be furnished by the Company), tools, equipment, labor, supervision and any other incidental items or services required to perform all of the work described herein.

2.5.9 Contractor shall be responsible for any and all engineering, drafting, field sketches, and field layout required for temporary supports, rigging, removals, and installation of all material.

2.5.10 Contractor shall be responsible for receiving, storage and security of all materials supplied by Contractor and material provided by Company. Contractor will be required to unload material in laydown areas as designated by the Construction Project Lead. Contractor will also be required to obtain items, where specified, from the storeroom. Contractor is responsible for developing an inventory list of material received.

2.5.11 Contractor shall be responsible for moving material supplied by the Company or Contractor from the Company's storeroom or the adjacent area to the jobsite, and returning unused material back to the storeroom along with an inventory list. Attach Form 4983 "Return Material Tag" to all returned material. Form 4983 will be provided by the Company.

2.5.12 Contractor will be responsible for proper disposal of all material.

2.5.13 Contractor supervision shall obtain necessary plant-specific training for the work they will perform, including Foreign Material Exclusion (FME).

2.5.14 Contractor employees shall observe Ameren's practices and procedures for Foreign Material Exclusion (FME). The Company may seek to recover costs for contractor non-compliance.

2.5.15 Explosives may only be used with written permission from the Company.

2.5.16 Ameren **will not** provide a nurse and first aid trailer for Ameren and contractor personnel.

2.6 Quality Assurance/Quality Control

2.6.1 Supplier shall provide a copy of its final QA/QC Plan. Upon review by Company, all Work shall be managed in accordance with such QA/QC Plan. The QA/QC Plan shall include such procedures and requirements as described in Section 1D and Q of this specification

2.6.2 Supplier shall submit a complete binder containing documented and signed QA/QC test results. In the event Company determines that QA/QC test results are not satisfactory, Supplier shall promptly take such actions necessary to achieve satisfactory results. Such procedure shall be repeated as necessary until QA/QC test results are satisfactory, which in no event shall be later than the substantial completion.

2.6.3 Supplier shall be audited and qualify under Owners Quality Management System.

2.7 Schedule Requirements

2.7.2 The services specified in this section include the planning, scheduling, and reporting required by the Contractor. The scheduling of services activities is the responsibility of the Contractor following the order to proceed. Contractor and subcontractor management personnel shall actively participate in its development.

2.7.3 The Schedule is required to assure adequate planning and coordination of the services with the work of others, for providing a means of measuring the progress of the work; to assist in appraising the reasonableness of the proposed schedule, to aid in evaluating the progress of the work, to assist in the evaluation of extension requests, and to support applications for payment.

2.7.4 Contractor shall provide an onsite scheduler, unless otherwise authorized by Ameren, to provide updates to the Project Schedule. Contractor scheduler will provide updates per the reporting section of this specification. Updated information shall include but is not limited to: Activities worked on, Actual durations and resources used, remaining durations, percent complete, expected finish dates.

2.7.5 Contractor will develop activities, resources and associated project logic for each added scope changes.

2.7.6 The scheduling tool shall be Primavera P6.

2.7.7 The Schedule shall be activity and cost loaded

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2.7.8 Critical Path Method Scheduling format shall be used in accordance with accepted practices.

2.7.9 Durations shall be in hours or days.

2.7.10 All schedule contingencies shall be identified to the Ameren Project Manager. Examples include, but are not limited to:

- Material Delivery
- Labor Availability or Productivity
- Weather
- Other

2.7.11 Owner activities, as defined throughout the project, shall be added to the schedule as requested, with the appropriate logical ties. Examples include, but are not limited to:

- Owner furnished equipment

- Regulatory decisions
- Milestones
- Site availability
- Other

2.7.12 Prior to the preparation of the final schedule, the Contractor shall meet with Ameren to determine the activity code structure and Work Breakdown Structure. The Activity Codes and Work Breakdown Structure (WBS) will be defined jointly by Ameren and the Contractor with remaining levels available for Contractor use. The WBS shall be defined to satisfy Ameren reporting requirements and shall typically include the following:

2.7.12.1 Level 1: Milestone Schedule - A Level 1 schedule addresses the planned normal sequence of events at a high level of detail usually at a milestone level. See the Schedule of Services, appended as Attachment H.

2.7.12.2 Level 2: Work Package (Scope) - A Level 2 schedule identifies the major activities, interface points, and duration estimates for the completion of the project. It shows all interfaces as defined by the Project Milestone Schedule by the vertical integration of the schedule hierarchy and includes all major milestones.

2.7.12.3 Level 3: Discipline - A Level 3 schedule expands the Level 2 schedule to specifically identify project activities and their associated logic ties. It reflects interrelationships between disciplines as well as schedule relationships to other organizations associated with the project. It shows all interfaces relative to the functional organization as defined in the Level 1 schedule by vertical integration of the schedule hierarchy. It includes all Major and Other Functional Organization Milestones to be completed for the entire project's scope.

2.7.13 Upon approval by Company of Contractor's resource loaded schedule, it shall reside and be updated on the Ameren network and shall be used as the working schedule.

2.7.14 Ameren will provide network access to Contractor for scheduling review and updates.

2.7.15 Contractor baseline shall be established after both Contractor, Owner's Project Manager and Project Scheduler mutually agree on schedule. This will be completed before start of work and not later than 30 days after execution of contract.

2.7.16 Contractor shall supply resources to coordinate, lead and attend weekly schedule development meetings including owner, contractor and all subcontractors in order to develop and approve the baseline project schedule.

2.7.17 The final structure and depth of the WBS shall be determined with input from the Company.

2.7.18 If at any time during the project, Ameren has the opinion that the completion dates identified in the schedule will not be met; the Contractor shall participate in a re-evaluation of the remaining work.

3.0 SCHEDULE MILESTONES

- Schedule Milestones will be mutually agreed to at the time of contract and will be amended as a contract document. Project completion and milestones shall be based on best practice EPC efforts, where by engineering and planning would be completed prior to procurement and construction. Project must be completed prior to December 2014.

3.1 General Project Schedule Milestones requested

Issue EPC Contract PO	TBD
Preliminary Design Review	TBD
50% Design Review Meeting	TBD
100% Ameren Design Approval	TBD
Procurement Activities	TBD
Construction Complete	TBD
Startup & Commissioning	TBD
Substantial Completion - Photovoltaic System Operational	TBD
Project Complete with Final Acceptance	TBD

4.0 REPORTING REQUIREMENTS

4.1 Progress Reporting and Meetings

- Contractor shall prepare a written monthly progress report detailing:
  - All activities occurring from the first to the last day for each month
  - All activities completed during the previous month
  - A tabulation and analysis of activities that were not complete as scheduled and plans for recovery
  - Activities scheduled for completion during the coming month
  - Major material procurement activity
  - Engineering and construction progress, both forecasted and actual
  - Earned Value Cost Report
  - Schedule Reporting
  - An assessment of the Project status by the engineering manager

- This report should be transmitted to the Company project manager by the Contractor along with the summary of the Project status by the seventh day of the following month each month through the term of the contract.

- In addition to the Progress Report, regularly scheduled weekly progress meetings/conference calls shall be held between Contractor and Ameren Missouri to review and document such items as:
  - All activities occurring during the week.
  - Engineering input and feedback from Ameren Missouri
  - Quality
  - Schedule
  - Conformance to Project
  - Review of engineer quality records
  - Engineers adherence to Project plans and procedures
  - Review of the effectiveness of the site safety program
  - Comparison of invoice and progress report
  - Compliance of actual progress to base-line schedule
  - Review of past month's progress report
  - Review of any open items from past meetings
  - Other items that the Owner or Owners Representative feel deserve special attention
  - Man-hours expended by each craft on each activity during the course of the work.

  In addition to leading and attending the weekly progress meeting, Contractor will be responsible for supplying weekly progress report meeting minutes within 24 hrs of meeting close to Owner's project manager, weekly report shall list a daily log of all activities in progress or completed along with contractors performing the work.

- Contractor shall provide daily activity and progress updates to Owner's project manager. Daily update shall list contractors on site, number of workers on site, status of completed activities, activities in progress and following day activities planned.

4.2 Schedule Reporting

- A schedule update shall be provided to the Ameren Missouri Project Manager on a weekly basis identifying engineering, procurement and construction. Contractor scheduler will provide updates regarding:
  - Activities worked on
  - Actual durations and resources used
  - Remaining durations
  - Percent complete
  - Expected finish dates
  - Achievement of milestones.

4.3 Cost Reporting

- An appropriate monetary value shall be assigned to each Activity Code or WBS of the schedule. Values shall be adjusted and balanced such that the total value of all activities equals the Contract price. Likewise, the subtotal of a group of activities shall equal the Schedule of Values total cost of that group. Values employed in the preparation of the Cost Report will be used only for comparison against the schedule of values in the progress payments and will not be considered as a basis for additions to, or deductions from, the Contract amount.

- Contractor shall supply a monthly tabular Earned Value Cost Report. Report shall be sorted and sub-totaled by the Schedule of Values and, as a minimum, shall reflect the following for each activity:
    - Schedule of Values Code/ID
    - Activity ID
    - Budgeted Cost otherwise known as Planned Value (PV)
    - Earned Value to Date (EV)
    - Actual Cost to Date (AC) including costs incurred but not invoiced
    - Physical Percent Complete
    - Earned Value This Period
    - Balance to Complete/Estimate to Complete (ETC)
    - Early/Actual Start Date
    - Early/Actual Finish Date
    - Cost Performance Index (CPI) – defined as CPI = EV/AC
    - Schedule Performance Index (SPI) – defined SPI = EV/PV
    - Estimate at Completion (EAC)
    - In addition, a graphical representation of the Earned Value Curves, including the Planned Value (PV), Earned Value (EV), and Actual Cost (AC) curves, is required.
    - Progress Payment for Approved Updates: If the Engineer fails to furnish the update information required to verify the Engineer's progress, the Engineer shall be deemed not to have provided a basis upon which Progress Payment may be made.

5.0 COMPANY AND MANUFACTURER'S DRAWINGS

5.2 The following drawings are intended to indicate the scope of the work to be done and details necessary for the items of work set forth in this specification, and are part of this specification. These drawings in general are to scale, but figures shall always be followed and drawings are not to be scaled. Contractor shall make any requests for additional drawings in writing to the Engineer.

- Belleau Google Earth Property Line
- Belleau ACAD-07001_topo_V2000 overlay zahner plat
- Belleau Substation 1_53287_002
- Belleau Substation 2_53595_001
- Belleau Substation 3_53596_002
- Belleau Substation Core Drills
- O'Fallon Substation Core Drills 1970s
- Property Site Plan_99886
- Property Survey Plat_609165
- Site Layout – EP001
- Grading Preliminary Plan – CS001
- Plan Details – CS010
- AC One Line – EE001
- DC One Line – EE010
- Site Camera Locations – CS001

6.0 MATERIALS AND EQUIPMENT FURNISHED BY CONTRACTOR

6.2 All supervision, labor, materials, equipment, tools, and any incidental items (except those specifically stated above) necessary to completely install each portion or component of the work shall be furnished by Contractor. These items shall include, but not necessarily limited to the following:

- The contractor shall furnish with the Company's approval photovoltaic panels, panel racking system, raceways or conduits (above and below grade), combiner boxes, inverters, transformers, system monitoring, associated medium and low voltage power and Modbus communication control and power wiring and all other equipment, tools, materials, labor or items required to deliver a fully operational solar facility.

- Following or in conjunction with the design and engineering of this project Contractor shall complete all procurement and construction activities to complete the project. Scope includes furnishing all labor, materials, equipment, tools and other items and services necessary for construction of the solar facility. Equipment and systems to be supplied include but are not limited to:

    - Photovoltaic solar panels and auxiliary equipment;
    - Combiner boxes;
    - Solar panel mounting and racking systems;
    - Re-combiner boxes;
    - Inverter equipment;
    - Transformers;
    - Remote Terminal Unit
    - Controls and instrumentation required for power plant operation and remote monitoring from single HMI on-site and off-site;
    - Meteorological weather station;
    - All interconnecting piping, fittings, pipe supports;
    - Communications shelter, HVAC and environmental controls;
    - Electrical, controls and instrumentation systems;
    - Plant communications systems; (permanent communications connection and service provided by Ameren)
    - Plant buildings for equipment as necessary;
    - Switchgear, and other electrical equipment;
    - Emergency Battery System for facility switchgear and RTU
    - Substation if required;
    - All construction, operating or other variances and permits;
    - All construction power and other utilities
    - Site work including foundations, concrete pads, grading, fencing, drainage, access roads and other necessary items for the entire facility site;
    - All other equipment and system required for a complete functioning solar power generating facility in accordance with applicable designs, codes, permits and standards and the contract documents.

- Contractor is fully responsible for coordination of all equipment providers and subcontractors, testing, shop drawing review and approval, inspection, delivery, receipt, storage, installation, full integration, commissioning and startup of all equipment purchased, either by Contractor, its subcontractors, suppliers, or Ameren Missouri. Full integration includes all mechanical, electrical, or controls interfaces between equipment and/or control or operating devices.

- Supplier shall install Equipment that is new, of good quality and suitable grade for the intended purpose. Such Equipment shall not be a lower grade or quality than specified in the design and engineering plans or in manufacturers' recommendations. Utility-grade equipment shall be used. Commercial or residential grade equipment shall not be acceptable. In no event may Supplier utilize Equipment with polychlorinated biphenyls (PCB). All equipment shall meet the requirements of the included specification divisions.

6.3 Security and Fencing

6.3.1 Contractor supply and be responsible for all aspects of security during construction until Final Acceptance, including the protection of contractor's and Owner's equipment. Contractor is responsibility for lost, stolen, damage goods or other liabilities prior to Final Acceptance

6.3.2 Scope of Work shall include installation of chain link fence, gates and other supporting equipment for perimeter security. This will include: fence framework, fabric, accessories, gates, removable

panels, roll-back sections, fence post foundations, card reader pedestals, camera poles, PIR poles, conduit, communications and power wire for security.

6.3.3 Contractor shall work with owner for final security design and layout. Contractor shall provide all labor and material as required for the installation of the physical security infrastructure. The site security scope includes but is not limited to:

1. Site perimeter fence
2. Man-gate with card access (access from entrance road)
3. Automated maintenance vehicle gate with card access pedestal and gate controller
4. Site perimeter conduit with pull cords, pull boxes, and security infrastructure for communications and power (minimum 2 – 3" conduits) to and from all devices to the communications building and/or power panel.
5. Terminal enclosures for dry transformers/control enclosures at camera poles and gate enclosure.
6. Foundations and pedestals for card readers, and gate control enclosure
7. Foundations and mounting post for site cameras
8. Poles for PIR devices located at corners of site or changes of fence direction

6.3..0 Owner will supply cameras and card reader hardware along with final testing of the physical security system. All other scope shall be supplied by Contractor.

6.3..1 Perimeter danger signage shall be provided and installed by Owner in accordance with Company standards.

6.3..2 Entrance gate signage shall be provided by Ameren in accordance with Company standards but shall be included in Contractors planning and permitting process.

6.3..3 Physical security system infrastructure shall be provided by Supplier in accordance with the approved design and the technical divisions of this specification 1D and Section 02831.

7.0 PROJECT MANAGEMENT

7.1 Supplier shall be responsible for all the management of the Project for the duration of the Work.

8.0 CONSTRUCTION AND CONSTRUCTION MANAGEMENT

8.1 Supplier shall develop a Project construction plan and oversee, coordinate and ensure the expeditious construction of the Project in accordance with specification and agreement. Supplier shall provide information and status on the employment of Subcontractors for the Project and require such Subcontractors to perform the Subcontracts in accordance with the relevant requirements of the Agreement. Supplier shall establish and maintain Project management control systems and provide construction management services in accordance with Good Industry Practices. Supplier shall not, and shall cause its Subcontractors not to, use or occupy the Project Site for any purpose other than the completion of the Project in strict accordance with the provisions of the specification, including the use of all easements only for the purposes indicated by the easement drawings, nor in a manner that would (a) violate any Applicable Laws; or (b) constitute a public or private nuisance or waste. Supplier shall provide all construction management services with an on-Project Site construction management team. Supplier shall be responsible for construction and construction management activities including:

1. All temporary office space, temporary power, sanitary facilities, communications equipment, and drinking water for Supplier's personnel on the Site. Supplier shall provide two (2) desks in separate office for use by Company. Company's Representative shall be provided with electrical power, air conditioning, two (2) telephones, internet connection, one bookcase, one file cabinet, and access to sanitary facilities in a manner similar to Supplier's office trailers.

2. Progress set of red-lined copies of all drawings, specifications, permits and Supplier installation manuals at the Project Site as required for As-Built(s).

3. Storage and maintenance of all installed Equipment during the performance of the Work consistent with the recommendations of the equipment suppliers and Good Industry Practices. Copies of all installed Equipment maintenance records shall be kept at the Project Site and included in the Turnover Packages. Supplier shall be responsible for obtaining any required off-Site warehouse space, temporary parking, staging, or lay-down areas.

4. Permanent equipment marking, labeling and signage for the Project. Warning signs shall be placed at key areas near Equipment and at Project entrances along the perimeter fence and otherwise as specified or required.

5. Recognizing and respecting all properties adjacent to the Project Site and use reasonable efforts to minimize disruption to neighbors (e.g., sediment control, dust control, traffic control, trash control, noise control, etc.) as applicable.

6. Complying with all Applicable Permit notification requirements, safety and work rules.

7. All field routed electrical collection systems shall be secured in a neat and orderly fashion and in accordance with all applicable code requirements.

9.0 DISTRIBUTION INTERCONNECTION

9.1 Plant interconnection point will be at Ameren Missouri's O'Fallon 34.5 KV bulk feeder 75. This 34.5 KV circuit runs overhead along the south property line of the proposed solar facility.

9.2 In conjunction with the design of the facility Ameren Missouri will complete an Interconnection Study to define all interconnection requirements for contractor.

9.3 Contractor shall be responsible for all cost of designing, procuring and installing interconnection facility for construction power, which is also expected to be utilized for service power for plant operations. Supplier shall be responsible for all permitting and applications to Ameren Missouri for a new 480 V service. Ameren Missouri would supply the pole34.5 kv mounted disconnect and a 480v meter, all other equipment, wiring, meter box, CT's… labor will be the responsibility of the contractor. Owner will provide final connection of Contractor's supplied cable to Ameren's 34.5kv connection point.

9.4 Supplier shall be responsible for the costs of designing, procuring equipment for and installing all interconnection facilities required for delivering capacity/energy to the interconnection point on the Company electrical system. All Interconnection Facilities shall be constructed in accordance with the Ameren Missouri guidelines identified in the interconnection study as applicable. Supplier shall fulfill all application, study and testing procedures to complete the interconnection process. During the initial start-up phase, Company shall be entitled to observe, test and verify the Facility's performance. In connection with its interconnection obligations, Contractor shall:

1. Provide relevant deliverables during the interconnection process, including but not limited to:

   a. Project Site Plan in AutoCAD, including:
      i. Description of all existing and proposed transmission and distribution lines required to connect to the Project.
      ii. Identification and description of the interconnection point demarcation and location.
   b. Communication Shelter design in AutoCAD with minimum area for three (3) racks along with additional space as described in the technical section of this specification for Company use
   c. Interconnection application with one and three-line electrical drawings. Expect ten (10)-calendar day turn-around for review and comments until approved.
   d. Switchgear shop drawings. Switchgear shall be pad mounted metal-clad type gear.
   e. Switchgear AC/DC schematic
   f. Signed Interconnection Construction Agreement and or Interconnection Agreement
   g. Temporary construction power requirements
   h. Separate permanent station power (incidental load) requirements
   i. Shelter battery information
   j. Contractor contact information
   k. Solar plant data points
   l. SEL-351 Relay information

9.5 Provide a schedule for interconnection.

9.6 Design and implementation of a step up transformer shall be performed in coordination with the Interconnection Study and the Interconnection Agreement, as applicable.

10.0 UTILITIES AND FACILITIES

10.2 Contractor shall supply sanitary facilities, drinking water and shower facilities (if needed) equipped with water heaters.

10.3 Temporary lighting, wiring, plumbing, globes, guard lights, barricades or any other items required for protection, facility of work, local regulation, or by law for public protection shall be provided by Contractor.

10.4 Lay down areas for equipment and material will be designated as close to work site as possible. Areas for tool, office, and change house trailers will be designated as close to work site as possible. Contractor's lay down area will be as determined by the Construction Project Lead.

10.5 Scaffolding and enclosures furnished, erected and later removed by Contractor to gain access for work scope shall not be attached to or restrict the thermal expansion or contraction of any pipelines or other equipment that operates at temperatures other than ambient. The scaffold or enclosures shall not restrict access to any equipment or area by the Company's employees.

10.6 Contractor is responsible for supply of water, electric power, compressed air or other utilities for his own use to complete the project.

11.0 OPERATIONS AND MAINTENANCE TRAINING

11.1 Supplier shall provide both hands-on operator training for Company technicians during start-up, as well as classroom training on-Site for technicians and engineers covering all aspects of the Project.

1. The classroom training session shall be designed to provide two (2) to three (3) Days of instruction. Supplier shall provide electronic versions, in editable form, of the training manual for each trainee, not to exceed twelve (12) copies. Training manuals shall include descriptions of all modes of operation, PV system basics, SCADA system, PLC overview and maintenance, Project Site safety issues, system operation, commissioning results, and a description of the preventative maintenance.

2. Field training shall be designed to provide instruction on health and safety, PV array wiring, module handling, inverter operation, Project Site design and layout (As-Built), grid connection, module cleaning, and all other topics specific to the Project Site. Field training shall be provided for up to ten (10) people in one (1) scheduled training session under this Agreement. A reasonable number of additional trainees shall be accommodated within the same training session at the incremental cost of additional training materials (manuals, etc.). Company shall have the right to reproduce all training materials at its own cost, solely for the use of Company’s employees.

3. Company shall have the right to videotape training sessions for Company use.

12.0 OWNERS MANUAL

12.1 Supplier shall provide an Owner’s Manual in editable, electronic format that will include detailed information, specification, model numbers, cut sheets, and outline drawings to include, but not be limited to, the following:

- Introduction
- Overview
- System components with cross reference to equipment tag numbers
- System description
- Safety guidelines
- Project Site safety procedures
- General warnings
- Definitions
- Hazardous locations
- System shutdown safety protocols
- System start and restart
- Supplier product certifications and patent information
- Product certifications
- Underwriters Laboratories
- Patent information
- System performance monitoring and reporting
- Data acquisition system
- PLC’s
- HMI and Wonderware Licenses
- Website
- Performance monitoring

- System specifications
- Modules
- Inverters
- As-Builts
- Inverter operation manual provided by manufacturer
- Inverter operating procedures
- Spare parts inventory
- Calibration certificates as applicable for recommended calibration schedule for instrumentation and sensors.

13.0 TURNOVER AND STARTUP-TESTING

13.1 Contractor is responsible for all aspects of testing, commissioning and startup prior to turn-over of the facility to Company. Prior to the execution, Contractor shall supply Company with a Startup, Commissioning and Training Plan. Plan shall include description of scope of work for commissioning; testing and startup activities; list all commissioning team members and responsibilities; review manufacturer's startup and equipment testing procedures; testing plan for power and control wiring, instruments, controls, transformers, switchgear, alarms, and monitoring; plan for startup of individual systems, plan for documenting all wiring and equipment has been installed and tested, plan for facility performance testing and procedure development, development of startup procedures, define construction boundaries and plant turn-over or partial turn-over.

13.2 Contractor shall develop turn-over package for each system startup, final turnover and acceptance. Packages shall document testing and verification was completed for each termination, wire connection, alarm, function, control, and protection. Turn-over package shall also include approved and completed startup procedure, vendor drawings, test data, installation instructions, service contracts, O&M manuals, recommended spare parts, service parts, special tools, warranty and guarantee information and all as-built drawings associated with specific equipment and package. Each package shall be organized and complete with a unique package number, a clear statement of scope and complete listing of the package contents. Documents and testing records to be included in the package shall include but are not limited to: Insulation meggar test for multi-conductor cables, insulation resistant and DC High potential for 15KV power cables, cable high potential checkout, transformer checkout, insulation meggar test for power cables, switchgear inspection record, relay settings and test report, motor control center checkout, transformer inspection record, lighting circuit/receptacle checkout report, lighting panel board inspection, loop functional checkout instrument calibration, instrument functional checkout, rebar placement record, concrete test report, soil and backfill placement, soil compaction test, wire check documentation, electrical circuit checkout, logic verification, PLC/instrument scaling, alarm functioning testing, loop checks, trip checks, relay function and calibration, communication testing.

13.3 The start-up tests shall commence upon the date mutually agreed upon by the Parties. Supplier shall provide a detailed start-up testing procedure prior to the proposed start-up date. Completion of start-up testing is required prior to Provisional Acceptance. Supplier's start-up testing procedures shall, at a minimum, include:

1. Review and confirm all QA/QC tests precedent to start-up testing have been successfully completed.

2. Detailed procedure for Facility start-up including switching sequencing.

3. Test electrical equipment in conformance with NETA Standard for Acceptance Testing Specifications

4. Test and energize inverters in conformance with manufacturer's recommended procedures. Note operating voltages. Confirm inverter is performing as expected.

5. Test under full sun conditions, take and record Facility operating data, such as but not limited to MWdc, MW, Vdc, Vac, Idc, Iac, Solar Radiation.

6. Test the system control and monitoring system to verify that it is performing correctly.

7. Test the communication system for off-Site monitoring.

8. Test the Facility metering and protective relaying.

9. Detailed procedure for interface and initialization with the Company grid.

10. Safety plan during start-up and commissioning.

11. During this period the Supplier staff shall train Company staff on Facility operations.

12. Documentation of successful start-up and commissioning procedure.

13. Creation of a “Punch List” of items that need to be either corrected or addressed.

14. Supplier shall provide a start-up Turnover Package to Company.

15. Performance and Capacity Testing

13.4 Supplier shall submit written notification to Company that the completion of start-up has occurred and the Facility has been synchronized to the grid.

14.0 PROCEDURE DEVELOPMENT

14.1 Contractor shall be responsible for development of procedures for the testing, operation and maintenance of the facility. Procedure development shall be in conjunction with input from the Company and per the Company’s format requirements. Procedure topics shall include: Trip Checks for electrical equipment, alarm definitions, equipment calibrations, plant startup, plant monitoring, plant shutdown, plant maintenance, inverter maintenance, panel maintenance, transformer maintenance, switchgear maintenance, WPA isolation.

15.0 PERFORMANCE TESTING

15.1 In accordance the Agreement, Supplier shall operate and maintain the Facility during the Performance Testing Period. Supplier shall remain responsible for oversight of the Facility during Performance Testing, Facility maintenance and Project Site security until Final Acceptance. Prior to achieving Final Acceptance, the Facility shall be subject to a Reliability Test and a Capacity Test and the test results submitted to Company for Company review.

15.2 Reliability Test

- Supplier shall submit a Reliability Test procedure prior to the date upon which Supplier expects to begin the proposed Reliability Test. The Reliability Test shall capture all components of the Facility that impact energy production and provide an operability status for the entire Facility based on Equipment performance. The Reliability Test procedure shall include a list of all Equipment monitored, including the method and frequency by which this data is captured and measured.

1. Supplier shall maintain a minimum of ninety-five percent (95%) Availability of the Equipment during the Reliability Test Period. In the event Supplier fails to meet the minimum Availability of ninety-five percent (95%), Supplier may restart the test, but in no event shall the Reliability Test continue beyond the Final Acceptance date as set forth in the schedule

2. Supplier shall provide full time supervisory and technical staff to support the operation of the Facility during the Reliability Test Period.

3. Upon completion of the Reliability Test Period, Supplier shall submit in writing a Company letter indicating that the Facility is ready for final testing and verifications.

15.3 Capacity Test.

- Supplier shall develop a Capacity Test Procedure in accordance with the Capacity Test Guidelines described in Technical Section 1D and Attachment D of the Contract. Supplier shall submit the Capacity Test Procedure prior to the date upon which Supplier expects to begin the proposed Capacity Test. The objective of the Capacity Test Procedure is for the Supplier to demonstrate to the Company that: (a) Supplier has reached its Guaranteed Capacity and (b) the Facility has achieved the Guaranteed Capacity at the Design Point Conditions.

16.0 SPARE PARTS

16.1 Supplier shall submit a list of recommended spare parts for the facility. Supplier shall include any requirements for spare parts as defined by any local law or regulation and according to Good Industry Practices. The recommended spare parts list shall detail the cost per individual spare part, number of spare parts, the total cost of each type of spare part required and a total cost estimate for all recommended spare parts. Supplier's spare parts list shall include the following information:

1. Number of recommended on-Site spare modules
2. Number of spare fuses, breakers and disconnects
3. Identification of replacement parts for trackers and tracker motors (as applicable)
4. Identification of replacement parts for inverters, transformers, and other power conditioning system equipment
5. Other recommended spare parts

16.2 Supplier shall specify how the recommended quantities of spare parts were developed and what the anticipated availability for the Project will be with the recommended spares inventory. Expected annual usage shall be indicated for scheduled and unscheduled replacements. Upon approval by Company of such spare parts list (the "Spare Parts Inventory"), the Spare Parts Inventory shall be attached to the contract and made a part hereof. Prior to Final Acceptance, Supplier shall procure, at Company's expense, the approved Spare Parts Inventory.

16.3 During the Supplier Warranty Period, as parts and supplies are used from the Spare Parts Inventory, Supplier shall replace such inventory, used for warranty repairs, at no cost to Company. Spare parts used from inventory for all non-warranty repairs, including vandalism or theft, will be paid by Company.

17.0 WORK, MATERIALS AND EQUIPMENT SUPPLIED BY COMPANY

17.1 Company will provide final interconnection labor for tie to the electric utilites existing 34.5kV system for the auxiliary power feed (Communication Building). Company will provide a utility meter for 480V aux service. All other equipment, wire, meter boxes, interconnection requirements and labor shall be supplied by contractor.

17.2 Company will provide final interconnection labor for tie to the electric utilities existing 34.5kv system. Ameren will also supply pole mount utility meter. Contractor will be responsible for all other devices, labor and materials for interconnection including communication from utility installed devices to balance of plant communications/control system.

17.3 Company will supply interconnection study for plant interaction with the utilities distribution grid. Contractor shall support study as described in this specification. Study will provide minimum utility requirements and equipment required by contractor for interconnection.

18.0 CONTRACTOR'S COST TRACKING PROGRAM

18.2 In addition to daily timesheets, Contractor shall furnish manpower and cost information to the Construction Project Lead for all "time & material" work on a weekly basis. Time & Material information is to be submitted on Contractor-supplied forms.

19.0 GENERAL INFORMATION

19.2 Contractor shall develop and be responsible for all details, which may be required to complete the work, but which are not included in this document. The Company retains the right of approval of all such details.

19.3 Upon completion, all work defined in this document shall be of a uniformly neat and workmanlike appearance. All costs of repair to meet this condition shall be to Contractor's account.

19.4 Contractor shall follow the manufacturer's or fabricator's guidelines and requirements for installation of all materials and equipment, except as modified by this Specification.

19.5 Contractor shall not have any materials, tools, equipment, etc., fall from elevated work areas. Contractor shall be responsible for designing his own means to prevent objects from falling.

19.6 Contractor shall not under any circumstance weld, cut or modify any pipe, any tube, any header, or any other boiler pressure part not included in the scope of work described herein without the written consent of the Construction Project Lead and/or Engineer.

19.7 Contractor shall be aware that there will be other contractors onsite during the Work as described in this Specification as well as Company GCMS and Plant forces. Contractor shall coordinate his work to minimize interferences with the work of other contractors and/or crafts.

19.8 Only Contractor's vehicles permanently marked with Contractor's name and displaying an Ameren Contractor Mirror Tag, shall be permitted on job site. Mirror tags are available from the Construction Project Lead only after verification of auto insurance and other criteria has been met. No personal vehicles be permitted on job site.

19.9 Upon admittance into the Plant, Contractor (including each and every employee or sub-contractor's employees) shall be subjected to a computer based training (CBT) program that describes the Plant Construction Job Work Rules. These work rules are similar to those listed in Section 1A. The training lasts approximately ¾ hour for the average worker. Employees cannot begin work until the training is completed.

19.10 Contractors must recognize the difference between special instrument air connections and service air connections and shall not use instrument air for their air supply needs.

19.11 Job Working Rules

Contractor must enforce the Ameren Job Working Rules, included in this specification as Appendix B, as well as the Contractor's own work rules. If the rules conflict, then the more restrictive rule applies.

END OF SECTION 1B

SECTION 1D – GENERAL TECHNICAL REQUIREMENTS

1.0 TECHNICAL REQUIREMENTS

1.1 This technical section together with attached divisions will outline the requirements of equipment, material and services that shall be followed as a basis to complete the final design, procurement and construction of the contract scope. It is expected the Contractor utilize and follow the requirements of this section and the technical divisions when developing a preliminary design and cost estimate as well as completing other deliverables of the project. If sections or portions of these documents or divisions are unrelated to the scope of work, contract shall note such issues to Ameren SPOC per the approved change request procedure required in the contract.

1.2 Codes, Standards, and Regulations

1.2.1 The Contractor shall, as a minimum, perform the necessary work to meet the requirements of the codes, standards and regulations set forth in this specification. In the exercise of his experience and knowledge of the equipment, materials and work covered by this Contract, the Contractor shall perform all work and provide materials and equipment in accordance with other codes, standards and regulations consistent with providing a safe and reliable product.

1.2.2 Any deviations from this specification shall be documented by the submittal of an alternate proposal. Alternate proposal shall list exception by specification section in numerical order on the first page of the alternate proposal. Alternate proposal shall list breaker data sheets from specification after exception sheet. Manufacturing schedule, delivery date, and price shall follow the proposal data sheets. Individual manufacturer specification technical selling points shall be listed at the end of the proposal along with the terms and conditions.

1.3 Equipment and materials shall be complete in all respects within the limits herein outlined. Errors or omissions required to be corrected in the field shall be done by the manufacturer or its duly authorized representative at the Vendor's expense.

1.3.1 The latest revisions or addenda to codes, standards and regulations set forth as the date of the Contract shall apply.

1.4 The following codes, standards and regulations, with the issue dates noted, shall be complied with except as modified by this Specification. Materials not specified shall be in accordance with references within the codes and standards listed, or if not listed, with the latest applicable industry standard wherever possible. Conflicts between either the codes, standards, or this Specification shall be brought to the attention of the Engineer for resolution.

a) American Society for Testing and Materials (ASTM)

b) National Electric Code (NEC)

c) The Basic Building Code of the Building Officials of Code Administrations International, Inc. (BOCA)

d) America Institute of Steel Construction (AISC)

e) American National Standards Institute (ANSI)

f) American Society of Mechanical Engineers (ASME)

g) Environmental Protection Agency (EPA)

h) National Fire Protection Association (NFPA)

i) Occupational Safety and Health Administration (OSHA)

j) American Welding Society (AWS)

k) American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)

l) Underwriters Laboratories, (UL)

m) Institute of Electrical and Electronic Engineers (IEEE)

n) American Concrete Institute (ACI).

o) American Iron and Steel Institute (AISI).

p) American Society of Civil Engineers (ASCE)

q) American Society for Nondestructive Testing (ASNT)

r) Concrete Reinforcing Steel Institute (CRSI).

s) International Building Code, (IBC – 2009)

t) Metal Building Manufacturers Association (MBMA).

u) Missouri Department of Transportation (MoDOT).

v) National Electrical Manufacturers Association (NEMA).

w) National Electric Safety Code (NESC).

x) International Fire Code.

y) Portland Cement Association (PCA)

z) Society for Protective Coatings (SSPC).

aa) Standard for Acceptance Testing Specification (ANSI/NETA)

2.0 CIVIL DESIGN CRITERIA AND CODE REQUIREMENTS

2.1 GENERAL

2.1.1 This article covers the design criteria that shall be used by the Contractor for all civil, structural, architectural, and material handling work related to this Project. The Contractor shall be responsible for providing complete design for all equipment and systems within the Contractor's Scope of Work and any additional design associated with coordination and interfaces with the Owner, and with others. The Contractor shall provide design documentation, whether identified or not identified, consistent with documentation associated with the installation of a new industrial solar field. These criteria are utilized to transfer design requirements and to present coordination requirements.

2.2 ARRANGEMENTS

2.2.1 The contractor’s arrangement of the equipment provided shall include consideration of installation, removal, disassembly, and maintenance requirements.

2.3 FOUNDATIONS

2.3.1 General Criteria

2.3.2 Foundations shall be designed using reinforced concrete to resist the loading imposed by the building, structure, or equipment being supported. The foundation design shall consider the following:

- Soil bearing capacities.
- Deep foundation capacities.
- Lateral earth pressures.

- Allowable settlements, including differential settlements.
- Structure, equipment, and environmental loadings.
- Equipment performance criteria.
- Access and maintenance.
- Temporary construction loading.
- Existing foundations and underground structures including their current settlement conditions.
- Sulfate levels in the soil. (Contractor to test soil to determine level of concentration in order to develop proper concrete mix design.)
- Review the need to provide cathodic protection for steel H-piles (if used).

2.3.3 Foundations shall be designed using static analysis techniques assuming rigid elements and linear soil pressure distribution so that the allowable settlement and bearing pressure criteria are not exceeded. Foundations shall be proportioned so that the resultant of the soil pressure coincides as nearly as possible with the resultant of the vertical loading. The minimum factors of safety against overturning and sliding shall be 1.5. Factor of safety against sliding for retaining walls shall also be 1.5. When using ASCE 7 load combinations that apply a 0.6 factor on dead load, the factor of safety for overturning and sliding is automatically set at approximately 1.67. For these special ASCE 7 ASD load combinations, the ratio of resisting forces (0.6 dead load) over driving forces (wind, seismic, or lateral loads) should be greater than 1.0 instead of 1.5.

2.3.4 Geotechnical exploration, testing, and analysis information shall be used to determine the most suitable foundation system. Elastic (short-term) and consolidation (long-term) foundation settlements shall be calculated and limited to the following approximate design values, except where loading onto or differential settlements relative to existing structures may require more conservative criteria:

- Total settlement - 1½ inches.
- Differential settlement - 0.1 percent slope between adjacent column support points.
- Frost depth is 30" inches for foundations and underground utilities.

2.3.5 The Contractor shall conduct geotechnical investigations and prepare geotechnical reports. The Contractor shall review existing available geotechnical information and determine if additional geotechnical investigations are required to support design of foundations. The Contractor shall conduct any additional geotechnical investigations and prepare a geotechnical report including the criteria that will be used for design of the foundations. The Contractor shall select the type of foundation systems for the equipment and building and structures. The Contractor shall consider access restrictions and vibration levels near existing structures for the selection of the types of foundation systems to be used.

2.4 SITE

2.4.1 The existing site is located next to a substation in O'Fallon, MO off of highway 79, which has been used for farming. The existing site generally slopes downhill from the south to the north. The entrance to the site is off highway 79. The contractor shall establish all benchmarks as required for construction and provide a minimum of 4 permanent benchmarks for future use.

2.4.2 Contractor shall be responsible for providing a connection to the county water supply for site potable water connection. At a minimum a ground mounted water faucet shall be provided inside the secure area adjacent to a substantial structure and protected with bollards.

2.4.3 The Contractor shall be responsible for a corrosion study to determine action required for foundation installation of the solar field and all ancillary equipment. The study shall be performed by a NACE certified corrosion engineer. A report detailing what is required to ensure a 30 year

minimum design life for all foundations shall be provided to the Company for review before foundation design is to begin.

2.4.4 The contractor shall be responsible for installation and maintenance of erosion control in accordance with the conditions set forth in its NPDES permit, which includes required inspections. Contractor shall plan and execute construction of earthwork methods to controls surface drainage for cuts and fills and prevent erosion and sedimentation. Controls shall pay for all fines and damages including any and all NPDES permit violations.

2.4.5 The Contractor shall provide a weed control plan to prevent weeds from entering the site. The plan shall also incorporate a soil treatment plan to prevent weed growth on the project site. The plan shall include a pre-emergent in areas to be disturbed and in those areas required for operation and maintenance of the facility. The contractor shall develop a grading and drainage plan for Company review, which shall be designed and installed in accordance with State and local codes and permit requirements. All structures required for such grading and drainage plan shall comply with applicable MoDOT standard specifications for drainage facilities.

2.4.6 The contractor shall provide fill material if necessary to meet final site grade. The contractor shall provide a soil analysis showing that the material does not contain any hazardous materials.

2.4.7 The contractor shall provide a geotextile fabric and 6 inches of MoDOT Type 5 rock throughout the entire solar field (entire fenced area) as the final surface. The rock shall be compacted to 95% standard proctor.

2.4.8 Fencing shall be placed around the entire site for security purposes. The fence shall be a minimum of 10 feet from all buildings, equipment, and panels. See Division 2830 for requirements.

2.4.9 A person gate and a 12 foot wide vehicle gate shall be installed to access the solar field. Each gate shall have a card reader installed for security access to the site. See Division 2830 for requirements.

2.4.10 Security cameras shall be installed at the perimeter of the site. See Division 2830 for requirements.

2.4.11 Contractor shall furnish and install a building to act as a storage enclosure / shelter at the project site. The enclosure shall be suitable for communications equipment, office, and storage suitable to operate the photovoltaic array that is being built. The building shall have walls to separate communications from storage and office. The building shall meet all applicable state and local codes.

2.5 ROADS

2.5.1 Construction Signage

2.5.1.1 The Contractor shall provide a temporary construction entrance sign. Company shall work with contractor to come up with approved design. Contractor shall be responsible for any other signage required by permits or in accordance with the agreement.

2.5.2 Construction Access

2.5.2.1 The Contractor shall abide by all load limits established by MoDOT and the government entity having jurisdiction over the Project Site. Supplier shall be responsible for providing, operating and maintaining at its sole cost equipment services and personnel with traffic control signage and protective devices, which meet the requirements of the MUTCD as required to allow traffic to flow on haul routes and on-Site access roads in a safe manner. Supplier shall be responsible for the construction of any temporary access around areas of excavation and other construction activity, as required. Temporary construction roads and staging areas shall be coordinated with Company, and shall be completely removed in their entirety after Final Acceptance and restored in strict accordance with all permit requirements. Supplier shall be responsible for making all necessary improvements to state, county and other roads outside of the Project Site, as required, to allow for delivery of Equipment in order to complete the Work.

2.5.3 Entrance Road off Highway 79 to Solar Field

2.5.3.1 The contactor shall provide an asphalt or concrete road from highway 79 to the entrance of the solar field. This road shall be rated for HS20 loading. The road shall be a minimum of 16 foot in width for two lanes of travel. It shall have a crown down the center and each lane shall be sloped 2% from the crown.

2.5.4 Solar Field Roads

2.5.4.1 Shall be a minimum of 16 feet in width and designed with a minimum loading of HS20. The roads shall be designed to allow access to maintain all equipment including replacement.

2.5.5 Vehicular Traffic

2.5.5.1 New and existing facilities, equipment, buildings, and utilities shall be protected from vehicular traffic by bollards or highway guardrails. This shall apply to all new roads and any existing roads that are relocated.

2.6 OVERHEAD UTILITIES

2.6.1 Existing overhead power lines are located within the proposed solar site. Use proposer clearances when working near power lines.

2.6.2 In general for all areas of the new facilities the design overhead clearance from roadway to bottom of any overhead obstruction shall be 30 feet except where specific approval of the Owner is given for a lower clearance.

2.7 UNDERGROUND UTILITIES

2.7.1 There are no known underground utilities located within the site. Contractor shall verify and determine location of any underground utilities.

2.7.2 Underground utilities shall be designed and installed with warning and location indicators for future excavations in the areas of buried utilities.

2.7.3 Underground utilities shall be designed and installed below the freeze line.

2.8 MATERIAL REMOVAL

2.8.1 All excavated material that cannot be reused shall be hauled off site. Top soil shall remain onsite.

2.9 RACKING

2.9.1 Racking shall be designed to meet IBC 2009 requirements and requirements of local AHJ. If steel racking is used it must be galvanized.

2.9.2 The racking shall be designed to allow for mowing/spraying equipment to get under the lowest attached panel. See Division 5, 05900.2.1 for Photovoltaic Racking.

3.0 ELECTRICAL AND CONTROLS DESIGN CRITERIA AND CODE REQUIREMENTS

3.1 ENVIRONMENTAL CONDITIONS

3.1.1 The new photovoltaic system will be located on the Belleau Substation Site. The equipment shall be designed to handle the site environmental conditions including blowing dust and cottonwood pollen. The environmental conditions will not disrupt combiner boxes, DC disconnect switches, inverters, transformers, and control/monitoring equipment. The electrical cabinets interior shall not collect the blowing dust and prevention shall not be prevented solely by cabinet filters.

3.2 SITE LIGHTING

3.2.1 Security site lighting is being requested. See Section 16502 for lighting specifications.

3.2.2 The lighting shall not cast shadows across any of the photovoltaic panels and shall be of LED type located at each inverter/transformer station.

3.2.3 The light intensity shall be a minimum of 2 foot-candles at ground surface or as required by the security system installed.

3.3 SOFTWARE MODEL DESIGN

3.3.1 The Contractor shall create an SKM Model to validate design and confirm tie in locations with a load flow study, short circuit evaluation, Arc Flash Hazard Analysis, coordination studies for entire facility based on medium voltage tie-in. All studies shall be assembled per NETA 2013.

3.3.2 Engineering and design shall include the appropriate sizing and cabling (above and below ground) that will connect all applicable Equipment to the point of interconnection. The Project electrical system shall be designed for electrical system losses on the DC wiring system shall have no more than two and one-half percent (2.5%) and losses on the AC wiring system no more than one and one-half percent (1.5%).

3.3.3 System fault current is greater than 10,000 Amps therefore the Supplier shall provide a Facility grounding design study, which shall include the study of all substations, fences, gates and all conductive surfaces. Such grounding study shall be performed in accordance with the NESC and IEEE standards for generating stations. Installation of Facility grounding shall be done in accordance with the results of the grounding study. Fences and gates shall be grounded in accordance with the grounding design.

3.4 METEOROLOGICAL STATIONS

3.4.1 Supplier shall submit MET station specifications and provide a sufficient number of MET Stations to provide adequate meteorological data to evaluate Facility performance. The number of MET Stations will be designed based on Project Site terrain and local variability; provided, however, in no event shall Supplier have less than one (1) MET Station with tow plan of array irradiance sensors. MET Stations shall tie to the main SCADA system which will have a battery backup system for both the weather station and SCADA. Each MET station shall have remote access capability to facilitate retrieval of all recorded data. All sensors and instrumentation shall be calibrated according to specifications and schedule as per manufacturer recommendations. MET stations shall have the capability of being modified to include additional sensors such as barometric pressure and humidity. All the data collected shall be routed to the site PLC for immediate indication as well as historical data.

3.5 MEDIUM VOLTAGE TIE-IN

3.5.1 The medium voltage connections shall be underground from solar array to the connection at 34.5KV meter pole.

3.5.2 Any installed breaker or disconnect switches shall be required to be locally and remote operated from the current PLC system if not already.

3.5.3 An outdoor mounted generation watt hour meter and revenue meter will be required for installation near the meter pole to monitor production that will be required to communicate with the PLC system.

3.6 AUXILIARY POWER

3.6.1 An auxiliary pad mounted power transformer will be provided by the Contractor. This transformer will provide 3-phase, 34.5 kV to 480 VAC power for auxiliary power to the solar site. During construction this transformer will provide construction power and eventually be converted to the plant auxiliary power supply. The Contractor will be responsible to provide a 42KA rated, 480VAC power panel as well as a 480VAC to 208/120VAC transformer to the 3 phase lighting panel rated at minimum 10kA. The contractor shall suggest MVA rating of transformer for construction and future plant auxiliary power. Contractor shall provide meter box and provisions to monitor power usage to the PLC system Provision for underground conduit, cable, CTs, PTs, metering box and interconnection requirements from auxiliary power pole to 480VAC panel location shall be the responsibility of the contractor.

3.6.2 One outdoor welding receptacle near the control building shall be field installed.

3.7 STEP-UP TRANSFORMER

3.7.1 The output of the inverter shall have conduit or bus duct to the low side of the step-up transformer.

3.7.2 The 34.5KV side of the transformer shall be isolated from the 34.5KV supply with a motor operated fuse disconnect switch or approved equivalent.

3.7.3 The fuses in the motor operated disconnect switch shall coordinate with the low side breaker from the output of the inverter.

3.8 CONVIENCE OUTLETS

3.8.1 120V weather resistant convenience outlets shall be installed near each inverter and transformer.

3.9 COMMUNICATIONS SHELTER/STORAGE ENCLOSURE

3.10 The Supplier shall design, furnish, fabricate and deliver communications shelter(s)/storage enclosure(s) at the Project Site. The shelter(s) and enclosure(s) can be one structure separated by walls or a combination of structures to serve the functions of shelter/enclosure for communications equipment and office and storage suitable to operate a solar PV array of this size and type to meet the OSHA clearance requirements, complete with all appurtenances as further described herein.

3.11 The communication shelter(s) shall be designed for local Project Site conditions and may be of steel, brick or concrete construction and meet local enclosure code requirements.

3.12 The communications shelter(s)/storage enclosure(s) shall include, but not be limited to, the following, unless noted otherwise:

3.12.1 Design and Engineering. Supplier shall design the shelter(s) and/or enclosure(s) per the applicable codes including IBC and ASCE 7 and submit all of the design and engineering plans described herein to Company for Company Review.

- Floor plan
- Elevations
- Reflective ceiling plan
- Enclosure details
- Electrical wiring plan and load calculations
- Mechanical plan

3.12.2 Manufacturing, transportation, delivery and installation.

- All metals, wood, plastics, gutters, downspouts, doors, windows necessary to complete construction.

3.12.3 Complete electrical branch wiring and main distribution panel (factory installed).

3.12.4 HVAC equipment.

3.12.5 The shelter/enclosure area(s) shall be of sufficient size to store all recommended spare parts and batteries. Enclosure(s) used for storage shall include door(s) (minimum width of eight feet (8')) and ramp for forklift access. The storage area floor shall be designed for forklift access.

3.12.6 The communication area shall include racking for Company communications equipment to be installed by Company. Space shall be left for 2 standard communications racks with wire management system. Rack shall have access of at least 3 ft. at front and back.

3.12.7 Communications shelter shall include space for HMI control maintenance area.

3.12.8 Communications shelter shall include space for telecommunications wall mounted positron (4' H x 4' W x 1' D)

3.12.9 Communication shelter(s)/storage enclosure(s) shall be lockable with a door position switch and card reader.

3.12.10 Communication shelter/storage enclosure shall supplied electrically by auxiliary service power circuit.

3.13 CONTROLS DESIGN CRITERIA

3.13.1 Supplier shall provide an overall monitoring and control system for the Facility comprised of the following:

3.13.1.1 Supplier shall provide a single, integrated HMI (Human Machine Interface) that is located in the Communications Shelter. This HMI shows the current real-time data being monitored at all points in the field. This HMI also allows for remote control operations of inverters and other possible devices in the field. This HMI does not require any external internet connection for displaying the real-time data or performing the control operations. Graphical user screens for the HMI shall be constructed using software such as Wonderware, or approved similar software.

3.13.1.2 Remote access to Facility SCADA shall be provided via Windows Terminal Server.

3.13.1.3 Supplier shall provide means of communicating all measured data values for the Facility to a Company supplied OSIsolft PI Node that also resides in the Communication Shelter. This data communication protocol shall be an industry standard that mutually agreed upon. Local buffering and storage of data is needed to handle possible communication interruptions. Minimum data storage shall be designed for four weeks. Supplier shall provide a final detailed list of all available measured data values for the Facility.

3.13.1.4 Supplier shall provide means of communicating all measured data values for the facility metering and distribution equipment (meter, relay data, pole mount switches) to a Company supplied RTU (Remote Terminal Unit) that also resides in the Communication Shelter. This data communication shall be an industry standard mutually agreed upon Local buffering and storage of data is needed to handle possible communication interruptions. Maximum data storage shall be designed for one week. Supplier shall provide a final detailed list of all available measured data values for the Facility.

3.13.1.5 Supplier shall provide means for external communications (external communications equipment provided by Ameren) to connect to the Facility SCADA for purposes remote monitoring and data transfer. This connection will be continuous in nature. This system will be in place and fully tested by Final Acceptance. The external communications will be a T1 coordinated with Ameren's Information Technology Department.

3.13.1.6 Supplier will be provide spare server/communications rack space, power, and cabling for Ameren supplied external communications equipment noted above (firewall, router, PI Node, etc).

3.13.1.7 WAN Connectivity and Information Security. After Final Acceptance, Company will provide pre-arranged escorted VPN access only to the Facility SCADA control system through the Company network for purposes of diagnostics or other remote access maintenance needs. If agree to by the Owner's data security upon final design the system may also provide data "push only" to cloud monitoring and diagnostic server which is used during the warranty period to monitor and respond to plant issues. No direct connection to the field by the Supplier is allowed after connection to the Ameren Network.

3.13.1.8 Supplier shall program the control software for the Facility on an industry-standard SCADA platform (Wonderware or approved alternative) for a local HMI and provide monitored data points using OSISoft PI Node.

3.13.1.9 Data collection points to be monitored by the SCADA system shall include:

1. MET Stations)
    a. PV module temperature (in addition to PV cell temperatures measured by the inverter)
    b. Two POA irradiance
    c. Ambient temperature
    d. Wind speed
    e. Wind direction
    f. Global Horizontal Irradiation

g. Rain

2. Inverters.
   a. AC Voltage
   b. DC Voltage
   c. AC Current
   d. DC current (may be multiple values)
   e. Kilowatt
   f. Kilowatt-hour

3. Metering
   a. SCADA system shall monitor and store data from the Project
4. Transformers
   a. Oil level alarm
   b. Pressure alarm
   c. Temperature alarm

5. All enclosures and shelters
   a. Environmental conditions
   b. HVAC/Climate Control Status
   c. Door position
   d. Fire and Smoke
   e. Security and closed circuit television.
   f. Standby battery alarms

6. Facility switchgear

7. Data storage and historian.
   a. Facility shall have four (4) weeks of minimum on-Site storage capacity for high resolution data. The exact storage details of high resolution data, such as dead-banding, will be determined during the detailed design phase, but at a minimum will include MET data
8. Networking infrastructure shall be an industrial Ethernet LAN throughout the Facility.

9. MET station,SCADA and other data logging systems shall be synchronized.

10. All monitored Facility generation Equipment shall be monitored to capture real time AC and DC electrical characteristics including
    a. Voltage
    b. Current
    c. Power
    d. Frequency
    e. Power Factor

11. All monitored Facility generation Equipment shall be monitored to capture all diagnostic information including
    a. Temperatures
    b. Alarms
    c. Status indicators
    d. Fault states

12. SCADA System Security. The operator and/or engineering stations shall be provided with security access to specific system functions and data.

b. HMI and Alarm shall follow Ameren Missouri's HMI & Alarming Philosophy.

c. There shall be at least three submittals for all hardware and software to be supplied for the Facility SCADA. The equipment list shall include each component name, manufacturer, model number, a description of the operation, quantity supplied, and any special setup, operation, and maintenance.

   i. Submittal One
      a. SCADA network diagram
      b. HMI software
      c. Communications protocols
      d. PLCs or controllers

e. HMI & Alarming configurations and standards document.

ii. Submittal Two

a. Draft HMI layout and screens
b. Draft Alarming matrix including alarm descriptions, priority, colors, and operator response.
c. Draft of user and station security
d. Panel shop drawings (if applicable),
e. Interconnection diagrams for wiring between components
f. Network diagram
g. Input/output listing showing point names, numbers, addresses.
h. Control Narrative (if applicable)

iii. Submittal three

a. HMI FAT
b. Finalized Controls Narrative (if applicable)
c. Operator and Maintenance Manuals
   - Start-up, shutdown, maintenance, and troubleshooting procedures
   - Equipment cut sheets
   - Equipment manuals
   - Updated earlier submittals

3.13.2 These manufacturers are the preferred providers for the plant for the type of equipment listed. If these products and providers do not produce a product capable of performing to the specifications required then the Contractor should select a suitable product from a different manufacturer and notify COMPANY of the need to deviate from the list of preferred equipment providers. All components are required to be NEMA rated regardless of manufacturer. IEC products are not acceptable.

3.13.3 Provide electronic copies of the control program configurations, proprietary configurations will not be accepted.

3.13.4 Support other project team members (including sub-contractors) as required to successfully complete the project.

4.0 Approved Equipment Manufacturers

4.1 The contractor is required to use products from the following manufactures for the purposes indicated in the design of the control system for the new Solar Panel control system whenever possible:

4.1.1 Local Panel Display: Panel View Plus 1500 Keypad / Touch, standard Communications, AC Power or approved equivalent

4.1.2 Terminal Blocks: Phoenix Contact OTTA-6T, UT-6, UT-10, UT-16, UT-35

4.1.3 Circuit Breakers: Square D or approved equivalent

4.1.4 Control Relays: Tyco Potter-Brumfield KRPA or approved equivalent

4.1.5 PLC: Allen Bradley Control Logix or approved equivalent

4.1.6 Protocol Converter: ProSoft Modbus TCP Converter or approved equivalent

4.2 The contractor is required to use products from the following manufactures for the purposes indicated in the design for the new solar facility whenever possible:

4.2.1 Transformers: Eaton/Cooper or approved equivalent

4.2.2 Inverters: Eaton or approved equivalent

4.2.3	Power Circuit Breakers:	Eaton or approved equivalent
4.2.4	Combiners/Array Disconnect:	Shoals or approved equivalent
4.2.5	Panels:	Yingli, Trina or approved equivalent
4.2.6	Racking System:	Powers Steel or approved equivalent
4.2.7	Meteorological Equipment:	As mutually agreed by Owner and Contractor

4.3 All equipment manufacturers and models shall be approved by Owner prior to Contractor procurement.

5.0 TESTING

5.1 The Owner reserves the right to observe the below tests being performed. Contractor shall inform Company 3 to 4 weeks in advance of any factory acceptance testing.

5.2 Contractor shall test all equipment in accordance with the latest revision of applicable IEEE and UL standards for the equipment.

5.3 All electrical equipment shall be tested in accordance with NETA 2013, Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems.

5.4 All equipment shall be fully tested at the factory (FAT) and also field tested to ensure they are fully functional per manufacturer's instructions

5.5 All equipment shall be functionally tested per manufacturer's recommendations and instruction manuals.

5.6 All 600V power cable, bus, panels, and other current carrying equipment shall be meggered at 500V or 1000V after installation but before initial energization. All medium voltage cable shall under-go a high potential (hi-pot) test. Record date and times and values on site megger report to be turned over after commissioning.

5.7 Functionally verify all control and communications system work as intended.

5.8 Meters and relays shall be tested in accordance to manufacturer's instructions. Ameren System Relay will also test the systems once they are turned over. All instrument transformers shall also be tested for proper ratio and polarity.

5.9 Grounding and bonding systems shall be verified and documented that these systems as installed meet NEC requirements.

5.10 Certified results of test data listed in above shall be included in the instruction manual. One copy of test results for each piece of equipment tested and purchased.

5.11 Provide a PV panel map, listing serial numbers in each string. From the manufactures test sheets sum the open voltage measurements and field check and open-circuit voltage of each string of panels prior to closing in a combiner box. Record date and time of test with ambient temperatures and record the W/m^2 value from the solar radiation meter.

5.12 Once the combiner fuse is closed on each string, measure and record the DC current value. Compare it with the Imp (Current Max Power) from the manufactures test sheets. Record date and time of test with ambient temperatures and record the W/m^2 value from the solar radiation meter.

5.13 Perform I-V curve test on each string per IEC 61829 and industry standards.

5.14 At each re-combiner junction box if used, record voltage and current from each field combiner box. Record date and time of test with ambient temperatures and record the W/m^2 value from the solar radiation meter.

5.15 Additional testing will be required to verify inputs and outputs of alternating current inverters, transformers and breakers per IEEE standards.

5.16 The Vendor shall notify the Owner of all tests not less than 7 days prior to the date of test to allow the Owner to observe testing of the equipment if so desired.

5.17 Certified copies of inspection and test reports shall be provided by the Vendor and Contractor for all test and inspections conducted on the specified equipment. One (1) copy of each report shall be submitted to the Owner within one (1) week after completion of each test or inspection as specified in Item 3.2 above.

5.18 A site acceptance test will be performed to verify voltage, current, and wattage requirements. A performance test will be performed to verify the rating after temperature and solar radiation compensation.

6.0 CAPACITY TEST

6.1 The Capacity Test shall determine the Corrected Capacity at the Design Point Conditions established in Table 1D-5.1.1 below in order for Supplier to achieve Final Acceptance. Since the Capacity Test will determine the Corrected Capacity for the Facility, as defined in Attachment D of the Contract, such test will be based on the relevant environmental conditions in the field at the time of such test, including field irradiance and temperature. The measured Capacity shall then be "corrected" to the Design Point Conditions as established in Table 1D-5.1.1 and the resulting Corrected Capacity shall be compared to the Guaranteed Capacity as set forth herein

6.1.1 TABLE 1D -5.1.1

Name of Project / Facility	Phase 1 Solar – Belleau Substation
City, State	O'Fallon, Missouri
County	St. Charles
Nameplate capacity (MWdc at STC)	5.754
Delivered capacity (MW to AMMO System)	4.5
Guaranteed Capacity (MW) corrected to DPC	4.5
Design Point Conditions for Guaranteed Capacity	
Performance Ratio	78.9% (per TYM2 model)
Module power temperature coefficient	-0.44%/°C
Module Cell Temperature	45 °C
Irradiance (POA)	1000W/m2
Atmospheric Air Mass	1.5
Projected annual delivered energy (MWh)*	7861 (per TMY2 model)
Interconnection Point	Ameren Missouri's 34.5 kV distribution system pursuant to the Interconnection Agreement, as applicable
PV Module technology	Polycrystalline
Facility Collection System Voltage	34.5 KV
Facility meter location	Ameren Missouri Pole Mount
* First twelve (12) months of operation	

7.0 PRE-SHIPMENT INSPECTION

7.1 The Owner reserves the right to inspect the equipment prior to shipment.

7.2 The Vendor shall notify the Owner of all Shipments not less than 14 days prior to the date of shipment to allow the Owner to inspect the equipment if so desired.

8.0 SHIPPING

8.1 The vendor shall include costs of shipping all materials and associated equipment together in the price quote.

8.2 The vendor shall be responsible for delivery to the Owner's site F.O.B. This shall include special work required to support delivery of heavy and/or oversized items such as, but not limited to, road repairs, road upgrades or extensions, power line disconnections and reconnections, bridge reinforcements, grade alterations, and the like. The Vendor shall provide and coordinate all special services required to complete all deliveries based on the existing conditions surrounding the site on the Contract Date.

8.3 The Vendor shall discuss with the Owner the routing of shipments and shall reroute the same as indicated by the Owner provided the freight rates and overall costs are no greater than by other routes.

8.4 Truck shipments will be accepted weekdays only between the hours of 8:30 A.M. and 2:30 P.M. (Central time). After-hour deliveries not provided for by contract may be refused until the next regular workday. Cost incurred by the Owner for offloading prior to or after normal working hours shall be back-charged to the Vendor unless prior authorization has been approved by the Owner.

8.5 Packages shall be clearly marked with the Contract Number and Purchase Order Number where applicable. Packing lists shall identify Contract Number, Purchase Order Number and item numbers and quantities, bills of lading shall identify the Contract number and Purchase Order Number.

8.6 Equipment shall be shipped completely factory assembled. Preparation for Shipment shall be in accordance with Manufacturer's standards unless otherwise noted in this specification. The Manufacturer shall be solely responsible for the adequacy of the preparation for shipment to ensure materials are received at their destination in EX-Works (EXW) conditions when handled by commercial carriers.

8.7 Equipment shall be boxed, crated, or otherwise suitably protected during shipment, handling, and storage. Components with moving parts which might be damaged in shipment, shall have all such moving parts securely blocked and braced. All items blocked and braced for shipment must be clearly identified and tagged accordingly. Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures.

8.8 Materials required for protection during shipping and storage shall be treated for fire resistance. Wood protection shall be Class A, fire retardant, pressure treated type.

8.9 Coated surfaces shall be protected against impact, abrasion discoloration, and other damages. Surfaces which are damaged shall be repaired.

8.10 Electrical equipment, controls, and insulations shall be protected against moisture and water damage. All external gasket surfaces and flange faces, couplings, rotating equipment shafts, bearings, and like items shall be thoroughly cleaned, coated with rust-preventive compound, and protected with suitable wood, metal, or other substantial type covering to ensure their full protection. Exposed threaded parts shall be greased and protected with metallic or other substantial type protectors. Damages due to insufficient protection shall be repaired by the Vendor.

8.11 Returnable containers and special shipping devices shall be returned by the manufacturer's field representative at the Vendor's expense.

8.12 A weatherproofed itemized list of the contents shall also be attached to the outside of each box.

8.13 Spare parts shall be shipped separate in heavily constructed wooden boxes. The boxes shall be designed as permanent storage enclosures. Separate boxes shall be used for the spare parts for each major piece of equipment. Where applicable, boxes shall be designed and constructed for return shipment of damaged or worn components for repair.

8.14 Spare parts shall be protected from damage due to moisture and dirt accumulation during an extended storage period by use of special coatings, airtight membranes, bags of desiccant, or other means acceptable to the Owner.

8.15 All separately packaged accessory items and parts shall be shipped with the equipment. Containers for separately packaged items shall be marked so that they are identified with the main equipment. An itemized packing slip, indicating what is in that container only, shall be attached to the outside of each container used for packing. A similar list shall be inside of each container. A master packing slip, covering all accessory items for a given piece of equipment which are shipped in separate containers, shall be attached to one container.

8.16 Vendor shall provide dimensions (H" x W' x D") and weight for each shipping container with approval drawings.

8.17 If materials require special fixtures or lifting rigs for offloading, such rigs or fixtures shall be provided at no additional cost with shipment.

9.0 RECEIPT INSPECTION

9.1 Materials or equipment purchased under this contract may be inspected at the specified receiving points and there accepted or rejected. Inspection will include the necessary testing for determining compliance with the specifications. All expense of initial acceptance tests will be borne by the Owner. The expense of subsequent test due to failure of materials or equipment first offered will be charged against the Vendor. The Owner may reject damaged materials or equipment at any point along the line of shipment with the return and shipment costs to the Vendor's account.

END OF SECTION 1D

SECTION 1E – DESIGN BASIS

The Design Basis Document identifies the design basis for systems, structures and components to clearly define the requirements and how each one is specifically met.

The Contractor shall provide a design basis document for each PV system that provides a detailed system description and outline of the equipment ratings, operating parameters, and design inputs.

The Contractor shall outline design criteria for each PV system including, but not limited to, wind load, PV panel and inverter efficiency, seismic importance factor, system voltage, number of inverters, PV system electrical protection requirements etc.

The Contractor shall determine and outline the applicable local codes, ordinances, standards, and permits required to complete this project at the site. The Contractor shall outline the permitting process and the length of time needed for review and approval. In addition, the Contractor shall identify all inspections required by the City, Utility, or any other jurisdiction.

The Contractor shall provide an electrical one line diagram of each system, which indicates all of the required and recommended components necessary as well as the electrical tie in point.

The Contractor shall outline the metering required for each PV system.

All Design Basis information shall follow the format and information listed per the template below.

A sample format for the design basis from AUE-TMP-ADM3203-01 is provided below:

DESIGN BASIS DOCUMENT		
<Site>-DB-<Plant System>-######	**<Site> Unit <#> - <Plant System>**	**Rev. 0**

1.0 System Overview

1.1 System Function

Section 1.1, System Function, provides a general description of the system/subsystem.

1.2 System Design

Section 1.2, System Design, provides the supporting design information for the system and its sub-systems, and how they relate to:

- Regulatory Requirements
- Industry/National Codes and Standards
- Performance/Design Requirements
- Asset Protection
- Personnel Safety

1.3 System Boundaries

Section 1.3, System Boundaries, contains the boundaries and/or scope of this Design Basis Document (DBD).

1.4 Interfacing Systems

Section 1.4, Interfacing Systems, provides a list of the interfacing plant systems. This list includes the EMPRV Location ID and Name.

2.0 Design Basis Information

2.1 General System Requirements

NOTE: If a design basis requirement applies to more than one section, the requirement should be made and all restatements of that requirement should be listed in the appropriate sections. The source document(s), including section titles, should be recorded after the Design Basis requirement and bolded.

Section 2.1, General System Requirements, provides a list of all Design Basis source documents related to the system for each of the following areas:

2.1.1 Regulatory Requirements

List the Source Documents that are associated with regulatory requirements or commitments. If none apply, state "There are no known Regulatory Requirements that apply to this section." Examples include:

- FERC
- NERC
- SERC
- DNR
- EPA, etc.

2.1.2 Codes and Standards

List the Source Documents that are associated with the applicable industry/national codes and standards. If none apply, state "There are no known Codes and Standards that apply to this section." Examples include:

- ANSI/IEEE
- National Electrical Code (NEC)
- National Electrical Manufacturer Association (NEMA)
- International Building Codes (IBC)
- American Concrete Institute (ACI), etc.

2.1.3 Performance/Design Requirements

2.1.4 List the Source Documents that are associated with the performance/design requirements. If none apply, state "There are no known Performance / Design Requirements that apply to this section." Examples include:

- Project Specifications
- Calculations
- Design Change Packages
- Manufacturer Manuals, etc.

2.2 Indications, Instrumentation and Controls (I&C) Requirements

Section 2.2, Indications, Instrumentation and Controls (I&C) Requirements, documents I&C Requirements that preserves the Design Basis of the system for the following areas:

2.2.1 Regulatory Requirements

2.2.1.1 Provide the applicable Regulatory Requirements from Section 2.1.1. If none apply, state "There are no known Regulatory Requirements that apply to this section."

2.2.2 Codes and Standards

2.2.2.1 Provide the applicable Codes and Standards Requirements from Section 2.1.2. If none apply, state "There are no known Codes and Standards that apply to this section."

2.2.3 Performance/Design Requirements

2.2.3.1 Provide the applicable Performance/Design Requirements from Section 2.1.3. If none apply, state "There are no known Performance/Design Requirements that apply to this section."

2.3 Electrical Requirements

Section 2.3, Electrical Requirements, documents the Electrical Requirements that preserves the Design Basis of the system for the following areas:

2.3.1 Regulatory Requirements

2.3.1.1 Provide the applicable Electrical Regulatory Requirements from Section 2.1.1. If none apply, state “There are no known Regulatory Requirements that apply to this section.”

2.3.2 Codes and Standards

2.3.2.1 Provide the applicable Electrical Codes and Standards Requirements from Section 2.1.2. If none apply, state “There are no known Codes and Standards that apply to this section.”

2.3.3 Performance/Design Requirements

2.3.3.1 Provide the applicable Electrical Performance/Design Requirements from Section 2.1.3. If none apply, state “There are no known Performance/Design Requirements that apply to this section.”

2.4 Mechanical Requirements

Section 2.4, Mechanical Requirements, documents the Mechanical Requirements that preserves the Design Basis of the system for the following areas:

2.4.1 Regulatory Requirements

2.4.1.1 Provide the applicable Mechanical Regulatory Requirements from Section 2.1.1. If none apply, state “There are no known Regulatory Requirements that apply to this section.”

2.4.2 Codes and Standards

2.4.2.1 Provide the applicable Mechanical Codes and Standards Requirements from Section 2.1.2. If none apply, state “There are no known Codes and Standards that apply to this section.”

2.4.3 Performance/Design Requirements

2.4.3.1 Provide the applicable Mechanical Performance/Design Requirements from Section 2.1.3. If none apply, state “There are no known Performance/Design Requirements that apply to this section.”

2.5 Civil / Structural Requirements

Section 2.5, Civil / Structural Requirements, documents the Civil / Structural Requirements that preserves the Design Basis of the system for the following areas:

2.5.1 Regulatory Requirements

2.5.1.1 Provide the applicable Civil / Structural Regulatory Requirements from Section 2.1.1. If none apply, state “There are no known Regulatory Requirements that apply to this section.”

2.5.2 Codes and Standards

2.5.2.1 Provide the applicable Civil / Structural Codes and Standards Requirements from Section 2.1.2. If none apply, state “There are no known Codes and Standards that apply to this section.”

2.5.3 Performance/Design Requirements

2.5.3.1 Provide the applicable Civil / Structural Performance/Design Requirements from Section 2.1.3. If none apply, state “There are no known Performance/Design Requirements that apply to this section.”

2.6 Maintenance Requirements

Section 2.6, Maintenance Requirements, documents the Maintenance Requirements that preserves the Design Basis of the system (e.g., Lubrication, Testing, Inspections, etc.) for the following areas:

2.6.1 Regulatory Requirements

2.6.1.1 Provide the applicable Regulatory Requirements from Section 2.1.1. These should be only the maintenance requirements required to preserve the Design Basis of the system. If none apply, state “There are no known Regulatory Requirements that apply to this section.”

2.6.2 Codes and Standards

2.6.2.1 Provide the applicable Codes and Standards Requirements from Section 2.1.2. These should be only the maintenance requirements required to preserve the Design Basis of the system. If none apply, state “There are no known Codes and Standards that apply to this section.”

2.6.3 Performance/Design Requirements

2.6.3.1 Provide the applicable Performance/Design Requirements from Section 2.1.3. These should be only the maintenance requirements required to preserve the Design Basis of the system. If none apply, state “There are no known Performance/Design Requirements that apply to this section.”

2.7 Other Requirements

Section 2.7, Other Requirements, documents Miscellaneous Requirements that preserves the Design Basis of the system for the following areas:

2.7.1 Regulatory Requirements

2.7.1.1 Provide miscellaneous Regulatory Requirements from Section 2.1.1. If none apply, state “There are no known Regulatory Requirements that apply to this section.”

2.7.2 Codes and Standards

2.7.2.1 Provide miscellaneous Codes and Standards Requirements from Section 2.1.2. If none apply, state “There are no known Codes and Standards that apply to this section.”

2.7.3 Performance/Design Requirements

2.7.3.1 Provide miscellaneous Performance/Design Requirements from Section 2.1.3. If none apply, state “There are no known Performance/Design Requirements that apply to this section.”

3.0 Settings, Ranges, and Components

3.1 System

Section 3.1, System, contains specific Design Basis operating parameters (i.e., temperature, pressure, flow, etc.) and explains why the operating parameters are what they are for a given system and its sub-system. This paragraph will summarize the Design Basis requirements covered in

section 2.0. Multiple sub-sections (i.e., 3.1.1) may be required to cover all sub-systems (i.e., BFW – drum, heaters, etc., could have their own paragraph).

3.2 Indications, Instrumentation and Controls

Section 3.2, Indications, Instrumentation and Controls, list the alarms / trips and indications in table format as shown below. These are the specific and critical alarms / trips and indications associated directly with Design Basis requirements. This is NOT a list of all alarms / trips and indications associated with this system.

3.2.1 Alarms / Trips

Alarm or Trip	Description	Design Basis	Setpoint
Enter the Tag Name or EMPRV Location ID of the Alarm / Trip	Provide a description of the Alarm / Trip	Section 2.0 Design Basis Reference	Actuation point for the Alarm / Trip

3.2.2 Indications

Indication	Description	Design Basis	Scaling
Enter the Equipment ID Number or EMPRV Location ID of the Indication	Provide a description and the location (i.e., control room, local, etc.) of the Indication	Section 2.0 Design Basis Reference	High and Low Values of the Indication

3.2.3 Switches

Switch	Description	Design Basis	Setpoint
Enter the Equipment ID Number or EMPRV Location ID of the Switch	Provide a description of the Switch	Section 2.0 Design Basis Reference	Actuation point for the Switch

3.3 Components

Section 3.3, Components, list the Component Description or Name and EMPRV Location ID as shown below. These are the specific components associated directly with Design Basis requirements. This is NOT a list of all components associated with this system.

3.3.1 Component Description / Name

- EMPRV Location ID

3.3.2 Component Description / Name

- EMPRV Location ID

4.0 REFERENCES

Section 4.0, References, provide only the references used to create this DBD. This is NOT a list of all of the references associated with this system.

4.1 Foreign Prints

4.1.1 Foreign Print Drawings

Drawing No.	Rev.	Ameren No.	Rev.	Title

4.1.2 Foreign Print Manuals

MFR No.	Rev.	Ameren No.	Rev.	Title

4.2 Electrical Drawings

Drawing No.	Rev.	Title

4.3 Mechanical Drawings

Drawing No.	Rev.	Title

4.4 Civil / Structural Drawings

Drawing No.	Rev.	Title

4.5 Procedures

Procedure No.	Rev.	Title

4.6 Calculations

Calc. No.	Rev.	Title

5.0 SCOPE OF CHANGE

Rev.	Description of Change	Date
0	Initial Document	<Date of Document>

6.0 APPENDICES

Include appendices as necessary.

END OF SECTION 1E

DIVISIONS

SECTION E000
ELECTRICAL EQUIPMENT AND SYSTEM VOLTAGES

Table E000-1 Electrical Equipment System Design Information

Power Supply Code	Continuous Voltage (Volts) – System Output Voltage	Design for Momentary Voltage Dip to X% of Nominal	Frequency (Hz)	Configuration	System Grounding	Transfer to Alternate Source	Max Sym Short-Circuit Amps
MV-1 Medium Voltage	13800 Nom 14520 Max 12420 Min	80	60 Nom 61.5 Max 58.5 Min	3-Phase, 3 Wire, Wye (3/PE)	Low Resistance (IT)	Fast Transfer	63,000 (3-Ph) 1,500 (L-G)
MV-2 Medium Voltage	4160 Nom 4368 Max 3744 Min	80	60 Nom 61.5 Max 58.5 Min	3-Phase, 3 Wire, Wye (3/PE)	Low Resistance (IT)	Fast Transfer	50,000 (3-Ph) 1,500 (L-G)
LV-1 Low Voltage (Power)	480 Nom 508 Max 432 Min	80	60 Nom 61.5 Max 58.5 Min	3-Phase, 3 Wire, Wye (3/PE)	Solidly Grounded	Manual with Live Bus Transfer	65,000 (3-Ph) 10,000 (L-G)
LV-2 Low Voltage (Lighting)	480Y/277 Nom 508Y/293 Max 432Y/249 Min	80	60 Nom 61.5 Max 58.5 Min	3-Phase, 4 Wire, Wye (3/N/PE)	Solidly Grounded (TN)	N/A	65,000 (3-Ph) 10,000 (L-G)
LV-3 Low Voltage (Power)	208Y/120 Nom 220Y/127 Max 187Y/108 Min	80	60 Nom 61.5 Max 58.5 Min	3-Phase, 4 Wire, Wye (3/N/PE)	Solidly Grounded (TN)	N/A	25,000(3-Ph) 10,000 (L-G)
UPS-1 UPS Power	208Y/120 Nom 220Y/127 Max 187Y/108 Min	80	60 Nom 61.5 Max 58.5 Min	3-Phase, 4 Wire, Wye (3/N/PE)	Solidly Grounded (TN)	Static 1/2 Cycle	25,000(3-Ph) 10,000 (L-G)
DC-1 DC Power	125 Nom 140 Max 105 Min at Battery Terminals	70	N/A	Two-Pole	Ungrounded	N/A	42,000 (P-P)
DC-2 DC Power	600 Nom 672 Max 528 Min at Photovoltaic Panel Terminals	70	N/A	Two-Pole	Ungrounded	N/A	42,000 (P-P)
CP-1 Control Power (AC)	120 Nom 127 Max 108 Min	80	60 Nom 61.5 Max 58.5 Min	Single-Phase, 2 Wire (1/N/PE)	Solidly Grounded (TN)	N/A	10,000 (L-L) 10,000 (L-G)

Definitions: N – neutral; PE – protective earth conductor; IT - unearthed transformer neutral; TN - transformer neutral earthed, frame connected to neutral.

SECTION E100
WIRING METHODS, CABLE AND RACEWAY

E100.1 General Requirements

In general, all devices furnished under these specifications and requiring electrical connections shall be designed for wiring into electrical enclosures with terminal blocks. Terminal blocks shall be furnished for conductors requiring connection to circuits external to the specified equipment, for internal circuits crossing shipping splits, and where equipment parts replacement and maintenance will be facilitated.

Electrical equipment shall be located in accessible areas. Control cabinets and wiring termination cabinets shall be accessible from platforms or at grade level. The control cabinets and wiring termination cabinets shall be located such that an electrician will not require the use of a ladder or stepladder to access the cabinets or panels to complete his work.

Splices of any kind will not be permitted. Pigtails for devices such as solenoid valves shall be terminated in a local junction box.

Unless otherwise specified, one spare normally open and one spare normally closed contact on each control switch and lockout relay shall be wired out to terminal blocks.

All wiring leaving an enclosure shall leave from terminal blocks and not from other devices in the enclosure. All spare contacts shall be wired out to terminal blocks for future use.

Auxiliary equipment such as terminal blocks, auxiliary relays, or contactors shall be readily accessible. Auxiliary equipment shall be located in compartments, enclosures, or junction boxes in such an arrangement that service personnel will have direct access to the equipment without removal of barriers, cover plates, or wiring. However, extra guarding of voltages greater than 240V (Plexiglas or other suitable nonconductive and/or grounded covering) in electrical cabinets with low voltage controls and/or wiring that may require servicing to reduce personal protective equipment (PPE) requirements shall be provided. These barriers should be easily removable by an electrician wearing gloves or other PPE.

All control switches should be accessible from outside of the cabinet, panel, or electrical enclosure.

Terminal blocks for external connections shall be grouped in the instrument and control compartment for easy accessibility, 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.

Terminal blocks shall not be mounted in compartments containing uninsulated conductors operating at voltages above 1000 volts.

When current transformers are supplied with the equipment furnished under these specifications, a shorting type terminal block shall be installed at an accessible location for each set of current transformers. The shorting terminal blocks shall be the nearest to the current transformers. No other shorting type terminal blocks are required unless specified otherwise. The shorting terminal blocks shall be furnished with white marking strips.

For safety reasons, the current transformer shall be grounded but the grounding shall occur only at the shorting terminal blocks. The grounding conductor shall be identified so that it may be disconnected in the field as required.

Materials containing lead or asbestos shall not be used in any of the wiring devices or cable.

Conductors of field cables 8 AWG and smaller shall be terminated on screw terminals with preinsulated ring type terminal connectors. All wiring for protective relays shall use preinsulated ring type terminal connectors. Unless UL listed, all factory wired equipment is to use these requirements. Except for internal wiring of OEM prewired electronic system cabinets, crimping ferrules with plastic insulating sleeves shall be provided on all stranded control conductors that are to be terminated to compression Type IEC terminal

blocks. Conductors for current transformer circuits shall be terminated with preinsulated ring type terminal connectors.

Each terminal block, terminal, conductor, relay, breaker, fuse block, and other auxiliary devices shall be permanently labeled to coincide with the identification indicated on the drawings. All terminals provided for termination of external circuits shall be identified by inscribing terminal designations acceptable to the Owner on the terminal block white marking strips with permanent black ink.

All internal wiring terminations shall be identified on heat-shrinkable conductor identification sleeves that are machine printed. A conductor identification sleeve shall be provided on each end of each internal conductor. Each sleeve shall be printed with both “from” and “to” end destinations identification using permanent black ink. Conductor identification shall be permanent, unaffected by age, heat, or solvents and not easily dislodged. Adhesive labels are not acceptable. Internal wire markings shall be approved by Owner. Wire markers shall be visible without having to turn or twist the wiring.

The arrangement of terminal designations and labeling on terminal blocks shall be acceptable to the Owner.

All connections requiring disconnect plug and receptacle type devices shall be provided with factory terminated conductors on each plug and receptacle. Plugs and receptacles shall be factory wired into junction boxes containing terminal blocks for external connections. All conductors on the disconnect portion of plug-receptacle assemblies shall be in a common jacket. The plug-receptacle assemblies shall have provisions for locking the devices together. The assembly shall also be watertight when installed outdoors.

All temporary wiring installed in the factory for equipment testing shall be removed prior to shipment of the equipment.

Reference to NEC means the codes and standards as defined by the USA National Electrical Code, ANSI/NFPA 70.

E100.2 Equipment Safety Grounding (Earthing)

All electrical equipment shall be grounded, including cable tray and conduits as shown on drawings or as required by applicable codes, particularly NEC Article 250.

Electrical equipment that is part of an integral shipping unit or assembly shall be furnished with a bare copper grounding pad. The pad shall be suitable for field connection to the station ground grid by the Contractor. Isolated logic system or single-point ground connections required for proper operation of electronic equipment shall be insulated from the equipment safety ground. Such connections will be extended, using insulated cable, to a single termination point suitable for field connections to the appropriate ground system by the Contractor.

Electrical equipment requiring grounding provisions shall include all enclosures containing electrical connections or bare conductors with the exception of control devices, such as solenoids, pressure switches, and limit switches, unless such devices require grounding for proper operation.

The raceway system shall not be considered to be a ground conductor except for itself. All metal conduits containing power circuits shall be provided with grounding type bushings and shall be wired together inside enclosures and connected internally to the enclosure grounding pad or grounding bus with bare copper conductor. The grounding bushing ground conductor shall be sized in accordance with NEC or other internationally recognized standard but shall not be less than 6 AWG bare copper conductor.

Minimum size should be #4/0 for ground grid, #2/0 for stub-ups and cable tray. EPC Contractor shall perform ground grid calculations and design the system per NEC 250 and IEEE 80 & IEEE 142.

Ground conductors shall be soft drawn, bare stranded copper strand Class B as defined in NEMA WC 3 (formerly ICEA S-19-81). All clamps, conductors, bolts, washers, nuts, and other hardware used with the grounding system shall be copper.

For welded joints, molds and powder charges for "self welding" process shall be as manufactured by Cadweld or approved equal. Use standard duty molds below 350 MCM and heavy duty molds for 350 MCM and above.

Ground rods shall be copper clad steel core with copper applied by extrusion process, or copper plated rods. Ground rods shall be ¾" x 10'.

Equipment grounding conductors shall have green insulation or green tape markings.

Use welded joints where the ground network connects to ground plates or building structural steel and for all buried or otherwise inaccessible connections. Follow manufacturer's instructions concerning molds, clamps, materials and procedures when making welded connections. Do not cover welded joints until they have been inspected by the Owner's Construction Supervisor. Joints must be capable of withstanding repeated hammer blows without rupturing at the weld.

Ground cables shall be installed such that they are protected from mechanical injury and routed to avoid interference with access doors or covers. In chemical areas where the bare ground conductors could corrode, insulated ground conductors shall be used. Ground conductors shall be buried to avoid tripping hazards. Ground stingers shall be used to ground equipment as much as possible.
Make bolted connections to equipment using suitable bar, cable with compression type terminals or copper strap. Where copper terminals or bars are connected to aluminum surfaces, tin the copper surface and clean the aluminum surface and coat with NO-OX-ID, or similar corrosion inhibitor. Aluminum busbars are not acceptable.

Equipment grounding conductors shall be run in conduit or raceway with phase wires.
No grounds shall be attached to the generator isolated phase bus duct.

Framework of motors, panelboards, and other metallic enclosures of electrical devices shall be electrically bonded to the grounding network.

Metallic conduits shall be effectively bonded to any metallic enclosures to which they are attached or entered into by metal-to-metal contact. Bonding between raceways and enclosures shall provide electrical continuity with capacity to safely conduct any possible fault current imposed on the system. Conduits that terminate at cable trays shall be attached to the trays using cable tray conduit clamps, which are UL listed to ensure continuity.

Bury ground wire directly in earth at depth specified on drawings. Backfill with earth material only. Rock or sand is not acceptable as backfill material.

Drive ground rod to full depth in direction as nearly perpendicular to top of yard as possible. Notify Owner's Construction Supervisor if obstructions are encountered that prevent full-depth penetration.

Install welded joints in accordance with instructions of manufacturer of molds and welding charges. Do not cover welded joints with earth until they have been inspected by Company Construction Supervisor. Joints must be capable of standing repeated blows with a hammer without rupturing at the weld.

E100.3 Electrical Interconnections

All electrical interconnections between devices, panels, and boxes shall use one of the following wiring methods as specified in Table E100-1:

> Nonarmored Cable. Nonarmored cable which is continuously supported and protected by conduit or installed in cable tray.

The installation of the cable and raceway system shall meet the requirements of NEC and the Owner.

The location and material used for the cable tray and conduit shall be designed for the identified hazards for that specific location. Conduit and cable tray routes shall be walked down with the Owner and Contractor before installation to identify hazards such as tripping, headroom, thermal, chemical, etc. Conduit and cable tray routes may be revised where possible to minimize or eliminate hazards at no additional cost to the Owner.

E100.4 Cable

Unless otherwise specified in Table E100-1, both nonarmored and armored cable shall meet the following minimum requirements:

Stranded copper conductors.

Cross-linked polyethylene (XLPE) or ethylene propylene rubber (EPR) insulation on power and control cables.

Chlorosulfonated polyethylene “Hypalon” or chlorinated polyethylene (CPE) jacket on all multi-conductor cables in the thicknesses noted on the cable data sheets in Section 16510.

Minimum size of 14 AWG for control cables.

Minimum size of 12 AWG for power cables.

Minimum size of 10 AWG for 480V and motor power cables

Minimum size of 10 AWG for current transformer cables.

Minimum size of 10 AWG for potential transformer cables.

Minimum size of 16 AWG for instrument and thermocouple extension cables.

Minimum size of 12 AWG for lighting/receptacle cables.

General service power and control cables, integral to the equipment furnished but not internal wiring of control cabinets or panels, shall be rated for the maximum service voltage but not less than 600 volts.

Method 1, Table E-2 (K-2) should be used for the color code for the control cable. In addition Color text or conductor number shall be shown on the individual cable conductors.

Cables which are routed through environmental conditions that differ along the cable run shall be selected using the environmental condition that results in the largest cable size. The cables shall be derated in accordance with the NEC.

All thermocouple cable shall use solid conductors with twisted and shielded pairs. Unless otherwise noted, insulation shall be color coded in accordance with ISA-MC96.1. This requirement also applies to thermocouple extension wire which is furnished internal to Contractor-furnished equipment.

All instrument cable for analog and low voltage signals shall use stranded copper conductors with twisted and shielded pairs or triads. These requirements also apply to instrument cable which is furnished internal to Contractor-furnished equipment.

Shielding of thermocouple and instrument cables shall consist of aluminum-polyester tape and copper drain wire.

Finished cables shall be capable of passing the IEEE 1202 (70,000 Btu/h) vertical tray flame test. This requirement also applies to multi-conductor control cable, instrumentation

cable, and thermocouple cable which are furnished internal to Contractor-furnished equipment including control panels and cabinets.

Additional requirements as defined in each applicable section.

E100.5 Conduit

All above ground conduit interconnections between devices, panels, boxes, and fittings shall be heavy wall rigid metal conduit which conforms to NEMA C80.1 and UL 6, minimum size of 3/4 inch diameter. All conduit connections shall be of the threaded type, and all conduit, couplings, and fittings shall be hot-dipped galvanized steel. The interior and exterior surfaces of all rigid metal conduit, couplings, and fittings shall have a continuous zinc coating with an overcoat of transparent enamel, lacquer, or zinc chromate. Liquidtight flexible metal conduit may be used as long as the length does not exceed 3 feet. All conduit that enters outdoor enclosures shall enter through raintight steel or malleable iron hubs or threaded openings. No conduit shall enter the top of any enclosure located outdoors, in a wet environment, or in an environment or location subject to washdown.

All liquidtight flexible metal conduits shall be constructed of continuously interlocked rust resistant metal core. Conduit shall be coated with sunlight resistant thermoplastic jacket. The conduit shall also resist heat, oil, and chemical breakdown and shall be UL listed.

One exterior locknut, one interior locknut, and one bushing shall be provided at the termination of each rigid metal conduit not terminated in a hub.

Grounding type insulated bushings with insulating inserts in metal housings shall be provided on all conduits not terminated in hubs and couplings. Bushings shall be galvanized.

All conduit fittings shall conform to the requirements of UL 514. All liquidtight flexible metal conduit fittings shall be galvanized steel or malleable iron with insulated throat.

Conduit fittings used on outdoor equipment shall be gasketed.

All conduit shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. Conduit shall be supported by means of conduit clamps and clamp-backs.

Moisture pockets shall be eliminated from conduits. If water cannot drain to the natural opening in the conduit system, a hole shall be drilled in the bottom of a pull box or conduit fitting provided in the low point of the conduit run.

PVC coated RGS conduit shall be used in corrosive areas.

PVC Schedule 40 shall be used for underground raceway. PVC Type DB or Schedule 40 shall be used in ductbanks. RGS conduit shall be used in ductbanks where shielding of cables is required.

PVC shall be avoided for risers. RGS shall be used for elbows.

Robroy elbows and PVC coated RGS conduit shall be used for all stubups and risers 18 inches above ground.

E100.6 Cable Tray

All cable trays furnished and installed by the Contractor shall be in accordance with this specification and/or drawings included with this specification. Cable tray components shall include cable tray, fittings, supports, accessories, and hardware required for a complete system.

Cable tray and associated component materials shall conform to the requirements of NEMA VE-1 for metal cable trays, NEMA FG-1 for fiberglass cable trays, and these specifications. In case of conflict between the NEMA standards publications and these specifications, the requirements of these specifications shall govern to the extent of such conflict. All cable tray components for similar cable tray materials shall be

manufactured by the same manufacturer. Specific cable tray sizes and routing shall be as indicated on the drawings.

Cable tray shall be aluminum ladder type tray with an 9 inch rung spacing on centers and shall be fabricated from copper free aluminum or aluminum alloy unless noted otherwise on the drawings or technical sections. Cable tray shall have a 4 inch loading depth with a minimum NEMA 16C classification. The rung spacing shall be maintained at the center line of all horizontal and vertical elbows. Individual rungs shall provide a minimum of 1 inch of cable support surface. Individual rungs shall support, without collapse, a 200 pound concentrated load applied at the mid-span of the rung, over and above the NEMA rated cable load with a 1.5 safety factor. All cable tray fittings shall have concentric curved radius fittings.

Hardware for aluminum cable tray shall be case hardened galvanized steel suitable for indoor and outdoor use. Hardware for aluminum cable tray in corrosive areas shall be Type 316 stainless steel.

Cable trays shall be cut to length as required. The trays shall be cut with saws and all surfaces over which the conductors and cables will be laid shall be ground or filed to remove any sharp edges which could cause damage to the cable jacket or insulation, either during installation or in normal service.

Cable trays shall be bracket supported from walls or columns and hanger supported from overhead structural members, at intervals not exceeding 10 feet, when measured along tray center lines between supports. All fittings shall be supported in accordance with NEMA VE-2 for metal trays.

Cable tray supports shall be capable of supporting the uniform weight of the trays, plus their NEMA rated cable loads, plus a 200 pound concentrated load without exceeding the allowable load limit for any element of the support system with a minimum safety factor of 2.0.

A 2/0 AWG bare, stranded copper, grounding conductor shall be installed on all power level cable trays containing single conductor power cables. The tray grounding conductor shall be installed on the outside of the tray side rails, along the entire length of the trays, attaching to each tray fitting and to each straight section of tray at 6 foot maximum intervals. The tray grounding conductor shall be attached to the trays using bolted ground clamps and shall be connected to the enclosure grounding system. Splices for the tray grounding conductor shall be made using compression connectors.

Cable trays containing multi-conductor power, control, or instrument cables shall not require a continuous ground conductor installed along the tray. These tray levels shall be grounded by means of a ground jumper extended from the tray side rail to the continuous ground conductor installed along a power level cable tray, to building steel, or to the enclosure grounding system.

Cable tray covers shall be installed for all outdoor cable tray. Cable tray covers shall also be installed for indoor cable trays at the following locations with the type of cover indicated. (Also refer to National Electrical Code (NEC) Article 392.6(D).) Cable tray covers shall be furnished with side flanges for strength:

Ventilated covers shall be installed on accessible vertical ladder type trays, starting 1 foot below the access floor or platform and extending to a height of 8 feet above the access floor or platform.

Covers shall be installed on horizontal trays located under grating floors, platforms, or insulated pipe. Covers shall extend at least 2 feet beyond the portion of the tray directly exposed beneath the grating floor, platform, or insulated pipe. Covers may be omitted on lower stacked ladder type trays where a covered tray at a higher elevation in the stack provides complete vertical shielding to the lower trays. Covers in these areas shall be as follows:

Power trays - tight-fitting, raised solid covers.

Control and instrument trays - tight-fitting or raised solid covers.

Solid covers shall be installed on all trays where there is potential for accumulation of oil or other combustible materials on the cables.

E100.7 Terminations

The capacities of conduit entrances and terminal enclosures for terminating the Owner's cable shall be coordinated with the Owner. Final sizes shall be acceptable to the Owner.

The criteria in Table E100-1 apply to wiring methods, cable, and raceway specified herein:

Table E100-1 Wiring Methods, Cable, and Raceway

Electrical Interconnections Between Electrical Enclosures, Devices, or Lighting	Nonarmored cable routed in tray and/or conduit
Thermocouple Cable Insulation Color Coding	ISA-MC96.1
Cable - Additional Requirements	600 volt multi-conductor power and control cable shall supply power to loads at 480 VAC and 250 VDC or less. 600 volt single-conductor power cable shall have XLPE insulation with no jacket (UL Type RHH/RHW-2/USE-2) or EPR insulation with CSPE jacket. 600 volt multi-conductor power and control cable shall have EPR or XLPE insulation with flame-retardant CSPE or CPE jacket. Multiconductor cable shall use the ICEA S-73-532, Appendix E, Method 1, Table E-2 (K2) color code All cables shall be UL listed for tray installation. Instrument cable shall be twisted shielded pairs or triads with 600 volt class insulation (minimum). This cable shall have XLPE or EPR insulation with flame retardant CSPE or CPE jacket (minimum). Single and multiple pairs shall have an overall shield. Multiple pairs shall also have pairs shielded. Gaitronics communication cable shall not be run with instrumentation cables. Thermocouple extension cable shall be rated 600 volts. Switchboard and panel wire shall be multi-stranded Type SIS VW-1, XLPE insulated for 600 volts.

SECTION E210
ELECTRICAL ENCLOSURE ASSEMBLIES

E210.1 General Requirements

Electrical enclosures shall be in accordance with Table E210-1, Table E210-2, and the following.

Electrical enclosures constructed from steel plate shall be reinforced as required to provide a true surface and adequate support for devices mounted thereon. Enclosures shall be of adequate strength to support mounted components during shipment.

Panel and cabinet doors shall be hinged with three point latch handles.

No through door disconnects shall be used. Only flange mounted disconnects are allowed on panels.

Junction boxes and pull boxes shall be provided without knockouts.

All junction boxes or pull boxes 4 inch trade size or smaller in any dimension shall be galvanized malleable iron or acceptable equal cast ferrous metal.

If epoxy coatings are specified, the coating shall consist of a coat of zinc rich epoxy primer followed by a finish coat of epoxy.

NEMA 4X junction boxes in high chloride and other corrosive areas shall be fiberglass. Enclosures fabricated from PVC are not allowed.

All indoor areas except electrical equipment rooms shall be subject to hosedown. Electrical equipment in the areas subject to hosedown shall be provided with enclosures rated for wet or direct water conditions.

All enclosures shall be manufactured from materials that will not degrade when subjected to sunlight. The surface of the sheet metal shall be prepared to ensure good conductivity and corrosion protection.

Junction boxes, electrical control panels, and cabinets shall be provided with an identification nameplate mounted on the front of the enclosure. The nameplate inscription shall be acceptable to the Owner Nameplates shall be phenolic with black letter or white background; attached with stainless steel screws. Nameplates shall be mounted with adhesives only on boxes that will be affected by the use of nameplates.

All electrical enclosures shall be mounted above finish floor. This shall be accomplished through housekeeping pads for large equipment such as, but not limited to, switchgear, control panels, MCCs, and transformers. Motors and skids shall be mounted on housekeeping pads or pedestals as appropriate to the application. Smaller panel, instruments, junction/terminal boxes, and other miscellaneous components may be mounted to Uni-strut or attached to structural members as appropriate. All housekeeping pads shall include leveling channels suitable for field balancing.

Table E210-1 Enclosure NEMA Rating Requirements

Location	Classification	NEMA Std. 250	Materials
Indoor Dry	Nonhazardous	Type 12	Galvanized or Painted sheet steel
Indoor Wet or Outdoor	Nonhazardous	Type 4 or 4X	Copper free aluminum
Indoor Electrical Rooms	Nonhazardous	Type 1	Galvanized or Painted sheet steel
Wet-Chemical Corrosive High-Chloride Areas	Nonhazardous	Type 4X	Fiberglass reinforced resin

E210.2 Electrical Enclosure Heating

Where electrical enclosure heating is specified, electrical space heaters, one adjustable thermostat, one fuse and fuse block or circuit breaker or other means of disconnect shall be provided completely wired in the enclosure. Humidistat should be used with the thermostats to control the space heaters on panels located outdoors. The space heaters, thermostat, humidistat, and circuit disconnect device shall not interfere with normal cable entrance into the enclosure or with maintenance or replacement of devices within the enclosure. Normal use of space heaters shall not change or discolor any painted surface.

Unless otherwise indicated, the operating range of the thermostat shall be coordinated with the project ambient temperature conditions.

Space heater capacity shall be as required to maintain the enclosure internal temperature above the dew point under the specified site conditions.

Space heater sheaths shall be of a corrosion-resistant, nonoxidizing material.

Table E210-2 Enclosure Space Heaters	
Rated Voltage	240 volts ac
Power Source	
Power Supply Code	LV-3
Voltage	120 volts

Control panel receptacles, lights, heaters, and other auxiliary systems shall be supplied separately from the panel control power and shall be protected with a fuse or circuit breakers.

Panel interior lighting shall be controlled by a door mounted switch and powered from a power panel.

SECTION E220
ELECTRICAL ENCLOSURE ASSEMBLIES

E220.1 General Requirements

All electrical equipment and devices located in areas subject to hazardous area classifications shall be furnished with a nameplate stating the equipment classification. The nameplate data shall include the Class or Zone, Division, Group, and Operating Temperature Designations as applicable to the design standard used to classify the areas. Classification identification nameplates and attachment pins shall be corrosion-resistant metal.

SECTION E230
CONTROL PANEL RECEPTACLES, LIGHTS AND COMMUNICATIONS

E230.1 General Requirements

A separate dedicated power feed shall be supplied for control panel receptacles, lights, heaters, and other auxiliary systems. This dedicated power feed shall be supplied separately from the power feed used for panel control power or the power feed used for the control systems inside the control panel or cabinet. The dedicated power feed for the control panel receptacles, lights, heaters, and other auxiliary systems shall be protected with a fuse or a circuit breaker.

Table E230-1 Receptacles

Description	Rated Voltage	Frequency	Ampacity	GFCI/ RCD	Configuration	Protection	Manufacturer/ Model
Socket Outlet	120, 2P + E	60 Hz	20 A	4 - 6 mA	NEMA 5-20R	Dry Location	Ameren Missouri Approved Suppliers
Single Pole Switch	120	60 Hz	20 A			Dry Location	Ameren Missouri Approved Suppliers

Table E230-2 Lighting

Application	Fixture	Lamp	Ballast	Rated Voltage	Frequency	Manufacturer/ Model
Control Panel Interior	Strip Fluorescent	T-8	Electronic Thermally Protected	120	60 Hz	Ameren Missouri Approved Suppliers

SECTION E300
ELECTRONIC SYSTEMS AND COMPONENTS

E300.1 General Requirements

Internal wiring of factory prewired electronic systems in cabinets may be installed according to the Contractor's standard as to wire size, insulation, and method of termination on internal equipment except that insulation for all wiring shall meet the UL 1581 VW-1 flame test. Conductor identification may be done by insulation color coding noted on the drawings.

The electronic systems shall be tested and verified capable of providing surge withstand capability in accordance with the requirements of ANSI C37.90.1.

All electrical equipment containing electronic logic systems shall be tested in accordance with the manufacturer's standard tests for a minimum of 48 hours under power prior to shipment from the factory. The system shall be tested as a complete assembly. Testing of individual components or modules will not be acceptable as system tests. The system test shall include a means of confirming the logic or mathematical design response of the system by simulating changes in system input. The test shall verify correct operation of the system at both high and low power source voltage limits.

SECTION E510
MOLDED-CASE CIRCUIT BREAKERS

E510.1 General Requirements

Unless otherwise specified, molded case circuit breakers used in equipment furnished under these specifications shall have a symmetrical RMS ampere interrupting capacity equal to or greater than the maximum short-circuit current values.

The breakers shall have a thermal magnetic type trip and shall be in accordance with UL 489.

Unless otherwise specified, molded case circuit breakers used in equipment furnished under these specifications shall have a symmetrical RMS ampere interrupting capacity equal to or greater than the maximum short-circuit current values as noted below.

Table E510-1 Molded Case Circuit Breaker Rating Requirements	
480VAC nominal continuous voltage	65,000 amps maximum 3-phase symmetrical short-circuit amps. 10,000 amps maximum line-to-ground maximum symmetrical short-circuit amps.
208Y/120VAC nominal continuous voltage	25,000 amps maximum 3-phase symmetrical short-circuit amps. 10,000 amps maximum line-to-ground maximum symmetrical short-circuit amps.
120VAC nominal continuous voltage	10,000 amps maximum line-to-line symmetrical short-circuit amps. 10,000 amps maximum line-to-ground maximum symmetrical short-circuit amps.

In addition to the ac interrupting ratings, all single-pole breakers, 2-pole breakers, and 3-pole breakers shall have minimum dc interrupting ratings per Table E510-2:

Table E510-2 Breaker DC Interrupting Rating Requirements	
Single-pole breakers	10,000 amperes at 125 volts dc
2-pole breakers	10,000 amperes at 250 volts dc
3-pole breakers	10,000 amperes at 250 volts dc

The Contractor shall furnish molded case breakers that meet or exceed system short-circuit requirements as determined during detailed design.

The circuit breakers shall be furnished by the same manufacturer as the equipment in which the breakers are installed.

SECTION E520
TERMINAL BLOCKS AND FUSE HOLDERS

E520.1 General Requirements

In general, manufacturer standard terminal blocks will be accepted provided they meet the requirements of this specification and quality levels equivalent to the manufacturer's terminal blocks listed in Table E520-1. Self-stripping terminal blocks, multiple deck (step type) terminal blocks, and angled terminal blocks will not be acceptable. Screw type terminals suitable for ring lug termination shall be furnished for all current transformer secondary lead connections.

Each terminal block shall be provided with a unique identifier. All terminal points shall have provisions to be uniquely identified on the terminal block white marking strip and, where permitted by the safety codes and standards, shall be without covers. Spare points shall be provided with blank strips that can be field marked with a permanent ink marking pen. Spare (unused) terminals shall be furnished evenly distributed on the terminal blocks for circuit modifications. No fewer than two spare unused terminals shall be furnished for every ten terminals used. Control power fuses may be mounted on terminal blocks.

No high density or stacking terminal blocks shall be allowed.

Terminal blocks shall be manufactured from materials that will not support combustion. Terminal blocks shall meet the Inflammability Class V0 rating in accordance with UL 94. All terminal blocks, except internal terminal blocks in factory prewired electronic systems cabinets and terminal blocks for thermocouple extension wire, shall be rated for 600 volts or greater. No more than two conductors shall be terminated at one connection point. For terminal blocks interfacing with the Owner's field cabling, one side of the terminal block shall be used by the equipment manufacturer for factory wiring and the other side of the terminal block shall be reserved for the Owner's field cabling terminations. All terminal blocks shall be sized appropriately for the AWG size of the conductor to be used.

Sliding link terminal blocks shall be used in all DCS cabinets and all skid mounted junction boxes.

Terminal blocks and fuse holders shall be finger safe.

Fuse blocks and fuse holders shall have blown fuse indicators.

The criteria in Table E520-1 shall apply to terminal blocks and fuse holders:

Table E520-1 Terminal Block and Fuse Holder Requirements

Terminal Block Type	Applications	Acceptable Termination Methods	Acceptable Construction	Approved Manufacturers
Feed-Through	Thermocouple Extension Wire	Strap Screw, Compression	Manufacturer's Standard	Ameren Missouri Approved Suppliers
Feed-Through	DCS I/O and PLC I/O	Compression, Strap Screw	Sliding Link	Ameren Missouri Approved Suppliers
Feed-Through	General Purpose	Strap Screw	Grouped Block, Bolted, Modular, Rail, Sliding Link	Ameren Missouri Approved Suppliers. All terminal blocks shall have covers.
Shorting	Current Transformer	Strap Screw	Grouped Block, Bolted	Ameren Missouri Approved Suppliers

Table E520-1 Terminal Block and Fuse Holder Requirements				
Terminal Block Type	**Applications**	**Acceptable Termination Methods**	**Acceptable Construction**	**Approved Manufacturers**
Power	600 Volt Power (8 AWG through 4/0 AWG)	Screw, Compression, Stud	Grouped Block, Bolted	Manufacturer's Standard
Feed-Through Terminal Blocks in Skid Mounted Junction Boxes	General Purpose	Strap Screw	Sliding Link	Ameren Missouri Approved Suppliers

E520.2 Compression Clamp Modular Terminal Blocks (IEC Requirements)
The modular terminal block systems shall be complete with mounting rails, end brackets, fixing brackets, covers, and test plugs as required. Terminal block colors shall be as follows: red for ungrounded power conductors, blue for power circuit neutral conductors, yellow-green for all ground conductors, and gray for all control circuit conductors.

Terminal spacing on compression clamp terminal blocks shall be capable of terminating 20 AWG to 8 AWG wire and shall have point-to-point spacing of not less than 0.315 inch. The clamping parts shall be made of copper alloys that are resistant to stress corrosion cracking. The clamping parts shall be designed to maintain a spring-like force when gripping the conductor. The copper alloy surface of the clamping units shall be protected by galvanic plating. The terminal screw shall be bronze and protected with galvanic plating. When possible, jumpering between adjacent terminal points shall be achieved with fixed bridges. All terminal screws shall be tightened with a calibrated screwdriver, and set to the recommended torques provided by the terminal block manufacturer. Torque values shall be approximately 1.5 times the test torque values defined in IEC 947-1, but approximately 40 percent below the fracture torque of the terminal screw.

For installations requiring "Increased Safety" terminal blocks, the terminal blocks shall have a CENELEC Certification Code marked on the terminal block.

Knife disconnect terminal blocks shall be suitable for terminating 20 AWG to 12 AWG. The knife disconnect shall be permanently attached to the block, shall have a continuous ampere rating of 15 amperes, and shall have a voltage rating of 600 volts or greater. Test ports shall be provided on both sides of the knife disconnect.

Mounting rails shall be of a top hat construction in accordance with EN 50 022. Rails not used as a grounding conductor shall be manufactured from steel with a corrosion-resistant coating. Rails used as a grounding conductor shall be manufactured from copper.

E520.3 Strap Screw Terminal Blocks
Strap screw terminal blocks shall be of heavy-duty construction capable of terminating a conductor from 16 AWG to 10 AWG. The point-to-point spacing shall not be less than 0.375 inch.

Shorting type terminal blocks shall be provided for use with current transformers.

E520.4 Power Terminal Blocks
Power terminal blocks shall be used for conductors 8 AWG and larger.

E520.5 Thermocouple Terminal Blocks
Thermocouple terminal blocks shall be provided for terminating thermocouple extension cable. The terminal blocks shall be capable of terminating solid conductors ranging from 20 AWG to 16 AWG. The current carrying parts of the terminal block shall be of the same materials as the thermocouple extension

wire. Termination points for extending the shield wire of the thermocouple extension cable shall be provided adjacent to the block or shall be integral to the block.

E520.6 Fuse Holders for Power Circuits

The fuse holders shall be in accordance with ANSI/UL 521 and shall have reinforced fuse contact clips.

The bases shall be molded phenolic, polyester, or other plastic having a Flammability Rating of V-0 when tested in accordance with UL 94. Porcelain, slate, and marble are not acceptable materials for fuse holder bases.

SECTION E530
ELECTRICAL ACCESSORIES

E530.1 Electrical Indicating Instruments

All metering devices shall be designed for flush mounting. All analog instrument scales shall consist of black markings on a white background.

All instrumentation with current elements shall be designed for use with current transformers having high overcurrent capability. The current elements shall be capable of 10 times the rated end scale overload values for a period of 1/2 second duration for a minimum of nine successive overloads with 1 minute between overloads without exceeding the deviations defined in the specified standard. Switchboard meters shall not open the circuit when subjected to 30 times the rated secondary current of the associated current transformer circuit for a period of 2 seconds.

The electrical indicating instruments shall be as specified in Table E530-6, Meter Requirements.

E530.2 Control Relays

General service auxiliary relays, interposing relays, and auxiliary relays shall be as specified in Table E530-1:

Table E530-1 Auxiliary Control Relay Requirements

Component	Manufacturer
General service auxiliary relays	Ameren Missouri Approved Suppliers
Interposing relays, Octal base type with relay status indicators	Owner approved equal
Auxiliary relays (Where current carrying requirements exceed the capacity of the general service auxiliary relays)	Ameren Missouri Approved Suppliers or Owner approved equal.
Time delay relays	Ameren Missouri Approved Suppliers

Timing relays for general service where the delay period is 1 minute or less shall be solid-state. Timing relays for critical service shall be solid-state. Timing relays shall be in accordance with the Ameren Missouri Approved Suppliers or Owner approved equal.

Time delays shall be implemented in the DCS unless otherwise noted or approved by the Owner.

Unless otherwise specified, dc relays that interface with the control system shall have a diode surge suppressor installed across the relay coil.

E530.3 Electrical Switches

Control switches shall be 600 volt, 20 ampere, multistage, rotary type. Unless otherwise specified, switches shall have black, fixed, modern, pistol grip type handles and engraved black plastic escutcheon plates with targets.

All push buttons and selector switches shall be heavy-duty oil tight. Field mounted push buttons and selector switches shall be heavy-duty oil tight in NEMA 4 or 4X enclosures.

Disconnect switches for power isolators shall be flange mounted.

Local control stations with "Start/Stop", “Open/Close” and/or "Hand/Auto/Off" controls should be provided for pumps,fans, and power operated valves (including air, pneumatic, electrically operated, and solenoid

valves). The configuration of these local control stations may vary depending on the application. Configuration and application of the local control stations shall be reviewed and approved by the Owner. These local control stations must be located in line of sight of the equipment. The local control stations are shown on the Owner schematics and standard wiring diagrams.

The electrical switches shall be as specified in Table E530-4, Electrical Switch Requirements.

E530.4 Indicating Lights

Indicating lights for local control stations shall be heavy-duty, oil tight, and shall permit light changing from the front. Luminous output shall be suitable for the location and ambient lighting conditions LED type indicators shall be used on panels and switchgear.

Indicating light lens colors shall meet the requirements in Table E530-2, Colors of Indicating Devices..

E530.5 Contacts

Contact ratings for all electrical accessory devices shall be suitable for interface with the Owner's or Contractor’s control system. The control system interrogation voltages will range up to 230 volts ac and between 24 and 250 volts dc.

All contacts that interface with the control system shall be electrically "dry." Solid-state switches or triac outputs are not acceptable for contacts that interface with the Owner's electronic control system.

Alarm contacts shall consist of at least one normally open and one normally closed contact "Form C."

Electrical accessory device contacts, including alarm contacts, wired to the control system consisting of DCS or PLC I/O cards, shall be suitable for switching currents in the milliampere range for the range of voltages listed above. The electrical accessory device contacts, including alarm contacts, shall allow the I/O cards to distinguish between a normally open and a normally closed contact.

E530.6 Fuses

Fuses shall be provided with ampere ratings sized for the application. The types and manufacturers of fuses shall be as specified in Table E530-5 Fuses and Fuse Block Requirements.

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E530.7 Colors of Indicating Devices and Actuators

Coding of indicating devices and switch actuators (push button, knob, selector switch, or handle) shall be subject to Owner review. If words or recognized abbreviations are required to describe the function of the indicating device or actuator, the language used shall be English. Indicating lights shall be energized when the condition described in Table E530-2 exists, and shall be de-energized when the condition does not exist. Unless permitted otherwise in the individual equipment specification, indicating light lens colors shall be as specified in Table E530-2, Colors of Indicating Devices.

ELECTRICAL ACCESSORY DEVICES - SUPPLEMENTAL REQUIREMENTS

Table E530-2 Colors of Indicating Devices			
Color	**Meaning**	**Explanation**	**Examples**
Green	Equipment de-energized; process stopped, not operating.	Normal off condition requiring no action by the operator	Motor stopped; valve (damper) closed; circuit breaker open, contactor de-energized, circuit is not energized
Red	Equipment energized; operating; process normal	Normal running condition requiring no action by the operator	Motor is running; valve (damper) open; circuit breaker is closed, device is energized; process within normal limits; cabinet/panel power available
White	Equipment advisory information function		Switchgear closing spring charged, control power available, bus available
Blue	Arc Flash Protection “enabled”		Arc Flash Protection “enabled”
Amber	Warning	Abnormal equipment or system status	Alarm present, equipment in “Local” (PTL); equipment on emergency feed

Table E530-3 Colors of Actuators		
Color	**Meaning**	**Examples**
Red	Emergency	Emergency-stop/off
Red	Normal stop/off	Normal stop; open breaker, contactor de-energized
Black	Normal start/on	Normal start; closed breaker, energize contactor

Table E530-4 Electrical Switch Requirements		
Application	**Description**	**Manufacturer/Style**
Control Switches	Control Panel	Ameren Missouri Approved Suppliers or Owner Approved Equal
Push Buttons and Selector Switches	Control Panel or Local	Ameren Missouri Approved Suppliers or Owner Approved Equal
Toggle Switches	Control Panel	Ameren Missouri Approved Suppliers or Owner Approved Equal

Table E530-5 Fuses and Fuse Block Requirements	
Application	**Manufacturer/Style**
Slow Blow Fuses	Owner Approved Equal Ameren Missouri Approved Suppliers
Fast Acting Fuses	Owner Approved Equal Ameren Missouri Approved Suppliers
Extremely Fast Acting Fuses	Owner Approved Equal Ameren Missouri Approved Suppliers

Table E530-6 Meter Requirements							
	Input Range						
Meter Type	**Voltage Element**	**Current Element**	**Transducer**	**Manufacturer**	**Accuracy Class (% of Full Scale Value)**	**Size (approx.**	**Display**
Panel Meter	0-150 V	0-5 A	4-20 mA	Ameren Missouri Approved Suppliers or Owner Approved Equal	3	3.5 in^2	Analog and Digital LED
Switch-Board Meters	0-150 V	0-5 A	4-20 mA	Ameren Missouri Approved Suppliers or Owner Approved Equal	1	4.5 in^2	Analog and Digital LCD

SECTION Q001
QULAITY SYSTEM REQUIREMENTS

The purpose of this section is to establish a set of requirements pertaining to the quality of supplied equipment, commodities, and/or services.

. If the Contractor believes that an inconsistency exists between this document and the specification(s) and referenced codes and standards, the Contractor shall immediately notify Owner for resolution.

The Contractor shall define and implement a detailed and documented project specific Quality Management System that is compliant with Ameren Missouri Power Operations Quality Management System (QMS) document number AUE-MAN-QMS-1001, dated 9/12/2008, and International Organization for Standardization (ISO) 9001:2000 Quality Management System requirements. Please note that AUE-MAN-QMS-1001 exceeds ISO 9001 requirements. The Contractor's work, including that of its sub-vendors and subcontractors, shall be performed to the quality requirements of AUE-MAN-QMS-1001. Bidders are also required to identify the Quality Management Program and Processes that will be followed for all indirect responsibilities of the contractor for this project (e.g.; professional services, contractors, subcontractors, fabricators, and vendors).

Each bidder is to provide, as part of their bid submittal, a completed QMS Verification Tracking Log form (document # AUE-FRM-000001) which demonstrates how the bidder's QMS aligns with the Project Quality Program performance criteria of AUE-MAN-QMS-1001.

Ameren Missouri QMS Application Aid – Engineering, Procurement and Construction Services (AUE-DI-000034) identifies by major topic the applicable sections of AUE-MAN-QMS-1001. It is provided to assist the bidder in demonstrating how their Quality program meets the requirements of Ameren's Quality Management (QM) program. The following QMS Application Aids are also provided to assist the bidder in demonstrating how their Quality Program meets the requirements of Ameren's Quality Management (QM) program for all indirect responsibilities (e.g.; professional services, contractors, subcontractors, fabricators, and vendors):

- Construction (w/procurement) only Services; AUE-DI-000031
- Engineering (w/ procurement) only Services; AUE-DI-000032
- Engineering and Construction Services; AUE-DI-000033

Ameren Project QMS Department will review, audit, and qualify the bidders' QMS program prior to award. These reviews will include the following:

- Review of the bidder's submitted written Quality Management program
- Evaluate the Bidders' QMS programs, and develop a "gap analysis" to identify any items that do not meet the intent of AUE-MAN-QMS-1001, and provide this gap analysis to the Bidders to bring the bidders' QMS into compliance.
    - NOTE: The Bidders will be expected to impose the same level of QMS on its sub-vendors and subcontractors. Where Sub-vendor and Subcontractor QMS shortfalls occur, the Bidders shall perform its own gap analysis to address the added QMS tasks required to fill these "gaps".
- Review and acceptance of the Bidders completed QMS Verification Tracking Log form.
- Review of Bidders Quality Management organization and assignment of roles and responsibilities, Company and Project. The Quality Management Organization Chart shall show the QMS interfaces with subcontractors and sub-vendors, and shall show the Contractor as a single party in overall control of QMS for the work.
- Customer and service provider reference inquiries where a similar completed project quality program approach was used.
- Bidder Quality organization/facility review including key personnel interviews and program/process demonstrations.

Ameren reserves the right, throughout the project life cycle (beginning with initial design through final acceptance and turnover), to audit the EPC Contractor and Team Members' Project Quality program, at no additional cost to Ameren, for purposes of demonstrating program and process adherence. Ameren audits can be scheduled or unscheduled.

Refer to Supplementary General Conditions Division 1D Ameren Design Basis and Design Control Requirements for additional QMS design basis and design control requirements.

Q001.1 General Quality System Requirements

Q001.1.1 Quality System

It is the Contractor's responsibility to define and implement a detailed and documented quality management system which ensures that all equipment and commodities supplied are in conformance with the required drawings and/or specifications. The Contractor shall meet all the requirements set forth in this document. The quality management system shall be capable of providing assurance that design, purchasing, materials, manufacturing, examination and testing equipment, shipping, storage, and related services comply with the Contract requirements.

The Contractor's quality management system shall include, at a minimum, procedures and/or methods to address the 22 elements of Ameren QMS and ensure the following processes are controlled and implemented:

- Design documents, drawings, specifications, procedures, inspection and test status, and procurement documents are current and accurate.
- Materials, equipment, and services conform to the requirements of the Contract.
- Receipt inspection, in-process inspection, examination, testing, checkout, and final acceptance testing are conducted.
- Shipping, storage, and preservation of equipment and commodities are adequate to prevent damage during the delivery and storage of the equipment.
- Quality system requirements are passed on to subtier suppliers for subcontracted work, and the Contractor has adequate oversight of subtier supplier activities.
- Defined process and requirements for reporting, evaluating, disposition, and closure of nonconforming product.
- Special processes, such as welding, heat treatment, hot forming, bending and nondestructive examination, are monitored.
- Personnel performing special processes, such as welding, nondestructive examinations, coatings, heat treatment, etc., are qualified.
- Inspection, measuring, and test equipment is appropriately maintained.
- Processes exist for verification, storage, use, and maintenance of client supplied product.

Applicable industry standards (such as ANSI, API, ASME, IEEE, AISC, etc.) shall be incorporated into the quality management system. The quality management system shall be made available to the Owner's Quality Management Services (QMS) Department for review, inspection, and/or audit upon request at the Contractor's facility.

The QMS shall include the Contractor's staffing plan for quality assurance and quality control personnel. This plan shall include a manager for office and onsite quality activities. Typical activities include:

- These quality assurance personnel and quality control inspectors shall monitor the engineering, procurement activities and inspection of the equipment and its installation.
- All quality assurance personnel and quality control inspectors shall be qualified in each of their respective areas to ensure effectiveness of their Quality Program.

Q001.1.2 Quality System Manual

The quality management system shall be documented in a quality system manual. One uncontrolled copy of the manual shall be submitted to the Owner. If the Contractor's program has been certified by a registered certification agency as satisfying the requirements of the governing code (e.g., ISO 9001 or ASME), a copy of the Certification Letter or Certificate of Authorization shall be submitted along with the required manual. The quality system manual shall be kept current by submittal of revisions as applicable throughout the life of this Contract.

Q001.1.3 Subsuppliers and Subcontractors

The Contractor shall obtain the Owner's approval in writing prior to using subtier suppliers for manufacturing activities.

All applicable requirements of the Contract (i.e., technical, quality, and administrative) shall be passed on to the applicable organizations within the Contractor and subtier supplier's companies. The Contractor shall ensure that subtier suppliers have the capabilities to fulfill Contract requirements. Contractors shall submit required procedures, drawings, and/or other submittals when required for approval and/or information of subtier supplier's capabilities, processes, or in-process work involving the fabricating and manufacturing of equipment and commodities for the Owner.

In accordance with this Specification, subtier supplier qualification and monitoring are the responsibility of the Contractor to ensure adherence to the same high quality standards of the Contractor. When deemed necessary, the Owner has the authority to perform quality audits and inspections, and monitor and/or review subtier supplier processes and facilities.

Q001.1.4 Inspection and Test Plan

In accordance with the Schedule of Contract Submittals, a detailed inspection and test plan (i.e., a Quality Assurance/Quality Control Plan) for the work/equipment shall be submitted to the Owner as specified in the Contract prior to starting fabrication. The Owner will designate any test witness points or other inspection points required. The inspection and test plan shall identify the inspection and testing points, including the acceptance criteria, for major components of the work and it shall be maintained current throughout the contract. The plan shall include the Contractor's strategy for inspecting subtier supplier's work, including inspection by the Contractor at his subtier supplier's facilities. The Contractor shall inspect the work of subtier suppliers to the extent necessary to ensure that proper materials and equipment are furnished and that fabrication and assembly are accomplished in accordance with the contract documents. Commercial, off-the-shelf, manufactured items may be exempted from these requirements.

Contractor shall provide a copy of its final QA/QC Plan. Upon review by Company, all Work shall be managed in accordance with such QA/QC Plan. The QA/QC Plan shall include such procedures and systems as follows:

- Pile design verification testing
- Road construction
- Compaction Testing
- Fill material requirements
- Rebar and conduit placement
- Backfill and compaction of trenches
- Concrete placement and testing
- All wire insulation testing – Megger Testing
- Mechanical system - trackers, mounting structures, tracker controls
- Factory testing of inverters and transformers

- PV source open circuit measurements – Voc at combiner boxes
- Fuse tests
- Termination pull testing
- All visual inspections
- Grounding continuity testing
- Earth ground resistivity testing
- PV module inspection and manufacturer documentation of factory test (STC) of every module
- Metering and instrumentation calibration testing
- Step-up transformer testing
- Inverter phase rotation and matching with utility
- Relay settings at the point of interconnection to Company
- Other Supplier prescribed procedures
- Weld inspection
- Welder specifications

All QA/QC testing procedures shall be witnessed and documented by a representative of the Supplier qualified to perform the Work. Company may observe and witness QA/QC as necessary in accordance with provisions of Section 4.10 of the Agreement. Qualified representative of the Supplier shall date and sign documentation indicating completion and acceptance of each QC/QA test procedure.

Supplier shall submit a complete binder containing documented and signed QA/QC test results. In the event Company determines that QA/QC test results are not satisfactory, Supplier shall promptly take such actions necessary to achieve satisfactory results. Such procedure shall be repeated as necessary until QA/QC test results are satisfactory, which in no event shall be later than the Provisional Acceptance date.

The Contractor shall keep the Owner informed of the progress of the work and Owner shall be given not less than five (5) Business Days' Notice of any shop tests, and not less than two (2) business days Notice of any field tests to be made by Contractor, its Subcontractors, and/or the OFE Suppliers in order that Owner may witness any such tests. Owner shall be notified of any nonconformance or dispositions thereof no later than ten (10) Business Days after its occurrence.

Owner and Contractor responsibilities are as follows:

- The Owner shall notify the Contractor of Owner's intention to attend the hold or witness points.
- The Owner may, at Owner's sole discretion, waive any agreed upon witness point. If Owner fails to attend at a hold or witness point after notifying Contractor of Owner's intention to attend, Owner shall be deemed to have waived its right to attend the witness point.
- If the Contractor fails to notify Owner of a hold or witness point, Contractor shall, or shall require Vendor or Subcontractor, as applicable, to suspend the work until such time as Owner has been notified of the hold or witness point and provided its response.
- The Owner's inspectors will not be authorized to change any provision of the equipment design Specifications without written authorization of the Owner, nor shall the presence or absence of an inspector relieve the Contractor from any requirements of this Agreement.
- The Contractor shall include hold and witness points in the project schedule.
- Field testing and Inspection - Before submitting any finished Work for inspection by the Owner, the Contractor shall completely inspect such Work and shall carry out all tests that the equipment require. The Contractor shall keep inspection and test records covering all phases of the Work and shall submit these records to the Owner on completion of the work on any system.

Q001.1.5 Inspections by Owner

The Owner may elect to perform assessments, quality audits, or witness testing at any time during the manufacturing process. The Owner may designate an authorized agent for assessments, witness testing, or quality audits. Authorized agent may be an employee of the Owner or an outside agency. When an outside agency is designated as an authorized agent for the Owner, such designation will be in writing with a copy provided to the Contractor. Hereinafter, when the term "Owner's representative" is used, it may also mean the Owner or the authorized agent.

The following requirements shall apply for Owner's inspection at the Contractor's mill, factory, yard, warehouse, or subtier supplier's facilities.

Q001.1.5.1 Access Rights

Subject to compliance with Contractor's safety policies and precautions, and at Owner's cost, the Owner shall:

- **Have the right to maintain any presence at the Site or at Contractor's or Subcontractors' facilities, as required by Owner at its sole cost and discretion.**
- **Have access at all reasonable times to any place where Work is being performed by Contractor or any Subcontractor to observe the Work.**
- **Have the right to be present during the designing, engineering, procuring, construction, Start-up, commissioning and testing, whether on or off the Site.**
- **Have access to all test procedures, quality control reports and test reports and data, including all adjustment, installation and alignment data for the Equipment.**

The Contractor shall coordinate with the Owner and give advance notice for any system or equipment testing or check- out.

The Owner may order any part or parts of the Work, whether or not installed or covered, to be examined should they believe that such Work is not in accordance with the requirements of this agreement. If, upon examination, such Work be found to not be in accordance with the requirements of this Agreement, the Contractor shall pay the cost of examination and correction of such work at its own expense with no extension in the completion date.

Q001.1.5.2 Surveillance Activities.

In accordance with the Contract designated hold points for witnessing, mill and/or factory tests shall be performed in the presence of the Owner's representative unless waived in writing by the Owner's representative. The Contractor shall bear all costs for such tests, except the compensation and expense of the Owner's representative.

Q001.1.5.3 Control of Special Processes.

It is Contractor's responsibility to ensure that qualified personnel are employed to perform special processes such as welding, nondestructive examination (NDE), coating, painting, etc. If special processes were conducted by unqualified employees, the Owner has the right to validate and test the product at Contractor's expense and/or reject the product.

Q001.1.5.4 Corrective Action.

Upon identification of a noncompliance with the requirements of the Contract, the Contractor shall document the noncompliance issue. For noncompliance issues where the nonconforming characteristic can be restored to a condition such that the capability of an item to function reliably and safely is unimpaired, even though that item still does not conform to the original requirement, the Contractor shall submit the noncompliance to the Owner for approval. During witness and hold point activities, if the Owner's representative identifies a noncompliance issue, the Contractor shall document the noncompliance issue and provide a copy of the documentation to the Owner's representative. If the

Contractor disagrees and does not document the noncompliance, the Owner's representative shall issue a corrective action report to the Contractor for disposition and action. The Contractor shall correct, in a timely manner, all deficiencies identified in the corrective action report.

Defective or Nonconforming Work - Correction of non-conforming work prior to the Warranty Period, the Contractor shall, at its sole cost and expense, promptly correct any part of the Work which is Defective or not in accordance with this agreement, regardless of the stage of its completion or time or place of discovery. The Contractor shall carry out a root cause analysis (RCA) for any deliverables that are classified to be defective or failures in critical equipment components or project execution processes that result in significant cost impacts.

Q001.1.5.5 Rejection.

If any items or articles are identified that do not meet the requirements of the specifications, the lot, or any faulty portion thereof, may be rejected. Before offering specified materials or equipment for shipment, the Contractor shall inspect the material and equipment and eliminate any items that are defective or do not meet the requirements of the Contract. The fact that equipment or materials have been previously inspected, tested, and accepted does not relieve the Contractor of responsibility in the case of later discovery of flaws or defects.

Q001.1.5.6 Receipt Inspection

Materials or equipment purchased under this Contract may be inspected at the specified receiving points and will either be accepted or rejected. Receipt inspection will include testing to determine compliance with the Contract specifications. Initial receipt inspection acceptance tests will be performed by the Contractor at the Contractor’s expense, including shipping cost, or the cost to correct and inspect the item will be charged to the Contractor.

Q001.2 ASME Boiler and Pressure Vessel Code Compliance

Q001.2.1 Quality System
In addition to the provisions of Article Q001.1, the Contractor's quality system shall comply with and be based on the applicable quality system requirements of the ASME Boiler and Pressure Vessel Code.

Q001.2.2 Quality System Manual

The quality system shall be documented in a quality system manual. One quality system manual shall be submitted to the Owner along with a copy of applicable ASME Certificates of Authorization. Revisions to the quality system manual shall be submitted to the Owner throughout the life of this Contract.

SECTION Q100
GENERAL WELDING REQUIREMENTS

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 time of (contract or specification) approval shall govern.

Q100.1 General

Any conflict identified between the requirements of this welding technical supplemental specification and the provisions of any applicable industry standard, code, regulation, or any specification, standard, or purchasing document contractually required for a given application shall be referred to Owner for resolution prior to the start of welding.

Where requirements of a referenced code or standard differ from the welding technical supplemental specification sections, the more stringent or restrictive requirements shall apply.

Any request for deviation from specified requirements shall be submitted in writing and shall include the proposed deviation, rationale for the deviation, any technical data supporting the deviation, and historical experience supporting the deviation.

Q100.2 Welding Processes

Unless otherwise specified, only shielded metal arc welding (SMAW), gas metal arc welding (GMAW), flux cored arc welding (FCAW), submerged arc welding (SAW), plasma arc welding (PAW), stud welding, and gas tungsten arc welding (GTAW) processes shall be permitted within the restrictions or limitations specified in the applicable welding technical supplemental specification section. Other welding processes may be used, provided the governing code or standard permits it and written approval has been granted by Owner.

Any limitation or restriction specified for GMAW short-circuit arc transfer or a variation of GMAW short-circuit arc transfer marketed by welding equipment manufacturers shall be applied the same, whether a constant voltage (CV) power supply or other power supply developed by a welding equipment manufacturer is used.

Q100.3 Welding Procedure Qualification

Welding procedures shall be prepared and qualified in accordance with the referenced code. Unless otherwise specified, each manufacturer or contractor is responsible for conducting the tests required by the referenced code to qualify the Welding Procedure Specification (WPS).

Welding procedure qualification with GMAW short-circuit arc transfer using a CV power supply shall not qualify a welding procedure for GMAW using a controlled variation of short-circuit arc transfer by a power supply other than CV or vice versa.

WPSs and applicable Procedure Qualification Records (PQRs) shall be submitted for review by Owner prior to start of fabrication. Submittal of welding procedures and applicable PQRs shall apply to all suppliers and subsuppliers. Contractors shall review the documents in accordance with the applicable code and specification requirements and shall accept all of their subsuppliers' welding procedures and applicable PQRs prior to submitting accepted documents to Owner.

Because of the number of different alloys within various alloy P-number or S-number groups, WPSs for welding P-number or S-number 8, 10H, and 41 through 49 alloy materials should identify the base materials by the Unified Numbering System (UNS) or alloy type to aid in the proper application of the WPS, e.g., P45 (UNS N08367, AL6XN). As an alternative to identifying the UNS number on the WPS, the UNS number of the base material or alloy type from the WPS may be cross-referenced to the WPS by other means.

Standard Welding Procedure Specifications (SWPSs) produced by the American Welding Society (AWS) may be used when permitted by the jurisdictional code. Any supplemental requirements mandated by the jurisdictional code shall be met.

Q100.4 Welder/Welding Operator Performance Qualification

Welders and welding operators shall be qualified in accordance with the referenced code. The welder and welding operator qualification records shall be available at the shop facility or construction site and shall be made available for review when requested.

Field personnel not qualified and certified as welders or welding operators are prohibited from performing any welding activities such as tack welds, temporary welds, permanent welds, manufacturing aids, tools, fixtures, or other welded items. The only field personnel not qualified or certified as welders or welding operators who are permitted to perform welding are personnel completing welding training or performing welding performance qualification testing required by the applicable referenced code or specification.

Shop personnel not qualified and certified as welders or welding operators are prohibited from performing any welding activity on materials designated for permanent or temporary installation by the contract, such as tack welds or temporary welds.

Welders and welding operators qualified for GMAW short-circuit arc transfer using a CV power supply shall not qualify a welder or welding operator for GMAW using a controlled variation of short-circuit arc transfer by a power supply other than CV or vice versa.

Each manufacturer or contractor is responsible for the qualification of welders or welding operators. Welder or welding operator performance qualification testing shall be performed under the full supervision and control of the manufacturer or contractor.

Q100.5 Filler Materials

Welding filler metal shall comply with the requirements of the referenced code and any modified requirements specified herein. The filler metal shall be as specified in the applicable WPS.

Unless otherwise specified, the welding filler metal for welding similar base metal types shall have a chemical composition as similar as possible to the base materials to be welded. The finished weld as deposited, or after postweld heat treatment (PWHT) when required, shall be at least equal to the base metal's minimum specified properties or characteristics as they pertain to strength, ductility, notch toughness, corrosion-erosion resistance, or other physical or thermal properties.

Unless otherwise approved in writing, the GTAW or PAW process shall require the addition of filler metal.

Unless otherwise specified or permitted by an approved deviation request, the use of the -G electrode/wire classification is prohibited. When permitted, welding procedures specifying "G" classification consumables shall be restricted to the same manufacturer and brand-name consumable used to weld the procedure qualification test coupon. The manufacturer and brand name shall be listed on the WPS and PQR. The manufacturer's standard, including the mechanical properties and chemical analysis, along with the request for using non-AWS classification or "G" classification consumables shall be submitted to Owner prior to fabrication.

SAW multipass weld deposits shall use an essentially neutral flux for welding carbon steels. Alloy, semiactive, or active fluxes shall not be used except as specified otherwise. Fluxes that compensate for losses of alloying elements are permitted. Active flux may be used for single pass welding of carbon steels, provided the weld deposit thickness is approximately 1/4 inch maximum each side for a double-V-groove joint design or approximately 1/4 inch one side for a single-V-groove joint design. The joint thickness shall not exceed 1/2 inch nominal.

When using the SAW process, the flux listed in the WPS is restricted to the specific brand-name flux used in the welding procedure qualification test. Any change in the flux brand name or designation shall require a new welding procedure qualification. For SAW welding of stainless or nickel-base alloy materials, only those fluxes specified by the flux manufacturer as suitable for the particular type of high alloy electrode to be used are permitted.

The SAW process shall not use recrushed slag.

SMAW low-hydrogen type electrodes, including stainless steel and nickel and nickel alloy electrodes, shall be purchased in hermetically sealed or vacuum packed containers only.

Q100.5.1 Filler Material for Welding Miscellaneous Materials
Unless otherwise specified, filler material selection shall be in accordance with the following requirements.

Q100.5.1.1 Filler Materials for Steel and Low Alloy Steel. For the SMAW process, all filler metal shall be of the low-hydrogen type when welding on either carbon steel or low alloy steel materials. Nonlow-hydrogen type electrodes (E6010 or E7010-A1 only) may be used only for root pass welding on carbon steel piping, unless otherwise specified by other welding technical supplemental specification sections. SMAW low-hydrogen type ferrous electrodes for all fill passes shall have a minimum tensile strength of 70,000 psi (495 MPa) as defined by the applicable SFA or AWS specification. When welding is required for existing unknown carbon steel materials, the carbon content shall not exceed 0.30 percent or 0.40 percent carbon equivalent (CE) as determined by CE=C%+ (Mn%/6+Si%/6).

For the FCAW process when welding carbon steel materials, only AWS filler metal Classifications E7XT-1, -5, -9, -12 with shielding gas shall be used (current AWS classifications also utilize either an "M" or "C" after the final digit).

Low alloy FCAW electrodes of nominal composition 2-1/4 Cr - 1 Mo and higher for use on pressure-retaining components shall be purchased with a diffusible hydrogen designation of H4 maximum (SFA-5.29).

The low carbon (-B2L, -B3L, -B6L, and -B8L), low alloy filler metal classifications are prohibited for welding 1-1/4 Cr - 1/2 Mo, 2-1/4 Cr - 1 Mo, 5 Cr-Mo, and 9 Cr-Mo alloy materials. The filler metal for welding these materials shall have a carbon content greater than 0.05 percent. Previously classified low alloy filler metal Classifications ER502, E502-XX, ER505, and E505-XX are not permitted for welding low alloy base materials.

Q100.5.1.2 Filler Materials for Dissimilar Material Welds. Filler metals for welding pressure retaining component materials of carbon steel or low alloy steel to austenitic stainless steel shall be in accordance with Table Q100-1:

Table Q100-1 Carbon Steel or Low Allow Steel Filler Metal Requirements

Service ≤500° F (260° C)		**Service >500° F (260° C)**	
ASME Specification	**AWS Classification**	**ASME Specification**	**AWS Classification**
SFA 5.9 or SFA 5.14	ER309 or ER309L ERNiCr-3	SFA 5.14	ERNiCr-3
SFA 5.4 or SFA 5.11	E309 or E309L ENiCrFe-3	SFA 5.11	ENiCrFe-3
SFA 5.22	E309TX-X or	N/A	N/A

Table Q100-1 Carbon Steel or Low Allow Steel Filler Metal Requirements			
Service ≤500° F (260° C)		**Service >500° F (260° C)**	
ASME Specification	**AWS Classification**	**ASME Specification**	**AWS Classification**
	E309LTX-X		

Where carbon steel or low alloy steel piping is to be welded to austenitic stainless steel components, and the carbon or low alloy steel piping is of such a thickness as to require PWHT, the end of the carbon or low alloy steel pipe shall be buttered with Type 309L, ERNiCr-3, or ENiCrFe-3 filler metal for system service ≤500° F (260° C) and shall be buttered with Type ERNiCr-3 or ENiCrFe-3 filler metal for system service >500° F (260° C); the buttered end shall be postweld heat treated. The buttering thickness shall be 3/16 inch minimum after final surface preparation. The weld joint shall then be made between the austenitic stainless steel and the buttering on the carbon or low alloy steel as applicable. This joining method is applicable only to groove welds unless written approval has been granted by Owner.

Filler metals for welding superaustenitic stainless steel Alloy AL6XN, UNS N08367, P-number 45 to carbon steel shall be in accordance with Table Q100-2:

Table Q100-2 Stainless Steel Alloy to Carbon Steel Filler Metal Requirements	
ASME Specification	**AWS Classification**
SFA 5.14	ERNiCrMo-3 or ERNiCr-3
SFA 5.11	ENiCrMo-3 or ENiCrFe-3

Q100.5.1.3 Filler Materials for Miscellaneous Alloy Materials. Filler metals for welding carbon steel to nickel-base alloys shall be in accordance with Table Q100-3:

Table Q100-3 Carbon Steel to Nickel-Base Alloy Filler Metal Requirements	
ASME Specification	**AWS Classification**
SFA 5.14	ERNiCr-3
SFA 5.11	ENiCrFe-3

Filler metals for welding superaustenitic stainless steel Alloy AL6XN, UNS N08367, P-number 45 shall be in accordance with Table Q100-4:

Table Q100-4 Stainless Steel Alloy Filler Metal Requirements	
ASME Specification	**AWS Classification**
SFA 5.14	ERNiCrMo-3
SFA 5.11	ENiCrMo-3

Filler metals for welding stainless steel Alloy 20, UNS N08020, P-number 45 shall be in accordance with Table Q100-5:

Table Q100-5 Alloy 20 Filler Metal Requirments	
ASME Specification	**AWS Classification**

Table Q100-5 Alloy 20 Filler Metal Requirments	
ASME Specification	**AWS Classification**
SFA 5.9	ER320LR
SFA 5.4	E320LR

Q100.5.1.4 Filler Material for Welding 300 Series Stainless Steels. Filler metal for welding austenitic stainless steel, ASME P-number 8 or S-number 8 base materials shall be in accordance with the following*:

Base Material Type/Grade 304 shall use Type 308 or 308L filler metal.

Base Material Type/Grade 304L shall use Type 308L filler metal.

Base Material Type/Grade 316, shall use Type 316 or 316L filler metal.

Base Material Type/Grade 316L shall use Type 316L filler metal.

*This selection requirement may not apply to cryogenic applications.

When austenitic stainless steel "H Grade" base materials (and/or 0.040 percent minimum carbon content) are specified by Owner, high carbon stainless filler metals with 0.040 percent minimum carbon shall be used.

When using Type 308, 309, 316, 317, 321, and 347 filler metals for design temperature applications above 800 F (427 C), the deposited carbon content shall be 0.040 percent minimum.

When FCAW austenitic stainless steel weld deposits require PWHT or are used at service temperatures >1,000° F (535° C), the electrodes shall have a formulation that does not intentionally add bismuth, and bismuth in the deposited weld metal shall not exceed 0.002 weight percent.

Filler metals for austenitic 300 series weld deposits for service temperatures >700° F (370° C) shall not exceed 10 FN (ferrite number).

Q100.5.2 Filler Material Control
Storage, handling, and drying of SMAW electrodes and SAW flux shall, as a minimum, be in accordance with the manufacturers' recommendations. In addition, SMAW low-hydrogen type carbon and low alloy steel electrodes shall be stored in ovens at 250° F (120° C) minimum after the hermetically sealed or vacuum packed container is opened. Bare rod in straight lengths shall be individually flag tagged, stamped, or otherwise identified with the AWS classification or product classification. Each spool of solid or cored rod shall be tagged, labeled, or otherwise identified with the AWS classification or product classification. Any SMAW electrodes that have been wet or have damaged coatings shall not be used. Any welding filler metals or fluxes not readily identifiable shall not be used. Low hydrogen SMAW electrodes that are cold to the touch must be discarded.

SAW fluxes for welding low alloy chromium-molybdenum steels (2-1/4 Cr - 1 Mo) and higher nominal weld deposit composition shall be baked prior to use. This requirement does not apply for fluxes used within the same work shift after removal from a hermetically sealed package or container. Flux that is exposed to an atmospheric exposure limit exceeding one work shift shall be baked prior to use, unless the flux is placed in a heated container within 10 hours of issuance. After baking, fluxes should be stored in hermetically sealed containers or (preferably) stored in a heated container until issuance. Storage in a heated container or baking shall be in accordance with the flux manufacturer's directions.

A written procedure for storing, handling, issuing, and reconditioning electrodes, wires, and fluxes shall be submitted for review by Owner.

SECTION Q121
WELDING OF CARBON, LOW ALLOY, & STAINLESS STRUCTURAL STEEL

Q121.1 General

This technical supplemental specification provides requirements for welding carbon, low alloy, and stainless structural steel, photovoltaic racking, and other welded steel structures as required by design, in accordance with AWS D1.1, Structural Welding Code - Steel or AWS D1.6, Structural Welding Code - Stainless Steel. Supplemental requirements for welding a seismic load-resisting system (SLRS) shall be in accordance with AWS D1.8, Structural Welding Code – Seismic Supplement, when seismic detailing or enhanced ductility is required by design.

Q121.2 Welding Processes

Permitted welding processes shall include the restrictions and limitations applicable to those processes as specified herein.

Q121.2.1 Welding Process Restrictions and Limitations

The Gas Metal Arc Welding (GMAW) process utilizing the short-circuiting transfer mode shall not be used in any application, except for the following:

AWS D1.1 – No exceptions.

AWS D1.6 – When welding base metals that have a maximum thickness of 3/16 inch.

AWS D1.8 – No exceptions.

The Flux Cored Arc Welding (FCAW) process shall only be used with shielding gas, except for the following:

AWS D1.1 – When welding base metals that have a maximum thickness of 1/2 inch and that use E71T-8 electrodes.

AWS D1.6 – No exceptions.

AWS D1.8 – When welding base metals that have a maximum thickness of 1/2 inch and that use E71T-8 electrodes. Furthermore, the electrodes shall meet the impact testing requirements of AWS D1.8, Annex B.

The weld progression for manual or semiautomatic vertical position welds shall be uphill, except for the following:

AWS D1.1 – Undercut may be repaired vertically downward, provided the preheat is in accordance with AWS D1.1, Table 3.2, but not lower than 70° F (20° C).

AWS D1.1 – When tubular products are welded, the progression of vertical welding may be upward or downward, but only in the direction in which the welder is qualified and as permitted by the Welding Procedure Specification (WPS).

AWS D1.6 – Using the prequalified Gas Tungsten Arc Welding (GTAW), GMAW-S, and FCAW-G processes, progression may be vertically downward for base metal with a 3/16 inch maximum thickness.

AWS D1.6 – Undercut may be repaired vertically downward on the joint faces only, without any base metal thickness limitations when using the prequalified GTAW and FCAW-G processes. When using the prequalified GMAW-S process, undercut may be

repaired vertically downward on the joint faces only for base metal with a 3/16 inch maximum thickness.

AWS D1.8 – AWS D1.1 requirements above shall apply.

Q121.3 Welding Procedure Qualification

Welding procedures shall be prepared and qualified or shall be prepared as prequalified in accordance with the applicable AWS code. All prequalified WPSs shall be in the form of a written document. For a WPS to be prequalified, conformance with all of the applicable requirements of AWS D1.1, Section 3 or AWS D1.6, Section 3 shall be required. When the scope of welding is for flue gas desulfurization (FGD) system components, such as ductwork and auxiliary attachments for ductwork, the welding of these components may be performed using WPSs qualified in accordance with ASME Section IX.

For AWS D1.1 welds, when the base metal is required to be Charpy V-Notch (CVN) impact tested by the design specification or contract documents, the WPS qualification shall include the CVN test requirements of AWS D1.1. The minimum CVN test temperature for the welding procedure qualification shall be at or below the minimum test temperature specified by the design specification or contract documents.

For AWS D1.8 welds (Demand Critical and Non-Demand Critical), CVN testing is mandatory. All WPS qualifications shall be performed in accordance with the CVN test requirements of both AWS D1.1 and AWS D1.8. The minimum CVN test temperature for the welding procedure qualification shall be at or below the minimum test temperature specified by the design specification or contract documents.

When the base metal is required to be CVN impact tested by the design specification or contract documents, the filler metal required by the WPS for welding the CVN base metal shall be classified with CVN impact testing at a test temperature at or below the test temperature specified by the design specification or contract documents.

Q121.4 Welder/Welding Operator Performance Qualification

Welders and welding operators shall be qualified in accordance with the applicable AWS code. As an alternative, welders and welding operators may be qualified in accordance with ASME Section IX within the welding personnel performance essential variable limitations permitted by the applicable AWS code.

For AWS D1.8 welding, the shielding gas for FCAW shall constitute an essential variable and any change shall require requalification.

For AWS D1.8 welding, the qualification for welding personnel using the Supplemental Welder Qualification for Restricted Access Welding shall remain valid for 12 months or the duration of the project, unless there is a specific reason to question the welder's ability.

Q121.5 Fabrication Control

Fabrication, assembly, and erection shall be in accordance with the applicable AWS code and the design documents.

When welds joining ASTM A588 weathering steels will experience exposure to atmospheric conditions and are left exposed, bare, unpainted, un-insulated, or otherwise visually observable in their final service condition, the filler metal required for welding shall comply with the requirements specified in AWS D1.1, Section 3.7.3 and Table 3.3.

When tensile forces are to be transmitted through full penetration groove welds on AISC material Groups 4 and 5 rolled shapes, or shapes built up by welding plates more than 2 inches thick together to form the cross section, the requirements of AISC J1.7 in the AISC 9th Edition or AISC J1.5 and J2.6 in the AISC 13th Edition, as applicable, shall apply.

Q121.5.1 Backing and Retainers
When required, backing shall be in accordance with the applicable AWS code.

Nonmetallic retainers or non-fusing metal retainers shall not be used unless specified in the WPS. When used, they shall be removed.

Q121.5.2 Preheat and Post-weld Heat Treatment
For AWS D1.1 prequalified carbon and low alloy steels, preheat shall be performed in accordance with AWS D1.1, Table 3.2, applicable to the materials listed and the design documents. The minimum preheat temperature shall be specified in the WPS.

For AWS D1.6 prequalified austenitic stainless steels, the minimum preheat temperature shall be 50° F (10° C). The minimum preheat temperature shall be specified in the WPS.

For AWS D1.1 or AWS D1.6 materials that are not prequalified, the minimum preheat temperature shall be in accordance with the preheat temperature established from the welding procedure qualification. The minimum preheat temperature shall be specified in the WPS.

For AWS D1.8 welding, the maximum inter-pass temperature shall not exceed 500° F (260° C).

When required by design, post-weld heat treatment shall be performed in accordance with the applicable AWS code and the design documents.

Q121.5.3 Weld End Preparation
When weld joint details are specified by the design documents, they shall be prepared in accordance with the design documents.

Q121.6 Nondestructive Examination (NDE)
In addition to the 100 percent Visual Examination (VE) required of all welds, other required NDE of welds shall be performed in accordance with the applicable AWS code and the design documents defined herein.

Supplemental VE of welds after galvanizing shall be performed as defined in Article Q121.6.1.1.1.

Unless otherwise specified, any weld defects identified by NDE shall have additional examinations conducted as required by Section 6.15 of AWS D1.1 (including AWS D1.8 welds) or Section 6.8 of AWS D1.6, as applicable. All defects found shall be removed, repaired, and re-examined by the same NDE method that identified the original defect.

Q121.6.1 NDE Requirements of Welds
Structures include buildings and non-buildings, as defined in ASCE 7. Non-building structures similar to buildings will require the same NDE methods as the appropriate building structure type.

Q121.6.1.1 Building Structures and Non-Building Structures Similar to Buildings. The following NDE methods are assigned to those welds that make up the main load-carrying members of building structures and non-building structures similar to buildings; these do not apply to auxiliary attachments or prefabricated buildings:

> Butt Joint Splices, Columns, Beams. Complete joint penetration (CJP) flange butt joint splices in columns and beams shall have 100 percent radiographic testing (RT) or ultrasonic testing (UT).
>
> CJP T-Joints. CJP T-joints shall have 100 percent RT or UT.
>
> Plate Girder and Built-Up Flexural Member Joint Welds. CJP flange butt joints shall have 100 percent RT or UT. Web-to-flange joints shall have 10 percent of their total

length (additive length, both sides) examined by magnetic particle testing (MT) or liquid penetrant testing (PT). Web butt joint splices shall have 25 percent of their total length examined by random RT or UT.

Columns and Built-Up Compression Member Joint Welds. CJP flange butt joints shall have 100 percent RT or UT. Web-to-flange joints shall have 10 percent of their total length (additive length, both sides) examined by MT or PT. Web butt joint splices shall have 25 percent of their total length examined by random RT or UT.

Note: Phased array UT may be used as an alternative to the conventional UT specified for the weld types above. When phased array UT is used, the procedure qualification shall be performed in accordance with AWS D1.1, Annex S, and the UT weld acceptance criteria shall be in accordance with AWS D1.1, Section 6, Part C.

SLRS – Demand Critical Welds. CJP groove welds shall have 100 percent MT or PT, and in materials 5/16 inch and greater, 100 percent RT or phased array UT of the welds, full length. Fillet welds shall have 100 percent MT or PT of the welds, full length.

Note: Conventional UT is prohibited on SLRS welds.

SLRS – Non-Demand Critical Welds. The NDE requirements shall be the same as those for SLRS – Demand Critical Welds, with an option for a reduction in the percentage of testing.

The MT or PT testing rate on CJP welds may be reduced, on an individual basis, to 10 percent, provided the individual's reject rate is demonstrated to be 5 percent or less. A sampling of at least 20 completed welds for a job shall be made for such reduction evaluation. The reject rate is the number of welds containing defects divided by the number of welds completed. When evaluating the reject rate of continuous welds greater than 3 feet in length where the effective throat thickness is 1 inch or less, each 12 inch increment or fraction thereof shall be considered as one weld. For continuous welds greater than 3 feet in length where the effective throat thickness is greater than 1 inch, each 6 inch increment or fraction thereof shall be considered as one weld.

The RT or UT testing rate for an individual may be reduced to 25 percent, provided the individual's reject rate is demonstrated to be 5 percent or less. A sampling of at least 40 completed welds for a job shall be made for such reduction evaluation (as described above).

To ensure proper implementation of the reduced testing, Contractor and/or Contractor shall submit a procedure directing this activity for Owner review. The procedure shall define the process to ensure compliance with the stated requirements and shall include the submittal of monthly reports to the Site Manager for field work and to the Engineer for shop work; the monthly reports shall identify the welder, weld identification, drawing reference, and test results.

This reduction is not permitted on welds in the k-area, at repair sites, and for weld tab removal and backing removal sites and access holes.

SLRS – Miscellaneous. Wide-flange k-areas shall be examined by MT or PT. Beam copes or weld access holes shall have an MT or PT surface examination prior to welding.

Q121.6.1.1.1 Supplemental Visual Examination Requirements of Welds after Galvanizing. The following welds and immediate adjacent areas (within 1 inch [25 mm] of the weld) shall be 100 percent visually examined by the responsible Contractor that performs the galvanizing not less than 48 hours after completion of galvanizing:

Butt joint splices, columns, and beams.

Beam clip angles.

Plate girder and built-up flexural member joint welds.

All areas requiring VE shall be examined for the presence of cracks. The acceptance criteria for the subject welds shall be "free from cracks."

If any cracks are visually identified after galvanizing, Owner shall be notified prior to repair. Owner may request additional NDE by MT examination of any similar joint types. Any cracks discovered by MT, but not previously identified by VE, shall require 100 percent MT examination of all similar joint types at the expense of Contractor. Any cracking detected by VE or MT shall be repaired at the expense of Contractor.

Visual inspection of the subject welds after galvanizing may be performed by personnel other than the responsible Contractor's Certified Welding Inspector (CWI). Personnel other than a CWI must have experience suitable to Owner for performing post-galvanizing weld visual inspection. Visual inspectors' qualifications and certificates or evidence of training or experience shall be submitted to Owner for review.

SECTION Q123
WELDING OF REINFORCING STEEL

Q123.1 General
This technical supplemental specification provides requirements for welding reinforcing steel and reinforcing steel to carbon and low alloy structural steel as required by design in accordance with AWS D1.4, Structural Welding Code – Reinforcing Steel. Only ASTM A615, deformed and plain billet steel bars for concrete reinforcement, and ASTM A706, low alloy steel deformed bars for concrete reinforcement, are permitted to be welded.

Q123.2.1 Welding Process Restrictions and Limitations
The Gas Metal Arc Welding (GMAW) process utilizing the short-circuiting transfer mode shall not be used in any application.

The Flux Cored Arc Welding (FCAW) process shall only be used with shielding gas.

The weld progression for manual or semiautomatic vertical position welds shall be uphill.

Q123.3 Welding Procedure Qualification
Welding procedures shall be prepared and qualified in accordance with AWS D1.4, except that Welding Procedure Specifications (WPSs) for fillet welds shall be considered prequalified. All prequalified WPSs shall be in the form of a written document.

Q123.4 Welder/Welding Operator Performance Qualification
Welders and welding operators shall be qualified in accordance with AWS D1.4.

Q123.5 Fabrication Control
Fabrication, assembly, and erection shall be in accordance with AWS D1.4 and the design documents.

Tack welds that do not become part of the permanent welds are prohibited. Tack welds shall be made using preheat requirements for permanent welds.

Spark testing of reinforcing steel is not acceptable.

Q123.5.1 Backing and Retainers
When required, backing shall be in accordance with AWS D1.4 and the WPS.

Nonmetallic retainers or non-fusing metal retainers shall not be used unless specified in the WPS. When used, they shall be removed.

Q123.5.2 Preheat and Inter-pass Temperature
Preheat shall be performed in accordance with AWS D1.4, Table 5.2, using the highest carbon equivalent number of the base metal specified by design. Carbon equivalent shall be calculated in accordance with Subsection 1.3.4 of AWS D1.4. Where it is impractical to obtain chemical analysis, the carbon equivalent shall be assumed to be >0.75 percent. The minimum preheat temperature shall be specified in the WPS.

Q123.5.3 Weld End Preparation
When weld joint details are specified by design documents, they shall be prepared in accordance with the design documents.

Q123.6 Nondestructive Examination (NDE)
In addition to the 100 percent visual examination required of all welds, other required NDE of welds shall be performed in accordance with AWS D1.4 when specified by the design documents.

SECTION Q130
WELDING OF ALUMINUM

Q130.1 General
This technical supplemental specification provides requirements for welding aluminum structures as required by design in accordance with AWS D1.2, Structural Welding Code – Aluminum. In addition, this technical supplemental specification provides requirements for welding aluminum supporting structures.

Q130.2.1 Welding Process Restrictions and Limitations
Only Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW) processes shall be used.

A gas or gas mixture used for shielding shall be welding grade and have a minimum purity of 99.997 percent and a dew point of -76° F (-60° C) or lower for argon, and a minimum purity of 99.995 percent and a dew point of -71° F (-57° C) or lower for helium.

The weld progression for manual or semiautomatic vertical position welds shall be uphill.

Q130.3 Welding Procedure Qualification
Welding procedures shall be prepared and qualified in accordance with AWS D1.2 for welding aluminum structures required by design.

Welding procedures shall be prepared and qualified in accordance with AWS D1.2 or ASME Section IX for welding aluminum isophase bus duct and associated aluminum supporting structures.

Q130.4 Welder Performance Qualification
Welders shall be qualified in accordance with AWS D1.2 for welding aluminum structures required by design. As an alternative, welders may be qualified in accordance with ASME Section IX within the welding personnel performance essential variable limitations permitted by AWS D1.2.

Welders shall be qualified in accordance with AWS D1.2 or ASME Section IX for welding aluminum isophase bus duct and associated aluminum supporting structures. As an alternative to AWS D1.2 or ASME Section IX performance qualification, welders may perform a workmanship sample of the type weld to be performed in production. The Welding Procedure Specification (WPS) used for the workmanship sample shall be the same WPS to be used for the production weld. The workmanship sample shall be completed prior to production welding. The following workmanship sample test and visual examination requirements shall apply:

For production fillet welds, the welder shall perform a fillet weld of the maximum size to be welded in production. The minimum length of weld shall be 6 inches.

For production groove welds, the welder shall perform a groove weld at least one half the thickness to be performed in production. The minimum length of weld shall be 6 inches.

Qualification testing on groove welds qualifies for fillet welds but not vice versa.

When multiple positions are to be welded in production, the most restrictive position for welding shall be chosen for welding the workmanship sample, or welding the workmanship sample in the vertical position qualifies all positions.

Visual examination of the completed workmanship sample test shall be performed and shall comply with the following acceptance standards:

The weld shall be free of cracks, lack of fusion, or incomplete penetration.

All craters shall be filled to the full cross section of the weld.

The edges of the weld shall blend smoothly with the base metal.

For groove welds, the face of the weld shall be flush with the surface of the base metal.

After successful completion of the workmanship sample test, a welder performance qualification test record shall be generated to document the test.

Q130.5 Fabrication Control
Fabrication, assembly, and erection for welding aluminum structures shall be in accordance with AWS D1.2 and the design documents.

Fabrication, assembly, and erection for welding aluminum isophase bus duct and associated aluminum supporting structures shall be in accordance with manufacturer's standard practice and design documents.

Preparation of base metal for welding shall be in accordance with AWS D1.2.

Weld joint end preparations shall be cleaned of thick aluminum oxide and foreign substances prior to welding. When grinding, care shall be taken to select nonloading type abrasives specifically intended for use on aluminum, and the abrasives shall be maintained free of lubricants and other foreign material.

Straight lengths of aluminum bare rod should be properly cleaned and wiped with a solvent, such as acetone or alcohol, prior to welding.

Anti-spatter compounds shall not be used.

Q130.5.1 Backing and Retainers
When required, backing shall be in accordance with AWS D1.2.

Nonmetallic retainers or nonfusing metal retainers shall not be used unless permitted by AWS D1.2 and specified in the WPS. When used, they shall be removed.

Q130.5.2 Preheat, Interpass Temperature, and Postweld Heat Treatment
Preheat shall be performed in accordance with the WPS applicable to the materials listed and the design documents. The minimum preheat temperature and maximum interpass temperature shall be specified in the WPS.

When fabricating AWS D1.2 heat treatable aluminum alloys or the 5000 series aluminum magnesium alloys containing more than 3 percent magnesium, the preheat and interpass temperatures shall not exceed 250° F (120° C). Holding time at this temperature shall not exceed 15 minutes. The minimum preheat temperature and maximum interpass temperature shall be specified in the WPS.

When required by design, postweld heat treatment shall be performed in accordance with the design documents.

Q130.5.3 Weld End Preparation
When weld joint details are specified by the design documents, they shall be prepared in accordance with the design documents.

Q130.6 Nondestructive Examination (NDE)
In addition to the 100 percent visual examination required of all welds, other required NDE of welds shall be performed in accordance with AWS D1.2 and the design documents.

SECTION Q301
MANUFACTURER'S STANDARD COATING

Unless otherwise specified, the manufacturer's standard coating systems shall be applied in the shop to ferrous metal surfaces of equipment and materials. The coating systems shall provide resistance to corrosion caused by weather and industrial environments. Surfaces that will be inaccessible after assembly shall be protected for the life of the equipment.

Coating material and application shall conform to the regulations of the air quality management agency having jurisdiction. Materials shall be formulated to contain less than 0.06 percent lead or chromium in the dried film.

Surfaces shall be cleaned, prepared, and coated in accordance with the coating manufacturer's instructions and specified codes. Surfaces to be painted shall be prepared, as necessary, to provide a smooth, uniform base for painting.

Coating films that show defects such as sags, checks, blisters, teardrops, fat edges, et cetera will not be accepted. Any coated surface that contains any of the previously mentioned defects shall be repaired or, if necessary, entirely removed from the member or unit involved and the surface recoated.

All internal surfaces that will be exposed to steam or treated feed-water shall be blasted with aluminum oxide (pink or white grade), cut steel wire (SAE J441), steel grit or steel shot. The blasting media used shall contain no more than 1.2 percent complexed silica and 0 percent free silica.

Surfaces to be finish painted after installation shall be shop painted with one coat of manufacturer's standard primer or as specified for that equipment item.

Touchup paint shall be provided for repair painting of at least 10 percent of the finish painted equipment surface. The touchup paint shall be the same type and color as the shop applied material. Application instructions shall be provided.

No coating shall be applied to surfaces within 3 inches of field welded connections.

Coating dry film thicknesses shall be measured using a magnetic or electronic thickness detector in accordance with SSPC-PA2. Additional coating shall be applied to all areas which show a deficiency in dry film thickness.

Q301.1 Control and Electrical Equipment
Control and electrical equipment, including panels, cabinets, switchgear, transformers, and motors, shall be finish painted. Exterior surfaces shall be the manufacturer's standard color unless specified otherwise. The interior portions of cabinets shall be painted a light reflecting color.

Q301.2 Mechanical Equipment
Mechanical equipment, including pumps, compressors, valves, valve operators, external piping surfaces, and other similar equipment, shall be cleaned, prepared, and primed. If mechanical equipment will operate at temperatures above 200° F (93° C) and will not be insulated, a high temperature coating system designed for the operating temperatures shall be applied.

Q301.3 Documentation
Shop drawings shall identify the shop applied coating systems. Data to be provided shall include the coating system manufacturer's name and product designation, the degree of surface preparation, dry film thickness, finish color, and Material Safety and Data Sheets (MSDS). Final dry film thickness test results shall be submitted to the Owner for verification in accordance with Section 1A, 5.0.

SECTION Q302
OWNER SPECIFIED EXTERIOR SHOP COATING

Shop coating systems for ferrous metal surfaces of equipment shall be as specified on the Coating System Data Sheets as specified in Section 09900. Where specific products are not listed, the coating materials shall meet the criteria indicated. Information assuring conformance with the specified criteria shall be submitted to the Owner.

Paint materials shall conform with and shall be applied in accordance with the regulations of the air quality management agency having jurisdiction. Paint materials that cannot be guaranteed by the manufacturer to so conform, whether or not specified by product designation, shall not be used. Alternate materials that do conform shall be proposed. Information on the alternate materials shall be submitted to the Owner for acceptance prior to application. Materials shall contain no greater than 0.06 percent lead or chromium in the dried film.

Surfaces shall be cleaned, prepared, and coated in accordance with the Coating System Data Sheet(s) and application specifications. Surfaces to be painted shall be prepared, as necessary, to provide a smooth, uniform base for painting.

Coating films that show defects such as sags, checks, blisters, teardrops, fat edges et cetera will not be accepted. Any coated surface that contains any of the previously mentioned defects shall be repaired or, if necessary, entirely removed from the member or unit involved and the surface recoated.

The Contractor shall furnish sufficient touchup paint for repairing 10 percent of the area on all factory painted external surfaces of each item of electrical equipment. The touchup paint shall be of the same type and color as the factory applied paint and shall be carefully packed to avoid damage during shipment. Complete painting instructions shall be furnished.

Coatings shall not be applied when the surface temperature is within 5° F (3° C) of the dew point. No paint shall be applied to surfaces within 3 inches of field welded connections.

Q302.1 Control and Electrical Equipment
Control and electrical equipment, including panels, cabinets, switchgear, motor control centers, transformers, motors, and other similar equipment, shall be cleaned and prepared, and given a complete finish coating system as specified on the Coating System Data Sheets. Control instruments and devices and computer equipment shall be furnished with the manufacturers' standard paint.

Q302.2 Mechanical Equipment
Mechanical equipment, including pumps, compressors, valves, valve operators, dampers, damper drives, mills, grinding apparatus, external piping surfaces, conveying machinery, and other similar equipment, shall be cleaned, prepared, and primed as specified on the Coating System Data Sheets.

The above requirement applies to equipment operating up to 200° F (93° C) and to equipment operating above 200° F (93° C) which will be insulated.

Q302.3 Structural Steel and Miscellaneous Metals
Structural steel and miscellaneous metals not specified to be galvanized, including all items fabricated of structural and miscellaneous steel such as ducts, tanks, hangers, supports, and similar fabricated steel assemblies, shall be cleaned, prepared, and primed as specified on the Coating System Data Sheets.

Q302.4 Hot Metal Surfaces
Hot metal surfaces include metal surfaces of electrical or mechanical equipment or structural steel and miscellaneous metals as defined above that have an operating or service temperature above 200° F (93° C). Hot metal surfaces shall be cleaned, prepared, and primed as specified on the Coating System Data Sheets.

Q302.5 Codes and Standards

Work performed under this specification shall be done in accordance with the codes and standards in Table Q302-1. The version that is latest adopted, published, and effective at the date of bid shall apply unless specifically stated otherwise. In the following list, SSPC refers to the Society for Protective Coatings:

Table Q302-1 Codes and Standards	
Application	**Code/Standard**
Shop, field, and maintenance painting	SSPC-PA1
Measurement of Dry Paint Thickness	SSPC-PA2

Q302.6 Documentation

Shop drawings shall identify the shop applied coating systems. Data to be provided shall include the coating system manufacturer's name and product designation, the degree of surface preparation, dry film thickness, finish color, and Material Safety and Data Sheets (MSDS).

Coating dry film thicknesses shall be measured using a magnetic or electronic thickness detector per SSPC-PA2. Additional coating shall be applied to all areas which show a deficiency in dry film thickness. Final test results shall be submitted to the Owner for verification in accordance with Section 1A, 5.0.

SECTION Q310
PRESERVATIVE COATINGS

Ferrous surfaces which should not be painted and are subject to corrosion shall be protected with preservative coatings. Other surfaces shall be coated with a rust-preventive compound.

Preservative coatings shall not be applied to stainless steel.

Machined surfaces of weld-end preparations shall be coated with consumable rust-preventive coating.

Q310.1 Materials
Preservative coating materials and applications shall be as follows. Other materials may be proposed provided manufacturer's data is submitted to the Owner for acceptance prior to application:

Table Q310-1 Materials

Description	Manufacturer/Product	Application
Consumable Rust Preventative (SPC)	D-C Sales & Engineering/ Deoxaluminite	0.75 mils Minimum DFT
Consumable Rust Preventative (SPC)	Tempil/ Bloxide	0.75 mils Minimum DFT
Oil Soluble Rust Preventative	Houghton/International/ Rust-Veto	0.3 mils Minimum DFT
Vapor Phase Corrosion Inhibitor	Cortec Corporation/ VpCI-309 SF	In accordance with manufacturer
Vapor Phase Corrosion Inhibitor	Daubert VCI, Inc/ Nox-Rust 1000 SF	In accordance with manufacturer

SECTION Q320
GALVANIZING

Structural steel members and steel assemblies shall be "pickled" after all cutting, punching, reaming, drilling, tapping, and other fabrication processes which would damage galvanizing have been completed. The pickling shall be done in accordance with the latest accepted practice and shall continue until all scale, rust, grease, and other impurities have been completely removed. The steel shall then be hot-dip galvanized.

When either member to be bolted is galvanized and where required by the detailed specifications, erection and structural bolts shall be galvanized.

Q320.1 Codes and Standards

Work performed under this specification shall be done in accordance with the codes and standards in Table Q320-1. The version that is latest adopted, published, and effective at the date of bid shall apply unless specifically stated otherwise:

Table Q320-1 Codes and Standards

Work	**In Accordance With**
Hot-dip galvanizing	ASTM A123 or ASTM A153
Bolt galvanizing	ASTM B695 Class 50

SECTION Q500
SHOP DRAWINGS AND INSTRUCTION MANUALS

This section, in conjunction with the Schedule of Submittals, stipulates the requirements for engineering data that Contractor shall submit for design information and review. Document submittal procedures shall be in accordance with the requirements of this Contract.

Q500.1 Submittal Requirements
Technical data shall be submitted in electronic format. Hard copy prints of the electronic files shall also be submitted, as specified in Appendix J and Section 1A, 5.0.

All shop drawings, instructions, manuals, and associated materials shall be in English. Drawings shall use standard ANSI symbology. All dimensions shall use ASME and standard English units, the dimensions shall not be in metric units.

Electronic technical data submittals shall be made in accordance with Appendix J.

Notification to Owner that submittals have been posted in accordance with Appendix J and other correspondence requirements of this Contract.

Q500.2 Compliance Reports
Reports shall be submitted that record the tests and/or calculations required in the specification technical sections. Reports shall be submitted for each piece of equipment or each plant system. Specified drawings shall be submitted with the compliance reports.

Q500.3 Not Used

Q500.4 Drawings
Owner’s drawing requirements are described in Appendix J.Drawings shall be in sufficient detail to indicate the kind, size, arrangement, component weight, breakdown for shipment, and operation of component materials and devices; the external connections, anchorages, and supports required; the dimensions needed for installation and correlation with other materials and equipment; and the information specifically requested in the Schedule of Submittals.

Contractor shall fully complete and certify drawings for compliance with the Contract requirements. Drawings shall have title block entries that clearly indicate the drawing is certified.

Each submitted drawing shall be project unique and shall be clearly marked with the name of the project, unit designation, Owner's Contract title, Owner's Contract file number, project equipment or structure nomenclature, component identification numbers, and Owner's name. Equipment, instrumentation, and other components requiring Owner-assigned identification tag numbers shall be clearly identified on the drawings. If standard drawings are submitted, the applicable equipment and devices furnished for the project shall be clearly marked.

Transmittal letters shall identify which Schedule of Submittals item (by item number) is satisfied by each drawing or group of drawings. The transmittal letter shall include the manufacturer's drawing number, revision number, and title for each drawing attached. Each drawing title shall be unique and shall be descriptive of the specific drawing content. Transmittal letters for resubmitted drawings shall include the Owner's drawing numbers.

Catalog pages are not acceptable, except as drawings for standard non-engineered products and when the catalog pages provide all dimensional data, all external termination data, and mounting data. The catalog page shall be submitted with a typed cover page clearly indicating the name of the project, unit designation, specification title, specification number, component identification numbers, model number, Contractor's drawing number, and Owner's name.

Drawings shall be submitted with all numerical values in English and/or metric (SI) units.

Q500.4.1 Drawing Submittal
Refer to Appendix J.

Q500.4.2 Drawing Processing
Contractor's engineering schedule shall allow a minimum of four (4) weeks for mailing, processing, and review of drawings and data by Owner.

Unless this Contract indicates that a drawing or engineering data submittal by Contractor is to be for Owner's information only, Owner, upon receipt of submittals, shall review and return same to Contractor, marked "No Exceptions Noted," "Exceptions Noted," "Received for Distribution," "Returned for Corrections," "Release for Record," "Void," or "Superseded." The timing of Contractor's submittals and Owner's review shall be in accordance with the Completion Dates for same as set forth in the Contract. The submittal of any drawing or other submittal document by Contractor to Owner under this Contract will be certification by Contractor that the information set forth therein is accurate in all material respects.

Q500.4.2.1 No Exceptions Noted (NE) or Received for Distribution (RD). Upon receipt of a submittal marked "No Exceptions Noted" or "Received for Distribution," Contractor may proceed with its Work to the extent of and in accordance with the submittal. Contractor shall not resubmit unless the drawing or document is revised, in which case it shall be resubmitted as a new document revision in accordance with Q500.4.2.7.

Q500.4.2.2 Exceptions Noted (EN). Upon receipt of a submittal marked "Exceptions Noted" and if Contractor concurs with Owner's comments, Contractor shall incorporate same and may proceed with its Work to the extent of and in accordance with the annotated submittal. Contractor shall submit to Owner within 14 calendar days a revision to the original submittal in which Owner's comments have been incorporated. If Contractor determines that it cannot incorporate Owner's comments without prejudice to Contractor's warranty or other obligations under this Contract, Contractor shall so advise Owner in writing within seven calendar days of its receipt of Owner's comments, stating the reasons therefore. Contractor may proceed with its Work to the extent of and in accordance with the annotated submittal only upon Owner and Contractor resolving Owner's comments.

Q500.4.2.3 Returned for Corrections (RC). Upon receipt of a submittal marked "Returned for Corrections," Contractor shall immediately take all necessary action to revise its submittal in accordance with Owner's comments, the Specification, and the Drawings, and shall resubmit to Owner for review the corrected original submittal, voiding previous information and adding new documents if required. In no event shall Contractor proceed with the affected Work until its revised submittals have been returned to Contractor marked "No Exceptions Noted" or "Exceptions Noted" by Owner.

Q500.4.2.4 Release for Record (RR). Receipt of a submittal marked "Release for Record" indicates that there are no specific objections to the document. Work may proceed. Certain project information required by the Owner's document management system may have been added electronically to the drawing and provided to Contractor for the record. Contractor shall not resubmit the drawing or document unless revisions to the design are required. If revisions are required, Contractor shall incorporate Owner's information and resubmit as a new revision. Owner's project-specific information shall be added if future revisions and submittals are made.

Q500.4.2.5 Void (VO) or Superseded (SS). Receipt of a submittal marked "Void" or "Superseded" does not require any action by Contractor. "Void" indicates that the submittal is no longer applicable to the project and is not being replaced by other drawings or data. "Superseded" indicates that different drawings or data have replaced the previously submitted drawings and data; this status does not pertain to revisions of the same drawings and data.

Q500.4.2.6 Hold (HO). A submittal may be given a status of "Hold" by the Owner, or the Contractor may have "Holds" on the submitted drawing.

For a Hold status designated by the Owner, the Contractor shall not proceed with the work that is designated on "Hold" except as specifically directed by the Owner. Additional information required for the Contractor to release the "Hold" will be transmitted from the Owner later.

The Contractor shall provide information to the Owner about the cause for any "Holds" designated on the drawing and immediately take all action necessary to resolve the "Holds". The Contractor shall resubmit the drawing for review once the "Holds" are removed from the drawing and should make all efforts to not submit drawings to the Owner until drawing review comments have been received back from the Owner.

Q500.4.2.7 Re-submittals. If during or subsequent to the completion of the submittal process, Contractor makes further changes to the equipment and materials shown on submittals that have been reviewed by Owner, the changes shall be clearly marked on the submittal by Contractor and the submittal process shall be repeated. If changes are made by Contractor after delivery to the Jobsite, as-built drawings indicating the changes shall be prepared by Contractor and submitted to Owner for review. Any resubmittal of information shall clearly identify the revisions by footnote or by a form of back-circle, with revision block update, as appropriate.

Q500.4.2.8 Owner's Review. Owner's review of drawings and other submittals will cover only general conformity of the data to the Specifications and Drawings, external connections, interfaces with equipment and materials furnished under separate specifications, and dimensions that affect plant arrangements. Owner's review does not include a thorough review of all dimensions, quantities, and details of the equipment, material, device, or item indicated or the accuracy of the information submitted. Review and comment by Owner of Contractor's Drawings or other submittals shall not relieve Contractor of its sole responsibility to meet the Completion Dates requirement of this Contract and to supply Goods that conform to the requirements of this Contract.

Q500.4.2.9 File Returns to Contractor. A copy of the manifest will be returned to Contractor indicating drawings statused as NE (No Exceptions Noted).

Each packet of drawings returned to Contractor will include a manifest generated by Owner. The manifest will include a list of drawings transmitted, manufacturer's drawing numbers, Owner's assigned drawing numbers, Owner's drawing titles, and the status of the drawings.

Files returned to Contractor will be in a format in accordance with Appendix J unless another format is agreed upon by Owner and Contractor.

Q500.5 Wiring Diagrams
Wiring diagrams shall be submitted in accordance with Appendix J and Section 1A, 5.0.

Q500.6 Instruction Manuals
Instruction manuals shall be submitted in accordance with Appendix J and Section 1A, 5.0.

SECTION Q501
INSTRUCTION MANUALS AND
OPERATION & MAINTENANCE (O&M) MANUALS

The Schedule of Submittals included in the Supplemental Terms and Conditions of this Contract, stipulates the requirements for Instruction Manuals that Contractor shall submit for design information and review. Document submittal procedures shall be in accordance with the requirements of this Contract and the following.

Q501.1 Submittal Requirements
Owner's drawing requirements are described in Appendix J and Section 1A, 5.0.

Q501.2 Instruction Manuals
Contractor shall furnish proof and final instruction manuals for the unloading, storage, installation, operation, and maintenance of the equipment. The manuals shall be delivered as specified in the Schedule of Submittals.

Manuals shall include the following information specific only to the furnished equipment. The documents or drawings submitted within the Instruction Manual shall be consistent with the documents or drawings previously submitted for Owner's review. Documents or drawings which were previously submitted for review and are included within the Instruction Manual shall be identical, with the same revision number. If these documents or drawings were revised due to design revisions subsequent to issuance of the Instruction Manuals, the document or drawing shall be resubmitted in accordance with Article Q500.4.2.7 so the Owner can provide updated drawings to the holders of the Instruction Manuals. Contractor shall edit manuals that cover multiple equipment models or designs by deleting or red-lining out portions of the manuals that do not pertain to the specific equipment provided.

Table of contents and index tabs. (If multiple volumes are required, a table of contents listing materials included in each volume shall be supplied for each volume.)

Specifications, test data, and all performance curves specified in the technical specifications.

Description of the equipment, including illustrations showing elevations, cross section, and all details of the equipment with all parts named, numbered, and identified with Owner's ID numbers. When multiple model numbers are shown on the drawings, the equipment supplied for the project shall be clearly identified.

Complete and detailed operating instructions, including safety precautions, philosophy of operation and, where applicable, process optimization techniques.

Detailed minor and major maintenance instructions, including description, use of special tools furnished, and preventive maintenance schedule.

Instructions for receiving, inspection, storage, and handling of equipment prior to installation.

Installation instructions.

Inspection procedures.

Troubleshooting guide.

All fluid systems schematics and piping diagrams.

Control logic diagrams, as applicable.

Electrical wiring diagrams, as applicable.

Calibration Data Sheet for each adjustable instrument included in the scope of supply.

Motor Information Sheets, as applicable.

Electric Actuator Information Sheets, as applicable.

Control Panel Arrangements, as applicable.

Contractor and Sub-Contractor operating and maintenance manuals.

Illustrated parts breakdown.

Assembly drawings.

Parts lists.

List of acceptable lubricants with quantity of lubricants required to satisfy the equipment fill requirements.

Nameplate information and shop order numbers for each item of equipment and associated component parts thereof.

List of recommended spare parts.

List of maintenance tools furnished with the equipment.

The above listed requirements are the minimum requirements; however, requirements that are clearly not applicable to the equipment may be deleted with Owner's approval. Additional information that is necessary for proper operation and care of the equipment shall also be included.

Q501.2.1 Binding
Each copy of the manuals shall be assembled and bound in three-ring or post binders designed for rough usage. Light-duty binders will not be acceptable.

Front covers and backbones of the manuals shall be permanently marked with lettering per the Typical Instruction Book Cover attached at the end of this section.

SECTION S100
SEISMIC DESIGN

S100.1 General

This article specifies the general criteria and procedures that shall be used to ensure that structures, components, and equipment meet performance objectives during and following a seismic event. The intent of these procedures is to minimize the hazard to human life. Buildings and structures may be damaged but remain suitable for occupancy and use, albeit in an impaired condition. The damage is anticipated to be repairable. Components and equipment are expected to remain in place without collapsing or breaking away from supports, and to remain intact to the extent that they do not create an ignition hazard or release hazardous materials.

The building structural system shall provide a continuous load path or paths, with adequate strength and stiffness to transfer all seismic forces from the point of application to the final point of resistance.

Components and equipment shall be attached so that seismic forces are transferred to the structural system of the building. These attachments shall be bolted, welded, or otherwise positively fastened. Frictional resistance due to gravity shall not be considered in evaluating the required resistance to seismic forces.

For seismic design of vessels, tanks, and other components, contents that are flammable, explosive, corrosive, acidic, caustic, toxic, or that otherwise present a danger to the general public if released shall be considered hazardous materials.

Seismic design shall be performed in accordance with IBC 2009 along with the applicable edition (as required by the specified building code) of the following references:

American Institute of Steel Construction (AISC), AISC 360, "Specification for Structural Steel Buildings."

American Institute of Steel Construction (AISC), AISC 341, "Seismic Provisions for Structural Steel Buildings."

American Concrete Institute (ACI), ACI 318, "Building Code Requirements for Structural Concrete."

American Concrete Institute (ACI), ACI 307, "Design and Construction of Reinforced Concrete Chimneys."

American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel Code" and all addenda.

American National Standards Institute (ANSI), "ASME Code for Pressure Piping, ASME B31.1, Power Piping."

Manufacturers Standardization Society of the Valve and Fitting Industry (MSS), MSS SP-58, "Pipe Hangers and Supports - Materials, Design, and Manufacture."

American Petroleum Institute (API), API 650, "Welded Steel Tanks for Oil Storage."

American Water Works Association (AWWA), AWWA D100, "Welded Steel Tanks for Water Storage."

National Fire Protection Association (NFPA), NFPA 13, "Standard for the Installation of Sprinkler Systems."

Other nationally recognized and accepted design standards and references as appropriate.

S100.2 Seismic Forces
Seismic forces shall be determined from the basic seismic parameters given in Table 3. The design forces and their distribution over the height of the building or structure shall be determined using a linearly elastic analysis model and the procedures listed in the specified building code. Load combinations, including seismic, shall be in accordance with the specified building code.

Hydrodynamic effects of contents shall be considered in the seismic design of vessels and tanks as required by the specified building code. Seismic dynamic forces shall be considered in the seismic design of below ground structures in addition to the static soil pressures.

S100.3 Seismic Design

S100.3.1 Buildings
Buildings shall provide sufficient strength and ductility to resist the specified seismic effects and may use any of the basic structural systems permitted by the specified building code. Usage of structural systems shall be in accordance with the limitations prescribed in the specified building code. The effects of both plan and vertical irregularities shall be considered, as required by the specified building code.

Buildings shall be seismically analyzed using either Equivalent Lateral Forces or Modal Analysis in accordance with the specified building code and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code.

"W" for buildings shall include the total dead load, the total operating weight of permanent equipment and the effective contents of vessels, and applicable portions of other loads, as required by the specified building code.

S100.3.2 Non-building Structures
Non-building structures include all self-supporting structures, other than buildings, bridges, and dams, that are supported by the earth; that carry gravity loads; and that may be required to resist seismic effects. These include, but are not limited to, photovoltaic racking, electrostatic precipitators, stacks, conveyor support structures, pipe racks, trussed towers, transmission towers and poles, tanks, vessels, bins, and hoppers. Design of non-building structures shall provide sufficient strength and ductility, consistent with the requirements for buildings, to resist the specified seismic effects.

Non-building structures shall be seismically analyzed using either Equivalent Lateral Forces or Modal Analysis in accordance with the specified building code, and shall meet all of the design, proportioning, detailing, inspection, and quality assurance provisions of the specified building code and other referenced codes.

"W" for non-building structures shall include all dead load as defined for buildings, and shall also include all normal operating contents of tanks, vessels, bins, and piping.

S100.3.3 Equipment
Seismic design of mechanical and electrical equipment, attachments, and supports shall consider the dynamic effects of the equipment; its contents; piping attached to its nozzles; and, when appropriate, its supports. Most mechanical and electrical equipment is presumed to be inherently rugged and capable of surviving strong motions and earthquakes provided it is adequately attached to the structure.

Equipment mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction. These seismic restraints shall be designed for twice the seismic force acting on the equipment. Seismic supports shall maintain positive engagement with the equipment.

If the equipment is essential and must remain functional after an earthquake or if the equipment contains hazardous materials, it may be seismically qualified by analysis, testing, or experience data in accordance with the specified building code. Adaptation of a nationally recognized standard such as ICC-ES AC 156 for qualification by testing is acceptable, provided the seismic capacity of the equipment equals or exceeds the requirements of the specified building code.

S100.3.4 Components
Components are architectural, mechanical, and electrical parts and portions that are attached to and supported by the building but are not part of the building structural system, such as nonbearing walls and partitions, ceilings, storage racks, access floors, tanks, piping, HVAC ductwork, elevators, electrical panels, cable tray, and other nonstructural items. Components shall have the same Seismic Design Category as the building to which they are attached.

Fire protection components, equipment, and piping shall be functional after an earthquake and shall be assigned the corresponding Importance Factor, I_p.

W_p for tanks, bins, and silos shall represent the weight of the tank structure and appurtenances and the operating weight of the contents at maximum rated capacity.

W_p for piping systems shall represent the total distributed operating weight of the piping system, including, but not limited to, any insulation, fluids, and concentrated loads such as valves, condensate traps, and similar components.

Seismic effects that shall be analyzed in the design of piping systems include the dynamic effects of the piping system, contents, and, when appropriate, supports. The interaction between the piping system and the supporting structures, including other mechanical and electrical equipment, shall also be considered.

In addition to seismic loadings, piping systems shall be designed to withstand dead plus operating loading, occasional (wind or hydrotesting) loading, and thermal loadings. Wind loadings shall not be considered as acting concurrently with seismic loadings.

S100.3.5 Not Used

S100.3.6 Not Used

S100.4 Documentation
Complete structural support and anchorage details shall be shown on all drawings, including the size of members, details of connections, anchor bolt sizes, etc.

All structural drawings shall be signed off on by a Professional Engineer registered in the state of Missouri.

The following seismic design data shall be indicated on the design drawings:

Occupancy Category.

Mapped Spectral Response Accelerations, S_s and S_1.

Spectral Response Coefficients, S_{DS} and S_{D1}.

Site Class.

Seismic Design Category.

For Structures and Non-building Structures Similar to Buildings:

Importance Factor, I.

Basic Seismic Force Resisting System.

Design Base Shear.

Seismic Response Coefficient, C_s.

Response Modification Factor, R.

Overstrength Factor, Ω_o

Analysis Procedure.

Seismic Drift.

Seismic Detailing.

For Nonstructural Components Including Equipment:

Component Importance Factor, I_p.

Seismic Design Force, F_p.

Component Response Modification Factor, R_p.

Component Amplification Factor, a_p.

Equipment and component drawings shall indicate the total load and/or loads to be transmitted to the structure that must ultimately restrain the components, equipment, or structure. This information shall include the weight, dimensions locating the center of gravity of the component or equipment, or the seismic design forces (magnitude, direction, and location) acting on the supports.

If requested by the Owner, design calculations shall be submitted for all structures, equipment, or components which are designed in accordance with this supplemental specification. If requested by the Owner, these calculations shall be certified by a professional engineer registered in the appropriate jurisdiction.

SECTION S300
STRUCTURAL DESIGN LOADS

S300.1 General

Design loads for all buildings, structures, structural elements and components, handrails, guardrails, and connections shall be determined according to the criteria specified in this section, unless the governing building code requires more severe design conditions. Loads imposed on structural systems from the weight of all temporary and permanent construction, occupants and their possessions, environmental effects, differential settlement, and restrained dimensional changes shall be considered.

The live loads used in the design of buildings and structures shall be the maximum loads likely to be imposed by the intended use or occupancy, but shall not be less than the minimum uniform live loads presented in Article S300.3, unless allowed by the governing building code. Components of the structural system may be designed for a reduced live load in accordance with the governing building code. Roofs shall be designed to preclude instability resulting from ponding effects by ensuring adequate primary and secondary drainage systems, slope, and member stiffness.

Structural elements supporting major equipment shall be designed for the greater of the uniform live load or the loading imposed by the actual equipment.

Construction or crane access considerations may dictate the use of temporary structural systems. Special considerations shall be made to ensure the stability and integrity of the structures during any periods involving use of temporary bracing systems.

S300.2 Design Loads

Design loads shall be in accordance with Table S300-1.

Table S300-1 Design Loads

Load Types	Criteria/Source
Dead Loads	ASCE 7, Tables C3-1 and C3-2.
Live Loads	Calculated weight of the contents of tanks, silos, bins, hoppers, in accordance with Table S300-1; movable loads, such as people, equipment, tools, and components during construction, operations, and maintenance; maximum loads likely to be imposed by intended use or occupancy, but not less than the loads in Article S300.3, nor actual equipment weight.
Impact Loads	Article S300.3 loads allow for ordinary impact conditions. Reciprocating or rotating machinery, elevators, cranes, pumps, and compressors shall have specific calculations addressing dynamic forces. Impact loads shall be as specified in ASCE 7 Sections 4.7 and 4.10 unless analysis indicates higher values are required.
Soil and Hydrostatic Loads	Below grade structures shall include lateral soil pressure, hydrostatic pressure or buoyancy, and potential surcharge loads from normal service or construction.

Table S300-1 Design Loads	
Wind Loads, buildings and structures	Basic design wind speed shall be in accordance with Table S300-3. No shielding shall be permitted for ground conditions or for adjacent structural members. Importance Factor, when required, shall be for structures supporting emergency services.
Wind Loads, concrete stacks	Loads and design in accordance with ACI 307.
Snow Load	Minimum ground snow load shall be in accordance with Table S300-3. Drift loads shall be applied to roof discontinuities and roof regions shielded by large roof-mounted equipment or machine penthouses.
Seismic Loads, buildings (by building, if appropriate)	Seismic loads for buildings shall be accordance with Table S300-3.
Seismic Loads, components and attachments	Seismic loads for components and attachments shall be accordance with Table S300-3. Amplification and response modification factors shall be in accordance with ASCE 7, Subsection 9.6.3.
Construction Loads, roads	AASHTO HS 20.
Construction Loads, railways	Cooper E80.

S300.3 Minimum Uniform Live Loads

Minimum uniform live loads shall be in accordance with Table S300-2.

Table S300-2 Live Loads	
Area	Live Load, psf
Ground Floor Slabs	
Shops, warehouses	350
Other structures	350
Suspended Floors	
Control Room	250
Storage Areas	250
Other Concrete Floors	250
Grating Floors	100
Roofs	30
Equipment Access Platform	50
Stairs	100

S300.4 Building Codes and Site Conditions

Minimum building codes and site conditions shall be in accordance with the applicable codes and Table S300-3.

Table S300-3 Building Codes and Site Conditions	
General Design Data:	
Building Code	IBC 2009
Occupancy Category	III
Site Elevation (Mean Sea Level), ft	440.0 - Sioux
Occupancy Classification	F1
Wind Design Data:	
Basic Wind Speed, V, Nominal 3 second gust wind speed at 33 ft above ground for Exposure C category, mph	90
Exposure Category	C
Topographic Factor, Kzt	1.0
Importance Factor (Wind Loads), I	1.15
Snow Design Data:	
Ground Snow Load, Pg, lb/ft2	20
Importance Factor (Snow Loads), I	1.1
Seismic Design Data:	
0.2 Second Spectral Response Acceleration, Ss (See Note 1)	0.4625 g - Sioux
1.0 Second Spectral Response Acceleration,S1 (See Note 1)	0.1452 g - Sioux
Site Class	D
Importance Factor (Seismic Loads), I	1.25

SECTION S500
BUILDING CODE REQUIRED SPECIAL INSPECTIONS AND TESTS FOR STRUCTURES AND STRUCTURAL COMPONENTS

This section includes administrative and procedural requirements for compliance with the International Building Code (IBC), Chapter 17, Structural Tests and Special Inspections.

The Owner will engage one or more qualified Special Inspectors and / or testing agencies to conduct structural tests and special inspections. The Special Inspectors and / or testing agencies shall not be in the employ of the Contractor.

Structural testing and special inspection services are required to verify compliance with requirements specified or indicated. These services do not relieve the Contractor of responsibility for compliance with other document requirements.

Specific quality-assurance and quality-control requirements for individual activities are specified in the sections that specify those activities. Requirements in those sections may also cover production of standard products.

Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and quality-control procedures that facilitate compliance with the other document requirements.

Requirements for the Contractor to provide quality-assurance and quality-control services required by the Owner, or Authority Having Jurisdiction are not limited by provisions of this section.

S500.1 Fabricators Approved to Perform Work Without Special Inspection
To be considered an Approved Fabricator that may perform work without Special Inspection under the provisions of IBC 1704.2.2, the Contractor shall submit copies of certifications from the International Accreditation Service (IAS) or other recognized and acceptable accreditation organization. Acceptance as an Approved Fabricator is subject to approval by the Authority Having Jurisdiction. If the Authority Having Jurisdiction does not accept the Contractor as an Approved Fabricator, Special Inspection shall be performed as required.

S500.2 Contractor's Responsibilities
The Contractor shall coordinate the inspection and testing services with the progress of the work. The Contractor shall provide sufficient notice to allow proper scheduling of all personnel. The Contractor shall provide safe access for performing inspection and onsite testing and shall ensure that all work requiring special inspection is inspected and/or tested prior to concealment.

The Contractor shall submit schedules to the Owner and testing and inspecting agencies. Schedules will note milestones and durations of time for materials requiring structural tests and special inspections.

The Contractor is responsible for providing the special inspector access to approved plans at the job site or fabrication shop as applicable.

The Contractor is responsible for retaining at the job site or fabrication shop as applicable, all special inspection records submitted by the Special Inspector and providing these records for review of the Authority Having Jurisdiction's inspector upon request.

Each Contractor shall submit the Contractor's Statement of Responsibility obtained from the Special Inspection agency to the Authority Having Jurisdiction and to the Owner prior to the commencement of work.

The Contractor shall repair and / or replace work that does not meet the requirements of the specification documents.

Contractor shall engage an engineer to prepare repair and / or replacement procedures. The Contractor's Engineer shall be registered in the state in which the project is located. The Contractor's Engineer shall be acceptable to the Authority Having Jurisdiction and Owner.

Procedures shall be submitted for review and acceptance by the Authority Having Jurisdiction and Owner before proceeding with corrective action.

The Contractor shall be responsible for costs of:

Re-testing and re-inspection of materials, work, and / or products that do not meet the requirements of the Contract Documents and shop drawings / submittal data.

Review of proposed repair and / or replacement procedures by the Owner and the inspectors and testing agencies.

Repair or replacement of work that does not meet the requirements of the Contract Documents.

S500.3 Precedence

The Special Inspector's reports and testing agencies results shall have precedence over reports and test results provided by the Contractor.

SECTION 01450
BUILDING CODE REQUIRED
SPECIAL INSPECTIONS AND TESTS

01450.1 General
This section includes administrative and procedural requirements required for compliance with the International Building Code (IBC), Chapter 17, Structural Tests and Special Inspections.

Structural testing and special inspection services are required to verify compliance with requirements specified or indicated. These services do not relieve the Contractor of responsibility for compliance with other construction document requirements.

Specific quality assurance and quality control requirements for individual construction activities are specified in the sections that specify those activities. Requirements in those sections may also include production of standard products.

Specified tests, inspections, and related actions do not limit Contractor's other quality assurance and quality control procedures that facilitate compliance with the construction document requirements.

Requirements for the Contractor to provide quality assurance and quality control services required by Owner or Authority Having Jurisdiction (AHJ) are not limited by provisions of this section.

01450.1.1 Scope of Work for Special Inspectors and Testing Agencies
The Owner will engage one or more qualified Special Inspectors and/or testing agencies to conduct structural tests and special inspections specified in this section and related sections and as may be specified in other divisions of these specifications. The Special Inspectors and/or testing agencies shall not be in the employ of the Contractor.

The EPC Contractor shall submit a statement / schedule of materials and work to be inspected along with application for building permit as required by building code.

01450.1.2 Definitions

Approved Agency: An established and recognized agency regularly engaged in conducting tests or furnishing inspection services, when such agency has been approved by the AHJ.

Approved Fabricator: An established and qualified person, firm or corporation registered and approved by the AHJ to perform work without Special Inspection.

Authority Having Jurisdiction (AHJ): The building official responsible for enforcing the building code.

Construction Documents: Written, graphic, and pictorial documents prepared or assembled for describing the design, location, and physical characteristics of the elements of a project necessary for obtaining a building permit. Construction documents include all supplemental instructions, sketches, addenda, and revisions to the drawings and specifications issued by the Registered Design Professional beyond those issued for a building permit.

Pre-engineered Structural Elements. Structural elements specified by the Registered Design Professional but which may be designed by a specialty Registered Design Professional. (Examples are items such as open web steel joists and joist girders; metal joists; pre-cast concrete elements; prefabricated metal buildings; tilt-up concrete panel reinforcement, and lifting hardware.)

Registered Design Professional: The individual Engineer of Record or Architect of Record in responsible charge of the design of elements within their specific discipline.

Shop Drawings/Submittal Data: Written, graphic, and pictorial documents prepared and/or assembled by the Contractor based on the Construction Documents.

Special Inspector: A qualified person who demonstrating competence, to the satisfaction of the AHJ and Registered Design Professional in responsible charge, for inspection of the particular type of construction or operation requiring special inspection. The Special Inspector shall be qualified as listed below.

Special Inspection, Continuous: The full time observation of work requiring special inspection by an approved Special Inspector who is present in the area where the work is being performed.

Special Inspection, Periodic: The part-time or intermittent observation of work requiring Special Inspection by an approved Special Inspector who is present in the area where the work has been or is being performed and at the completion of the work.

Structural Observation: Visual observation of the structural system by a representative of the Registered Design Professional for general conformance to the approved construction documents. Structural observations are not considered part of the structural tests and special inspections and do not replace inspections and testing by the testing agency or Special Inspector.

Testing Agency: A qualified materials testing laboratory under the responsible charge of a licensed professional engineer, approved by the AHJ and the Registered Design Professional, to measure, examine, test, calibrate, or otherwise determine the characteristics or performance of construction materials and verify confirmation with construction documents.

01450.1.3 Inspection and Testing Agency Qualifications

Special Inspectors shall not have a financial interest in projects for which they provide Special Inspection.

Minimum qualifications of inspection and testing agencies and their personnel shall comply with ASTM E329 Standard Specification for Agencies in the Testing and/or Inspection of Materials Used in Construction or IAS AC 291 Accreditation Criteria for IBC Special Inspection Agencies.

Inspectors and individuals performing tests shall be certified for the work being performed as listed below and in the appendix of ASTM E329. Certification by organizations other than those listed must be submitted to the AHJ for consideration before proceeding with work. In addition to these requirements, the local jurisdiction may have additional requirements. It is the responsibility of the testing and inspection agencies to meet local requirements and comply with local procedures.

Submit the attached Request for Approval of Special Inspector form for each proposed Special Inspector. The credentials of all Inspectors and testing technicians shall be provided. The qualifications of all personnel performing Special Inspection and testing activities are subject to the approval of the AHJ.

Table 01450-1 Abbreviations

Abbreviation used in this Section	Description
AIA	Architect licensed in the state of the project, specializing in the design of building structures
Licensed Engineers	
PE/SE	Structural Engineer (SE) or Professional Engineer (PE) licensed in the state of the project, specializing in the design of building structures
PE/GE	Geotechnical Engineer (GE) or Professional Engineer (PE) licensed in the state of the project, specializing in soil mechanics and foundations

Table 01450-1 Abbreviations	
Abbreviation used in this Section	**Description**
PE/EE	Electrical Engineer (EE) or Professional Engineer (PE) licensed in the state of the project, specializing in electrical systems
PE/ME	Mechanical Engineer (ME) or Professional Engineer (PE) licensed in the state of the project, specializing in mechanical systems
EI/EIT	Engineering Intern or Engineer-in-Training: a graduate engineer who has passed the Fundamentals of Engineering examination working under the direct supervision of a Professional Engineer licensed in the state of the project and with a minimum of one year of experience performing inspections
American Concrete Institute (ACI) Certification	
ACI-CFTT	Concrete Field Testing Technician - Grade 1
ACI-CCI	Concrete Construction Inspector
ACI-LTT	Laboratory Testing Technician - Grade 1 and 2
ACI-STT	Strength Testing Technician
American Welding Society (AWS) Certification	
AWS-CWI	Certified Welding Inspector
AWS/AISC-SSI	Certified Structural Steel Inspector
American Society of Nondestructive Testing (ASNT) Certification	
ASNT	Nondestructive Testing (NDT) Technician For Ultrasonic Testing (UT) and Radiographic Testing (RT) Certified as Level III through examination by ASNT or certified as Level II by their employer for flaw detection. For Magnetic Particle Testing (MT) and Liquid Penetrant Testing (PT) certified as Level II by their employer or certified as Level III through examination by ASNT and certified by their employer
International Code Council (ICC) Certification	
ICC-SMSI	Structural Masonry Special Inspector
ICC-SWSI	Structural Steel and Welding Special Inspector
ICC-SFSI	Spray-Applied Fireproofing Special Inspector
ICC-RCSI	Reinforced Concrete Special Inspector
ICC-SBSI	Structural Steel and Bolting Special Inspector
ICC-WSI	Structural Welding Special Inspector

Table 01450-1 Abbreviations	
Abbreviation used in this Section	**Description**
National Concrete Masonry Association	
NCMA	Concrete Masonry Testing Technician
National Institute for Certification in Engineering Technologies (NICET)	
NICET-CT	Concrete Technician - Levels II, III & IV
NICET-ST	Soils Technician - Levels II, III & IV
NICET-GET	Geotechnical Engineering Technician - Levels II, III & IV

Table 01450-2 Qualification Standards	
Inspection or Testing Item	**Qualification Standards**
Fabricators	Varies by product as listed below
Steel Construction - Welding Inspection	ICC-SWSI, ICC-WSI, AWS-CWI or AWS/AISC-SSI
Steel Construction - Nondestructive Weld Testing	ASNT
Steel Construction - Details	PE/SE, ICC-SWSI, ICC-SBSI or AWS/AISC-SSI
Steel Construction - High Strength Bolts	PE/SE or ICC-SBSI
Concrete Construction - Field Tests	ACI-CFTT or NICET-CT
Concrete Construction - Field Inspection	PE/SE, ICC-RCSI, ACI-CCI or NICET-CT
Concrete Construction - Laboratory Testing	ACI-LTT, ACI-STT or NICET-CT
Masonry Construction - Field Inspection	PE/SE or ICC-SMSI
Masonry Construction - Laboratory Testing	NCMA
Soils (special grading, excavation and filling)	PE/GE, NICET-ST or NICET-GET under the direct supervision of Registered Civil (geotechnical) Engineer
Pile Foundations	PE/GE, Appropriate structural material inspection and NICET-ST or NICET-GET under the direct supervision of Registered Civil (geotechnical) Engineer
Wall Panels and Veneers	ICC-SMSI
Sprayed Fire-Resistant Materials	ICC-SFSI
Post Installed Anchors in Concrete	ICC Building Inspector, ICC-RCSI, or PE/SE
Post Installed Anchors in Masonry	ICC Building Inspector, ICC-SMSI, or PE/SE
Smoke Control Systems	Refer to IBC 1704.16.2
Other Architectural Systems	ICC Building Inspector, AIA, or PE/SE
Mechanical Systems	ICC Building Inspector or PE/ME
Electrical Systems	Refer to NFPA 70

01450.1.3.1 Structural Steel Testing Agency Requirements. The following should be submitted to the Registered Design Professional and the AHJ prior to beginning testing:

Written practices for monitoring and control of the inspection and testing agency operations including the following:

Inspection and testing agency's procedures for the selection and administration of inspection personnel, describing the training, experience, and examination requirements for qualification and certification of inspection personnel.

Inspection and testing agency's inspection procedures, including general inspection, material controls, and visual welding inspection.

Qualifications of management and quality assurance personnel designated for the project.

Qualification records for inspectors and NDT technicians designated for the project.

NDT procedures and equipment calibration records for NDT to be performed and equipment to be used for the project.

01450.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 01450-3 Codes and Standards

Work	**In Accordance With**
Building Code	2009 International Building Code (IBC)
Seismic Criteria for Nonstructural Components	ASCE 7-05
Standard Tests and Practices	Listed American Society for Testing and Materials (ASTM) specifications
Concrete	ACI 318-08
Masonry	ACI 530-08 and ACI 530.1-08
Structural Steel	AISC Steel Construction Manual, Thirteenth Edition
Structural steel welding	AWS D1.1 Structural Welding Code - Steel
Aluminum welding	AWS D1.2 Structural Welding Code - Aluminum
Sheet steel welding	AWS D1.3 Structural Welding Code - Sheet Steel

Table 01450-3 Codes and Standards	
Work	**In Accordance With**
Structural steel bolting	Research Council on Structural Connections Specification for Structural Joints Using ASTM A325 or A490 Bolts, June 30, 2004
Intumescent Fire-Resistive Coating	Association of the Wall and Ceiling Industry (AWCI) Technical Manual 12-B, Second Edition; Standard Practice for the Testing and Inspection of Field Applied Thin Film Intumescent Fire-Resistive Materials; an Annotated Guide

01450.1.5 Conflicting Requirements, Reports, and Test Results

01450.1.5.1 General. If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to the Registered Design Professional for a decision before proceeding.

01450.1.5.2 Minimum Quantity or Quality Levels. The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to the Registered Design Professional for a decision before proceeding.

01450.1.5.3 Precedence. The Special Inspector's reports and testing agencies results shall have precedence over reports and test results provided by the Contractor.

01450.1.5.4 Conflicts. Where a conflict exists between the construction documents and approved shop drawings/submittal data, the construction documents shall govern unless the shop drawings/submittal data are more restrictive. All conflicts shall be brought to the attention of the Registered Design Professional.

01450.1.6 Technical Attachments
Included as part of this section of the specifications are the following forms and schedules:

Statement of Special Inspections.

Schedule of Special Inspections.

Request for Approval of Special Inspector.

Request for Approval to Provide Special Inspection of Non-Local Fabrication.

Contractor's Statement of Responsibility.

Fabricator's Certificate of Compliance.

Final Report of Special Inspections.

SECTION 02220
EARTHWORK

02220.1 General

02220.1.1 Scope of Work
Scope of Work shall include completing earthwork and shall include other services as specified under these technical specifications.

02220.1.2 Not Used

02220.1.3 Performance and Design Requirements
Performance and design requirements for earthwork are indicated in Article 02220.3.

02220.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 02220-1 Codes and Standards

Work	In Accordance With
Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)	ASTM D2487
Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)	ASTM D2488
Material Specification	ASTM C33 or Missouri Standard Specifications for Highway Construction
Excavations	OSHA

02220.1.5 Materials
Refer to Table 02220-3, included at the end of this section.

02220.1.6 Not Used

02220.1.7 Test Requirements
The following testing shall be conducted in accordance with the specified source. Material, compaction, and testing requirements are found in Table 02220-3.

This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Contractor unless specifically identified as Owner-conducted. If identified as Owner-conducted, costs for the initial test will be the responsibility of the Owner. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure.

Table 02220-2 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Standard Test Method for Particle Size Analysis of Soils	ASTM D422	Contractor
Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3)	ASTM D698 (Standard Proctor)	Contractor
Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method	ASTM D1556	Contractor
Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)	ASTM D1557 (Modified Proctor)	Contractor
Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method	ASTM D2167	Contractor
Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table	ASTM D4253	Contractor
Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density	ASTM D4254	Contractor
Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D4318	Contractor
Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)	ASTM D6938	Contractor

02220.2 Not Used

02220.3 Execution

02220.3.1 General

This article covers general earthwork; removal and disposal of debris; excavation; the handling, storage, transportation, and disposal of excavated material; sheeting, shoring, and protection work; preparation of sub-grades; dewatering; protection of adjacent construction; backfill; construction of fills and embankments; surfacing and grading; and other appurtenant work.

Before starting any excavation work onsite, the Contractor shall contact Infrared Diagnostics, Inc. (1-636-519-9808) or Dig Rite (1-800-344-7483) to locate interferences. A vacuum excavation contractor shall be used to remove soil in the area of interferences and utilities.

The Below Grade Excavation Checklist form, included at the end of this section, shall be completed for all excavations and provided to the Owner.

02220.3.2 Sheeting and Shoring
The stability of previously constructed structures and facilities shall not be impaired or endangered by excavation work. Previously constructed structures and facilities include both structures and facilities existing when this construction began and structures and facilities already provided under these specifications.

Adequate sheeting and shoring shall be provided to protect and maintain the stability of previously constructed structures and facilities and the sides of excavations until they are backfilled. Sheeting, bracing, and shoring shall be designed and built to withstand all loads and restrain all settlement caused by earth movement or pressure and shall maintain the shape of the excavation.

02220.3.3 Removal of Water
Adequate dewatering equipment shall be provided to remove and dispose of all surface and ground water entering excavations and other parts of the work. Each excavation shall be kept dry. Control of ground water shall be accomplished in a manner that will preserve the strength of the foundation soils, will not cause instability of the excavation slopes, and will not result in damage to existing structures. Where necessary to these purposes, the water level shall be lowered in advance of excavation, utilizing wells, well points, or similar methods. The water level (measured in piezometers) shall be maintained continuously about 1 foot below the prevailing excavation level, or it shall be lowered to within about 1 foot of impermeable strata. Open pumping with sumps and ditches, if it results in boils, loss of fines, softening of the ground, or instability of slopes, will not be permitted. Wells and well points shall be installed with suitable screens and filters so that continuous pumping of fines does not occur. Dewatering shall continue until the construction is no longer affected by ground or surface water. The dewatering system shall only pump water that is clear and free of fines, with a sand content less than 10 ppm. The discharge shall be arranged so that samples can be collected. The turbidity of discharge samples shall be less than 50 NTU.

Surface water shall be diverted to the extent possible to prevent entrance into excavations.

Pipe or conduit used for drainage purposes shall be kept clean and free of sediment. Temporary drainage piping that is not a part of the permanent construction shall be removed at the completion of the work.

When the work is completed, all parts of the permanent plant drainage system used for water disposal that have been damaged by dewatering operations shall be repaired. Dewatering work shall not overload the plant drainage system. Dewatering discharge shall be in a manner and location designated by the Owner.

Header systems may be laid on top of the ground provided they do not obstruct plant operations, construction activity, or traffic. Groundwater systems shall operate continuously, if necessary, to maintain the specified water level.

Proposed dewatering systems shall be submitted to the Owner for review.

02220.3.4 Blasting
Blasting or other use of explosives for excavation will not be permitted.

02220.3.5 Classification of Excavated Materials
No classification of excavated materials will be made. Excavation work shall include the removal and handling of excavated materials regardless of the type, character, composition, or condition. If contaminated soil is uncovered during excavation the Owner shall be notified immediately.

02220.3.6 Freezing Weather Restrictions
Backfill and fill shall not be placed during freezing weather unless acceptable to the Owner. Earth material shall not be placed on frozen surfaces, and frozen materials, snow, or ice shall not be placed in any fill or backfill.

02220.3.7 Preservation of Trees
Trees shall be preserved and protected as much as possible. Unless specifically authorized by the Owner, trees shall be removed only from areas within the construction limits. Removal of additional trees may be permitted by the Owner when necessary for the effective execution of the work.

Trees left standing shall be protected from permanent damage. Construction equipment and vehicles shall be parked outside the dripline of trees designated to remain. Trimming of standing trees shall be as directed by the Owner.

02220.3.8 Maintenance of Traffic
The Contractor shall conduct his work with as little interference as possible with the work of other suppliers. Whenever it is necessary to cross, obstruct, or close roads, driveways, parking areas, and walks, the Contractor shall provide and maintain suitable and safe bridges, detours, or other temporary expedients at his own expense.

02220.3.9 Unauthorized Excavation
Material excavated below the bottom of concrete structures to be supported on the sub-grade shall be replaced with concrete placed monolithically with the concrete above. Rock fill or lean concrete may be used, if acceptable to the Owner. Material excavated below structures supported on piles or piers shall be replaced with crushed rock or gravel. The crushed rock or gravel shall be compacted to a density equal to or greater than the density of the adjacent undisturbed soil. The dimensions of the unauthorized excavation should be documented. Unauthorized excavation shall be reported to the Owner immediately.

02220.3.10 Testing
Laboratory testing shall be performed by an independent testing laboratory acceptable to the Owner. Field sampling and testing shall be performed by NICET Level II Construction Materials Testing technicians or a NICET Level II Construction Materials Testing technician employed by an independent testing company.

Field samples shall be taken at locations selected by the Owner. If, in the opinion of the Owner, additional field control tests are necessary, such tests shall be made. Field density tests shall be taken so as to represent the average density over the depth of the layer.

The terms "maximum density" and "optimum moisture content" shall be as defined in ASTM D698 or ASTM D1557.

Relative density for compacted crushed rock materials shall be determined in accordance with ASTM D4253 and D4254. The term "relative density" shall be as defined in ASTM D4254.

A copy of each test result shall be furnished to the Owner on the day the test is performed. Testing requirements are provided in Table 02220-3.

02220.3.11 Site Preparation
Sub-grades for permanent construction, including sub-grades for fills and embankments, shall be stripped of surface vegetation, sod, debris, and organic topsoil. Surface vegetation shall be removed complete with roots to a depth of approximately 4 inches below the ground surface.

All combustible and other waste materials shall be removed from the construction areas. Disposal shall be as specified in Section 02231. Open burning is not permitted at the site.

Organic topsoil that is free of trash, vegetation, rocks, and roots shall be stockpiled for later use by the Owner.

02220.3.12 Roadway Roadbeds
Roadway roadbed construction shall include excavation, sub-grade preparation, and construction of fills and embankments. In excavated roadbed areas, overburden shall be removed and the sub-grade shaped to line, grade, and cross section. Soft, organic, and other unacceptable material shall be removed from the sub-grade and replaced. The replacement material shall meet the requirements of Article 02220.3.16 - Structural Fill.

The sub-grade shall be compacted in accordance with Table 02220-3 and finished to a uniform surface to allow for proper drainage. The sub-grade shall be finished to within 0.1 foot of the elevation indicated on the Contractor's design drawings.

Ditches and drains along the sub-grade shall be maintained for effective drainage. When ruts of 2 inches or more in depth are formed, the sub-grade shall be reshaped and recompacted.

Materials shall not be stored or stockpiled on sub-grades.

02220.3.13 Fills and Embankments
Fills and embankments shall be constructed to lines and grades indicated on the Contractor's design drawings.

02220.3.13.1 Materials. To the maximum extent available, earth materials obtained from excavation shall be used for the construction of fills and embankments. Additional material shall be obtained from borrow areas.

Fill and embankment material shall be earth only and shall be free from brush, stumps, logs, roots, debris, and organic or other deleterious materials. Fill and embankment material obtained from offsite sources shall be free of contamination. The fill/embankment material supplier shall provide documentation that the material is free of contamination.

02220.3.13.2 Sub-grade Preparation. The sub-grade shall be scarified and rolled to provide for bonding of overlying lifts. The sub-grade surface shall be well bonded to the previous layers of fill. Sub-grade preparation shall be witnessed and approved by a qualified soil technician and construction management. Areas identified as soft or excessively disturbed shall be removed and replaced with soil compacted as described for General Fills and Embankments in Table 02220-3. Sub-grade shall be sealed with a smooth drum roller when inclement weather is expected, then scarified prior to adding overlying lifts. Standing water shall not be permitted. Areas that have been exposed to heavy rain or standing water shall be allowed to dry to within 2 percent of optimum water content prior to adding overlying lifts.

After the sub-grade has been prepared, it shall be proofrolled under the observation of a geotechnical engineer or qualified construction technician to verify acceptance. Proof rolling shall be completed using a fully loaded tandem dump truck or similarly heavy equipment. Soft areas shall be removed and replaced as detailed above. Proofrolling shall be completed prior to placing any fill.

02220.3.13.3 Placement and Compaction. Fill and embankment materials shall be placed in approximately horizontal layers. Material deposited in piles or windrows shall be spread and leveled before compaction.

Water shall be added to meet the moisture content required in Table 02220-3 and worked into each layer using harrow, disk, blade, or other acceptable equipment to provide a uniform moisture content. If the material fails to meet the specified density in Table 02220-3, compaction methods shall be altered.

02220.3.13.4 Borrow Areas. Material necessary to complete fills and embankments shall be excavated from borrow areas and hauled to the fill or embankment site. Borrow material will not be available on the Owner's property and shall be furnished from an acceptable source.

02220.3.14 Structure Excavation
Excavation for structures shall be completed to the designated lines and elevations. Machine excavation shall be controlled to prevent undercutting the sub-grade elevations indicated on the Contractor's design drawings.

Excavated materials that meet the specified requirements may be used for the fills, embankments, and backfills.

Vertical faces of excavations shall not be undercut to provide for extended footings. Excavations should be performed in accordance with OSHA recommendations.

02220.3.15 Structure Sub-grades
Sub-grades for structures shall be firm, dense, free from mud, thoroughly compacted to the specified density in Table 02220-3, and sufficiently stable to remain firm and intact. Sub-grades should be checked for acceptance by a Geotechnical Engineer prior to rebar placement in the foundation excavation.

Structure sub-grades that that are considered unacceptable by the Geotechnical Engineer shall be over-excavated and replaced with structural fill. The dimensions of the overexcavation shall be documented.

A lean concrete mudmat with a minimum thickness of 4 inches shall be placed in all structure excavations.

Sub-grades that are otherwise solid, but become mucky on top due to construction operations, shall be stabilized. The top layer of muck should be removed and replaced with compacted structural fill or lean concrete.

The finished elevation of stabilized structure sub-grades shall not be above the sub-grade elevations indicated on the Contractor's design drawings.

02220.3.16 Structural Fill
Structural fill is fill placed beneath structures. Structural fill shall consist of materials compacted to the required density as provided in Table 02220-3.

Particular care shall be taken to compact structural fill beneath pipes, drives, roads, or other surface construction. When a trench passes through structural fill, the fill shall be placed and compacted to at least 12 inches above the top of the pipe elevation before the trench is excavated.

02220.3.17 Structural Backfill
Backfill around and outside of structures shall be deposited in approximately horizontal layers. Backfill shall be mechanically compacted in accordance with Table 02220-3. Compaction of structure backfill by rolling will be permitted provided the desired compaction is obtained and damage to the structure is prevented. Compaction of structure backfill by inundation with water will not be permitted.

Backfill material shall be composed of earth only and, to the extent possible, shall be void of wood, grass, roots, broken concrete, stones, trash, or other debris.

No tamped, rolled, or otherwise mechanically compacted backfill shall be deposited or compacted in water.

All backfill material shall consist of loose earth having a moisture content as required in Table 02220-2 to obtain the specified density of the compacted soil. Moisture content shall be distributed uniformly. Water added for correction of moisture content shall be distributed uniformly prior to compaction.

02220.3.18 Compacted Rock Fill
Compacted rock fill shall consist of crushed rock. Compaction shall be performed with vibrating mechanical compactors. Crushed concrete meeting gradation and requirements may be used with Owner's approval.

Crushed rock for compacted fill shall be handled and placed in a manner that will prevent segregation of sizes. The fill material shall have the moisture content specified in Table 02220-3 to achieve compaction required in Table 02220-3.

02220.3.19 Compacted Sand Fill
Compacted sand fill material shall consist of clean, natural sand.

Sand fills shall be placed on undisturbed or compacted sub-grade. Sand shall be compacted using mechanical vibrators. Compaction and moisture content shall be in accordance with Table 02220-3.

02220.3.20 Not Used

02220.3.21 Not Used

02220.3.22 Maintenance and Restoration of Fills, Embankments, and Backfills
Fills, embankments, and backfills that settle or erode before final acceptance of the work, and pavement, structures, and other facilities damaged by such settlement or erosion, shall be repaired. The settled or eroded areas shall be filled, compacted, and graded to conform to the elevation indicated on the Contractor's design drawings or to the elevation of the adjacent ground surface. Damaged facilities shall be repaired in a manner acceptable to the Owner.

Earth slopes of the roads constructed under these specifications shall be maintained to the lines and grades indicated on the Contractor's design drawings until the final acceptance of the work.

02220.3.23 Final Grading
After all construction work has been completed, all ground surface areas disturbed by construction activities shall be graded. The grading shall be finished to the contours and elevations indicated on the Contractor's design drawings or, if not indicated, to the matching contours and elevations of the original, undisturbed ground surface. The final grading shall provide smooth uniform surfaces and effective drainage of the ground areas.

02220.3.24 Disposal of Materials
Surplus earth and materials not suitable for the work shall be spoiled on the site in a manner and location designated by the Owner. Material not suitable for work shall be spoiled separately from surplus material. Stockpiles of surplus material shall be free from brush, trees, debris, or other organic or deleterious materials. Offsite disposal may be used, if allowed by the Owner. Disposal shall be in accordance with all federal, state, and local governing requirements.

BELOW GRADE EXCAVATION CHECKLIST

Project No.: _____ Project Title: _____

Location of Excavation (attach sketch if necessary)

_____

Date Completed	
_____	Project Analyzed for Need to Excavate
_____	Project Review for Boundary of Excavation
_____	Project Review for Underground Utilities with Plant Drawings
_____	Mark Surface Area of Dig, Indicating Location of Known Interferences
_____	Call Infrared Diagnostics, Inc. or Dig Rite, if Needed
_____	Arrange for Vacuum Contractor to Remove Soil
_____	Review Project with Excavator

_____
Project Manager/Supervisor

_____
Supervising Engineer

_____
Superintendent of Technical Support

Table 02220-3
Materials, Compaction, and Testing Requirements

Material	Plasticity Require-ments	Gradation Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Field Density Test Frequency	Required Field Water Content	Field Water Content Test	Required Lift Thickness	Remarks
Roadway roadbed	-	-	ASTM D698	3 initial tests; further tests as directed	95% max. dry density	ASTM D6938;	One test per 500 sy, or as required	-2% to +2% of optimum water content	ASTM D6938	8 in. loose depth	-
General Fills and embank-ments	-	Well-graded material with 6 inch max; 3 inch max in upper 18 inches	ASTM D1557, Method C or D698	3 initial tests, further tests as directed	92% max. dry density; 95% of D698	ASTM D6938)	One test per 500 cy, or 2 tests per lift, whichever is greater	-2% to +2% of optimum water content	ASTM D6938; ASTM D1556	8 in. thick lift prior to compact-ion (loose lift)	Top 1 inch of each lift shall be scarified to promote bonding between lifts. (unless compacted with sheepsfoot)

Table 02220-3
Materials, Compaction, and Testing Requirements

Material	Plasticity Require-ments	Gradation Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Field Density Test Frequency	Required Field Water Content	Field Water Content Test	Required Lift Thickness	Remarks
Structure sub-grade	-	-	ASTM D1557, Method C	1 initial test; further tests as directed	95% max. dry density	ASTM D6938;	One test per 1,000 sy, or as required. Min one per foundation for foundations over 10 sy	-2% to +2% of optimum water content	ASTM D6938; (10% of tests to be ASTM D1556)	8 in. depth	-
Structural fill (fills beneath structures)	Nonplastic	3 inch maximum; ≤5 percent minus No. 200, well graded	ASTM D1557, Method C	3 initial tests, further tests as directed	95% max. dry density	ASTM D6938;	One test per 200 cy, or as required	-2% to +2% of optimum water content	ASTM D6938; (10% of tests to be ASTM D1556)	8 in. thick lift prior to compact-ion (loose lift)	-

Table 02220-3
Materials, Compaction, and Testing Requirements

Material	Plasticity Require-ments	Gradation Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Field Density Test Frequency	Required Field Water Content	Field Water Content Test	Required Lift Thickness	Remarks
Structure backfill (fills adjacent to founda-tion)	Structure backfill placed against below grade walls shall be non-swelling material with a liquid limit (LL) less than 40 and a PI less than 15.	3 inch max ≤15 percent minus No. 200	ASTM D1557, Method C	3 initial tests; further tests as directed	95% max. dry density	ASTM D6938;	One test per 200 cy, or as required	-2% to +2% of optimum water content	ASTM D6938; (10% of tests to be ASTM D1556)	8 in. thick lift prior to compact-ion (loose lift) when using self propelled equip-ment. 6-in. thick lift when using walk behind equip-ment.	Compact-ion by inundation with water will not be permitted.
Compacted rock fill	Nonplastic	1-1/2 in. max. to crusher fines	ASTM D4253 and D4254	3 initial tests; further tests as directed	70% relative density	ASTM D6938; (10% of tests to be ASTM D1556)	One test per 200 cy, or 2 tests per lift, whichever is greater	As required to achieve field density	ASTM D6938; (10% of tests to be ASTM D1556)	8 in. thick lift prior to compact-ion (loose lift)	-

Table 02220-3
Materials, Compaction, and Testing Requirements

Material	Plasticity Require-ments	Gradation Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Field Density Test Frequency	Required Field Water Content	Field Water Content Test	Required Lift Thickness	Remarks
Compacted sand fill	Nonplastic	≥75% minus No. 4; ≤10% minus No. 200	ASTM D1557, Method C	3 initial tests; further tests as directed	90% max. dry density	ASTM D6938; (10% of tests to be ASTM D1556)	One test per 200 cy, or as required	0% to +4% of optimum water content	ASTM D6938; (10% of tests to be ASTM D1556)	8 in. thick lift prior to compact-ion (loose lift)	-
Surplus earth and materials not suitable for the work	-	-			Compac-tion shall be by not less than three passes of a bulldozer					Spread uniformly in approxi-mately 12 in. thick lift prior to compact-ion (loose lift)	Spoil in a manner and location designated by Owner. Disposal shall be in accordance with all federal, state, and local require-ments pertaining to construc-tion landfills.

Table 02220-3
Materials, Compaction, and Testing Requirements

Material	Plasticity Require-ments	Gradation Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Field Density Test Frequency	Required Field Water Content	Field Water Content Test	Required Lift Thickness	Remarks
Sand drainage fill	Nonplastic	Uniformly graded from No. 4 to No. 100 sieve	ASTM D4253 and D4254	3 initial tests; further tests as directed	65% relative density	ASTM D6938	One test per 500 cy, or as required	As required to achieve field density	ASTM D6938	4 in. compacted	Clean concrete sand
Drainage filter material	Nonplastic	Uniformly graded from 1-1/2 inch to No. 4	ASTM D4253 and D4254	1 initial test; further tests as directed	65% relative density	ASTM D6938	One test per 500 sy, or as required	As required to achieve field density	ASTM D6938	4 in. compacted	Washed rock or crushed gravel

ASTM D698 = Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3).

ASTM D1556 = Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
ASTM D1557 = Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft³).
ASTM D4253 = Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
ASTM D4254 = Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
ASTM D6938 = Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

SECTION 02315
TRENCHING

02315.1 General

02315.1.1 Scope of Work
Scope of Work shall include completing trenching and shall include other services as specified under these technical specifications.

02315.1.2 Not Used

02315.1.3 Performance and Design Requirements
Performance and design requirements for trenching are indicated in Article 02315.3.

02315.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 02315-1 Codes and Standards

Work	In Accordance With
Standard Specification for Aggregates or "Standard Specifications for Highway Construction"	ASTM C33 or Missouri Department of Transportation MoDOT
Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)	ASTM D2487
Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)	ASTM D2488
Excavations	OSHA

02315.1.5 Materials
The following materials shall be used:

Table 02315-2 Materials

General	
Component	**Material**
Refer to Table 02315-4, included at the end of this section	

02315.1.6 Not Used

02315.1.7 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 Subcontractor unless specifically identified as Owner-conducted. If identified as Owner-conducted, costs for the initial test will be the responsibility of the Owner. However, the Subcontractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 02315-3 Test Requirements

Tests	In Accordance With	Conducted By
Refer to Table 02315-4, included at the end of this section		
Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3)	ASTM D698 (Standard Proctor)	Contractor
Standard Test Methods for Laboratory Compaction characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)	ASTM D1557 (Modified Proctor)	Contractor
Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table	ASTM D4253	Contractor
Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density	ASTM D4254	Contractor
Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method	ASTM D1556	Contractor
Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)	ASTM D6938	Contractor
Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method	ASTM D2167	Contractor
Standard Test Method for Particle Size Analysis of Soils	ASTM D422	Contractor
Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D4318	Contractor

Table 02315-3 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders	ASTM D4832	Contractor

02315.2 Not Used

02315.3 Execution

02315.3.1 General
This article covers general trenching and includes preparation of the construction areas; removal and disposal of debris; trenching; the handling, storage, transportation, and disposal of excavated material; sheeting, shoring, and protection work; preparation of subgrades; dewatering; protection of adjacent construction; backfill; pipe embedment; construction of pipe bedding and trench backfill; surfacing and grading; and other appurtenant work.

All excavations, sheeting, shoring, and temporary excavation support shall be performed in accordance with OSHA 29 CFR Part 1926 Subpart P, "Excavations."

Before starting any excavation work onsite, the Contractor shall contact Infrared Diagnostics, Inc. (1-636-519-9808) or Dig Rite (1-800-344-7483) to locate interferences. A vacuum excavation contractor shall be used to remove soil in the area of interferences and utilities.

The Below Grade Excavation Checklist form, included at the end of Section 02220, shall be completed for all excavations and provided to the Owner.

02315.3.2 Sheeting and Shoring
Refer to Article 02220.3.2.

02315.3.3 Removal of Water
Refer to Article 02220.3.3.

02315.3.4 Blasting
Blasting or other use of explosives for excavation will not be permitted.

02315.3.5 Classification of Excavated Materials
Refer to Article 02220.3.5.

02315.3.6 Freezing Weather Restrictions
Refer to Article 02220.3.6.

02315.3.7 Preservation of Trees
Refer to Article 02220.3.7.

02315.3.8 Maintenance of Traffic
Refer to Article 02220.3.8.

02315.3.9 Unauthorized Excavation
Refer to Article 02220.3.9.

02315.3.10 Testing
Refer to Article 02220.3.10.

02315.3.11 Trench Subgrades
Subgrades that are otherwise solid, but become mucky on top due to construction operations, shall be stabilized by reinforcing them with one or more layers of crushed rock or gravel.

Not more than 1/2 inch depth of mud or muck shall be allowed to remain on stabilized trench bottoms when pipe embedment material is placed.

02315.3.12 Pipe Trench Excavation
No more trench shall be opened in advance of pipe laying than is necessary to expedite the work.

Trench excavation shall be open cut from the surface except where boring is required.

02315.3.12.1 Alignment and Grade. The alignment and grade or elevation of each pipeline shall be fixed and determined by means of batter boards and offset stakes, laser beam equipment, or surveying instruments, unless otherwise accepted.

02315.3.12.2 Limiting Trench Widths. Trench widths shall provide adequate working space and pipe clearance during installation. Trench width shall be kept to a minimum to allow installation and compaction around the piping.

Where necessary to reduce earth load on trench banks to prevent sliding and caving, banks may be cut back on slopes that shall not extend lower than 1 foot above the top of the pipe.

For single pipes, the maximum trench width measured at the bottom of the pipe shall be the pipe outside diameter plus 24 inches for pipes 48 inches outside diameter and smaller. For single pipes larger than 48 inches outside diameter, the maximum width measured at the bottom of the pipe shall be the pipe outside diameter plus 48 inches.

For multiple pipes in a common trench, the maximum trench width shall be based on the outside diameter of the outside pipes. The maximum clear distance between the trench wall and the adjacent pipe shall be 24 inches for 48 inch and smaller pipes and shall be 48 inches for pipes larger than 48 inches.

02315.3.12.3 Unauthorized Trench Widths. If the width of the lower portion of the excavated trench exceeds the maximum specified, corrective measures shall be taken. These may include the use of a stronger pipe, special pipe embedment, or concrete encasement, as required by the loading conditions. The corrective measures shall be submitted to the Owner for engineering review.

02315.3.12.4 Mechanical Excavation. Mechanical equipment shall not be used in locations where operation would cause damage to trees, buildings, culverts, or other existing property, utilities, or structures above or below ground. Hand excavating methods shall be used in these locations.

02315.3.12.5 Trench Depth. Pipe trenches shall be excavated to the depth required for the installation of embedment material or concrete for encasement below the underside of the pipe.

02315.3.12.6 Bell Holes. Bell holes shall provide adequate clearance for tools and methods used to install the pipe. No part of any bell or coupling shall be in contact with the trench bottom, walls, or embedment when the pipe is jointed.

02315.3.13 Pipe Embedment
Embedment materials and placement shall conform to the requirements of these specifications and to Drawing 81112-DS-0053 included as an attachment to this specification.

02315.3.13.1 Embedment Classes. Pipe embedment classes shall be as indicated on the Drawing 81112-DS-0053 and the following requirements:

Class A bedding shall be used with the following piping materials:

Pressure lines without cathodic protection coating.

Pipe with joints that can open and admit embedment material into the pipe.

Class B bedding shall be used with the following piping materials:

Pressure lines without cathodic protection coating. Pipe with cathodic protection coating.

Class C bedding shall be used with the following piping materials:

All not included in Class A or Class B.

02315.3.13.2 Placement and Compaction. Embedment material shall be spread on the trench bottom and the surface graded to provide a uniform and continuous support beneath the pipe at all points between bell holes or pipe joints. The material shall be compacted with vibrating platform type compactors. Compactive effort and moisture content shall be adjusted to provide a firm but slightly yielding support for the pipe.

After each pipe has been placed in final position on the bedding material and shoved home, sufficient pipe embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

Embedment material shall be deposited and compacted uniformly and simultaneously on sides of the pipe to prevent lateral displacement. Each layer shall be uniformly compacted.

Vibrating compactors shall be used to compact sand, crushed rock, and crushed gravel. Pipe coatings shall not be damaged during placement and compaction. Jetting is not allowed.

02315.3.14 Trench Backfill
Trench backfill above the pipe embedment shall be compacted for the full depth of the trench above the embedment.

The top portion of backfill beneath established lawn areas shall be finished with at least 6 inches of topsoil similar to the topsoil in adjoining lawn areas.

Compacted backfill material shall be either job excavated material or material furnished by the Contractor from offsite sources. The method of compaction and the equipment used shall be appropriate for the material being compacted and shall not transmit damaging shocks to the pipe. Backfill material obtained from offsite sources shall be free of contamination. Inorganics must be within normal background levels for the site area. The backfill material supplier shall provide documentation that the material is free of contamination.

02315.3.15 Duct Bank Trenching
Trenches for duct banks shall be excavated to lines indicated on the Contractor's design drawings or at other locations acceptable to the Owner and to within 1/2 inch of the depth required. Trenches shall be excavated to permit the duct bank to rest on undisturbed earth or rock. Where it is necessary to trench through backfill, the earth shall be well compacted before the duct bank is installed.

Trenches shall be wide enough to provide ample room for workmen engaged in handling and installing the ducts. Where it is necessary to reduce the earth load on trench banks to prevent sliding or caving, trench banks may be cut back on slopes.

02315.3.16 Pavement Removal and Replacement
Cuts in concrete and asphalt pavement shall be no larger than necessary to provide adequate working space for proper installation of pipe ducts structures and appurtenances. Cutting shall be started with a concrete saw and shall provide a clean groove at least 1-1/2 inches deep along each side of the trench.

Concrete and asphalt pavement shall be removed over trenches excavated for pipelines so that a shoulder not less than 6 inches in width is left between the cut edge of the pavement and the top edge of the trench. Trench width at the bottom shall not be greater than at the top. Trenches shall not be undercut. Pavement cuts shall be straight or accurately marked curved lines parallel to the centerline of the trench.

If the trench parallels the length of concrete walks and is all or partially under the walk, the entire walk shall be removed and replaced. Where the trench crosses drives, walks, curbs, or other surface construction, the surface shall be removed and replaced between existing joints or saw cuts.

Surfaces shall be replaced over backfilled trenches crossing surfaced areas. Replacement surfacing shall match the existing surfacing and be finished flush with the adjoining surfaces. Base material for surfacing shall match the thickness and density of the material excavated.

02315.3.17 Pipe Casing Under Roadways and Railroads
Where traffic must be maintained on roadways and railroads, pipelines and duct banks may be installed in a casing bored under the roadway or railroad. The depth of the bored casing below railroads must comply with AREMA guidelines.

Complete details of the proposed methods, materials, and time schedule shall be submitted to the Owner. Work shall not begin on the crossing until written notification to proceed has been obtained from the Owner.

Casing pipe shall be new smooth wall pipe of welded steel construction with a minimum yield point of 35,000 psi. The casing pipe shall be cleaned and coated both inside and outside with two coats of coal tar paint. Paint shall be Kop-Coat "Bitumastic Super Service Black" as manufactured by Sherwin Williams or 46-465 H.B. Tnemecol as manufactured by Tnemec.

Joints in the casings shall be welded. Pipe ends shall be machine cut and beveled at an angle of 37-1/2 degrees. The beveled ends shall be butted and aligned axially and welded to provide a full strength joint capable of resisting all stresses, including jacking stresses.

The casing pipe shall be installed using jacking equipment. The hole shall be encased as the earth is removed from the interior of the casing. Excavation without the concurrent installation of the casing pipe is unacceptable. The installation of the casing shall not disrupt traffic nor damage the railroad or road grade and shall provide accurate alignment and grade of the pipe. There shall be no space between the earth and the outside of the casing.

Water shall be prevented from entering the excavation. If necessary, a dewatering system shall be provided to dewater the jacking pits.

02315.3.17.1 Controlled Low Strength Material (CLSM) Backfill. After installation of duct bank in casing pipe, the entire annular space between the duct and the casing shall be filled with CLSM.

02315.3.18 Maintenance and Restoration of Trench Backfills
Trench backfills that settle or erode before final acceptance of the work, and pavement, structures, and other facilities damaged by such settlement or erosion, shall be repaired. The settled or eroded areas shall be filled, compacted, and graded to conform to the elevation indicated on the Contractor's design drawings or to the elevation of the adjacent ground surface. Damaged facilities shall be repaired in a manner acceptable to the Owner.

02315.3.19 Final Grading
Refer to Article 02220.3.23.

02315.3.20 Disposal of Materials
Refer to Article 02220.3.24.

Table 02315-4
Materials, Compaction, and Testing Requirements

Material	Gradation Requirements	Plasticity Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Frequency	Field Water Content	Field Water Content Test	Lift Thickness	Remarks
Trench subgrades	-	-	-	-	-	-	-	-	-	-	Trench subgrades shall be firm, dense, free from mud and sufficiently stable to remain firm and intact.
30 inch pipe or smaller: Crushed rock or crushed gravel embedment	Perform at least two gradation tests; at least 95% passing 1/2" sieve and not more than 5% passing No. 4 sieve	Nonplastic	-	-	-	-	-	-	-	8" max	Minimum 4 passes with vibratory flat plate tamper
>30" to 60": Crushed rock or crushed gravel embedment	Perform at least two gradation tests; at least 95% passing 3/4" sieve and not more than 5% passing No. 4 sieve	Nonplastic	ASTM D4253 and ASTM D4254	2 initial tests; further tests as directed	70% Relative Density	ASTM D6938	One test per 100 feet of trench for each lift	-	-	8" max	

Table 02315-4
Materials, Compaction, and Testing Requirements

Material	Gradation Requirements	Plasticity Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Frequency	Field Water Content	Field Water Content Test	Lift Thickness	Remarks
Pipe larger than 60": Crushed rock or crushed gravel embedment	Perform at least two gradation tests; at least 95% passing 1-1/2" sieve, 50% passing 3/4" sieve, and not more than 5% passing No. 4 sieve	Nonplastic	ASTM D4253 and ASTM D4254	2 initial tests; further tests as directed	70% Relative Density	ASTM D6938;	One test per 100 feet of trench for each lift	-	-	8" max	-
Sand embedment	Perform at least two gradation tests; at least 95% passing No. 4 sieve and not more than 5% passing No. 100 sieve	Nonplastic	ASTM D698, Method C	2 initial tests; further tests as directed	95% Max. Dry Density	ASTM D6938;	One test per 100 feet of trench for each lift	-	-	8" max	Clean sand

Table 02315-4
Materials, Compaction, and Testing Requirements

Material	Gradation Requirements	Plasticity Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Frequency	Field Water Content	Field Water Content Test	Lift Thickness	Remarks
Groundwater barrier	-	Cohesive material (GC, SC, CL, or CH as indicated in ASTM D2487, Table 1)	ASTM D698, Method C	2 initial tests; further tests as directed	95% Max. Dry Density	ASTM D6938	One test for each groundwater barrier	0% to +2% of optimum water content	ASTM D6938	8" max	Material may be finely divided suitable job excavated material, free from stones, organic matter, and debris
Trench backfill	3" max particle size	LL < 40; PI < 15	ASTM 698, Method C	2 initial tests; further tests as directed	95% Max Dry Density	ASTM D6938;	One test per 100 feet of trench for each lift	-2% to +2% of optimum water content	ASTM D6938	8" max	-
Trench backfill traversing subgrades of streets, roads, railroads, parking areas, underground piping,	3" max particle size	-	ASTM D698, Method C	2 initial tests; further tests as directed	95% Max Dry Density	ASTM D6938;	One test per 100 feet of trench for each lift	-2% to +2% of optimum water content	ASTM D6938	8" max	

Table 02315-4
Materials, Compaction, and Testing Requirements

Material	Gradation Requirements	Plasticity Require-ments	Maximum Density	Maximum Density Test Frequency	Required Field Density	Field Density Test	Frequency	Field Water Content	Field Water Content Test	Lift Thickness	Remarks
underground electrical ducts and conduit, and other facilities subject to damage by settlement											

SECTION 02831
SECURITY & FENCE & GATES

02831.1 General

02831.1.1 Scope of Work

Scope of Work shall include installation of chain link fence, gates and other supporting equipment for perimeter security. This will include: fence framework, fabric, accessories, gates, removable panels, roll-back sections, fence post foundations, card reader pedestals, camera poles, PIR poles, conduit, communications and power wire for security.

Contractor shall work with owner for final security design and layout. The attached drawings represent the standard security requirements for the Owner. Contractor shall provide all labor and material as required for the installation of the physical security infrastructure. The site security scope includes but is not limited to:

1. Site perimeter fence
2. Man-gate with card access (access from entrance road)
3. Automated maintenance vehicle gate with card access pedestal and gate controller
4. Site perimeter conduit with pull cords, pull boxes, and security infrastructure for communications and power (minimum 2 – 3" conduits) to and from all devices to the communications building and/or power panel.
5. Terminal enclosures for dry transformers/control enclosures at camera poles and gate enclosure.
6. Foundations and mounting posts for card readers, and gate control enclosure
7. Foundations and mounting post for site cameras
8. Poles for PIR devices located at corners of site or changes of fence direction

Owner will supply cameras and card reader hardware and installation of those devices along with final testing of the physical security system. All other scope shall be supplied by Contractor.

02831.1.2 Codes and Standards

Unless otherwise stated herein, this materials is to be manufactured and tested in accordance with the latest publications of the following American Society for Testing and Materials (ASTM) standards:

ASTM Standard A491 Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric
ASTM Standard A53/A53M Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded and Seamless
ASTM Standard A153/A153M Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM Standard A1011/A1011M Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability
ASTM Standard A90/A90M Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc and Zinc-Alloy Coatings
ASTM Standard F626 Standard Specification for Fence Fittings
ASTM Standard C94/C94M Standard Specification for Ready-Mixed Concrete

02831.2 Drawings and Data

The fence and security system shall be constructed in accordance with the appropriate customer drawings. The attached layouts are for bid purposes and do not represent the actual site configuration. Actual site configuration and location of security equipment shall be determined based on the specific site layout provided by the contractor and reviewed/approved by the Owner.

02831.3 Materials and Requirements
Perimeter security fencing and gates can be constructed from: Chain Link, Section 02831.3.1

02831.3.1 Chain Link

02831.3.1.1 Chain Link Fabric
In accordance with ASTM Standard A491, latest revision; 7' 0" high, made of No. 9 gauge steel wire, woven in a 1 inch mesh and coated with a Class II aluminum coating of 0.4 oz/sf. Top and bottom selvedges shall have a twisted and barbed finish.

02831.3.1.2 Chain Link Fabric (Alternate)
When required, fabric shall be, Privacy Master$_{TM}$, as specified in section 02831.3.1 except with a 2 inch mesh with colored slats already in the wire as made by Privacy Master$_{TM}$. The privacy slats which are pre-inserted at the time of manufacture shall be double wall, self-locking (without staples), and wide to provide a tight fit in the fence fabric. The slats shall be manufactured from virgin, high density polyethylene. Color shall be as specified by customer.

02831.3.1.3 Chain Link Fence Installation
The fence shall follow the earth grade unless otherwise specified. It shall be neat, plumb, aligned true, stretched taut, and free from sags and bellies. Sufficient terminal posts must be provided to insure that bottom closure shall be within one inch of the earth grade surface elevation.

02831.3.1.4 Fabric Ties
Fabric shall be fastened to the line posts and top rail with 9 gauge tie wires and coated with a Class II aluminum coating of 0.4 oz/sf. (aluminum ties are not permitted) spaced no more than 24 inches apart. Standard fabric stretcher bars and stretcher bars bands shall be furnished where required.

02831.3.1.5 Tension Bar
The tension bar for baric to SS-40/WT-40 pipe and gate posts shall be a minimum ¼ inch dia. Galvanized steel bar and shall conform with ASTM A153. (Heavy gauge wire is not acceptable.)

02831.3.1.6 Posts
Posts shall be made of Allied SS-40 or Wheatland WT-40 pipe, sized as follows:

SS-40 or WT-40

Line Posts……2.375" OD (3.12 lb/ft)
Terminal (end/corner/pull) Posts……4.00" OD (6.57 lb/ft)
Gate Posts, for openings
(a) Single to 6' or double to 12' include……..4.00" OD (6.57 lb/ft)
(b) Single over 6' to 13' include or
double over 12' to 26' include……..6.625" OD (18.99 lb/ft)

Length	For 7' 0" Fabric
Line Posts	9'-10"
Terminal and Gate Posts	11'-2"

Posts shall be evenly spaced, but in no instance should spacing greater than 8 feet be used for 1" mesh chain link baric or Privacy Master$_{TM}$ for chain link fabric.

02831.3.1.7 Gates
Gates shall be constructed of SS-40/WT-40 1.875" OD pipe (2.28 lb/ft). top of gate shall be 8' above earth grade and match top of fence barbed wire and top of fence fabric with 8" of space below gate to allow installation of 6" of crushed rock, (as shown in Exhibit 1 Sheets 3 and 4).

02831.3.1.8 Gate Hardware
For man gates: Latch – gate, with 2" OD collar for gate frame and fork for 4" OD gate post. Pioneer Latch Model No. 2509 as manufactured by Merchants Metals, Minneapolis, MN.

For drive gates: Latch – drive gate for 2" OD gate frames. Pioneer Latch Model No. 2507 as manufactured by Merchants Metals, Minneapolis, MN.

02831.3.1.9 Removable Panels
Removable panels shall be of standard construction, framed with SS-40/WT-40 1.625" OD (1.84 lb/ft).

02831.3.1.10 Braces
Braces shall be made of SS-40/WT-40 1.625" OD (1.84 lb/ft). Braces shall be installed between each terminal and gate posts and the first adjacent post, midway between the top rail and the ground. All braces shall use two 5/16" galvanized steel truss rods complete with truss tightener that shall conform to ASTM F626 with one installed from the bottom of all gate posts and terminal posts to the center of the adjacent line posts and the second installed from the middle of all gate posts and terminal posts to the top of the adjacent line posts.

02831.3.1.11 Top Rails
The top rail shall be made of SS-40/WT-40 1.625" OD (1.84 lb/ft), provided with couplings approximately every 20 feet that shall conform to ASTM F626. Couplings shall be outside sleeve type and at least 7" long. One coupling in every five shall have a heavy spring to take up expansion and contraction of the top rail. The rail shall pass through the base of line post tops and form a continuous brace from end to end of each stretch of fence. The top rail shall be securely fastened to terminal posts by means of malleable iron or pressed steel clamps.

02831.3.1.12 Barbed Wire
Barbed wire shall be Copperweld Steel Co. "Alumoweld" Four Point Type Light Weight (two 0.080" diameter strands). If Alumoweld barbed wire is not available, two 12.5 gauge strands, with an aluminum coating equal to that specified per the fence fabric may be substituted and shall conform to ASTM F626.

02831.3.1.13 Extension Arms
For fences with 7 foot fabric, galvanized standard construction extension arms arranged to carry three strands of barbed wire shall be provided for line posts. The topmost strand shall be approximately 12" above the fence. Extension arms shall be 45 degrees to the outside. The three strands of barbed wire on terminal and gate posts and gates shall be attached directly to the vertical post or gate frame. All arms are to be constructed of 14 gauge pressed steel and conform to ASTM F626.

02831.3.1.14 Galvanizing and Steel Pipe
Galvanized steel pipe for posts, gates, top rail and removable panels shall be in accordance with ASTM standard A53, latest revision. No used, re-rolled, or open seam material will be permitted. Other fittings, hardware, and gate hardware shall be galvanized according to ASTM Standard A153, latest revision.

02831.3.1.15 Bottom Tension Wire
The bottom tension wire should be No. 7 gauge aluminum coated spring coil or crimped wire and conform to ASTM A491. Minimum weight of coating shall be 0.40 oz/sf of wire surface. Tension wire shall be stretched taut from terminal to terminal post and evenly fastened to each intermediate post 6 inches above the grade line. Tension wire shall be attached to the fence fabric with steel hog rings (aluminum hog rings are not permitted) every 24 inches.

02831.3.1.16 Painting
When required fence shall be painted using the following process:

02831.3.1.16.1
The fence fabric, posts, gates, and hardware shall be cleaned with PORTERPREP$_{TM}$ Heavy Duty Cleaner per the manufacturer's recommendations and then power washed with clean water.

02831.3.1.16.2
The fence fabric, posts, gates, and hardware shall then be sprayed with Henkel METALPREP® 79 per the manufacturer's recommendations.

02831.3.1.16.3
The fence fabric, posts, gates, and hardware shall be painted with PORTER GUARD® DTM Acrylic Primer/Finish per the manufacturer's recommendations.

02831.3.1.16.4
The fence fabric, posts, gates, and hardware shall be painted with one coat of PORTER GUARD DTM Acrylic Gloss Enamel per the manufacturer's recommendations

02831.3.3 Support Footings

02831.3.3.1 Chain Link Footings
Post shall be set in the center of concrete footings and extended 34" below the finished earth grade. Footings shall be set 1" above and extend 36" below the finished earth grade. The top of the footing shall be sloped away from the post to drain moisture. In most instances, fence posts are installed before yard rock is placed. The installer shall make sure that the concrete footing extends one inch above earth subgrade but a minimum of 4 inches below finished rock surface after rock is placed.

02831.3.3.2 Chain Link Footing Size
Footings shall be 10 inch or greater in diameter for Line Posts and 15 inches or greater for Terminal and Gate Posts.

02831.3.3.5 Footing Concrete
Unreinforced concrete with a minimum compressive strength of 4,000 psi at 28 days.

02831.3.4 Fence Gaps
Any gaps in fencing at gates or termination of fence at control house, switchgear, other equipment, or non-conductive fencing shall be no more than 4" and must be uniform.

02831.3.5 Gate Spacing
The space between the double leaf drive gates when in the closed position shall not be less than 2 inches, nor greater than 4 inches.

The space between the man gate and the fence post when in the closed position shall not be less than 2 inches, nor greater than 4 inches.

The space below all gates to the top of rock when in the closed position shall not be less than 2 inches, nor greater than 4 inches.

02831.3.6 Gate Catches
All double gates shall be provided with semi-automatic outer catches to secure gate in the open position.

02831.3.7 Security Equipment
Security camera poles (fixed or point, tilt zoom) shall be wood 35 foot high class 5 or approved equivalent. Final depth above grade shall be at least 30 feet. Camera pole shall be selected to locate the camera rigidly to reduce video movement or shaking.

Motion Detector Pole (PIR) shall be minimum of 8' above final grade. Pole made be constructed from 3 inch schedule 40 conduit or approved equivalent.

Card readers shall be installed at least one man gate locations, one vehicle maintenance gate and all door access point to communication shelter.

Security system design shall have provision for crash button to be installed at strategic location such as communications building. Crash button is merely a button that communicates with the security system control scheme to allow emergency egress from the site.

Pull boxes shall be installed as necessary to allow for installation of security equipment and wire.

If site lighting is selected then security system shall be capable of interfacing and reacting to security system. Example, site lighting shall be capable of being turned on or increase lighting intensity via output from the security control panel

Security camera shall be installed at each fence corner or change in direction of the fence line.

Motion detectors shall be installed as shown in examples, approximately 9 feet on each site of camera poles allowing the PIR motion detection beam to intersect on front side camera pole at fence corners.

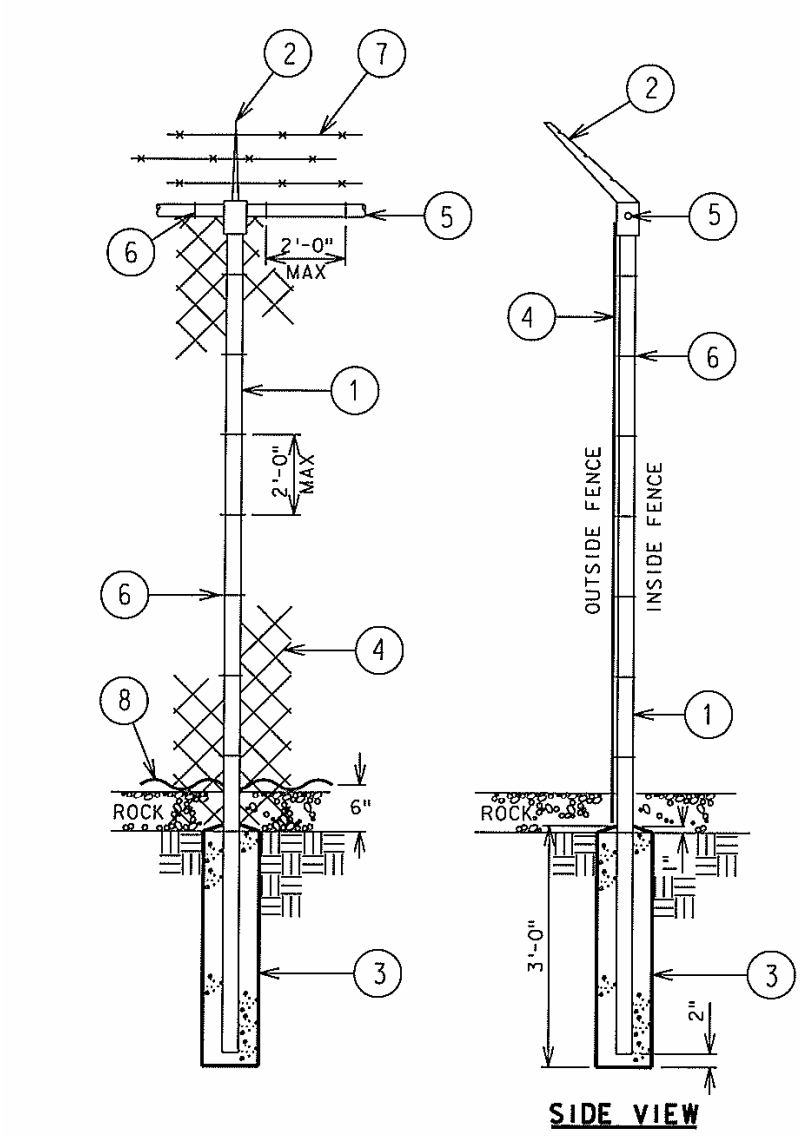
Camera and or PIR poles near or adjacent to roadway or vehicle access ways shall have bollard installed adjacent to each pole for protection. A maximum of 4 feet access shall be allowed between bollards.

02831.3.8 Reference Drawings
Attached for reference are typical details.

Chain Link Line Post Section: See Exhibit 1 Sheet 1
Chain Link Corner Section: See Exhibit 1 Sheet 2
Chain Link Man Gate Section: See Exhibit 1 Sheet 3
Chain Link Drive Gate Section: See Exhibit 1 Sheet 4
Fence and Gate Examples
Gate & Misc. Details Examples
Security Equipment and Location Example

EXHIBIT 1

CHAIN LINK FENCING DETAIL DRAWINGS
TRANSMISSION AND DISTRIBUTION DESIGN
SUBSTATION DESIGN STANDARDS



SIDE VIEW

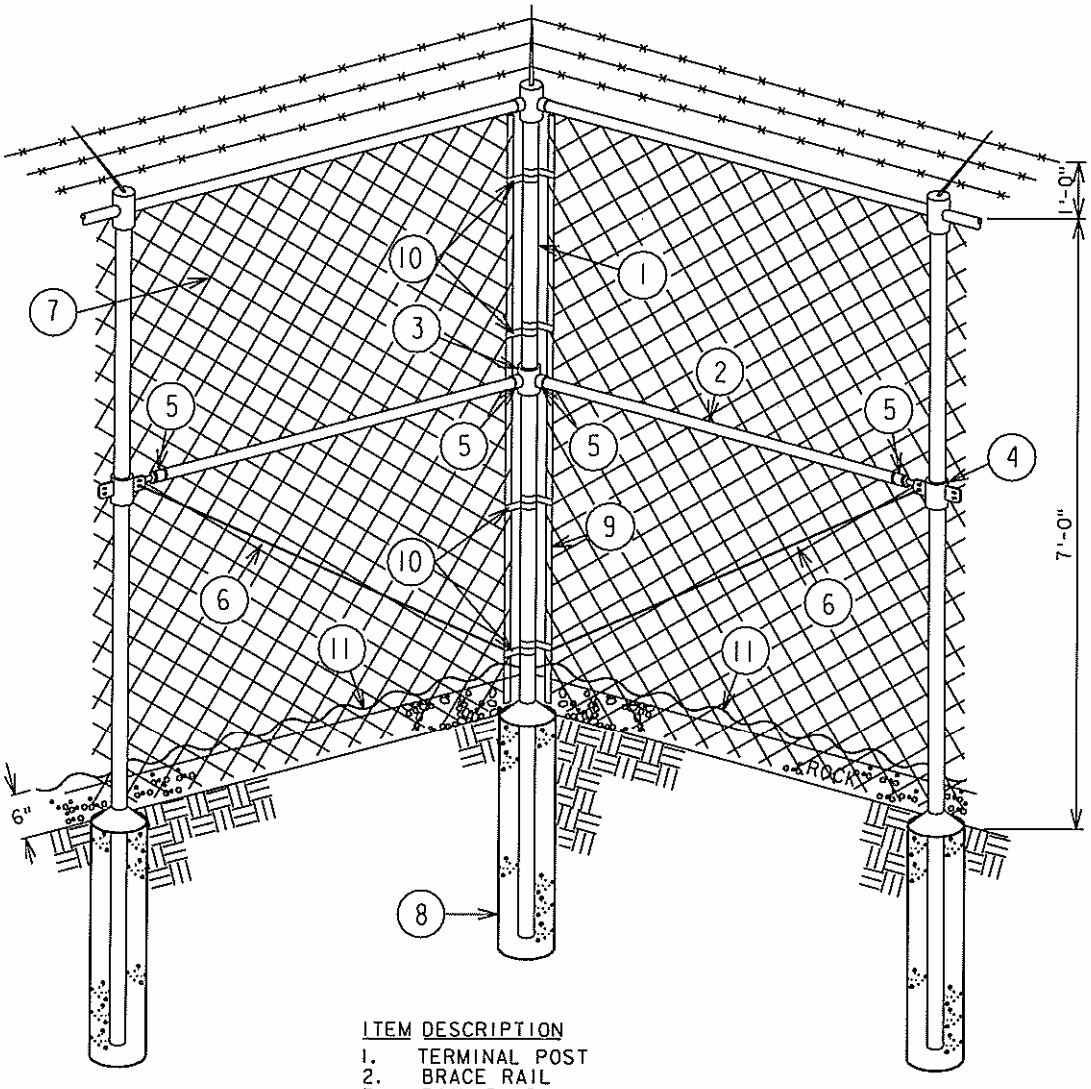
ITEM	DESCRIPTION
1.	LINE POST
2.	EXTENSION ARMS
3.	4000 psi CONCRETE
4.	84" FENCE FABRIC
5.	TOP RAIL
6.	FABRIC TIES
7.	BARBED WIRE
8.	TENSION WIRE

NOTES:

1. CHAIN LINK FABRIC BOTTOM TO BE FLUSH WITH TOP OF CURB IN LOCATIONS OF FENCING ON CURB

TYPICAL LINE POST SECTION

EXHIBIT 1



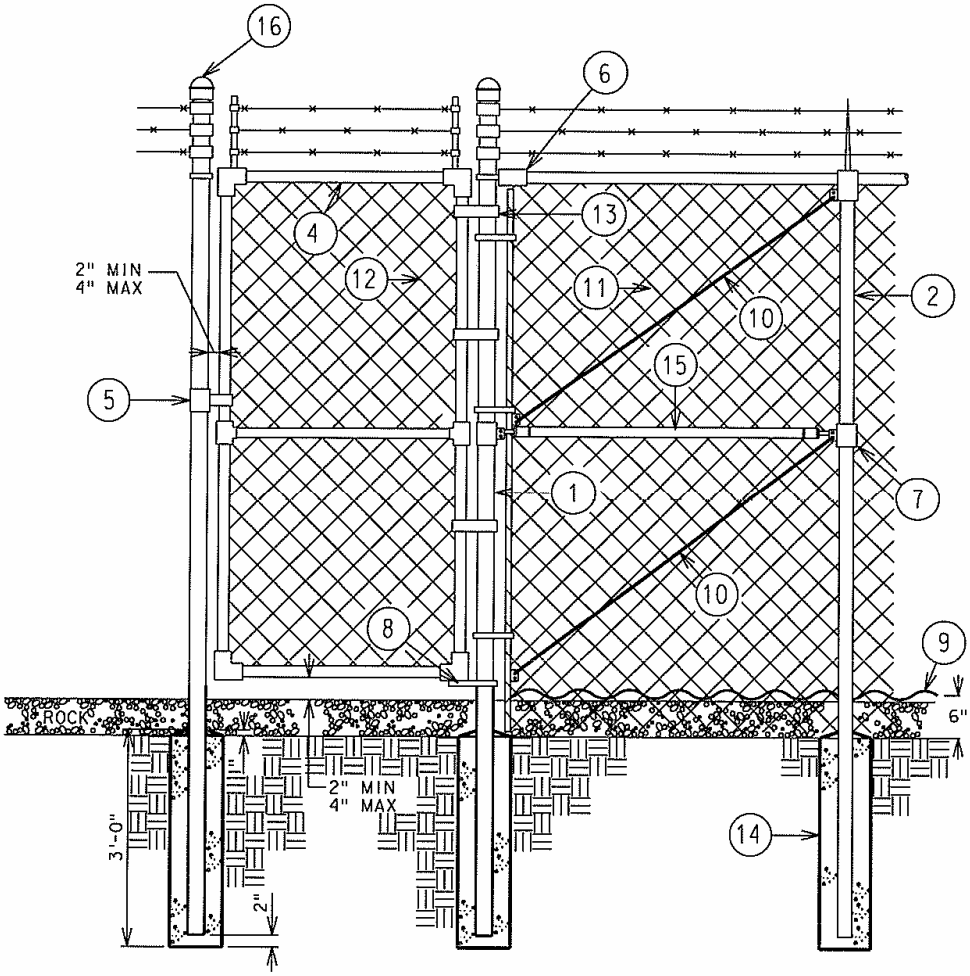
ITEM	DESCRIPTION
1.	TERMINAL POST
2.	BRACE RAIL
3.	RAIL BAND
4.	BRACE RAIL BAND w/2 ATTACHMENTS
5.	SOCKET FITTING
6.	TRUSS ROD w/TRUSS TIGHTENER
7.	84" FABRIC (AS REQUIRED)
8.	4000psi CONCRETE (AS REQUIRED)
9.	TENSION BAR
10.	BAND, TENSION BAR
11.	TENSION WIRE

NOTES:

1. CHAIN LINK FABRIC BOTTOM TO BE FLUSH WITH TOP OF CURB IN LOCATIONS OF FENCING ON CURB

TYPICAL CORNER SECTION

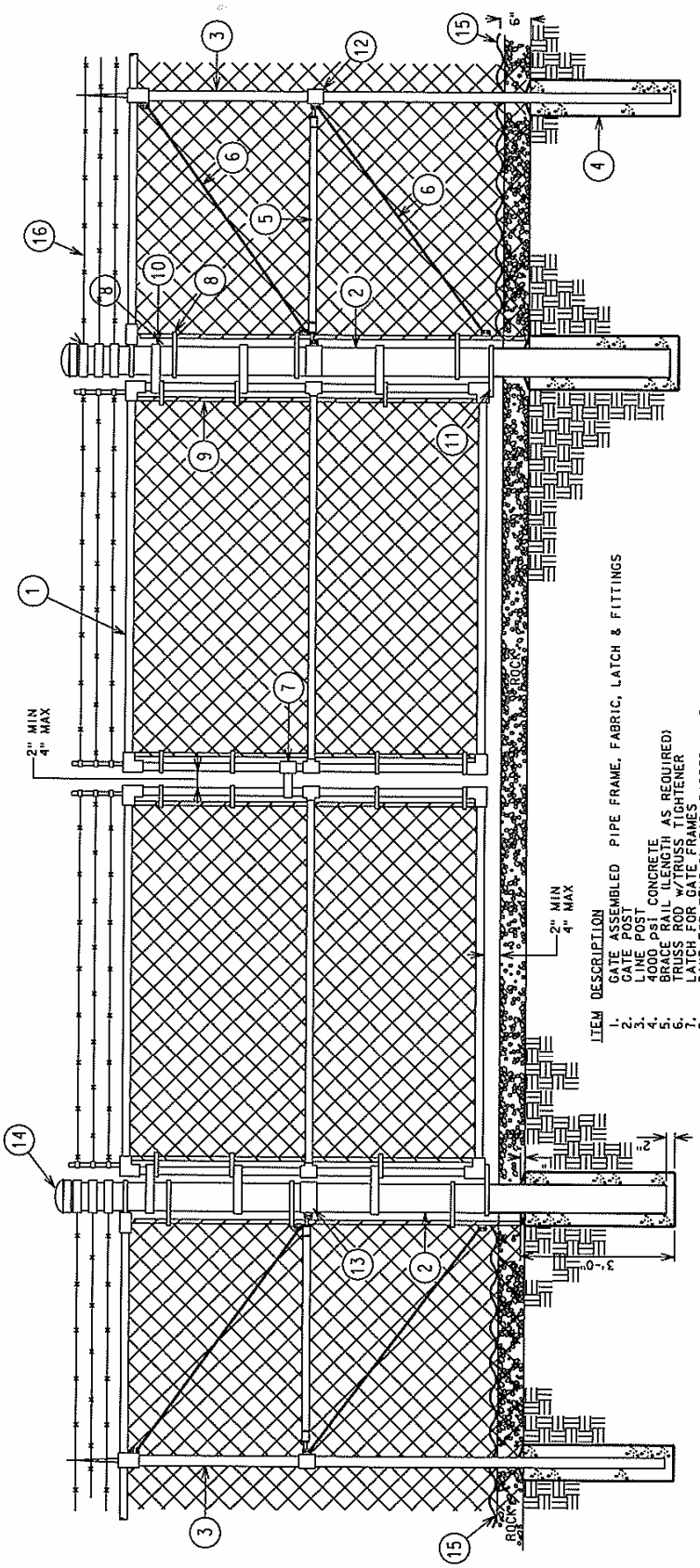
EXHIBIT 1



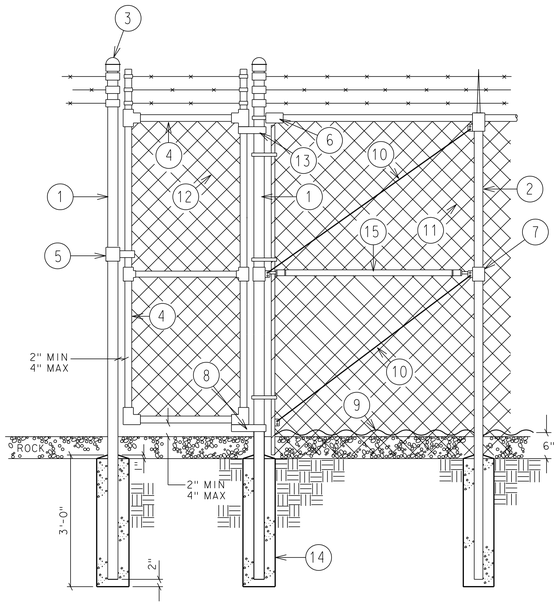
ITEM	DESCRIPTION
1.	TERMINAL GATE POST
2.	LINE POST
4.	GATE FRAME (AS REQUIRED)
5.	MAN GATE LATCH
5.	BRACE RAIL (LENGTH AS REQUIRED)
6.	BAND FOR RAIL
7.	BAND W/2 ATTACHMENTS FOR BRACE RAIL AND TRUSS
8.	BOTTOM GATE HINGE
9.	TENSION WIRE
10.	TRUSS ROD W/TRUSS TIGHTENER
11.	120" FENCE FABRIC (AS REQUIRED)
12.	FENCE FABRIC (AS REQUIRED) (HEIGHT VARIES)
13.	TOP GATE HINGE
14.	4000 psi. CONCRETE
15.	BRACE RAIL (LENGTH AS REQUIRED)
16.	POST CAP

TYPICAL MAN GATE SECTION

EXHIBIT 1



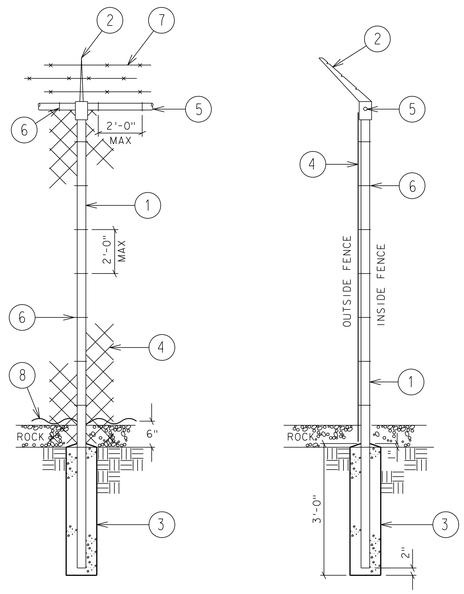
TYPICAL DRIVE GATE SECTION



ITEM DESCRIPTION

1. TERMINAL GATE POST
2. LINE POST
4. GATE FRAME (AS REQUIRED)
5. MAN GATE LATCH
6. BAND FOR RAIL
7. BAND w/2 ATTACHMENTS FOR BRACE RAIL AND TRUSS
8. BOTTOM GATE HINGE
9. TENSION WIRE
10. TRUSS ROD w/TRUSS TIGHTENER
11. 84" FENCE FABRIC (AS REQUIRED)
12. FENCE FABRIC (AS REQUIRED)(HEIGHT VARIES)
13. TOP GATE HINGE
14. 3000 psi CONCRETE
15. BRACE RAIL (LENGTH AS REQUIRED)

"TYPICAL MAN GATE SECTION"

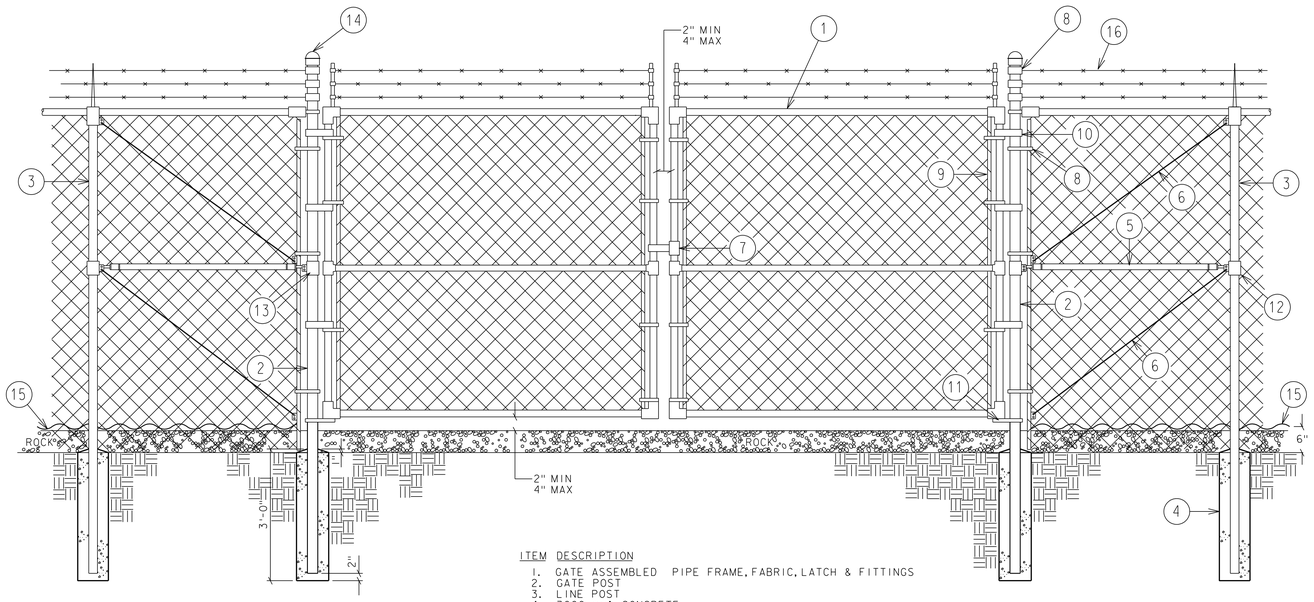


SIDE VIEW

ITEM DESCRIPTION

1. LINE POST
2. EXTENSION ARMS
3. 3000 psi CONCRETE
4. 84" FENCE FABRIC
5. TOP RAIL
6. FABRIC TIES
7. BARBED WIRE
8. TENSION WIRE

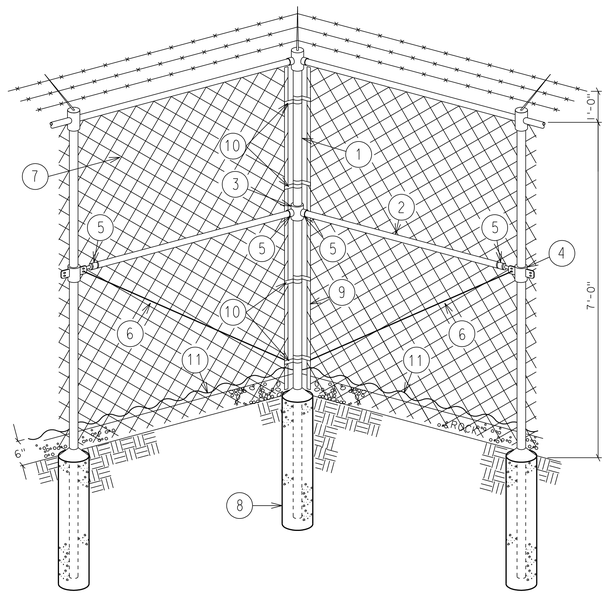
"TYPICAL LINE POST SECTION"



ITEM DESCRIPTION

1. GATE ASSEMBLED PIPE FRAME, FABRIC, LATCH & FITTINGS
2. GATE POST
3. LINE POST
4. 3000 psi CONCRETE
5. BRACE RAIL (LENGTH AS REQUIRED)
6. TRUSS ROD w/TRUSS TIGHTENER
7. LATCH FOR GATE FRAMES
8. BAND FOR TENSION BAR, BARBED WIRE, TRUSS ROD
9. TENSION BARS
10. TOP GATE HINGE
11. BOTTOM GATE HINGE
12. BAND w/2 ATTACHMENTS FOR BRACE RAIL & TRUSS
13. BAND FOR BRACE4" O.D. PIPE
14. TERMINAL POST CAP
15. TENSION WIRE
16. BARBED WIRE

"TYPICAL DRIVE GATE SECTION"

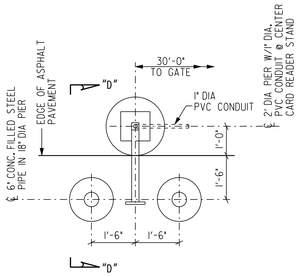


ITEM DESCRIPTION

1. TERMINAL POST
2. BRACE RAIL
3. RAIL BAND
4. BRACE RAIL BAND w/2 ATTACHMENTS
5. SOCKET FITTING
6. TRUSS ROD w/TRUSS TIGHTENER
7. 84" FABRIC (AS REQUIRED)
8. 3000psi CONCRETE (AS REQUIRED)
9. TENSION BAR
10. BAND, TENSION BAR
11. TENSION WIRE

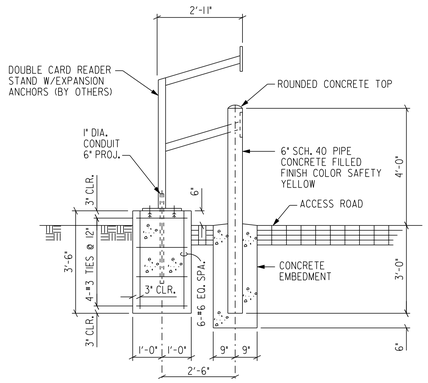
"TYPICAL CORNER SECTION"

FENCE & GATE EXAMPLES



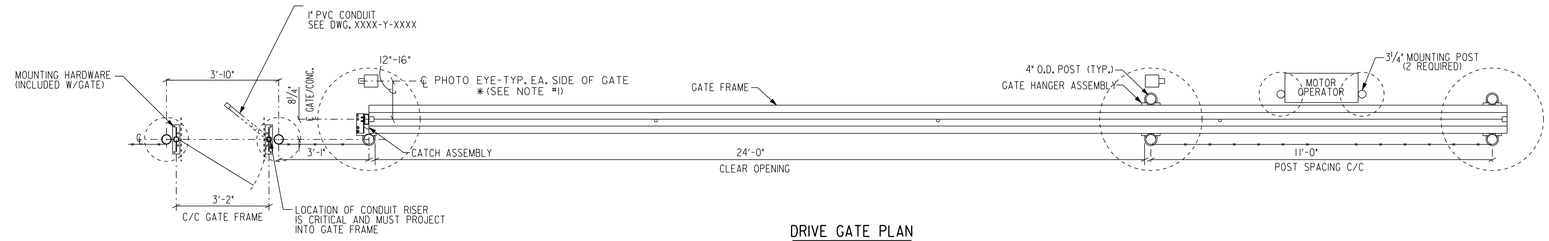
PLAN DETAIL - CARD READER @ SLIDE GATE

2 REQ'D - 1-INSIDE, 1-OUTSIDE GATE
SEE DWG.

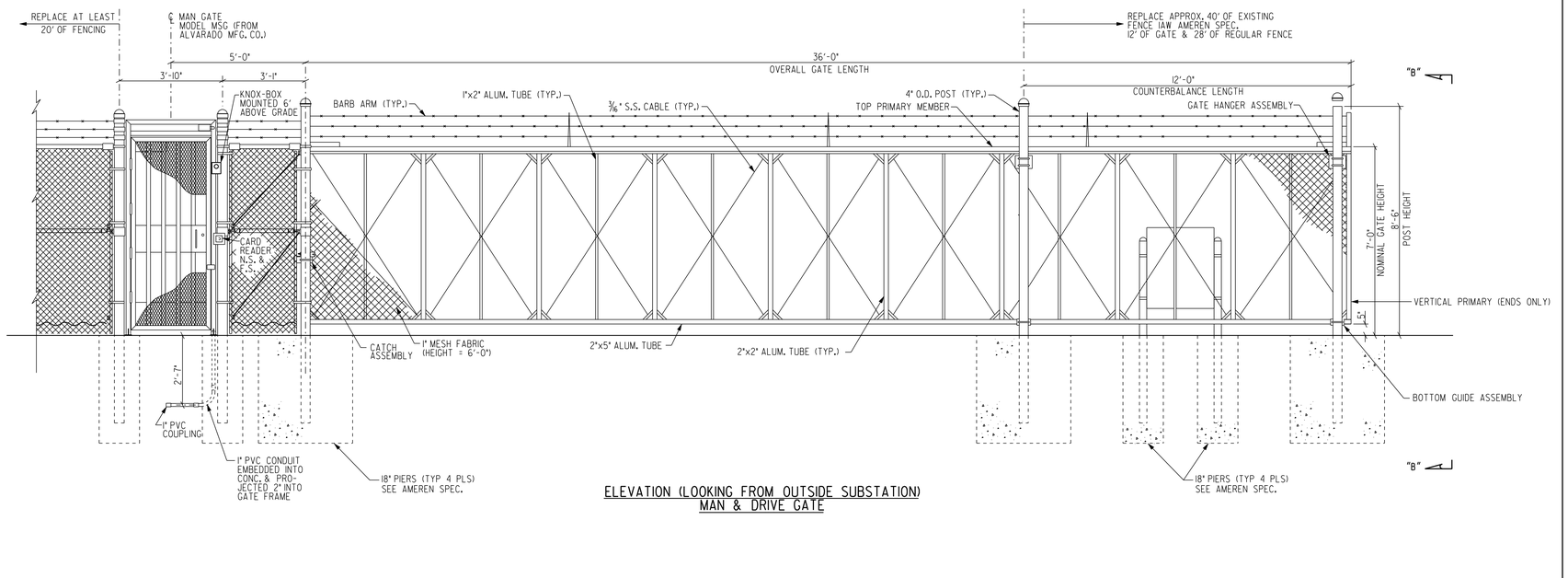


SECTION "D-D"

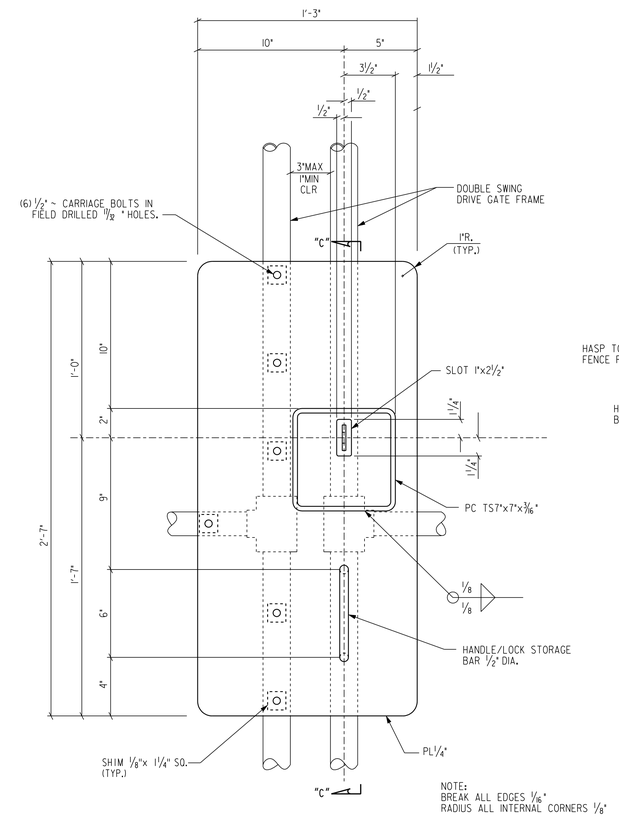
PATCH EXCAVATED
& DISTURBED PAVEMENT
AREAS IN-KIND



DRIVE GATE PLAN

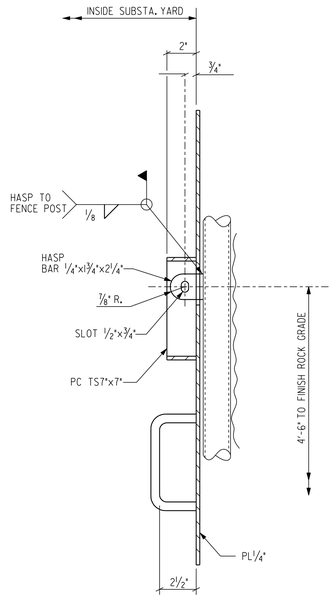


ELEVATION (LOOKING FROM OUTSIDE SUBSTATION)
MAN & DRIVE GATE



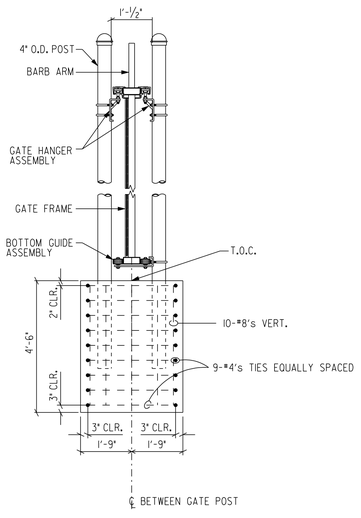
ELEVATION
(INSIDE LOOKING OUT)

NOTE:
BREAK ALL EDGES 1/16"
RADIUS ALL INTERNAL CORNERS ⅛"

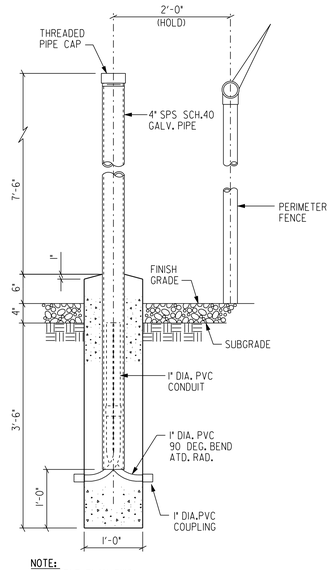


SECTION "C-C"

INSIDE ACCESS ONLY LOCK DETAIL



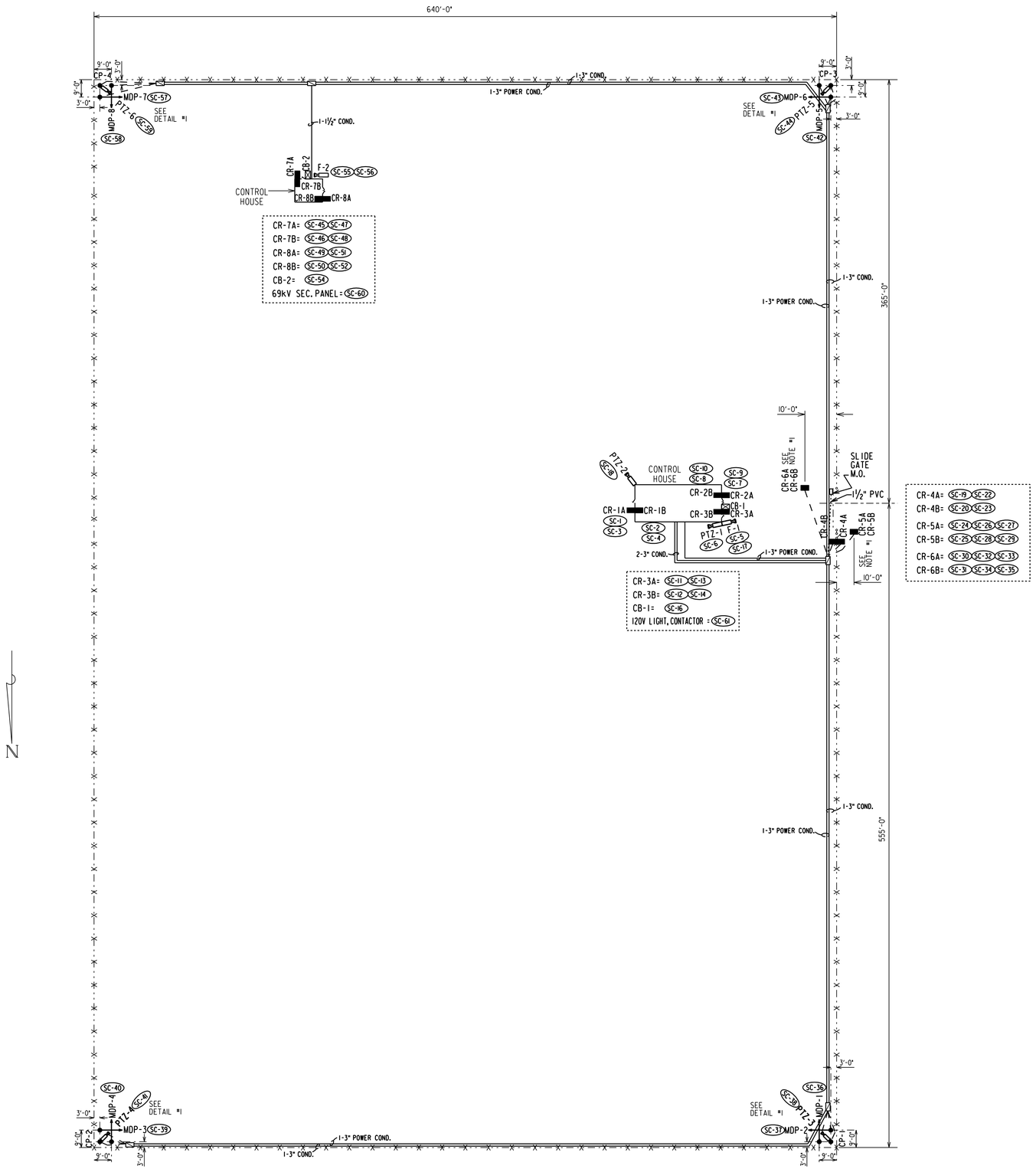
SECTION "B-B"
REINFORCING TYPICAL



NOTE:
SEE CABLE PLAN DWG.
FOR DIRECTION & NO. OF 1" CONDUITS
TO BE USED AT EACH FDN.

PIPE FOUNDATION

GATE & MISC. DETAILS EXAMPLES



LEGEND:

Schedule C

CRASH BUTTON ⊠ CB-

CARD READER ■ CR-

PULL BOX ▭ •2

CAMERA POLE (WOOD 35'-0" HIGH CLASS 5) ●

MOTION DETECTOR POLE (MDP) 8'-0" HIGH USING 3" SCHED. 40 CONDUIT (ARROW INDICATES DIRECTION OF COVERAGE) ●→

SECURITY CABLE No. (SC-)

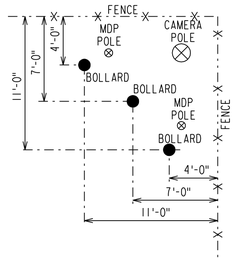
1" PVC — — ·

DIRECT BURIAL ELECTRICAL WIRE ------

SECURITY CAMERA ▭
(F=FIXED - PTZ=POINT, TILT & ZOOM)

400W MH DIRECTIONAL LUMINAIRE, "F" (FIXED CAMERA) F-

120V A.C. OUTLET, 400W MH DIRECTIONAL LUMINAIRE, "PTZ" (PAN CAMERA) PTZ-



DETAIL "I"
(BOLLARD LOCATION)

NOTES:

*1. DENOTES HI/LOW CARD READER. SEE DRAWING XXXX-X-XXXXXX FOR DETAIL.

2. PULL BOXES SHALL BE 13"x24" STACKABLE QUAZITE BOXES, W/EXTRA HEAVY DUTY COVER. CAT #PGI342 HHOO OR EQUAL.

3. FOR LIGHTING CIRCUITS RUN 2C #6 TO EACH JUNCTION BOX. FROM JUNCTION BOX TO EACH LUMINAIRE RUN 3C #10. GROUND EACH LUMINAIRE.

4. A 18"x18"x6" OUTDOOR RATED ALUM. JUNCTION BOX SHALL BE MOUNTED ON EACH CAMERA POLE. A 12V, 20A, DUAL GFCI OUTLET SHALL BE INSTALLED IN EACH CABINET.

LOCATION EXAMPLE

SECTION 03210
CONCRETE REINFORCEMENT

03210.1 General

03210.1.1 Scope of Supply

Scope of supply shall include furnishing concrete reinforcement and appurtenances and shall include other services as specified under these technical specifications.

Scope of supply shall include the items in the below table:

Table 03210-1 Scope of Supply	
Deliverables, Materials, or Work	**Scope of work**
Reinforcement detailing (reinforcing steel placement drawings and cut sheets	Included
Field placement of reinforcement	Included
Mechanical couplings	Included
Bar supports	Included
Detailing of bar supports	Included

Scope of supply shall also include the determination of the quantity of bar supports and the size and quantity of bar standees.

03210.1.2 Not Used

03210.1.3 Performance Requirements

Performance requirements for the materials to be furnished under this section of these specifications are indicated below:

Table 03210-2 Performance Requirements	
Materials	**Requirements**
Reinforcing steel sizes indicated on Contractor's design drawings, in.	US standard units
Billet steel bars, grade	60 ksi
Low alloy steel bars, grade	60 ksi
Shop coatings for reinforcing steel	None
Mechanical splices shall develop	125 percent of reinforcement yield strength

03210.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 03210-3 Codes and Standards	
Work	**In Accordance With**
Fabrication of reinforcement and appurtenances	ACI 301, Structural Concrete for Buildings; ACI 315, Details and Detailing of Concrete Reinforcement; ACI 318, Building Code Requirements for Reinforced Concrete

03210.1.5 Materials
The following materials shall be used:

Table 03210-4 Materials	
Component	**Material**
Reinforcing steel	
Billet steel	ASTM A615
Low alloy steel	ASTM A706, Grade 60
Bar supports	CRSI Class 3 unexposed, Class 1 exposed
Mechanical splices	Metal filled or threaded couplers, designed for a minimum of 125 percent of the bar yield strength
Welded wire fabric	ASTM A185 or A497

03210.1.6 Approved Manufacturers of Components
For the following components, the manufacturers listed below provide examples of the quality of workmanship required by these specifications. If the Contractor 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 Owner:

Table 03210-5 Approved Manufacturers of Components	
Component	**Manufacturer**
Mechanical splices - metal filled	Refer to "Supplemental General Conditions, Appendix C - Ameren Missouri Approved Suppliers"
Mechanical splices - threaded coupler	Refer to "Appendix C - Ameren Missouri Approved Suppliers"

03210.1.7 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 Contractor unless specifically identified as a Bid Option or Owner-conducted. Tests identified as an option are to be priced separately. If identified as Owner-conducted, costs for the initial test will be the

responsibility of the Owner. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 03210-6 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Tensile Tests	ASTM A615 and A706	Manufacturer

03210.2 Products

03210.2.1 Work Included Under These Specifications
The work under this specification shall include furnishing concrete reinforcement and providing miscellaneous materials and services complete as specified. Concrete reinforcement shall be delivered to designated lay-down areas at the construction site.

03210.2.2 Materials

03210.2.2.1 Reinforcing Steel. Straight bars of all diameters and bent bars with a diameter less than 1-1/2 inches shall be deformed billet steel bars. Bent bars with a diameter greater than 1-1/2 inches shall be deformed low alloy steel bars.

Reinforcing steel shall be accurately formed. The details of fabrication shall conform to the codes and standards specified.

03210.2.2.2 Not Used.

03210.2.2.3 Accessories. Bar supports, standees, ties, spacers, bolsters, inserts, and other concrete accessories used to secure reinforcing in position shall be furnished.

Detailed drawings of the support system for reinforcement in pile caps and ground floors shall be submitted with the placing drawings and bar lists.

03210.2.2.4 Certification. Certification of compliance with these specifications shall be provided for all reinforcing steel furnished. Certification of compliance with all tests required by the material specification shall be included. These tests shall include material composition, bend tests, and tensile tests as a minimum.

03210.2.2.5 Welding. Welding of reinforcement is prohibited. Reinforcement with unauthorized welds shall be removed and replaced.

Welded chairs and supports may be used.

03210.2.3 Placement Drawings and Bar Lists
Bar lists and reinforcement placement drawings shall be prepared and submitted to the Owner for acceptance. Each bar list and placement drawing shall clearly identify the grade of reinforcing required by that drawing.

03210.2.3.1 Drawing Requirements. Each drawing submitted shall indicate the name of the project, the unit designation, the contract title, the contract number, the name of the building structure, the concrete placement number, and the Contractor's name.

The Owner's identification number will be affixed by the Owner to each Contractor's initially submitted placing drawing. This number shall be maintained on all subsequent drawing submittals in the identical format and location as originally indicated by the Owner.

03210.2.3.2 Reinforcing Spacing. Reinforcement for concrete shall have the concrete protective cover specified in the codes and standards.

The clear distance between individual parallel bars shall not be less than 1.5 times the maximum size of coarse aggregate in the concrete; nor less than one nominal bar diameter; nor less than 1 inch in beams, 1-1/2 inches in columns, or 2 inches in other locations. Where reinforcements in beams are placed in two or more layers, the bars in the upper layer shall be placed directly above the bars in the lower layer and the clear distance between layers shall not be less than 1 inch. Clear distance limitations between individual bars shall also apply to the clear distance between a contact lap splice and adjacent splices or bars.

03210.2.3.3 Splices. Splices shall conform to the codes and standards specified. Lap splice lengths shall permit all bars to be spliced at the splice location with no reduction in splice length as a result of staggered splice locations or excess reinforcement unless otherwise indicated on the Contractor's design drawings. Splices in horizontal reinforcement placed in vertical wall sections shall be detailed in accordance with top reinforcement requirements. Splices shall not be used in regions of maximum bending stress.

Splices for bars with a diameter greater than 1-1/2 inches shall be mechanical splices.

Mechanical splices under tension shall develop the minimum strength specified herein. Mechanical splice manufacturer's inspection criteria shall be furnished to the Owner.

03210.3 Execution

Reinforcement shall be delivered to the jobsite packaged in bundles. Each shipment shall contain all bundles required for one or more concrete placements. Each bundle shall be tagged with a sturdy, durable, weatherproof tag which includes the following information:

Placement number (according to Owner's designation). If bar is a dowel bar, the placement number shall be the first of the two placements.

Bar diameter.

Number of bars in bundle.

Position/Shape number.

Bar length.

Weight of bundle.

Graphical description of bar shape.

Each shipment shall contain a complete bundle-by-bundle inventory that duplicates all the information listed on all the tags of all the bundles listed.

Each bundle shall be securely bound. Every binding shall be capable of safely holding the entire weight of the entire bundle.

Rebar shall be free from dirt, debris, etc.

Rebar fabrication shall be in accordance with CRSI "Manual of Standard Practice".

SECTION 03311
CAST IN PLACE CONCRETE

03311.1 General

03311.1.1 Scope of Work
Scope of work shall include receiving and placing concrete and reinforcement, constructing required formwork, and furnishing materials, equipment, and labor to complete the cast-in-place concrete work including other services as specified herein.

03311.1.2 Not Used

03311.1.3 Performance and Design Requirements
Performance requirements for the cast-in-place concrete shall be as follows:

Table 03311-1 Performance and Design Requirements

Component	Material
Mechanical splices shall develop	125 percent of yield strength of spliced bars
Cold weather placement	
Maximum time interval for measuring concrete temperature during the protection period, hours	12
Finishes for formed concrete surfaces exposed to view	Standard finish (rough form finish)
Finishing unformed surfaces	
Screeding	Where indicated on the Contractor's design drawings
Floating	Flat surfaces and floors not otherwise specified
Brooming	Roads, sidewalks, and walkways
Troweling	Where indicated on the Contractor's design drawings

If cable trenches are used, the surface should be steel troweled finish to allow for cable pulls.

03311.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 03311-2 Codes and Standards	
Work	**In Accordance With**
Structural concrete for buildings	ACI 301
Hot weather concreting	ACI 305R
Cold weather concreting	ACI 306R and ACI 301
Building code requirements for reinforced concrete	ACI 318
Recommended practice for concrete formwork	ACI 347R
Splices in reinforcing steel	ACI 318
Tolerances	AISC Manual of Steel Construction, Code of Standard Practice, ACI 117, ACI 301
Finishes and finishing	ACI 301
Sampling and testing for strength	ACI 318, Section 5.6

03311.1.5 Materials

The following materials shall be used:

Table 03311-3 Materials	
General	
Component	**Material**
Form ties	Removable end, permanently embedded body type. In liquid retaining structures, provide integral water stops.
Polyethylene sheeting	ASTM D4397, 6 mil
Water stops	
Construction joints	PVC ribbed or serrated, 6 inches by 3/8 inch, with "O" bulb closed center section
Expansion or isolation joints	PVC ribbed or serrated, 9 inches by 3/8 inch, with "O" bulb closed center section
Water stops – hydrophilic	
Concrete joints and pipe penetrations through concrete walls with doubly reinforced and 8 inch or greater thickness	Expanding preformed rubber strip, expansion coefficient by volume exceeding 1.5 when saturated
Curbs and concrete joints with less than 8 inch thickness	Bentonite/butyl rubber strip
Expansion joint filler	ASTM D1752, Type 1 sponge rubber or closed cell PVC or polyethylene foam
Polyurethane sealant	ASTM C920, Type M, Grade P, Class 25,

Table 03311-3 Materials	
General	
Component	**Material**
	Use T
Membrane curing compound and floor sealer	ASTM C1315, Type 1, Class A, acrylic copolymer, with a minimum 25 percent solids, nonyellowing, maximum moisture loss 0.08 lb/ft^2 in 72 hours
Membrane curing compound, dissipating type, where specified herein or indicated on the drawings	ASTM C309, Type 1, Class A, maximum moisture loss 0.11 lb/ft^2 in 72 hours
Epoxy bonding adhesive (joints between existing and new concrete)	ASTM C881, Types I and V, moisture insensitive, 100 percent solids
Epoxy anchoring system (dowels and anchors)	ASTM C881, Type IV, Grade 3
Anchor bolt sleeves	Plastic

03311.1.6 Approved Manufacturers of Components

For the following components, the manufacturers listed below provide examples of the quality of workmanship required by these specifications. If the Contractor 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 Owner:

Table 03311-4 Approved Manufacturers of Components	
Component	**Manufacturer**
PVC water stops - 9 inch	Refer to "Supplemental General Conditions, Appendix C - Ameren Missouri Approved Suppliers"
PVC water stops - 6 inch	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Hydrophilic water stops	
Hydrophilic water stops (curbs and concrete surfaces less than 8 inch thickness)	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Adhesive anchoring system	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Epoxy bonding compound (joints between existing and new concrete)	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Form coating	Refer to "Appendix C - Ameren Missouri Approved Suppliers"

03311.1.7 Test Requirements

The following testing shall be conducted in accordance with the specified source. Testing intervals and execution are specified in Article 03311.3.17.

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

Table 03311-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Slump test	ASTM C143	Contractor
Air content	ASTM C231	Contractor
Concrete test cylinders	ASTM C31	Contractor
Compression test	ASTM C39	Contractor
Compression strength test	ACI 318, Chapter 5	Contractor
Concrete temperature	ASTM C1064	Contractor

03311.2 Products
Materials and product requirements are provided in Articles 03311.1.5 and 03311.1.6.

03311.3 Execution

03311.3.1 General
Work shall include design and construction of formwork; installation of reinforcing steel and other embedments; concrete placement, finishing, curing and other appurtenant work; and provision of miscellaneous materials and services complete as specified. Concrete reinforcement and embedments are covered in separate sections.

03311.3.2 Placement of Steel Reinforcement
Reinforcement shall be accurately positioned and secured in place with wire ties or suitable clips. Bare metal supports shall not be used in contact with forms for exposed concrete surfaces.

The clear distance between individual parallel bars shall not be less than 1.5 times the maximum size of coarse aggregate in the concrete; not less than one nominal bar diameter; and not less than 1 inch in beams, 1-1/2 inches in columns, or 2 inches in other locations. Where reinforcements in beams are placed in two or more layers, the bars in the upper layer shall be placed directly above the bars in the lower layer and the clear distance between layers shall not be less than 1 inch. Clear distance limitations between individual bars shall also apply to the clear distance between a contact lap splice and adjacent splices or bars. Steel reinforcement shall be installed in accordance with CRSI "Manual of Standard Practice."

On significant pours. Ameren Missouri shall sign off all reinforcement and forms before concrete is placed. The Contractor shall notify the Owner at least 3 days in advance of any major pour to provide Owner time for inspection.

03311.3.2.1 Splices. Splices shall conform to the specified codes and standards. Lap splice lengths shall permit all bars to be spliced at the splice location with no reduction in splice length due to staggered splice locations or excess reinforcement unless otherwise indicated on the Contractor's design drawings. Splices in horizontal reinforcement placed in vertical wall sections shall be spliced in accordance with top reinforcement requirements. Splices shall not be used in regions of maximum bending stress.

Lapped splices shall not be used for bars with a diameter greater than 1-1/2 inches. Splices for bars with a diameter greater than 1-1/2 inches shall be made with mechanical splices.

Mechanical splices under tension shall develop the minimum strength specified in Article 03311.1.5. The first four splices made by each operator shall be made in the presence of the mechanical splice manufacturer's representative and the Owner. Each operator shall make splices in the same splicing positions (vertical, horizontal, angle, or special) to be made for the project. All procedures used shall be acceptable to the mechanical splice manufacturer's representative and the Owner.

Reinforcing bar splices shall be welded only when directed by the Owner.

03311.3.2.2 Not Used.

03311.3.2.3 Reinforcement Installed in Hardened Concrete. Reinforcement installed in hardened concrete shall be anchored with the specified epoxy anchoring system. Holes shall be drilled to a depth sufficient to develop the tensile strength of the reinforcing bar as recommended in the manufacturer's literature. Reinforcement shall be installed in accordance with manufacturer's installation instructions.

If reinforcement is encountered while drilling existing concrete, drilling shall stop and the Owner shall be contacted. Reinforcement shall not be cut without the Owner's consent.

03311.3.3 Formwork
Forms shall be designed and constructed to produce hardened concrete having the shape, lines, and dimensions indicated on the Contractor's design drawings.

Vertical surfaces of footings extended above finished grade shall be formed.

03311.3.3.1 Construction. Forms shall be sufficiently tight to prevent leakage of mortar and shall maintain position, shape, and alignment during and after placement of concrete.

Suspended members supported by concrete columns or piers shall be formed to allow the column or pier forms to be removed without disturbing the supports for the suspended members.

03311.3.3.2 Form Ties. Form ties shall have sufficient strength, stiffness, and rigidity to support and maintain the form in proper position and alignment without the use of auxiliary spreaders. Outer ends of the permanently embedded portions of form ties shall be at least 1 inch back from adjacent outer concrete faces. Permanently embedded portions of form ties that are not provided with threaded ends shall be constructed to allow the removable ends to be broken off by twisting without chipping or spalling the concrete surface. Form ties shall be acceptable to the Owner.

Form ties in exposed surfaces shall be uniformly spaced.

03311.3.3.3 Edges and Corners. Chamfer strips shall be placed in forms to bevel all salient edges and corners except buried edges and edges that are designated on the drawings to receive special treatment. Equipment bases shall have formed beveled projecting edges for all vertical and horizontal corners unless indicated otherwise on the drawings. Bevel dimensions shall be 3/4 inch by 3/4 inch unless indicated otherwise on the Contractor's design drawings.

03311.3.3.4 Form Removal. Forms shall not be removed from structures until the concrete in the structure has sufficient strength to support the weight of the structure and any superimposed load, including loads from construction operations. The Contractor shall be responsible for limiting any applied loadings. There shall be no evidence of damage to concrete and no excessive deflection or distortion of members due either to the removal of forms or to loss of support.

Supporting formwork shall not be removed from horizontal members until the concrete has attained at least 75 percent of the specified 28 day compressive strength as determined by cylinders made and cured in the field. Shores shall not be removed before concrete has attained 28 day compressive

strength as specified herein. Shoring shall be left in place and reinforced as necessary to carry any construction equipment or materials placed thereon.

When forms are removed before the specified curing is completed, measures shall be taken to immediately continue curing. In cold weather conditions, adequate thermal protection for the concrete shall be provided.

03311.3.4 Embedments
Anchor bolts, castings, steel shapes, conduit, sleeves, masonry anchorages, and other materials embedded in the concrete shall be accurately positioned and securely anchored.

Location tolerances for anchor bolts, and for structural members, embedded structural steel shapes, and plates, shall be in accordance with AISC Manual of Steel Construction Code of Standard Practice.

Tolerances for equipment anchorages shall be as required by Article 03311.3.15.1.

Anchor bolts shall be provided with sufficient threads to permit a nut to be installed on each side of the form or template. The nuts shall secure the bolt in its proper position.

Pipe sleeves, conduit, and other embedments shall be within 1/4 inch of their design locations unless specified otherwise on the Contractor's design drawings or other specification sections.

Embedments shall not be welded to structural reinforcement.

Embedments shall be clean when they are installed. After concrete placement, exposed surfaces of embedments shall be cleaned of all concrete spatter and other foreign substances.

Anchor bolt sleeves, handrail sleeves, and similar openings in concrete susceptible to filling with water and freezing shall be filled with closed cell PVC expansion joint filler for protection until grouting. The upper neck of plastic anchor bolt sleeves shall be cut out and the annular space filled with closed cell PVC expansion joint filler or other means acceptable to the Owner.

03311.3.4.1 Water Stops. Water stops shall be clean and free from coatings that weaken the bond with concrete. Each PVC water stop shall be continuous throughout the length of the joint. Intersections shall be made using factory prefabricated crosses, tees, and ells. The performance of the splice shall be equal to that of the continuous material and shall be made in strict conformance with the recommendations of the water stop manufacturer. Hydrophilic water stops shall be installed as recommended by the water stop manufacturer.

Water stops shall be maintained in proper position until the concrete has been deposited and compacted.

03311.3.5 Placement
The handling, depositing, and compacting of concrete shall conform to these specifications. Adjustments may be made for weather or placement conditions.

The Owner shall be notified at least 24 hours in advance of the times and locations where concrete is being placed.

Concrete shall not be pumped through aluminum or aluminum alloy pipe.

Construction joints indicated on the Contractor's design drawings shall define the limits of each concrete pour.

Sub-grades shall be moistened with water prior to concrete placement. The sub-grade shall not contain puddles or wet, soft, unstable or muddy areas when the concrete is placed.

Concrete placed against rock or existing concrete shall have loose pieces of rock removed and the exposed surface cleaned with a high-pressure hose before concrete is placed.

The space receiving concrete shall be clean and clear of debris and standing water, and the entire installation shall be acceptable to the Owner before concrete is placed.

Surfaces encrusted with dried mortar or concrete from previous placement operations shall be cleaned before placing new concrete.

03311.3.5.1 Bonding to Hardened Concrete. The surface of hardened concrete, upon which fresh concrete is placed, shall be rough, clean, and damp. The hardened surface shall be cleaned of all laitance and foreign substances, shall be washed with clean water, and shall be in a saturated-surface-dry condition by soaking with potable water for 8 to 24 hours before the fresh concrete is placed. Excess water shall be removed from the surface receiving concrete prior to placement.

The surface of hardened concrete shall be prepared by one of the following methods:

At the time of the initial concrete placement, a retarding agent shall be applied to the fresh concrete. After hardening, the concrete shall be pressure washed to remove the laitance and to expose the aggregate.

The hardened concrete shall be roughened to approximately 1/4 inch amplitude. The concrete may be roughened at the time of the initial concrete placement or by mechanical means after the concrete has hardened. The roughened surface shall expose the aggregate and have an open pore structure.

The prepared surface shall receive one of the following surface bonding treatments:

A 2 inch thick mortar puddle shall be deposited on hardened concrete in wall and column forms immediately before placing fresh concrete. The mortar puddle shall be the specified concrete mix, at the same water content, with the coarse aggregate omitted.

An epoxy bonding adhesive shall be used. The epoxy bonding adhesive shall be installed in accordance with the manufacturer's instructions. Concrete shall be placed before the adhesive sets.

03311.3.5.2 Conveyance and Distribution. Concrete shall be conveyed to the placement location by methods that prevent separation or loss of the ingredients.

03311.3.5.3 Depositing Concrete. Concrete shall be deposited in horizontal layers. The depth of a layer shall not exceed 24 inches. Each layer of concrete shall be plastic when succeeding layers are placed. Concrete shall be deposited without moving it laterally in the forms for a distance exceeding 5 feet, unless otherwise accepted by the Owner.

Plastic concrete is defined as concrete that allows the head of an operating immersion type vibrator head to penetrate its full length into the previously placed concrete by means of its own weight.

Concrete that is no longer plastic shall be prepared as specified in Article 03311.3.5.1 and slushed with mortar puddle. Mortar puddle shall be the specified concrete mix with the coarse aggregate omitted. The preparation of the in-place concrete shall be acceptable to the Owner before the successive layer of concrete is placed.

03311.3.5.3.1 Underwater concrete placement. Concrete placed under water shall be placed with a tremie system or other method acceptable to the Owner. A placement plan covering the number of tremie pipes, locations, and rate of placement shall be provided to the Owner prior to beginning placement activities. At the option of the Owner, a preplacement meeting may be scheduled to review

this plan and to coordinate placement activities and construction interfaces associated with this placement.

Tremie pipes shall be between 8 and 10 inches in diameter, or as required, to prevent aggregate blockage within the pipe during concrete placement. The concrete shall be placed at a rate to maintain the tremie pipe in the concrete mass with a minimum 3 foot head of concrete above the tremie pipe mouth.

03311.3.5.4 Consolidation. Concrete shall be compacted using mechanical immersion type vibrating equipment. Mechanical vibrators shall maintain at least 9,000 cycles per minute when immersed in the concrete. Each vibrator shall be driven by a 1-1/2 hp or larger motor. The number and type of vibrators shall be acceptable to the Owner.

03311.3.5.5 Hot Weather Concreting. Hot weather concreting shall be in accordance with the recommendations of the codes and standards specified.

At air temperatures of 90° F and above, special procedures shall be used to keep the concrete as cool as possible during placement and curing.

03311.3.5.6 Cold Weather Concreting. Cold weather concreting shall comply with the codes and standards specified. When the average of the highest and lowest temperature during the period from midnight to midnight is expected to drop below 40° F for more than 3 successive days, concrete shall meet the following minimum temperatures immediately after placement and shall be maintained at these temperatures throughout the curing period:

55° F for sections less than 12 inches in the least dimension.

50° F for sections 12 inches to 36 inches in the least dimension.

45° F for sections 36 inches to 72 inches in the least dimension.

40° F for sections greater than 72 inches in the least dimension.

Calcium chloride shall not be used.

Concrete shall not be placed on frozen ground. If the sub-grade is frozen, it shall be removed before concrete is placed.

If freezing weather is expected, the sub-grade receiving concrete shall be protected from freezing.

03311.3.5.7 Mass Concrete. Concrete for structures indicated on the Contractor's design drawings as mass concrete shall meet the following additional requirements. The temperature of concrete when deposited shall not exceed 70° F nor be less than 35° F, unless the Contractor submits an alternative placement plan for acceptance by the Owner.

The Contractor shall coordinate with the concrete supplier to meet the temperature requirements for the concrete at the delivery point.

The concrete shall be cooled gradually so that the drop in concrete surface temperature during and at the conclusion of the specified curing period does not exceed 20° F in any 24 hour period.

Concrete placed in cold weather shall meet the requirements for cold weather placement.

03311.3.6 Joints

03311.3.6.1 Construction Joints. Construction joints shall be located and constructed as indicated on the Contractor's design drawings. If an alternative arrangement of construction joints is desired or if they are not located on the drawings, drawings locating and detailing the proposed joints shall be submitted to the Owner before detailing and fabricating reinforcing steel. These joints shall be installed only where acceptable to the Owner.

All construction joints subjected to differential hydrostatic pressure shall be provided with a water stop. Water stops shall be furnished in other joints as indicated on the Contractor's design drawings.

03311.3.6.2 Movement Joints. Movement joints may be expansion, contraction, or isolation joints. These joints shall be located and constructed as indicated on the Contractor's design drawings. Expansion joint filler shall be firmly bonded to the previously placed joint face with a suitable adhesive. The new concrete shall be poured directly against the joint filler. Accessible edges of each joint shall be sealed with polyurethane sealant.

Movement joints shall be as detailed on the Contractor's design drawings.

Joints indicated on the Contractor's design drawings and those subjected to differential hydrostatic pressure shall be provided with a water stop installed as indicated on the Contractor's design drawings.

03311.3.6.3 Slab Control Joints. If sawed control joints are used, sawed joints shall be 1/8 inch to 5/32 inch wide with a minimum depth of one fourth of the slab thickness but not less than 1 inch. Reinforcement shall not be cut during joint sawing. These joints shall be located as indicated on the Contractor's design drawings. Cutting shall begin as soon as the concrete has hardened sufficiently to prevent dislodging aggregate. Sawing shall be completed within 12 hours of completing placement.

03311.3.7 Openings in Concrete

Concrete wall and floor openings for piping and other fixtures, installed after the walls and floors are built, shall allow sufficient space to properly compact concrete to fill the space around the pipe or fixture. The top of each wall opening shall be sloped or beveled to provide adequate space for placing and compacting the pipe embedment concrete. Water stops shall be provided around wall openings below grade and floor openings that are exposed to weather or submergence.

03311.3.8 Finishing Formed Surfaces

The standard finish shall be a rough form finish. Fins and other surface projections exceeding 1/4 inch shall be removed from all formed surfaces except exterior surfaces that will be covered with earth backfill. Surface finish shall be that imparted by the forms.

03311.3.9 Finishing Unformed Surfaces

No surface treatment will be required for buried or permanently submerged concrete. Unformed surfaces, designated as screeded surfaces on the Contractor's design drawings, shall be finished by screeding only. Surfaces designated as floated surfaces and all surfaces not otherwise designated shall be finished by screeding and floating. Surfaces designated as troweled surfaces shall be finished by screeding, floating, and troweling.

Float finished and screeded surfaces shall be finished to provide a flat profile within 1/4 inch deviation as measured from a 10 foot straightedge. Trowel finished surfaces shall be finished to form a flat plane. The surface profile shall not deviate more than 1/8 inch when measured from a 10 foot straightedge.

03311.3.9.1 Screeding. Screeding shall provide a concrete surface conforming to the designated elevations and contours with all aggregates completely embedded in adjacent mortar. Surface irregularities in screeded surfaces shall be limited to the tolerances specified.

03311.3.9.2 Floating. The surfaces shall be screeded and given an initial float finish as soon as the concrete has stiffened sufficiently to work. Coarse aggregate disturbed by the float or causing a surface irregularity shall be removed and replaced with mortar. Initial floating shall produce a surface of uniform texture and appearance.

Initial floating shall be followed by a second floating at the time of initial set. The second floating shall produce a smooth float finish of uniform texture and color.

Floating shall be performed with hand floats or suitable mechanical compactor floats.

03311.3.9.3 Troweling. Surfaces designated on the Contractor's design drawings shall receive a steel trowel finish. Troweling shall be performed after the second floating when the surface has hardened sufficiently to prevent excess cement from being drawn to the surface. Troweling shall produce a dense, smooth, uniform surface free from blemishes and trowel marks.

03311.3.9.4 Brooming. Brooming shall follow the float finish for surfaces so designated on the Contractor's design drawings. Brooming shall be done with an acceptable steel or fiber broom not less than 18 inches wide. Adjacent strokes of the broom shall overlap slightly. Broomed surfaces shall be free of porous spots, irregularities, depressions, and small pockets or rough spots.

03311.3.9.5 Aggregate Exposure. Surface mortar shall be removed and the aggregate exposed from surfaces that will be covered with mortar, concrete, or grout at a later time. The method used shall be effective and acceptable to the Owner.

03311.3.9.6 Edging. Unless specified to be beveled, exposed edges of floated or troweled surfaces shall be edged with a tool having a 1/4 inch corner radius.

03311.3.9.7 Finishing Mortar. Finishing mortar shall be added if there is not sufficient mortar available from the concrete mix. The proportions for this finishing mortar shall be 2.4 parts of concrete sand to one part of portland cement, by weight, mixed with enough water for proper application. Slump for finishing mortar shall not exceed 2 inches.

03311.3.10 Separate Finishes

Certain slab surfaces shall be finished with a separate concrete finish or floor covering as indicated on the Contractor's design drawings.

Base slab surfaces shall be ground or filled until each surface is within the specified tolerances and is acceptable to the Owner. Low areas shall be filled. High spots shall be ground slightly lower than required and then filled and smoothed to the proper elevation and surface.

Surfaces that receive epoxy set quarry tile and resilient tile shall be flat with a profile that shall not deviate more than 1/8 inch from a 10 foot straightedge placed on any part of the surface. These surfaces shall be either trowel finished concrete at the elevation indicated on the Contractor's design drawings or a float finished surface set 1/8 inch low and leveled with trowel finished fill material.

Surfaces that receive a mortar set quarry tile, ceramic tile, or terrazzo finish shall be given a smooth, tight, and uniform float finish with a profile tolerance of 1/4 inch as measured from a 10 foot straightedge.

03311.3.11 Curing

Concrete shall be protected from loss of moisture for not less than 7 days after the concrete is placed.

Concrete with mineral admixtures shall be cured for 14 days.

Troweled surfaces, except those that receive a separate finish or coating, shall be cured with a membrane curing compound. Float finished surfaces, except those that receive a separate finish, may be cured with either a membrane curing compound or with water. Only water curing shall be used if the

surface receives a separate finish unless the curing compound is compatible with the surface finish that will be installed.

03311.3.11.1 Water Curing. Water saturation of concrete surfaces shall begin as quickly as possible after initial set of the concrete, but not more than 30 minutes. The rate of water application shall be regulated to provide complete surface coverage with a minimum of runoff. The concrete surface shall not be permitted to dry.

Water retaining structures shall be water cured.

03311.3.11.2 Membrane Curing. Membrane curing compound shall be applied within 30 minutes after final finishing of the surface or as soon as possible after finishing without causing damage to the surface. Membrane curing compound shall be spray applied at a coverage rate recommended by the compound manufacturer. A dissipating curing membrane may be used in lieu of wet curing on surfaces that will be covered at a later date with mortar, concrete, dampproofing, tile, or coating.

03311.3.12 Not Used

03311.3.13 Repairing Defective Concrete
Surface defects in formed concrete shall be repaired to the satisfaction of the Owner within 24 hours at the Contractor's expense. Concrete that is porous, honeycombed, or otherwise defective to a depth in excess of 1 inch shall be cut out and removed to sound concrete. Edges shall be square cut to avoid feathering. Bonding surfaces shall have the laitance removed and the coarse aggregate exposed. A bonding compound shall be used between the hardened and repair concrete profile. When epoxy bonding adhesive is used, surfaces shall be prepared and the compound applied as recommended by the bonding agent manufacturer.

Defective concrete shall be replaced within 48 hours after the forms have been removed.

Concrete repair work shall not interfere with the curing of surrounding concrete. Mortar and concrete used in repair work shall be adequately cured and shall be finished to match adjacent surfaces.

03311.3.14 Duct Banks
Reinforcing steel and other magnetic materials installed in duct banks shall be parallel to the lengths of the ducts unless they enclose all the ducts of the duct bank.

Hardened surfaces that receive additional concrete shall have the surface prepared in accordance with Article 03311.3.5.1. The surface shall be thoroughly wetted and a thin coating of cement mortar shall be spread over the surface before concrete is placed.

Duct bank concrete shall be carefully compacted to avoid damaging the conduit. Concrete shall be worked around reinforcements and embedments and into the corners of the forms.

Red dye concrete shall be used.

03311.3.15 Tolerances
Tolerances shall be in accordance with ACI 117. The offset between adjacent pieces of formwork facing material for surfaces exposed to view shall not exceed 1/2 inch and for concealed surfaces shall not exceed 1 inch. Embedments shall meet the tolerances of Article 03311.3.4.

03311.3.15.1 Equipment Bases. Concrete bases and their embedments for structures and equipment shall meet the following tolerance requirements in addition to those already specified, unless otherwise specified by the equipment supplier.

Concrete form dimensions and placement shall be within 1/2 inch of the dimensions and locations indicated on the Contractor's design drawings. The top of the forms shall be accurately set to the designated elevation and within the specified tolerances.

The elevation of all points on all float finished surfaces shall be within 1/4 inch of the elevation indicated on the Contractor's design drawings. The elevation of all points on all trowel finished surfaces shall be within 1/8 inch of the elevation indicated on the Contractor's design drawings.

Anchor bolts and all other materials that are embedded in the concrete shall be accurately positioned and securely anchored. The center of each anchor bolt group or cluster shall be within 1/8 inch of the location indicated on the Contractor's design drawings. The center-to-center dimensions between the anchor bolts in a group or cluster shall be within 1/16 inch of the dimensions indicated on the Contractor's design drawings.

Elevation of top of anchor bolts shall be within 1/4 inch of the elevation indicated on the Contractor's design drawings.

03311.3.17 Field Control Testing
Tests shall be conducted in accordance with the following.

03311.3.17.1 Sampling. Field control tests shall be made at the point of placement in the presence of the Owner. Sampling should be performed for each 100 cubic yards or fraction thereof of each concrete mix placed each day. Equipment, supplies, and qualified personnel necessary for the field control testing shall be supplied.

Tests shall be performed by an acceptable independent testing laboratory or Contractor's qualified quality assurance (QA) personnel in accordance with the codes and standards specified in Article 03311.1.7. The frequency specified for each field control test is a minimum. Additional field control tests shall be made if requested by the Owner.

03311.3.17.2 Slump. A slump test shall be made from each of the first three batches mixed each day. An additional slump test shall be made for each additional 50 cubic yards of concrete placed that day.

When plasticizers and superplasticizers are added at the site, the slump shall be measured and recorded before and after the addition.

03311.3.17.3 Air Content. An air content test shall be made from one of the first three batches mixed each day and from each batch of concrete used to make compression test cylinders.

03311.3.17.4 Concrete Temperature. A concrete temperature test shall be made from one of the first three batches mixed each day and from each batch of concrete used to make compression test cylinders.

03311.3.17.5 Compression Tests. Concrete compression test cylinders shall be made each day concrete is placed. A set of five test cylinders shall be made from the same batch at intervals required by the referenced standard in Article 03311.1.7 unless alternate intervals are specified by the Owner.

Each set of compression test cylinders shall be marked or tagged with the date and time of day the cylinders were made, the location in the work where the concrete represented by the cylinders was placed, the delivery truck or batch number, the air content, and the slump.

For each set of cylinders, one cylinder shall be tested at an age of 7 days, two cylinders shall be tested at an age of 28 days, and two cylinders shall be stored until otherwise directed by the Owner.

03311.3.17.6 Test Reports. Test reports shall contain the information specified by ASTM C39 and the following additional information:

Date, time, and ambient temperature of pour.

Location of pour.

Mix class.

SECTION 03316
CONCRETE SUPPLY

03316.1 General

03316.1.1 Scope of Supply
Scope of supply shall include furnishing materials and batching, mixing, and delivering concrete to the point of placement. The scope of supply also includes other services as specified under these technical specifications.

03316.1.1.1 Pre-Job Concrete Conference. The Contractor shall attend a pre-job concrete conference that will include the Owner, placement contractor, testing contractor, and others as deemed necessary by the Owner. The time and location will be determined by the Owner.

The meeting will be for coordination of the supply, placement, finishing, and control testing. Issues impacting the execution of the work will be covered and decisions on resolving these issues will be documented and implemented in the work.

03316.1.1.2 Contractor's Onsite Representative during Delivery and Placement. The Contractor shall have a representative onsite during the supply and delivery of concrete. This representative shall have direct communication with the batch plant and shall be kept informed of any delays or other issues involving the steady supply of concrete to the placement location. This representative will also be monitoring weather and placement conditions at the site and communicating this information back to the batch plant so that adjustments in batching and delivery can be made to facilitate the steady consistent delivery of concrete to the point of placement. These services shall be included in the base cost of the concrete supply.

03316.1.2 Not Used

03316.1.3 Performance and Design Requirements
Performance and design requirements for concrete supply include the following:

Table 03316-1 Performance and Design Requirements

Mix Criteria and Limiting Requirements

Mix Class	Usage	Design Strength at 28 Days, psi	Maximum Coarse Aggregate Size, in.	Maximum Slump, in.	Maximum Slump with Superplasticizer (HRWR),* in.
A1	Lean work slabs, duct bank, fill concrete	2,000	1.5	6	10
B1	General usage	4,000	1	4	8
C1	Structure in contact with water or exposed to aggressive environment	5,000	1	4	8

Table 03316-1 Performance and Design Requirements					
Mix Criteria and Limiting Requirements					
Mix Class	**Usage**	**Design Strength at 28 Days, psi**	**Maximum Coarse Aggregate Size, in.**	**Maximum Slump, in.**	**Maximum Slump with Superplasticizer (HRWR),* in.**
D1	Foundation piers and cased reinforced concrete piling	4,000	0.75	4	8
E1	Underwater concrete	4,000 psi	1	6-9	--
* High range, water reducing.					
Mix Class	**Usage**	**Maximum Water/ Cementitious Materials Ratio**	**Air Content, percent**		**Cement Type**
A1	Lean work slabs, duct bank, fill concrete	0.55	0		As determined by Contractor
B1	General usage	0.45	3-6		As determined by Contractor
C1	Structure in contact with water or exposed to aggressive environment	0.40	3-6		As determined by Contractor
D1	Foundation piers and cased reinforced concrete piling	0.45	0		As determined by Contractor
E1	Underwater concrete	0.45	3-6		As determined by Contractor

03316.1.4 Codes and Standards

Work performed under these specifications shall be 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 03316-2 Codes and Standards	
Work	**In Accordance With**
Mix design and qualification	ACI 301 and ACI 318

Table 03316-2 Codes and Standards	
Work	**In Accordance With**
Concrete proportions	ACI 318, Chapter 5
Batch plant and production facilities	ASTM C94 and Concrete Plant Standards of the Concrete Plant Manufacturers Bureau
Ready-mix concrete	ASTM C94
Making, curing, and storing concrete cylinders	ASTM C192
Water soluble chloride limits	ACI 318, Chapter 4

03316.1.5 Materials

The following materials shall be used:

Table 03316-3 Materials	
General	
Component	**Material**
Cement	ASTM C150; type as determined by Contractor based on the degree of corrosiveness of the soil and groundwater and its affect on the cement type
Supplementary Cementitious Materials	
Fly ash	ASTM C618, Class C or F
Loss on ignition	Class C, 2 percent maximum (Class C not permitted with Type II or Type V cement); Class F, 4 percent maximum
Fine aggregate	ASTM C33; clean, natural sand
Coarse aggregate	ASTM C33, Class Designation 4S (include requirements of Appendix XI with documentation)
Chemical admixtures	
Water reducing	ASTM C494, Type A
Retarding	ASTM C494, Type B
Accelerating, noncorrosive, nonchloride type	ASTM C494, Type C
Water reducing, normal, mid-range, and retarding	ASTM C494, Type D
Water reducing, normal, mid-range, accelerating, non-corrosive, nonchloride type	ASTM C494, Type E
Water reducing, high range (extended slump life type)	ASTM C494, Type F

Table 03316-3 Materials	
General	
Component	**Material**
Water reducing, high range and retarding (extended slump life type)	ASTM C494, Type G
Air-entraining agent	ASTM C260

03316.1.6 Not Used

03316.1.7 Test Requirements

The following testing to support the mix designs 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 Contractor unless specifically identified as a Bid Option or Owner-conducted. Tests identified as an option are to be priced separately. If identified as Owner-conducted, costs for the initial test will be the responsibility of the Owner. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 03316-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Water soluble chloride ion testing	ASTM C1218	Contractor
Total air content	ASTM C231 and verified with ASTM C138	Contractor
Aggregate compliance	ASTM C33	Contractor
Aggregate soundness	ASTM C88	Contractor
Sand equivalent for fine aggregate	ASTM D2419	Contractor
Aggregate bulk specific gravity	ASTM C127 and C128	Contractor
Potential reactivity of aggregates	ASTM C33, Appendix XI	Contractor
Mortar bar method	ASTM C227	Contractor
Chemical method	ASTM C289	Contractor
Concrete cylinder compressive strength tests at 7 and 28 days	ASTM C39	Contractor
Initial set	ASTM C403	Contractor
Slump	ASTM C143	Contractor
Air content	ASTM C231	Contractor
Sulfate resistance	ASTM C452 or ASTM C1012	Contractor
Total water soluble chloride ion content	AASHTO Method T260	Contractor

Table 03316-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Concrete temperature	ASTM C1064	Contractor
Aggregate sampling	ASTM D75	Contractor
Aggregate sieve analysis (aggregate gradation)	ASTM C136	Contractor
Unit weight of concrete	ASTM C138	Contractor

Table 03316-5 Test Requirements, Concrete Material Control	
Concrete Material Control Testing Intervals	
Fine aggregate testing interval, tons	150
Coarse aggregate testing interval, tons	300
Sand equivalent, tons	150

03316.2 Products

03316.2.1 Work Included Under These Specifications
Concrete and miscellaneous materials and services shall be furnished complete as specified. Unless otherwise specified, the Contractor shall coordinate concrete delivery. Concrete shall be delivered to designated pour areas at the construction site. The point of delivery shall be at the discharge chute of the trucks.

03316.2.2 Materials
Materials shall meet the specifications listed in Article 03316.1.5.

03316.2.2.1 Material Control Testing. The following tests and the test reports shall be performed during the progress of the work. The testing frequency is specified in Article 03316.1.7.

03316.2.2.1.1 Aggregate gradation. Sampling and testing shall occur as specified in Article 03316.1.7 and at least every 6 months.

03316.2.2.1.2 Sand equivalent. The sand equivalent test shall be conducted each time the sand gradation tests are conducted.

03316.2.2.1.3 Supplementary cementitious materials (fly ash). Certified copies of sub-supplier's (source) test reports showing chemical composition and physical analysis for each shipment shall be provided to the Owner. The certification shall confirm compliance with the specifications. The certificate shall be signed by the mineral admixture sub-supplier.

03316.2.2.1.4 Cement. Certified copies of Contractor's (source) test reports showing chemical composition and physical analysis shall be submitted for each shipment delivered. Certification shall show that the cement complies with these specifications. The certificate shall be signed by both the cement manufacturer and the Contractor.

03316.2.3 Limiting Requirements
Unless otherwise specified, each concrete mixture shall be designed and controlled, within the following limits, to provide a dense, durable concrete suitable for the expected service conditions.

Each concrete mixture shall be designed and concrete shall be controlled within the limits specified in Article 03316.1.5.

03316.2.3.1 Cement Content Limits. The minimum quantity of portland cement or combined portland cement and mineral admixture in the concrete shall be as specified below.

Maximum cement content, when Type I cement is used, shall not be more than 1.15 times the minimum cement content specified. When a Type II or Type V cement is used, the cement content shall not be increased more than necessary to achieve the required compressive strength average (f'cr).

Table 03316-6 Minimum Cement Content

Aggregate Size, inch	Normal Exposures, lb/yd^3	Water Retaining Structures and Chemical Exposures, lb/yd^3 *	Concrete Placed Underwater, lb/yd^3
1-1/2	470	517	600
1	520	536	620
3/4	540	564	640
*Use these cement contents for concrete placed in regions with frequent freeze/thaw cycles.			

03316.2.3.2 Maximum Water-Cementitious Material Ratio. The maximum water-cement ratio shall be determined on a cement mass basis. If fly ash is used, the combined mass of cement and pozzolan shall be used to determine the water-cementitious materials ratio.

03316.2.3.3 Supplementary Cementitious Materials. When included in the concrete, supplementary cementitious material shall be within the following percentages of the combined weight of cementitious material:

Fly ash	15 to 20 percent

Class C fly ash shall not be used for concrete exposed to sulfates in service, unless sulfate resistance is documented by testing. Testing shall be by ASTM C452, ASTM C1012, or other method acceptable to the Owner.

03316.2.3.4 Aggregates. Fine aggregate shall be clean, natural sand. Artificial or manufactured sand will not be acceptable. Coarse aggregate shall be crushed rock, washed gravel, or other inert granular material.

Final gradation of the coarse aggregate shall conform to maximum nominal size grading requirements of the referenced standards when one size of aggregate or a combination of two or more sizes is used.

When specified to be performed in Article 03316.1.7, sand equivalent for fine aggregate shall not be less than 75 for an average of three samples tested.

The maximum coarse aggregate content consistent with workability and minimizing shrinkage shall be used in the mixture.

03316.2.3.5 Ratio of Fine to Total Aggregates. The ratio of fine to total aggregates, based on solid volumes (not weights), shall be as follows:

Table 03316-7 Ratio of Fine to Total Aggregates		
Coarse Aggregate Size from No. 4 Sieve to	**Ratio**	
	Minimum	**Maximum**
3/4 inch	0.35	0.50
1 inch	0.30	0.46
1-1/2 inches	0.25	0.42

03316.2.3.6 Slump. Concrete slump shall be kept as low as possible, consistent with proper handling and thorough consolidation. When a superplasticizer is used, slump shall be at least 2 inches and shall not exceed 3 inches before the addition of the superplasticizer.

If superplasticizer is to be dispensed at the ready-mix plant, the concrete mix design shall be based on the maximum slump specified in Article 03316.1.3. If superplasticizer is to be dispensed at the site, the slump shall not exceed the maximum specified slump before superplasticizer is added.

03316.2.3.7 Initial Set. The initial set shall be attained 5-1/2 hours ±1 hour after the water and cement are added to the aggregates for each concrete mixture. The quantity of retarding admixture shall be adjusted to compensate for variations in temperature and job conditions.

03316.2.3.8 Total Air Content. The total volumetric air content of concrete after placement shall be within ±1.5 percent of the specified value. Air-entraining admixture may be omitted from concrete for interior slabs to be trowel finished.

A plan for maintaining the specified air content during transit and placement shall be submitted to the Owner before placement begins.

03316.2.3.9 Chemical Admixtures. Unless otherwise acceptable to the Owner, all chemical admixtures shall be from one manufacturer and shall be compatible. Chemical admixtures that are compatible with other admixtures and concrete materials shall not have an adverse effect on the required properties of the concrete nor the specified limiting requirements. The chemical admixture content, batching method, and time of introduction to the mixture shall comply with these specifications and with the manufacturer's recommendations. The chemical admixture manufacturer shall provide qualified field services as necessary, at no additional cost to the Owner.

Chemical admixtures used in the concrete shall minimize shrinkage and shall be as recommended in writing by the chemical admixture manufacturer prior to conducting the laboratory trial concrete mixture testing. No calcium chloride or admixture containing calcium chloride shall be used. Chemical admixtures containing unrefined or raw lignosulfonic acids ("lignins") or their salts will not be acceptable.

Combinations of chemical admixtures which cause premature or local dehydration or post-compaction settlement of the concrete surface shall not be used. If any such undesirable characteristics are observed, the use of the mixture shall be discontinued and an alternate mix design used.

A water reducing chemical admixture shall be included in all structural concrete. When specified, a superplasticizer shall also be used in concrete. At the option of the Contractor, a superplasticizer may be used in all concrete. When a superplasticizer is used, the chemical admixture manufacturer shall recommend to the Owner, in writing, the type of superplasticizer to be used with the required water reducing admixture to achieve the specified initial set times. Superplasticizer may be dispensed into the concrete at the plant or at the jobsite and shall be mixed in accordance with the admixture manufacturer's recommendations. Each superplasticizer dose, when dispensed at the site, shall be easily verifiable and recorded on the delivery ticket. The superplasticizer for each load shall be accurately proportioned into a separate container prior to dispensing the admixture into the concrete. When truck mounted dispensers

are used, the system shall not be flushed or cleaned with water until after the entire load of concrete has been discharged. When redosing of superplasticizer at the site is permitted by the Owner, redosing shall be done only once. Redosing procedures shall be as recommended by the chemical admixture manufacturer.

When chemical admixtures are used in large dosage rates (10 oz or more per 100 lb of cementitious material), their water content shall be included in the total unit water content.

03316.2.3.10 Pumped Concrete. Coarse aggregate size for pumped concrete mixtures shall be limited to a maximum of 1-1/2 inches.

The slump of concrete, with or without a superplasticizer, that is discharged into the pump may exceed the specified maximum slump value by the amount of slump loss in the pumping system, up to a maximum of 1 inch. The slump loss shall be determined by tests made at each end of the pumping system.

03316.2.3.11 Special Requirements for Hot Weather. A water reducing retarder shall be included in the concrete mix when the temperature of the concrete placed exceeds 75° F.

03316.2.3.12 Strength. Concrete shall achieve an average strength above the specified design strength provided in Article 03316.1.3. Statistical data for 28 day strengths and the moving average of three 28 day strengths shall be maintained for each mix.

03316.3 Execution

03316.3.1 Proportioning

03316.3.1.1 Mix Design. A tentative concrete mixture shall be designed and tested in the laboratory for each size and combined gradation of aggregates and for each mix specified for use on the work.

Concrete proportions shall be established based on field experience, laboratory trial mixtures, or both. Established mixes with documented historical records meeting the specified requirements for the concrete may be used for the work. The qualification records for these mixes shall be submitted for acceptance prior to beginning the work. If these records are acceptable, additional mix design testing is not required.

Mixtures shall be adjusted in the field as necessary, within the limits specified, to meet the requirements of these specifications.

03316.3.1.2 Preliminary Review. Reports covering the source and quality of concrete materials and the concrete proportions proposed for the work shall be submitted to the Owner for review before performing the required trial mixture designs and before concrete work is started. Review of these reports will be for general acceptability only, and continued compliance with all contract provisions will be required.

03316.3.1.2.1 Mix design. Design quantities and test results on each mix shall be accepted before concrete work is started. The report on each tentative concrete mix and on the proposed concrete mixture shall contain the information required in the Schedule of Submittals.

03316.3.1.3 Mix Design Testing. Unless specified otherwise, all tests and reports required for preliminary review shall be made specifically for this project. All materials shall be tested in accordance with the specified test methods, and reports for these tests shall be prepared specifically for this project. If the source of any concrete materials is changed during the contract, the materials and the new mix design shall be tested in accordance with the specified preliminary review requirements. Reports shall then be submitted for review.

The tests listed in Article 03316.1.7 shall be performed and reported for each mix class as required by the referenced codes and standards, unless modified by the following requirements.

03316.3.1.3.1 Initial set. Initial set tests shall be made at ambient temperatures of 70° F and 90° F to determine compliance with the specified time for initial set. The test at 70° F shall be made using concrete containing the specified normal set/water reducing admixture and, when required, air-entraining admixture. The test at 90° F shall be made using concrete containing the specified retarding/water reducing admixture and, when required, air-entraining admixture.

03316.3.1.3.2 Trial batch with superplasticizer. A preliminary test on a trial batch shall be conducted at the project site, using the proposed superplasticizer in the accepted mixture design to determine the correct dosage. When superplasticizer is not included in the trial mixture, the trial batch tested at the site shall be used to determine the compatibility of the superplasticizer with the other materials used in the concrete, including the other admixtures.

03316.3.1.3.3 Alkali-aggregate reactivity. When specified, alkali-aggregate reactivity potential shall be determined in accordance with Appendix XI of ASTM C33. Aggregates shall be tested in accordance with ASTM C289 and C295 to determine potential reactivity. Aggregates which do not indicate a potential for alkali reactivity or do not have reactive constituents may be used without further testing. Aggregates which indicate a potential for alkali reactivity shall be further tested in accordance with ASTM C227 or C1105, as appropriate, using a cement containing less than 0.6 percent alkalis. At the discretion of the Owner, testing in addition to that indicated in Appendix XI of ASTM C33 may be performed on potentially reactive aggregates. Nonreactive aggregates shall be imported if, in the opinion of the Owner, local aggregates exhibit unacceptable potential reactivity.

03316.3.1.3.4 Water soluble chloride. Maximum water soluble chloride ion concentrations in hardened concrete at an age of 28 days shall not exceed the limits expressed as a percentage of mass of cement as specified in the referenced code in Article 03316.1.4.

Test results shall be reported as the percentage of water soluble chloride ions in the concrete and as a percentage of chloride ion relative to the mass of cement in the concrete.

Testing of the concrete components, except aggregates, for water soluble chloride ions shall be done during material and mix qualification and at the discretion of the Contractor during the course of supply. Copies of the reports on such tests shall be furnished to the Owner.

The hardened concrete and each gradation of aggregate used in the concrete shall be tested each time a chloride ion test is conducted on a concrete mixture.

03316.3.2 Batching

Aggregates, mineral admixture, and cement shall be measured by weight. Aggregate weights shall be adjusted for the moisture content.

Correct proportions of admixtures shall be dispensed automatically.

The amount of water required to produce the desired slump shall be batched automatically. Additional water needed to maintain a uniform slump shall be added manually by the mixer operator. This additional site-added water shall be limited to a volume that maintains the total mix water to within the volume defined by the maximum specified water-cement ratio for that mix. Slump shall be kept uniform. Aggregates shall float uniformly throughout the mass. The concrete shall flow sluggishly when vibrated.

03316.3.3 Mixing

Concrete shall be mixed until all ingredients are uniformly distributed throughout the batch. Mixers shall not be loaded in excess of their rated capacities.

If the mixing water is added at the worksite, only the prescribed amount of mixing water required by the mix design shall be placed in the mixing tank, unless the tank is equipped with a meter allowing the amount of water added to each batch to be verified. If water content does not exceed limiting requirements, water may be added to the concrete at the discharge point. Only one application of water will be allowed. The water shall be incorporated into the mix by at least 30 revolutions of the truck mixer at mixing speed.

If a high range water reducer (superplasticizer) is used, slump shall be controlled by the addition of measured amounts of admixture instead of adding water.

03316.3.4 Delivery

Delivery tickets shall be prepared for each load of concrete. Tickets shall be presented to the Contractor receiving the concrete to acknowledge receipt of the concrete. These signed delivery tickets shall be distributed as follows:

Original to the Contractor and one copy to the Owner.

Delivery tickets shall indicate the following:

Serial number of ticket.

Truck number.

Mix class of concrete.

Quantity delivered (include weights of constituent materials).

Date and time of delivery.

Outdoor temperature in the shade.

Time when cement was combined with water or wet aggregates.

Design slump without superplasticizer.

Design slump after addition of with superplasticizer.

Numerical sequence of delivery.

Time of concrete discharge from the truck and time when the truck is released after discharge.

Quantity and type of admixtures.

Site dispensed admixtures and volume dispensed.

Allowable water permitted after batch water added, and quantity of extra water added.

Percent moisture compensation for each type of aggregate.

Both "heated" or "cooled" concrete checkoffs.

Concrete temperature at batch plant.

Concrete shall be discharged within 90 minutes or before the drum has revolved 300 revolutions after the introduction of the mixing water to the cement and aggregates, or the introduction of the cement to wet

aggregates. In hot weather, or under conditions contributing to quick stiffening of the concrete, a shorter time period may be required by the Owner. Concrete that does not meet this time requirement may be rejected.

03316.3.4.1 Hot Weather Concrete. Concrete delivered in hot weather shall be in accordance with the recommendations of the codes and standards specified. Hot weather concrete procedures shall include cooling the mix water, aggregates, and cement; the addition of ice; and other processes to accomplish the concrete work.

Concrete temperature at the time of placement shall not exceed 95° F. Loss of slump, flash set, and cold joints are unacceptable.

At air temperatures of 90° F and above, special procedures shall be used to keep the concrete as cool as possible during placement.

03316.3.4.2 Cold Weather Concrete. When the average of the highest and lowest temperature during the period from midnight to midnight is expected to drop below 40° F for more than 3 successive days, concrete shall be delivered to meet the following minimum temperature immediately after placement:

55° F for sections less than 12 inches in the least dimension.

50° F for sections 12 inches to 36 inches in the least dimension.

45° F for sections 36 inches to 72 inches in the least dimension.

40° F for sections greater than 72 inches in the least dimension.

03316.3.4.3 Mass Concrete. Concrete supplied for mass concrete sections shall be delivered so the temperature of concrete when deposited does not exceed 70° F or is not less than 35° F, unless the Contractor submits an alternative plan for acceptance by the Owner.

Concrete delivered in cold weather shall meet the requirements for cold weather placement.

03316.3.5 Evaluation and Acceptance of Concrete
Concrete will be evaluated for compliance with all requirements of the specifications. Concrete strength will be only one of the criteria used for evaluation and acceptance of the concrete. The results of all tests performed on the concrete and other data and information concerning the procedures for handling, placing, and curing concrete will be used to evaluate the concrete for compliance with the specified requirements.

03316.3.5.1 Compression Test Evaluation. Compressive strength test results will be evaluated for compliance with the specified strength requirements and the specified requirements that relate to durability.

A strength test shall be the average of the compressive strengths of at least two cylinders made from the same concrete sample tested at 28 days.

03316.3.5.1.1 Strength. When required for compliance with the strength requirement, the strength level of the concrete will be considered satisfactory when the averages of all sets of three consecutive strength tests equal or exceed the specified compressive strength, f'c, and no individual strength test result falls below the specified compressive strength by more than 500 psi.

03316.3.5.2 Not Used.

03316.3.5.3 Substandard Concrete. Strength of delivered concrete shall meet the minimum compressive strength specified. If a test cylinder indicates that the concrete strength is less than the specified minimum, the concrete represented by the test shall be investigated at the Owner's option. The investigation shall include sampling and testing of the concrete in place to verify the results of the cylinder test. The Contractor shall cooperate with the Owner during sampling and testing and shall pay all associated costs, including the replacement of concrete for the samples removed.

SECTION 03611
GROUTING

03611.1 General

03611.1.1 Scope of Work
Scope of work shall include surface preparation, grout materials, placement, and curing of grout placed under baseplates and soleplates for equipment and structures.

03611.1.2 Not Used

03611.1.3 Performance and Design Requirements
Unless otherwise specified below, performance and design requirements for the grouting are indicated in Article 03611.1.5.

03611.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 03611-1 Codes and Standards

Work	In Accordance With
Grout mixing and placing	Manufacturer's instructions

03611.1.5 Materials
The following materials shall be used:

Table 03611-2 Materials

General	
Grouting	**Application**
General purpose non-shrinking cementitious grout	Structural columns, tank bases, stationary equipment, and pumps and compressors up to 25 hp
Precision non-shrinking cementitious grout	Structural columns and equipment experiencing light to moderate dynamic loads; equipment with large baseplate area requiring long grout flow distances; equipment requiring precision alignment
Epoxy grout	Moderate nonacidic chemical exposures or dynamic machinery such as pumps and motors, when specified in Article 03611.1.3
Acid resistant grout	Areas where acid exposure exists, such as acid storage tanks, acid regeneration racks, battery rooms, and acid containment areas
Prejob grout meeting	Yes

Table 03611-3 Materials	
Specific	
Component	**Material**
General purpose non-shrinking cementitious grout	Grout shall meet ASTM C1107 and the following additional requirements within the temperature range of 50° F and 90° F: Compressive strength shall be a minimum of 5,000 psi at 28 days. Extended working times shall be 30 minutes at a flowable consistency. Grout shall not bleed at the manufacturer's maximum recommended water content.
Precision non-shrinking cementitious grout	Unless specifically listed as an acceptable product below, grout shall meet ASTM C1107 and the following additional requirements within the temperature range of 45° F and 90° F: Compressive strength shall be a minimum of 5,000 psi at 28 days. Extended working times shall be 60 minutes at a flowable consistency. Grout shall not bleed at the manufacturer's maximum recommended water content.
Epoxy grout	100 percent solids, thermosetting epoxy resins and inert fillers with minimum 7 day compressive strength of 12,000 psi. Modulus of elasticity shall be at least 3×10^6.
Acid resistant grout	Acid resistant grout shall be as specified under Article 03611.1.6.

03611.1.6 Approved Manufacturers of Components

For the following components, the manufacturers are listed below provide examples of the quality of product and field support services required by these specifications. If the Contractor wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be identified and supporting data provided. Acceptance of the manufacturer as a substitute is at the discretion of the Owner:

Table 03611-4 Approved Manufacturers of Components	
Component	**Manufacturer**
General purpose non-shrinking cementitious grout	Ameren Missouri Approved Suppliers
Precision non-shrinking cementitious grout	Ameren Missouri Approved Suppliers
Epoxy grout	Ameren Missouri Approved Suppliers

Table 03611-4 Approved Manufacturers of Components	
Component	**Manufacturer**
Acid resistant grout	Ameren Missouri Approved Suppliers

03611.1.7 Test Requirements
The following testing for cement grouts shall be conducted in accordance with the specified standards listed in the following table. Strength shall meet the requirements of ASTM C1107. This testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Contractor. Field testing of the grout shall be performed as follows.

03611.1.7.1 Field Flow Cone Testing. Field flow cone tests shall be performed as specified below to establish the water content that will meet the fluid consistency performance for the grout. The maximum and minimum water content shall be established to confirm the fluid consistency will meet the specified grout strength. Grout cubes shall be made and tested from the same batch that the flow cone measurements are taken at the upper and lower water content range being established for the placement.

Contractor may propose a method to establish the water content limits for the fluid consistency as a substitute for the flow cone tests, if acceptable to the Owner. Adequate documentation shall be provided to substantiate the reliability for this substitute procedure:

Flow cone testing shall be performed at the following frequency:

Prior to the first grouting operation as directed by the Owner.

Each new lot of grout material.

Compression testing shall be performed at the following frequency:

A minimum of one compression test for each individual placement operation each grouting day, if less than 5 cubic feet.

One compression test for each additional 5 cubic feet or fraction thereof, for each individual placement operation.

Table 03611-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Field flow cone (20 to 30 seconds reading)	ASTM C939	Contractor
Field compression test cubes (three 2 inch cubes)	ASTM C109 as modified by ASTM C1107	Contractor

03611.2 Products
The product shall be as specified in Article 03611.1.5.

03611.3 Execution

03611.3.1 Baseplate Grouting
Baseplates shall be grouted in place to obtain a uniform and solid bearing surface. Grouting methods used shall provide complete, void free filling of all space beneath the baseplate. Alignment or level of baseplates shall not be disturbed during grouting procedures.

All anchor bolt sleeves shall have closed cell foam and excess water removed prior to grouting operations.

03611.3.1.1 Pre-Job Grout Meeting. If specified in Article 03611.1.5, a pre-job grout meeting shall be held with the grout manufacturer's representative to confirm mixing and placement procedures to ensure proper grout performance for conditions expected at the jobsite. The Owner shall be invited to attend this meeting.

Upon 72 hours' notice, the manufacturer shall make available, at a time and place designated by the Owner, a well-trained manufacturer's representative for pre-installation and/or jobsite conferences. This representative must be knowledgeable in the installation and use of his product as it relates to the project at hand.

03611.3.2 Surface Preparation
Hardened concrete surfaces where grout is to be placed shall be mechanically prepared by chipping or sandblasting to remove laitance, to expose sound surface mortar, and to provide a fractured aggregate surface. Prepared surfaces shall be cleaned to remove oil, grease, curing compound, or other foreign materials that prevent a proper bond between grout and concrete. Surface preparation for epoxy and acid resistant grout shall be in accordance with the manufacturer's instructions. For cementitious grout, the prepared surface shall be flooded with potable water for 8 to 24 hours prior to grout placement and the surface shall be wet without standing water or puddles immediately prior to grout placement. If compressed air is used to blow off excess water, the air compressor shall have an oil separator.

Prepared surfaces shall be in accordance with the grout manufacturer's recommendations.

03611.3.3 Alignment and Leveling
Baseplates shall be set in place over anchor bolts, properly aligned, and leveled using three-point control. Leveling shall be accomplished using leveling screws with nuts above and below temporary lugs attached to the base.

Steel wedges may be used for leveling in lieu of leveling screws. Precautions shall be taken to prevent steel wedges from being dislodged during grout placement. Steel wedges shall be encapsulated by a minimum of 2 inches of grout.

Wood blocking or wood wedges shall not be used.

Steel wedges used with cementitious non-shrinking grout may remain in place but must be completely covered with the grout.

03611.3.4 Mixing
Grout shall be mixed as recommended by the grout manufacturer.

03611.3.5 Placement
Proper alignment and level shall be verified and accepted by the Owner before placing grout. Grout shall be used immediately after mixing before stiffening occurs. The temperature of the grout at placement shall not exceed the manufacturer's recommendations. Placement methods used shall provide grout surfaces that are completely filled, without voids.

Low dams enclosing the base shall be used to contain flowable grout mixtures. Adequate space shall be provided between the dam and base to permit pouring and manipulation of the grout. The top of the dam shall be higher than the bottom of the base. The space below the base shall be completely filled. All air and water pockets shall be eliminated to create a solid grout mass without voids.

03611.3.6 Cementitious Grout

03611.3.6.1 Finishing. Grout shall remain undisturbed after placing until a stiff set is obtained. The dam shall be removed, and the edges shall be finished by removing excess grout. The edges shall be beveled at an angle of approximately 45 degrees. Exposed edges of the foundation and adjacent surfaces shall be cleaned to remove all grout.

03611.3.6.2 Curing. When finishing is completed, wet curing shall be provided by applying liberal amounts of potable water for a minimum of 24 hours unless required otherwise by the grout manufacturer's instructions. Following wet curing, curing compound acceptable to the Owner may be applied to all exposed surfaces as an alternative to continued wet curing. During wet curing, a covering of wet rags and polyethylene sheets may be used to maintain the grout in a wet environment for the period of time required by the manufacturer's standards. The grout shall not be allowed to freeze during the curing period.

Special procedures shall be used to keep the grout cool when air temperatures of 90° F or higher are encountered.

03611.3.7 Epoxy and Acid Resistant Grouts
Placing, finishing, and curing of epoxy and acid resistant grouts shall be in accordance with the manufacturer's instructions.

SECTION 05120
STRUCTURAL STEEL

05120.1 General

05120.1.1 Scope of Work

Work under these specifications shall include furnishing structural steel, erecting structural steel, and providing miscellaneous materials and services complete as specified herein:

Scope of Supply:
Structural steel detailing and production of fabrication and erection.
Material procurement, fabrication, surface preparation, coating application, and shipping in accordance with these specifications and the Contractor's design drawings.
Scope of Erection:
Receipt, inspection, unloading, storage, and erection of materials furnished under these specifications.
Preparation of galvanized slip-critical connection faying surfaces.
Supply and install touchup coatings.

05120.1.1.1 Miscellaneous Materials and Services. Miscellaneous materials and services not otherwise specifically called for shall be furnished by the Contractor in accordance with the following:

All high strength bolts, nuts, and washers required for the materials furnished under these specifications.

Holes in columns for safety cable, in accordance with OSHA.

All other component parts and connection materials required for a complete structural framing system.

Grounding lug holes near base of all columns. The holes shall be suitable for two hole grounding lugs.

All shims required at structural steel connections and column shim packs when required.

Tests and inspections required by the specifications.

05120.1.1.2 Miscellaneous Materials and Services for Erection. Miscellaneous materials and services not otherwise specifically called for shall be furnished by the Contractor in accordance with the following:

Supply and install safety cables in all areas left unprotected by permanent railings. Safety cables shall be removed after the permanent railing systems are in place.

Supply all fit-up bolts, welding electrodes, welding, and other fasteners that are necessary for the completion of the work.

Supply and install all post-installed mechanical expansion type concrete anchors necessary for the completion of the work. The manufacturer's installation instructions shall be strictly followed.

Supply, install and remove all temporary bracing, rigging, attachments, and supports.

Survey and lay out the work from the designated control points.

Provide detailed erection procedures for any lift over 50 tons to the Owner for approval 15 calendar days prior to the lift.

Grout and grouting (refer to Section 03611).

Set, shim, level and grout all baseplates and shear posts.

Tests and inspections required by the specifications.

05120.1.2 Not Used

05120.1.3 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 05120-1 Codes and Standards

Work	**In Accordance With**
Structural steel	AISC Steel Construction Manual, Thirteenth Edition
Structural steel	AISC Code of Standard Practice for Steel Buildings and Bridges, AISC 303-05, March 18, 2005. Articles 1.7.1, 1.7.2, 3.6, 4.4, 4.5, 6.5.1, 6.7.4, 7.1, 7.2, 7.6, 7.7, 7.13.3, 7.16, 7.17, 8.4, 8.5.4, 9.3, 9.4, 9.5, 9.6, and 10.4.2 of the above referenced code shall not apply, nor shall any other requirement of this code which conflicts with the requirements of these specifications and documents.
Structural steel	AISC Specification for Structural Steel Buildings, AISC 360-05, March 9, 2005, with Commentary and Supplements. AISC Seismic Provisions for Structural Steel Buildings, 341-05, March 9, 2005, with Commentary and Supplements
Structural steel	AISC Certification Standard for Steel Building Structures (STD)
Structural steel	OSHA Standards – 29 CFR Part 1926 Subpart R, Steel Erection
Structural steel	ASTM A6/A6M

Table 05120-1 Codes and Standards	
Work	**In Accordance With**
Crane rail installation	CMAA Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling Cranes – No. 70
Bolting	Research Council on Structural Connections Specification for Structural Joints Using ASTM A325 or A490 Bolts, June 30, 2004
Welding	ANSI/AWS D1.1 Structural Welding Code - Steel
Coatings	SSPC Paint Application Specification No. 1, "Shop, Field and Maintenance Painting"

05120.1.4 Materials

The following materials shall be used:

Table 05120-2 Materials	
Component	**Material**
Structural steel shapes and plates	ASTM A36/A36M or ASTM A572/A572M, Grade 50 or ASTM A992/A992M
Structural steel baseplates and plate over 4 inches thick	ASTM A36/A36M or ASTM A588/A588M, Grade 42
Structural steel shim plates and fill plates	Material to match parent steel material
Structural tubes	ASTM A500, Grade B
Steel pipes	ASTM A53, Type E or S, Grade B
Crane rails	
Rails	ASCE
Rail splices	Bolted
Rail attachments	Patented rail clips
High strength bolts, nuts, and washers	
ASTM A325, Type 1 bolts	7/8 inch diameter
Direct tension indicators	ASTM F959, compatible with bolts
Flat and beveled hardened washers (where required)	ASTM F436, compatible with bolts
Heavy hex nuts	ASTM A563, compatible with bolts
Welding electrodes	Low hydrogen types, with a minimum tensile strength = 70,000

Table 05120-2 Materials	
Component	**Material**
Ladders	ASTM A36/A36M
Post-installed mechanical anchors	Federal Specification A-A-1923A, Type 4; ACI 318, Appendix D; IBC compliant; and tested to ICC AC-193 with corresponding ICC ESR report Hilti Kwik-Bolt TZ Expansion Anchor (ICC ESR-1917 report) or Hilti HDA Undercut Anchor (ICC ESR-1546 report)
Post-installed adhesive anchors	IBC compliant and tested to ICC AC-308 with corresponding ICC ESR report Adhesives: Hilti HIT RE 500-SD (ICC ESR-2322 report) Anchors: Hilti HAS Standard Rods (A36) Hilti HAS Super Rods (A193 B7) Hilti HIT-TZ Rods
Open web steel joists	As specified in the "Catalog of Standard Specifications and Load Tables for Steel Joists and Joist Girders" of the Steel Joist Institute

05120.1.5 Additional Requirements
Additional requirements for the materials and coatings to be furnished under this section of these specifications are indicated herein:

Table 05120-3 Additional Requirements	
Connection Requirements	Shop welded, field bolted
Bolting Requirements	
Slip-critical connection scope	All connections with oversized or long-slotted holes in one or more plies
Pre-tensioned connection scope	All structural connections not required to be slip-critical; threads included in the shear plane
Snug-tightened connection scope	Connections to nonstructural steel components
Slip-critical connections, contact surface class	Class B
Control of bolt tension	DTIs or Twist-off bolts
Coating Requirements	

Table 05120-3 Additional Requirements	
Structural steel shapes, plates, tubes and pipes - Exterior location	Hot-dip galvanized. Optionally ductwork support steel may be painted in accordance with Section 09900.
Ladders - Exterior location	Hot-dip galvanized
Structural steel shapes, plates, tubes and pipes - Interior location	In accordance with Section 09900
Ladders - Interior location	In accordance with Section 00900
Crane rails	None
High strength bolts, nuts, and washers	Mechanically galvanized in accordance with ASTM B695 Class 50 (A325 and F1852 only). All connection components shall receive the same coating. When bolts are galvanized, washers and nuts shall be mechanically galvanized.
Additional Coating Requirements	
Shop or Field touchup	Touchup painting shall be in accordance with Section 09900 and the material supplier's recommendations.

05120.1.6 Approved Manufacturers of Components

For the following components, the manufacturers listed below provide examples of the quality of workmanship required by these specifications. If the Contractor 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 Owner:

Table 05120-4 Approved Manufacturers of Components	
Component	**Manufacturer**
High strength bolts	Approved US supplier
Patented rail clips	Refer to "Supplemental General Conditions, Appendix C - Ameren Missouri Approved Suppliers"
DTIs, DTIs using a silicon gel marker to indicate full-tension are not acceptable	Refer to "Appendix C - Ameren Missouri Approved Suppliers"

05120.1.7 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 Contractor unless specifically identified as a Bid Option or Owner-conducted. Tests identified as an option are to be priced separately. If identified as Owner-conducted, costs for the initial test will be the responsibility of the Owner. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 05120-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Nondestructive Testing of Welds		Contractor
Testing of High Strength Bolts by Bolt Manufacturer, ASTM A325, A490, and F1852	ASTM A325, ASTM A490, and ASTM F1852, Production Lot Method	Manufacturer
Testing of DTIs	ASTM F959, Article 10.2, Production Lot Method	Manufacturer

05120.2 Products

05120.2.1 Drawing Requirements
Contractor produced drawings shall be in accordance with the following requirements:

Each drawing submitted shall indicate the name of the project, the unit designation, the contract title, the contract number, the name of the building structure, and the Contractor's name. In addition, the Owner's identification number will be affixed by the Owner to each Contractor's initially submitted shop drawing. This number shall be maintained on all subsequent submittals of the drawings in the identical format and location as originally indicated by the Owner. Submittals shall be in accordance with Appendix J and Section 1A, 5.0.

Erection drawings shall be submitted with, or prior to, the submittal of the corresponding detail drawings.

A field bolt list indicating the number and length of each bolt shall be submitted.

Details of the proposed typical beam connections shall be submitted with the first package of drawings.

Erection drawings shall include baseplate setting plans.

Each detail drawing shall include a Bill of Material. The total weight, area, or length of material on each sheet shall be listed on every detail drawing.

Each detail drawing shall indicate the mark number of each fabricated piece as assigned by the Contractor and list any material identification numbers assigned by the Owner.

Detail drawings shall indicate the top elevation of all horizontal members.

05120.2.2 Materials
Materials shall be new and unused and shall conform to the following.

05120.2.2.1 Steel Certification. Signed chemical-composition and mechanical-property mill certifications shall be obtained for all steel purchased under this specification. If requested, a copy of the mill certifications shall be provided to the Owner.

05120.2.2.2 Bolt Inspection - Manufacturer. High strength bolts shall be tested by the manufacturer prior to shipment in accordance with the Production Lot Method. If requested, a copy of the inspection test reports shall be forwarded to the Owner.

The Owner reserves the right to independently test the bolt materials. Should the bolt materials be found to be defective, they shall be replaced at the Contractor's expense.

05120.2.2.3 DTIs - Manufacturer. DTIs shall be inspection tested by the manufacturer prior to shipment in accordance with the Production Lot Method described in ASTM F959, Article 10.2. If requested, a copy of the inspection test reports shall be forwarded to the Owner.

The Owner reserves the right to independently test the DTIs. Should the DTIs be found to be defective, they shall be replaced at the Contractor's expense.

05120.2.3 Structural Steel Fabrication

05120.2.3.1 Tolerances and Fabrication. Structural steel shall be fabricated to the dimensions, arrangements, sizes and weights, or thicknesses indicated on the drawings or required by these specifications.

Structural steel shall be fabricated to tolerances that will permit field erection within AISC tolerances, except that the displacement of any column center line from the established column line shall not be more than 1 inch at any point in the total height of the column.

Girts and other members, to which wall panels will be attached, shall be fabricated to allow the faces of these members to be field aligned in true vertical planes within 1/8 inch tolerance. Connection holes of girts shall be slotted to allow adjustment between girts and their supports.

Crane runway girders shall be fabricated with the following tolerances. Sweep shall not exceed 1/4 inch in a 50 foot girder length. Camber shall not vary from the camber given on the drawings by plus or minus 1/4 inch in a 50 foot girder length. Squareness shall be maintained within 18 inches of each girder end such that the flanges in this zone shall be free of curvature and normal to the girder web. Crane runway girders and their supports shall be furnished with shim packs that will allow the girder and crane rail assembly to be installed within the specified erection tolerances.

Cuts, copes, and holes shall be clean cut without torn, ragged edges or burrs.

Unnecessary bolt holes in structural steel materials less than 1-1/2 inches in thickness shall be filled with weld metal and ground smooth. These repairs shall be made before preparing the member for shop painting or galvanizing. Unnecessary bolt holes in structural steel material 1-1/2 inches or greater in thickness shall be plugged with high strength bolts.

The radius of beam copes and weld access holes shall be provided free of notches and shall be in accordance with AWS D1.1. Repair of notches shall be in accordance with AWS D1.1.

The locations and details of all welded splices in structural members or components shall be acceptable to the Owner. Unauthorized splices are not allowed. Splices will not be permitted in areas of high stress. The Owner's acceptance of splice locations shall be obtained before fabrication.

Holes and other provisions for field connections shall fit when the units are assembled in the field. Where required by the Contractor's design drawings or by the necessity of proper identification and fitting of field connections, the connections shall be matchmarked.

05120.2.3.2 Bearing Surfaces. Contact surfaces at column splices and other compression joints requiring contact bearing shall have the bearing surfaces prepared to a common plane by milling, sawing, or other acceptable means.

Bearing surfaces of column connections at baseplates and column splices shall be square and in full contact with each other. Gaps not exceeding 1/16 inch in a contact joint will be acceptable, provided the

vertical tolerances of these specifications are met and 70 percent of the joint is in full contact. Out-of-square column connections exceeding these limits shall be corrected by the Contractor at no expense to the Owner.

05120.2.3.3 Splice-Fill Plates. Fill plates shall be detailed and provided for all gaps of 1/16 inch and greater in column splices and vertical bracing connections. Where fill plates are required to correct for variations in depth of the spliced columns and vertical bracing, sufficient plates shall be provided to allow for rolling tolerances, etc.

Erection holes shall be provided in the web or splice plate of each column section.

05120.2.3.4 Column Baseplates. Baseplates shall be cut to the proper size. The baseplate top shall be pressed or milled at the bearing surface to provide full bearing to the column.

Each loose baseplate shall be provided with shim packs.

05120.2.3.5 Monorails and Crane Runways. Steel beams used as monorails shall be straight and level. The upper surface of the lower flange of each beam shall be smooth and free of projections. Top surfaces of the lower flange at joints shall be close fitting. Stops made from angles shall be bolted to the beam at each end of the monorail to limit travel of the hoist trolley.

Crane runway girders shall be fabricated to the tolerances specified herein. Crane rails shall be fabricated with tight joints at the rail splices. Rail ends shall be finished by milling or grinding to ensure tight fit-up. Crane rail accessories shall be provided for tight fit installation and shall include splice plates, bolts, nuts, rail clips, and end stops.

05120.2.4 Bolted Connections

Bolt holes shall be standard size, nominally 1/16 inch larger than the nominal bolt diameter unless noted otherwise. Bolt holes in clip angle connections shall be short slotted perpendicular to the length of the angle unless otherwise noted. Holes in gusset plates shall be oversized unless otherwise noted. In the event oversized holes are used in an outer ply, hardened washers shall be installed over the oversized hole. Where long-slotted holes are used in an outer ply, plate washers shall be provided and installed over the long-slotted hole.

Contact surfaces of slip-critical connections coated with organic or inorganic zinc are acceptable provided that the requirements for the specified AISC surface condition (Class B) are met.

All bolts shall be furnished with lubricated nuts. Hardened washers (flat and beveled) shall be furnished in accordance with the recommendations on the Research Council's Specification for Structural Joints.

The Contractor shall furnish a 2 percent overage of each size and length of field bolt, plus an additional five bolts of each size and length.

05120.2.5 Welding

Welding of structural steel shall be in accordance with the requirements in Q100, Q121, Q130, and Appendix W.

All welds shall receive 100 percent visual inspection. Butt joint splices, complete penetration T-joints, plate girder welds, and built-up column welds shall be tested as Q100, Q121, Q130, and Appendix W.

A welding sequence and distortion control program shall be prepared by the Contractor and submitted to the Owner in accordance with AWS D1.1 for welded sections exceeding 2-1/2 inches in thickness and for complex built-up sections.

05120.2.6 Coatings
Coatings shall be in accordance with Section 09900. Shop paint shall not be applied within 3 inches of any field welded connection.

When galvanizing is specified for structural steel members, all connection components shall be galvanized.

05120.3 Execution

05120.3.1 General
Structural steel materials shall be erected in a safe and workmanlike manner. Erection shall be in accordance with the requirements of OSHA Standard 29 CFR Part 1926, Subpart R, Steel Erection.

The Contractor shall store the structural steel materials in a manner that will prevent the materials from being damaged or subject to deterioration prior to erection. Steel materials shall not be stored in direct contact with the earth. Care shall be exercised to prevent damage of the steel coatings, and to prevent ponding of water that could damage the surfaces of galvanized materials.

05120.3.2 Steel Erection
All materials erected under this specification shall be erected in accordance with the specified standards, the erection drawings, and these specifications.

Shop and field beam connections shall correspond to the typical beam connection details included herein, unless special connections are indicated on the Contractor's design drawings. Where special connections are required, they shall conform to details indicated on the Contractor's design drawings.

When a Class A/C hand brushed galvanized surface condition is specified, the faying surfaces of the slip-critical connections shall be roughened by means of hand wire brushing. Power wire brushing shall not be permitted.

Full pre-tensioning of high strength bolts shall be required at all slip-critical and pre-tensioned connections, and where noted on the Contractor's design drawings.

Fastener components shall be protected from dirt and moisture in closed containers at the site of installation. Only as many fastener components as are anticipated to be installed during the work shift shall be taken from protected storage. Fasteners components that are not incorporated into the work shall be returned to weather protected storage at the end of the shift.

The length of high strength bolts installed in field connections will be determined in accordance with the Research Council's Specification for Structural Joints. The Contractor shall exercise care in following the field bolt list so as to eliminate the need for additional "long" bolts. Additional "long" bolts shall be provided only at the Contractor's expense.

Baseplates shall be carefully leveled and aligned before they are grouted. The elevation of the top of the baseplates shall be within 1/16 inch of the design elevation. The differential elevation of the milled surface high and low extremes shall not exceed 1/32 inch. Grouting shall be performed as specified under Section 03611. Shim packs shall either be removed from beneath the baseplates after they have been grouted and the resulting void filled with grout, or the shim packs may be left in place. If left in place, the minimum grout cover measured between the edge of the baseplate and the nearest shim shall be 1-1/2 inches.

After steel erection, all lifting lugs used for erection purposes shall be removed and the area around the lug ground smooth and flush with the adjacent area.

Open holes due to mismatched connections shall be filled with machine bolts and nuts or by welding. Welding shall be ground smooth.

05120.3.2.1 Tolerances. Except as otherwise specified, erection tolerances shall be as specified in the codes and standards referenced in Article 05120.1.3, except that the displacement of any column center line from the established column line shall not be more than 1 inch at any point in the total height of the column.

Gaps of 1/16 inch or greater in contact surfaces between member and splice plate for column splices and vertical bracing connections shall require fill plates.

Girts and other members attaching to rigid wall panels shall be erected within tolerances that will permit faces of such members to be field aligned by the Contractor in true vertical planes within 1/8 inch tolerance. Connection holes of girts will be slotted to provide proper adjustment between girts and their supports. The girt alignment shall be acceptable to the metal wall panel erector.

After final girt adjustments, the girts shall be securely bolted with high strength bolts. Where indicated on the Contractor's design drawings, temporary bolts shall be removed and girts shall be welded in place.

Crane runway girders shall be erected to a tolerance that will allow the crane rails to meet the erection tolerances specified herein. Crane rails shall be centered on the center line of the runway girder and erected to the tolerances specified herein. The maximum eccentricity of the center of rail to center line of girder shall be three-quarters of the girder web thickness.

05120.3.2.2 Bolting. The condition of the contact surfaces of each slip-critical type connection shall be in accordance with the slip-critical connection class requirements specified in the technical requirements. Prior to erecting the steel, the contact surfaces shall be inspected for compliance with the requirements given in the referenced edition of the Research Council's Specification for Structural Joints.

Contact surfaces at bearing type field connections may be painted or galvanized, but shall be free of foreign substances.

Connections requiring bolts of higher strength than ASTM A325 shall be examined after assembly to verify that the proper strength bolts have been installed.

Tightening of bolts shall be controlled using the method indicated in Article 05120.1.5. The work shall be done by competent and experienced bolting crews.

Bolted connections shall be drifted to proper position and the holes inspected to ensure that bolt threads will not be damaged by forcing the bolts in place. Connections shall be tightly drawn together using not less than 25 percent of the total number of bolts in the completed joints, but never less than two bolts. Bolts for initial tightening shall be distributed uniformly about the joint. Either fit-up bolts or high strength bolts may be used for this purpose.

Ungalvanized ASTM A325 bolts that have been tightened no more than one-third turn beyond "snug-tight" may be loosened and retightened. Ungalvanized ASTM A325 bolts tightened more than one-third turn beyond "snug-tight" shall not be reused without inspection by the Owner. ASTM A490 bolts and galvanized ASTM A325 bolts which have been tightened beyond "snug-tight" shall not be reused. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts is not considered a reuse.

Smooth beveled washers shall be used when the bearing faces of the bolted parts have a slope of 1 to 20 or greater with respect to a plane normal to the bolt axis.

All bolts and nuts shall be lubricated prior to installation to assure that proper tension can be obtained.

05120.3.2.2.1 Bolting pre-installation verification. Fastener assemblies of each combination of diameter, length, grade and lot to be used in pre-tensioned connections shall be tested with a tension

calibrator at the jobsite prior to commencing bolt installation on the work. Pre-installation verification shall be in accordance with the Research Council's Specification for Structural Joints.

05120.3.2.2.2 DTIs. When using DTIs, tightening shall be done in accordance with the manufacturer's written instructions, the Research Council's Specification for Structural Joints, and the following.

Special care shall be taken to ensure that each DTI is of the correct capacity and grade for its intended use.

Any ASTM A325 or A490 bolt that has been tightened sufficiently to deform the DTI shall not be loosened and retightened.

Inspection of the installed DTI shall be in accordance with the manufacturer's written instructions.

Bolts found to be undertensioned shall be tightened to the correct tension by the Contractor. DTIs shall be inspected after the connection in snug-tight, but before pre-tensioning and inspected again after pre-tensioning. Inspections shall use the appropriate feeler gauge recommended by the manufacturer.

05120.3.2.2.3 Twist-off bolts. When using twist-off bolts, tightening shall be done in accordance with the manufacturer's written instructions, the Research Council's Specification for Structural Joints, and the following.

Special care shall be taken to store the bolting components properly. Twist-off bolts shall not be relubricated, except by the bolt manufacturer.

Joints assembled with twist-off bolts shall first be snug-tightened. Compacting the joint to the snug-tight condition shall progress systematically from the most rigid part of the joint. If the splined end of a bolt is severed during snug-tightening of the connection, then the bolt shall be replaced. Once the connection has been compacted to a snug-tight condition, the bolts shall be pre-tensioned using tools and methods recommended by the manufacturer and progressing systematically from the most rigid part of the joint in a manner that will minimize relaxation of previously pre-tensioned bolts.

05120.3.3 Welding

Welding of structural steel shall be in accordance with the requirements in Q100, Q121, Q130, and Appendix W.

All welds shall receive 100 percent visual inspection. Butt joint splices, complete penetration T-joints, plate girder welds, and built-up column welds shall be tested as Q100, Q121, Q130, and Appendix W.

All welding of stair stringer miters, closure plates, extension pieces, and similar welding applications shall be continuous welds and shall be ground smooth.

05120.3.4 Touchup Painting

The Contractor shall inspect fabricator applied paint films prior to the erection of the materials. Damaged or inadequate paint films of shop primed structural steel materials, all accessible surfaces of field welds, unpainted surfaces at slip-critical connections, ungalvanized field connection bolts, and damaged galvanized surfaces shall be cleaned and touchup painted.

Touchup paint for shop primed materials, all accessible surfaces of field welds, ungalvanized bolts, and damaged galvanized surfaces shall be as specified in Section 09900 and the material supplier’s recommendations.

SECTION 05500
MISCELLANEOUS METALS

05500.1 General

05500.1.1 Scope of Work
Work under these specifications shall include furnishing and erecting miscellaneous metals and services complete as specified herein:

05500.1.1.1 Miscellaneous Materials and Services for Procurement. Miscellaneous materials and services not otherwise specifically called for shall be furnished by the Contractor in accordance with the following:

Tests and inspections required by the specifications.

05500.1.1.2 Miscellaneous Materials and Services for Erection. Miscellaneous materials and services not otherwise specifically called for shall be furnished by the Subcontractor in accordance with the following:

Supply all fit-up bolts, welding electrodes, welding, and other fasteners that are necessary for the completion of the work.

Survey and lay out the work from the designated control points.

Test and inspect as required by the specifications.

Provide document submittals as specified in Appendix J and Section 1A, 5.0

05500.1.2 Not Used

05500.1.3 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 05500-1 Codes and Standards

Work	**In Accordance With**
Structural steel	AISC Steel Construction Manual, Thirteenth Edition
Structural steel	AISC Code of Standard Practice for Steel Buildings and Bridges, AISC 303-05, March 18, 2005. Articles 1.7.1, 1.7.2, 3.6, 4.4, 4.5, 6.5.1, 6.7.4, 7.1, 7.2, 7.6, 7.7, 7.13.3, 7.16, 7.17, 8.4, 8.5.4, 9.3, 9.4, 9.5, 9.6, and 10.4.2 of the above referenced code shall not apply, nor shall any other requirement of this code which conflicts with the requirements of these specifications and documents.

Table 05500-1 Codes and Standards	
Work	**In Accordance With**
Structural steel	AISC Specification for Structural Steel Buildings, AISC 360-05, March 9, 2005, with Commentary and Supplements. AISC Seismic Provisions for Structural Steel Buildings, 341-05, March 9, 2005, with Commentary and Supplements.
Structural steel	AISC Quality Certification Program for Structural Steel Fabricators
Structural steel	ASTM A6/A6M
Bar grating	ANSI/NAAMM MBG 531
Heavy-duty bar grating	ANSI/NAAMM MBG 532
Checkered steel floor plate	ASTM A786/A786M
Steel for banding of panel ends and kickplates	ASTM A36/A36M, ASTM A1011/A1011M, or acceptable equal
Welding	ANSI/AWS D1.1 Structural Welding Code – Steel
Coatings	SSPC Paint Application Specification No. 1, "Shop, Field and Maintenance Painting"

05500.1.4 Materials
The following materials shall be used:

Table 05500-2 Materials	
Component	**Material**
Structural steel shapes and plates	ASTM A36/A36M; ASTM A992/A992M; ASTM A572/A572M, Grade 50
Structural steel shim plates and fill plates	Material to match parent steel material
Structural tubes	ASTM A500, Grade B
Steel pipes	ASTM A53, Type E or S, Grade B
High strength bolts, nuts, and washers	
ASTM A325, Type 1 bolts	7/8 inch diameter
Direct tension indicators	ASTM F959, compatible with bolts
Flat and beveled hardened washers (where required)	ASTM F436, compatible with bolts
Heavy hex nuts	ASTM A563, compatible with bolts
Welding electrodes	Low hydrogen types, with a minimum tensile strength = 70,000 psi

Table 05500-2 Materials	
Component	**Material**
Anchor rods (anchor bolts)	ASTM F1554 Grades 36 with nuts conforming to ASTM A563, Grade A heavy hexagon
Anchor rod sleeves	ASTM A53 standard weight pipe or ASTM A36 plate or plastic sleeves
Post-installed mechanical anchors	Federal Specification A-A-1923A, Type 4; ACI 318, Appendix D; IBC compliant; and tested to ICC AC-193 with corresponding ICC ESR report. Hilti Kwik-Bolt TZ Expansion Anchor (ICC ESR-1917 report) or Hilti HDA Undercut Anchor (ICC ESR-1546 report)
Post-installed adhesive anchors	IBC compliant and tested to ICC AC-308 with corresponding ICC ESR report. Adhesives: Hilti HIT RE 500-SD (ICC ESR-2322 report) or Hilti HIT HY 150 (ICC ESR-3013 report) Anchors: Hilti HAS Standard Rods (A36) Hilti HAS Super Rods (A193 B7) Hilti HIT-TZ Rods
Threaded inserts for concrete	Hilti HIS and HIS-R Internally Threaded Inserts with HIT RE 500-SD Adhesive
Continuous inserts for concrete	Unistrut P3200 Series, hot-dip galvanized with P3712P inserts installed to prevent concrete seepage
Lifting lugs for concrete	Dayton/Richmond Utility Anchor Lifting System. Lugs designed for safe working loads
Pulling-in irons	Condux International 12-inch with retaining plate and cross bar, galvanized
Iron castings for manhole/catch basin access and inlets	ASTM A48 Class 35 or better
Manhole steps	M. A. Industries steel reinforced copolymer polypropylene steps
Floor doors, vault hatches	Bilco or acceptable equal
Heavy-duty rectangular bar grating	
Mark	As indicated on the Contractor's design drawings
Banding of panel ends	Required, size thickness and depth to match bearing bars

Table 05500-2 Materials	
Component	**Material**
Kickplate	4 inches above top of grating by 1/4 inch thick
Fasteners	Saddle clips with Nelson, Erico, KSM studs or Hilti grating disk system or G-Clips
Checkered steel floor plates	ASTM A786/A786M, 1/4

05500.1.5 Additional Requirements

Additional requirements for the materials and coatings to be furnished under this section of these specifications are indicated herein:

Table 05500-3 Additional Requirements	
Component	**Material**
Connection Requirements	Shop welded, field bolted
Bolting Requirements	
Slip-critical connection scope	All connections with oversized or long-slotted holes in one or more plies
Pretensioned connection scope	All structural connections not required to be slip-critical, threads included in the shear plane
Snug-tightened connection scope	Connections to non-structural steel components
Slip-critical connections, contact surface class	Class B
Control of bolt tension	Direct tension indicators (DTIs) or Twist-off bolts
Coating Requirements	
Embedded structural steel shapes and plates, threaded inserts, continuous inserts	Hot-dip galvanized
Anchor rods	Hot-dip galvanized, nuts uncoated
Bollards	Hot-dip galvanized with safety yellow plastic sleeves
Structural steel shapes, plates, tubes and pipes - Exterior location	Hot-dip galvanized.
Structural steel shapes, plates, tubes and pipes - Interior location	In accordance with Section 09900
Floor doors, vault hatches	Manufacturer's standard coating
Iron castings	None
Post-installed anchors	Galvanized

Table 05500-3 Additional Requirements	
Component	**Material**
High strength bolts, nuts, and washers	Mechanically galvanized in accordance with ASTM B695 Class 50 (A325 and F1852 only) All connection components shall receive the same coating. When bolts are galvanized, washers and nuts shall be mechanically galvanized.
Heavy-duty rectangular bar grating	Manufacturer's standard or hot-dip galvanized
Checkered steel floor plates	Hot-dip galvanized

05500.1.6 Approved Manufacturers of Components

For the following components, the manufacturers identified in Article 05500.1.4 or listed below provide examples of the quality of workmanship required by these specifications. If the Contractor 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 Owner:

Table 05500-4 Approved Manufacturers of Components	
Component	**Manufacturer**
High strength bolts	Approved US supplier
Direct tension indicators (DTIs), using a silicon gel marker to indicate full-tension, are not acceptable	Ameren Missouri Approved Suppliers
Plastic anchor rod sleeves	Ameren Missouri Approved Suppliers
Rectangular metal bar grating and stair treads and heavy-duty bar grating	Ameren Missouri Approved Suppliers
Checkered steel floor plate	Ameren Missouri Approved Suppliers
Iron castings	Ameren Missouri Approved Suppliers

05500.1.7 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 Contractor unless specifically identified as a Bid Option or Owner-conducted. Tests identified as an option are to be priced separately. If identified as Owner-conducted, costs for the initial test will be the responsibility of the Owner. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 05500-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Nondestructive Testing of Welds		Contractor

Table 05500-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Testing of High Strength Bolts by Bolt Manufacturer, ASTM A325, A490 and F1852	ASTM A325, ASTM A490 and ASTM F1852, Production Lot Method	Manufacturer
Testing of Direct Tension Indicators	ASTM F959, Article 10.2, Production Lot Method	Manufacturer

05500.1.8 Not Used

05500.1.9 Supplemental Specifications
Technical supplemental specifications that are applicable to the work covered under this technical specification section are identified and included in Table 01400-1.

05500.2 Products

05500.2.1 Drawing Requirements
Contractor-produced drawings shall be in accordance with Table 01400-1 and the following requirements:

Each drawing submitted shall indicate the name of the project, the unit designation, the contract title, the contract number, the name of the building structure, and the Contractor's name. In addition, the Owner's identification number will be affixed by the Owner to each Contractor's initially submitted shop drawing. This number shall be maintained on all subsequent submittals of the drawings in the identical format and location as originally indicated by the Owner.

Erection drawings shall be submitted with, or prior to, the submittal of the corresponding detail drawings.

A field bolt list indicating the number and length of each bolt shall be submitted.

Details of the proposed typical beam connections shall be submitted with the first package of drawings.

Each detail drawing shall include a Bill of Material. The total weight, area, or length of material on each sheet shall be listed on every detail drawing.

Each detail drawing shall indicate the mark number of each fabricated piece as assigned by the Contractor and list any material identification numbers assigned by the Owner.

Detail drawings shall indicate the top elevation of all horizontal members.

05500.2.2 Materials
Materials shall be new and unused and shall conform to the following.

05500.2.2.1 Steel Certification. Signed chemical-composition and mechanical-property mill certifications shall be obtained for all steel purchased under this specification.

05500.2.2.2 Bolt Inspection - Manufacturer. High strength bolts shall be tested by the manufacturer prior to shipment in accordance with the Production Lot Method.

The Owner reserves the right to independently test the bolt materials. Should the bolt materials be found to be defective, they shall be replaced at the Contractor's expense.

05500.2.2.3 DTIs - Manufacturer. DTIs shall be inspection tested by the manufacturer prior to shipment in accordance with the Production Lot Method described in ASTM F959, Article 10.2.

The Owner reserves the right to independently test the DTIs. Should the DTIs be found to be defective, they shall be replaced at the Contractor's expense.

05500.2.3 Miscellaneous Steel Fabrication
Miscellaneous steel shall be fabricated to the dimensions, arrangements, sizes and weights, or thicknesses indicated on the Contractor's design drawings or required by these specifications.

Embedded materials shall be accurately fabricated and assembled. Warped or bent sections which do not fit into the concrete forms as required shall be replaced with suitable materials.

Miscellaneous steel shall be fabricated to tolerances that will permit field erection within AISC tolerances, except that the displacement of any column center line from the established column line shall not be more than 1 inch at any point in the total height of the column.

Cuts, copes, and holes shall be clean cut without torn, ragged edges or burrs.

Unnecessary bolt holes in structural steel materials less than 1-1/2 inches in thickness shall be filled with weld metal and ground smooth. These repairs shall be made before preparing the member for shop painting or galvanizing. Unnecessary bolt holes in miscellaneous steel material 1-1/2 inches or greater in thickness shall be plugged with high strength bolts.

The radius of beam copes and weld access holes shall be provided free of notches and shall be in accordance with AWS D1.1. Repair of notches shall be in accordance with AWS D1.1.

The locations and details of all welded splices in structural members or components shall be acceptable to the Owner. Unauthorized splices are not allowed. Splices will not be permitted in areas of high stress. The Owner's acceptance of splice locations shall be obtained before fabrication.

Holes and other provisions for field connections shall fit when the units are assembled in the field. Where required by the Contractor's design drawings or by the necessity of proper identification and fitting of field connections, the connections shall be matchmarked.

05500.2.4 Bar Grating Fabrication
Grinding of crossbar ends is not required if the spacer bars project no more than 1/8 inch beyond the outside bearing bars and the overall panel width used in laying out the work is adjusted to allow for extensions.

Kickplates shall be provided where indicated on the Contractor's design drawings and as required by applicable codes.

Where openings are indicated in gratings, such as for the passage of pipes, grating sections shall be laid out so that each opening will be centered on a joint between sections. All openings shall be provided with a kickplate of formed steel plate or standard weight steel pipe welded to the bearing bars.

All kickplates shall extend the full depth of the grating and extend 4 inches above the top surface of the grating.

05500.2.5 Bolted Connections
Bolt holes shall be standard size, nominally 1/16 inch larger than the nominal bolt diameter unless noted otherwise. Bolt holes in clip angle connections shall be short slotted perpendicular to the length of the

angle unless otherwise noted. Holes in gusset plates shall be oversized unless otherwise noted. In the event oversized holes are used in an outer ply, hardened washers shall be installed over the oversized hole. Where long-slotted holes are used in an outer ply, plate washers shall be provided and installed over the long-slotted hole.

Contact surfaces of slip-critical connections coated with organic or inorganic zinc are acceptable, provided that the requirements for the specified AISC surface condition (Class B) are met.

All bolts shall be furnished with lubricated nuts. Hardened washers (flat and beveled) shall be furnished in accordance with the recommendations on the Research Council's Specification for Structural Joints.

The Contractor shall furnish a 2 percent overage of each size and length of field bolt, plus an additional five bolts of each size and length.

05500.2.6 Welding
Welding of miscellaneous steel shall be in accordance with the requirements Q100, Q121, Q130.

All welds shall receive 100 percent visual inspection. Butt joint splices, complete penetration T-joints, plate girder welds, and built-up column welds shall be tested as Q100, Q121, Q130.

05500.2.7 Coatings
Coatings shall be in accordance with Section 09900. Shop paint shall not be applied within 3 inches of any field welded connection.

When galvanizing is specified for structural steel members, all connection components shall be galvanized.

05500.3 Execution

05500.3.1 General
Miscellaneous steel and miscellaneous metals shall be erected in a safe and workmanlike manner. Erection shall be in accordance with the requirements of OSHA Standard 29 CFR Part 1926, Subpart R, Steel Erection.

The Contractor shall store the miscellaneous metals in a manner that will prevent the materials from being damaged or subject to deterioration prior to erection. Materials shall not be stored in direct contact with the earth. Care shall be exercised to prevent damage of the steel coatings, and to prevent ponding of water that could damage the surfaces of galvanized materials.

Fasteners shall be furnished in suitable containers, which shall remain closed until the fasteners are required for erection.

Metals to be placed in concrete shall be installed as specified in Section 03311 and located as indicated on the Contractor's design drawings to the tolerances specified in Section 03311 and on the Contractor's design drawings.

05500.3.2 Steel Erection
All materials erected under this specification shall be erected in accordance with the specified standards, the Contractor's design drawings, the erection drawings, and these specifications.

Shop and field beam connections shall correspond to the typical beam connection details included herein, unless special connections are indicated on the Contractor's design drawings. Where special connections are required, they shall conform to details indicated on the Contractor's design drawings.

When a Class A/C hand brushed galvanized surface condition is specified, the faying surfaces of the slip-critical connections shall be roughened by means of hand wire brushing. Power wire brushing shall not be permitted.

Full pretensioning of high strength bolts shall be required at all slip-critical and pretensioned connections, and where noted on the Contractor's design drawings.

Bolts and bolting components shall be protected from dirt and moisture in closed containers at the site of installation. Only as many fastener components as are anticipated to be installed during the work shift shall be taken from protected storage. Fastener components that are not incorporated into the work shall be returned to protected storage at the end of the shift.

The length of high strength bolts installed in field connections will be determined in accordance with the Research Council's Specification for Structural Joints. The Contractor shall exercise care in following the field bolt list so as to eliminate the need for additional "long" bolts. Additional "long" bolts shall be provided only at the Contractor's expense.

After steel erection, all lifting lugs used for erection purposes shall be removed and the area around the lug ground smooth and flush with the adjacent area.

Open holes due to mismatched connections shall be filled with machine bolts and nuts or by welding. Welding shall be ground smooth.

05500.3.2.1 Bolting. The condition of the contact surfaces of each slip-critical type connection shall be in accordance with the slip-critical connection class requirements specified in the technical requirements. Prior to erecting the steel, the contact surfaces shall be inspected for compliance with the requirements given in the referenced edition of the Research Council's Specification for Structural Joints.

Contact surfaces at bearing type field connections may be painted or galvanized, but shall be free of foreign substances.

Connections requiring bolts of higher strength than ASTM A325 shall be examined after assembly to verify that the proper strength bolts have been installed.

Tightening of bolts shall be controlled using the method indicated in Article 05500.1.5. The work shall be done by competent and experienced bolting crews.

Bolted connections shall be drifted to proper position and the holes inspected to ensure that bolt threads will not be damaged by forcing the bolts in place. Connections shall be tightly drawn together using not less than 25 percent of the total number of bolts in the completed joints, but never less than two bolts. Bolts for initial tightening shall be distributed uniformly about the joint. Either fit-up bolts or high strength bolts may be used for this purpose.

Ungalvanized ASTM A325 bolts that have been tightened no more than one-third turn beyond "snug-tight" may be loosened and retightened. Ungalvanized ASTM A325 bolts tightened more than one-third turn beyond "snug-tight" shall not be reused without inspection by the Owner. ASTM A490 bolts and galvanized ASTM A325 bolts which have been tightened beyond "snug-tight" shall not be reused. Retightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts is not considered a reuse.

Smooth beveled washers shall be used when the bearing faces of the bolted parts have a slope of 1 to 20 or greater with respect to a plane normal to the bolt axis.

All bolts and nuts shall be lubricated prior to installation to assure that proper tension can be obtained.

05500.3.2.1.1 Bolting pre-installation verification. Fastener assemblies of each combination of diameter, length, grade, and lot to be used in pretensioned connections shall be tested with a tension calibrator at the jobsite prior to commencing bolt installation on the work. Pre-installation verification shall be in accordance with the Research Council's Specification for Structural Joints.

05500.3.2.1.2 DTIs. When using DTIs, tightening shall be done in accordance with the manufacturer's written instructions, the Research Council's Specification for Structural Joints, and the following.

Special care shall be taken to ensure that each DTI is of the correct capacity and grade for its intended use.

Any ASTM A325 or A490 bolt that has been tightened sufficiently to deform the DTI shall not be loosened and retightened.

Inspection of the installed DTI shall be in accordance with the manufacturer's written instructions.

Bolts found to be undertensioned shall be tightened to the correct tension by the Contractor. DTIs shall be inspected after the connection is snug-tight, but before pretensioning, and inspected again after pretensioning. Inspections shall use the appropriate feeler gauge recommended by the manufacturer.

05500.3.3 Welding
Welding of structural steel shall be in accordance with the requirements in Q100, Q121, Q130..

All welds shall receive 100 percent visual inspection. Butt joint splices, complete penetration T-joints, plate girder welds, and built-up column welds shall be tested as Q100, Q121, Q130.

All welding of stair stringer miters, closure plates, extension pieces, and similar welding applications shall be continuous welds and shall be ground smooth.

05500.3.4 Bar Grating Installation
Each section of rectangular bar grating shall be securely fastened in place with not less than two fasteners at each support.

Rectangular grating shall be installed so that spacer bars and load carrying bars in adjacent panels are in alignment.

Grating fasteners shall be in accordance with Article 05500.1.4 and shall be installed in accordance with the manufacturer's requirements. The fastener system shall be acceptable to the Owner.

When saddle-clips are supplied, welded stud type bolts including nuts and washers shall be included. Saddle-clips shall be galvanized and as specified in the NAAMM manual. Studs shall be Nelson Stud Welding, Erico Products Blue Arc, KSM Welding Systems, or acceptable equal. Welded stud type bolts shall be size 1/4-20 with pitch diameter base. Stud length after welding shall be approximately 1/8 inch less than the grating depth. Nuts shall conform to ANSI B18.2.2. Studs, washers, and nuts shall be zinc plated in accordance with ASTM B633, Service Condition SC4.

When the Hilti Grating Disk System is used, disks shall be either electro-galvanized Type X-FCM or hot-dip galvanized Type X-FCM-F and carbon steel threaded studs shall be electro-galvanized Type EM8-15-14FP10. Grating disks shall be sized according to height of grating.

05500.3.5 Touchup Painting
The Contractor shall inspect fabricator applied paint films and inform the Owner of inadequate coatings prior to the erection of the materials. Damaged or inadequate paint films of shop primed structural steel materials, all accessible surfaces of field welds, unpainted surfaces at slip-critical connections, ungalvanized field connection bolts, and damaged galvanized surfaces shall be cleaned and touchup painted.

Touchup paint for shop primed materials, all accessible surfaces of field welds, ungalvanized bolts, and damaged galvanized surfaces shall be as specified in Section 09900 and the material supplier's recommendations.

SECTION 05900
PHOTOVOLTAIC RACKING

05900.1 General

05900.1.1 Scope

This section covers the furnishing and installation of the structures, racking, foundations and all other items required to furnish and install a complete structural system capable of supporting solar module installations.

05900.1.2 Design Criteria and Performance Requirements

Structural framing for ground mount solar systems shall be designed and analyzed for wind, snow and seismic loading per IBC 2009.

Structure manufacturer shall provide structural analysis and supporting structural calculations that have been independently reviewed, signed and stamped by Professional Engineer (PE) in the state of Missouri.

05900.1.3 Quality Assurance

The structure shall be manufactured in accordance with standard approved practices. Testing shall be performed in accordance with ASTM standards including but not limited to:

ASTM A6 - General Requirements for Delivery of Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use.
ASTM A992 - Standard Specification for Structural Steel Shapes
ASTM A36 - Standard Specification for Carbon Structural Steel.
ASTM A307 - Carbon Steel Externally Threaded Standard Fasteners.
ASTM A325 - High Strength Bolts for Structural Steel Joints.
ASTM A500 - Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Round and Shapes.
ASTM A501 - Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
AWS A2.0 - Standard Welding Symbols.
AWS D1.1 - Structural Welding Code.
AISC Manual for Steel Construction LRFD 13th Edition - Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.
AISC - Code of standard practice for steel buildings and bridges.
AISC - Specification for Structural Joints using ASTM A325 or A490 Bolts approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation and endorsed by AISC.

05900.1.4 Submittals

Drawings shall be submitted by the manufacturer prior to the start of manufacturing in accordance with Appendix J and Section 1A, 5.0. No ordering or fabrication of materials shall commence until submittal drawings are approved by the Company.

The structure manufacturer shall submit drawings and design calculation signed and sealed by a Professional Engineer in the state of Missouri per Section 1A, 5.0.

At a minimum, submittal drawings shall include the following:
a. Title/Cover Sheet
b. Foundation Plans (piers/piles)

c. Anchoring Details
d. Structural Plans and Elevations
e. Framing Details
f. Racking Details

05900.1.5 Material Delivery, Storage and Handling

As much of the racking system as practical shall be shipped pre-assembled to reduce the amount of loose hardware and field labor.

Materials shall be delivered to the jobsite in original manufacturer's packaging.

05900.2 Products, Materials, and Components

05900.2.1 General Structure Design and Component Details

The structure shall be designed and detailed according to good engineering practice. The structure shall be a series of connected galvanized steel or aluminum frames supporting galvanized steel or aluminum purlins. Purlins shall support the solar modules, either directly or using a racking system.

A minimum of clearance of 1'-6" shall be maintained at the lowest point of the ground mount structure unless otherwise specified.

The ground mount racking system shall support the solar PV panels at a 30 degree angle.

Racking system shall be capable in supporting configurations of either 4 panels high in the landscape orientation or 2 panels high in portrait orientation.

Racking system shall be adjustable to accommodate various size and thickness of monocrystalline, polycrystalline and thin film panels and various string lengths.

05900.2.2 Materials

Frame components shall be constructed with hot dip galvanized steel with G-235 process, aluminum tubing or other cold formed or extruded shapes.

Racking extrusions and other components shall be hot dip galvanized steel with G-235 process or aluminum Alloy 6105 –T5.

All bolts 1/2" diameter and larger shall be A325 or A490.

All bolts, nuts and washers, unless otherwise noted, shall have a hot dip galvanized finish.

05900.2.3 General Notes

All materials shall be new, of good quality and without defects which would lessen quality of work.

Ground mount structure erection drawings shall be furnished at time of material shipment.

05900.2.4 Warranty

Ground mount structure manufacturer shall provide a ten (10) year warranty on materials and workmanship from the date of substantial completion.

Ground mount structure manufacturer shall provide complete warranty information on all manufacturers providing accessories within the system.

05900.3 Execution

05900.3.1 Installation

Racking support system shall be installed plumb

Installation shall be completed in accordance with the manufacturer’s recommendations

SECTION 07920
CAULKING, SEALING, AND FIREPROOFING

07920.1 General

07920.1.1 Scope of Work
Scope of work shall include designing, furnishing and installing caulking, sealing, and firestopping materials and appurtenances and shall include other services as specified under these technical specifications.

This specification provides general guidance to the selection of the required materials and to the erection process. The Contractor is to edit this specification as needed, based on the actual detailed designs. Revisions and/or substitutions to the specified materials need to be submitted to the Owner for review and acceptance prior to making the change.

07920.1.2 Not Used

07920.1.3 Performance and Design Requirements
Performance and design requirements for the caulking, sealing, and firestopping are indicated in Article 07920.1.5.

07920.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 07920-1 Codes and Standards

Work	In Accordance With
Firestopping	ASTM E814, Test Method for Fire Tests of Through Penetration Fire Stops ASTM E84, Test Method for Surface Burning Characteristics of Building Materials ASTM E119, Test Method for Fire Tests of Building Construction and Materials ASTM C719, Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants under Cyclic Movement UL Fire Resistance Directory, Volume 2 UL 1479, Fire Tests of Through Penetration Fire Stops UL 2079, Tests for Fire Resistance of Building Joint Systems UL 263, Fire Tests of Building Construction and Materials UL 723, Surface Burning Characteristics of Building Materials Warnock Hersey Certification Listings Factory Mutual Research Corporation, FMRC Approval Guide

07920.1.5 Materials
The following materials shall be used:

Table 07920-2 Materials	
General	
Component	**Material**
Urethane sealant (nonsag) gun grade	
Multicomponent	Two or three component, modified polyurethane, ASTM C920, Type M, Grade NS, Class 25, use NT, M, A, O
Single component	ASTM C920, Type S, Grade NS, Class 25, use NT, M, A, O
Urethane sealant (self-leveling), two component	ASTM C920, Type M, Grade P, use T
Acrylic sealant nonsag, solvent release type	Fed Spec TT-S-00230
Silicone sealant	ASTM C920, Type S, Grade NS, Class 25, use NT, G, A, O
Primer	As recommended by the sealant manufacturer
Joint filler (for joints in concrete pavement and walks)	Preformed, ASTM D1752, Type I, closed cell plastic foam (PVC or polyethylene)
Backup material	Polyethylene or polyurethane foam
Firestopping	ASTM E814, UL 1479, and UL 2079; no volatile organic compound

Table 07920-3 Materials	
Specific	
Caulking and Sealing Applications--Sealant Type	**Location to be Caulked or Sealed**
Urethane (nonsag)	Entire perimeter of frames for exterior metal doors, both sides or Entire perimeter of metal louvers, both sides or Entire perimeter of metal dampers and metal shutters or Entire perimeter of aluminum windows, both sides or Control joints in masonry walls or Perimeter of aluminum door and window units, both sides or Joints between precast concrete units or Watertight joints in aluminum sheet metalwork, unless otherwise specified or Perimeter of aluminum door and window units, both sides or Joints between masonry and cast-in-place concrete, where indicated on the Contractor's design drawings or Joints on underside of precast concrete roof units where exposed to view in finished construction or Other exterior locations where caulking is indicated on the Contractor's design drawings, specified in other sections, or required for weatherproofing
Urethane sealant (self-leveling)	Horizontal joints in concrete walks or drives or Horizontal joints in traffic bearing concrete decks and slabs
Acrylic sealant	Entire perimeter of frames for interior metal doors and windows, both sides or Other interior locations where caulking is indicated on the Contractor's design drawings or specified in other sections
Silicone sealant	Around floor type urinals and water closets or Around floor sinks or Other locations where silicone sealant is indicated on the Contractor's design drawings
Firestopping Applications (Fire Rated)--Firestopping System	
Provide firestop systems with fire ratings equal to, or in excess of, fire resistance rating of construction assembly penetrated as determined by ASTM E814	Penetrations through fire resistant walls or floors with penetrating items, such as pipe, conduit, cables, cable trays, ductwork, or other items
Provide joint sealants with fire resistance rating, as determined by UL 2079, equal to, or in excess of, the fire resistance rating of the construction in which the joint occurs	Gaps between fire rated walls and the floor/ceiling, walls, or roof ceiling assembly or Expansion joints within fire rated walls and floors or Gaps between perimeter edge of floor and exterior curtain wall

Table 07920-3 Materials	
Specific	
Provide firestop systems with fire ratings equal to, or in excess of, fire resistance rating of construction assembly	Other locations as necessary to achieve required fire rating
In addition to the locations called out, firestop shall be applied around any new penetrations into the existing plant terminal rooms.	

07920.1.6 Approved Manufacturers of Components

The Owner has prequalified the following manufactured components. Contractor may propose additional nonlisted components. In such case, supporting documentation shall be provide as proof that the proposed component satisfies the requirements of this specification. Acceptance of the manufacturer as a substitute is at the discretion of the Owner:

Table 07920-4 Approved Manufacturers of Components	
Component	**Manufacturer**
Urethane sealant (nonsag)	
Multicomponent	Refer to "Supplemental General Conditions, Appendix C - Ameren Missouri Approved Suppliers"
Single component	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Urethane sealant (self-leveling), two component	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Acrylic sealant nonsag, solvent release type	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Silicone sealant	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Primer	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Backup material	Refer to "Appendix C - Ameren Missouri Approved Suppliers"
Firestop systems	Refer to "Appendix C - Ameren Missouri Approved Suppliers"

07920.2 Products

07920.2.1 General

This article covers materials and installation for caulking, sealing, and firestopping.

The terms "caulking" and "sealing," as used on the drawings and in these specifications, are synonymous and either/or both terms shall indicate the materials specified herein. There shall be no oil-based caulking used on this project.

Sealants shall be neatly and properly installed where indicated on the drawings. Where a joint requiring sealing is indicated and the sealant is not noted, the correct sealant for the particular application shall be installed.

Firestop shall be provided in order to maintain the fire resistance integrity of the building in specific locations indicated on the Contractor's design drawings. All fire rated systems must be classified by UL with an assigned system number.

07920.2.2 Colors
Sealant colors shall be as selected by the Owner from the manufacturer's color range. Different colors may be required for different applications. Where not specified, sealants shall be manufacturer's standard gray color.

07920.3 Execution

07920.3.1 Joint Preparation
All surfaces to receive sealants shall be clean, dry, and free of loose materials, dust, grease, oil, or wax. All such surfaces shall be wiped with a clean cloth saturated with a suitable solvent and primed, if required, before the sealant is applied.

Unless otherwise recommended by the sealant manufacturer and permitted by the Owner, the depth of sealant in a joint shall be equal to the width of the joint, but not more than 1/2 inch. Where silicone sealants are used, the depth of the sealant as measured from the crown of the backup shall be not less than 1/8 inch or more than 3/8 inch. Backup material shall be provided as necessary to control the depth of sealant; it shall be of suitable size so that when compressed 25 to 50 percent, the space will be filled. Backup material shall be rolled or pressed into place in accordance with the manufacturer's installation instructions, avoiding puncturing or lengthwise stretching. For joints in concrete pavement walks, joint filler and backup material shall be installed before sealant is placed.

Firestopping system preparation shall follow manufacturer's instructions to mask adjacent surfaces to protect from damage by material installation. Where necessary, clean surface area of oil, dirt, and mil scale as well as any preparation required by the manufacturer.

07920.3.1.1 Installation. Caulking and sealing work shall be completed before any field painting work is started. The air temperature and the temperature of the surfaces to be caulked or sealed shall be above 40° F when the work is performed but not above 100° F, except as recommended by the manufacturer.

Sealants shall be applied with either a cartridge type or bulk type caulking gun, either hand or air pressure activated. Beads shall be run slowly to ensure complete filling of the joint cavity to avoid air pockets. Sealed joints shall be neatly tooled using solutions and methods as recommended by the sealant manufacturer.

Upon completion of the caulking and sealing work, each sealed joint shall have a smooth, even finish, flush with the edges of the sealing recess, and all adjacent surfaces shall be clean. Sealant shall not lap onto adjacent surfaces. Any sealant applied which prevents the painting of adjacent surfaces to a clean line, or leaves an excess of material outside the joint and feathered onto surfaces, shall be removed and the joint resealed.

Firestopping work shall be performed by a firm with expertise in firestopping or similar materials. Installer shall be licensed or otherwise approved by the firestop material manufacturer. All substrates and conditions shall be inspected for compliance with installation requirements. Opening size, condition, penetrating items, and other conditions affecting performance of firestop system shall be confirmed. Work shall not proceed until unsatisfactory conditions have been corrected.

Appropriate firestop systems shall be installed as shown in UL Fire Resistance Directory, Vol. 2 and in strict accordance with the manufacturer's written application instructions as well as any approved submittal documents.

Firestopping forming or damming materials and other required accessories shall be installed to support fill material during installation and curing periods. After cure period, all combustible forming materials shall be removed. Fill materials for through penetration firestop systems shall be installed by proven technique to do the following:

Completely fill voids and cavities to appropriate depth.

Ensure contact and adherence of sealant to substrates and penetrating items.

Finish sealant flush and smooth with surface.

Each firestop system at each penetration shall be identified with an appropriate sign as follows:

WARNING, DO NOT DISTURB.

RATED THROUGH PENETRATION FIRESTOP SYSTEM.

The finished firestop system should not be covered or enclosed until inspection by an authorized official is complete. Any damaged or incorrectly installed firestopping systems shall be repaired by restoring them to proper condition, in accordance with UL system classification and written manufacturer's instructions.

SECTION 09900
PROTECTIVE COATINGS

09900.1 General

Cleaning, surface preparation, and coating application shall be as specified herein and shall meet or exceed the coating manufacturer's recommendations. When the manufacturer's minimum recommendations exceed the specified requirements, the Contractor shall comply with the manufacturer's minimum recommendations.

09900.1.1 Scope

This section covers furnishing materials, labor and required preparation and application equipment and tools for the protective coatings. The work includes surface preparation, protection of surfaces, inspection, and other appurtenant work for equipment and surfaces designated to be coated.

This specification provides the general guidance to the required materials and to the application process. The Contractor shall edit this specification as needed based on the actual detailed designs. Revisions and or substitutions to the specified materials shall be submitted to the Owner for review and acceptance prior to making the change.

09900.1.2 Not Used

09900.1.3 Coating Applications and Material Requirements

The protective coating materials are listed in Article 09900.2.2.

Table 09900 – 1 Protective Coatings	
Description	
Structural Steel (Exterior, new)	Refer to Table 09900-4
Structural Steel (Interior, new)	Refer to Table 09900-8
Structural Steel (Existing, rusted)	Refer to Table 09900-6
Grating, Floorplates and Exterior Railings (galvanized)	Refer to Table 09900-7
Concrete Block Walls	Refer to Table 09900-9
Concrete	Refer to Table 09900-10

Except as otherwise noted, the following areas and items shall not be coated:

Metal wall panels and flashings (exterior).

Glass and glazing.

Acoustical ceiling.

Aluminum surfaces.

Brass and Bronze.

Quarry tile or ceramic tile.

Resilient floor coverings.

Hardware.

Floor plates.

Embedments (galvanized).

Grating.

Galvanized ductwork, dampers, and fan boxes.

Light fixtures, except supports.

Electrical conductors, insulated or uninsulated.

Electrical conduits, wireways, and junction boxes (except as otherwise specified).

Cable trays and supports.

Chromium plated metals.

Gauges.

Rotating shafts and couplings.

Rubber belts, skirting, gaskets, and idler disks

09900.1.3.1 Delivery and Storage. All coating products shall be received and stored in accordance with the coating manufacturer's recommendations and the following:

Products shall be delivered to the site in a timely manner to avoid delays in construction.

Products shall be stored and protected from weather, extremes in temperatures, and direct sun.

Paint materials shall be received in sealed original labeled containers, bearing manufacturer's name, type of paint, brand name, color designation and instructions for mixing and/or reducing.

Paint materials shall be stored between a minimum ambient temperature of 45°F and a maximum of 90° F, in a well ventilated area, unless required otherwise by manufacturer's instructions.

Precautionary measures shall be taken to prevent fire hazards and spontaneous combustion.

09900.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 09900-2 Codes and Standards	
Work	**In Accordance With**

Table 09900-2 Codes and Standards	
Work	**In Accordance With**
Fabrication details, surface finish requirements, and proper design considerations for tanks and vessels to be lined for immersion service	NACE RP0178
Mineral and Slag Abrasives	SSPC-AB 1
Newly Manufactured or Remanufactured Steel Abrasives	SSPC-AB 3
Solvent cleaning	SSPC-SP 1
Hand tool cleaning	SSPC-SP 2
Power tool cleaning	SSPC-SP 3
White metal blast cleaning	SSPC-SP 5 / NACE No. 1
Near white blast cleaning	SSPC-SP 10 / NACE No. 2
Commercial blast cleaning	SSPC-SP 6 / NACE No. 3
Brush-off blast cleaning	SSPC-SP 7 / NACE No. 4
Power tool cleaning to bare metal	SSPC-SP 11
Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultra-High Pressure Water Jetting Prior to Recoating	SSPC-SP 12
Surface Preparation of Concrete	SSPC-SP 13
Shop, field, and maintenance painting of steel	SSPC-PA 1
A guide to safety in paint application	SSPC-PA Guide 3
Standard procedure for evaluating painting contractors	SSPC-QP 1
Visual standard for abrasive blast cleaned steel	SSPC-VIS 1
Visual standard for power and hand tool cleaned surfaces	SSPC-VIS 3

09900.1.5 Regulatory Requirements
All materials shall conform to applicable code for flame/fuel/smoke rating requirements for finishes.

All coatings, thinners, etc., shall be lead and chromate free, and VOC compliant. Volatile organic compounds per gallon of coating shall be limited to less than 3.5 pounds/gallon (preferably less than 2.8 pounds/gallon) in the coatings thinned, ready to apply state.

Zinc Dust Powder shall be ASTM D520, Type II Zinc Version.

09900.1.6 Not Used

09900.1.7 Approved Manufacturers of Components
Refer to Article 09900.2.2.1 for approved manufacturers.

09900.1.8 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 Contractor unless specifically identified as a Bid Option or Owner-conducted. Tests identified as an option are to be priced separately. If identified as Owner-conducted, costs for the initial test will be the responsibility of the Owner. However, the Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 09900-3 Test Requirements

Tests	In Accordance With	Conducted By
Indicating moisture in concrete by the plastic sheet method	ASTM D4263	Contractor
Indicating oil or water in compressed air	ASTM D4285	Contractor
Measurement of wet film thickness by notch gauges	ASTM D4414	Contractor
Field measurement of surface profile of blast cleaned steel	ASTM D4417	Contractor
Pull-off strength of coatings using portable adhesion testers	ASTM D4541	Contractor
Discontinuity (Holiday) testing of nonconductive protective coatings on metallic substrates	NACE RPO188	Contractor
Measurement of dry paint thickness with magnetic gauges	SSPC-PA 2	Contractor

09900.1.11 Submittals

A coating system submittal shall be provided in accordance with Appendix J, Section 1A, 5.0, and Q500 and shall include the following:

Product data sheets.

Material safety data sheets (MSDS).

Surface preparation requirements and application instructions for each coating system furnished under this section.

Ventilation, dehumidification or heating requirements.

Details concerning explosion proof lighting.

Coating termination and/or transition details for use at pipe supports, tank nozzles, welded seams and other points of this nature.

Repair procedures for damaged areas and detected holidays.

Quality assurance/quality control plan.

Name of coating inspector and level of certification held.

A separate coating system submittal shall be developed and submitted for each variation or change in a coating system or surface to be coated.

Protective coating and lining work shall be undertaken by applicators, including supervisors and workers, qualified by commercial experience installing the types of materials specified. To satisfy this experience requirement, the applicator shall be certified to SSPC-QP 1 or equivalent and shall submit to the Owner a work history demonstrating a record of performance of such applications.

When the proposed products will be in contact with potable water, the Contractor shall submit certifications that the proposed systems are in compliance with ANSI/NSF 61.

Contractor shall submit color cards for all coatings proposed for use, together with specifications to the Owner for review and color selection.

Approval of the Contractor submittals must be provided by the Owner prior to the commencement of work.

09900.1.12 Quality Assurance
The product manufacturer shall be a company specializing in manufacturing quality paints and finish products with 10 years' experience.

The applicator shall be a company specializing in industrial painting and finishing with 5 years' documented experience.

09900.1.12.1 Certification. The Contractor shall review and approve in writing the coating manufacturer's recommendations for the intended service. Any variations from these specifications or the coating manufacturers published recommendations shall be submitted in writing and approved by the Owner.

09900.1.12.2 Manufacturer's Services. The services provided by the coating manufacturer shall include review of the project before surface preparation; certification, in writing, of the applicator and the coating materials to be used.

09900.1.13 Warranty
The Contractor shall warrant each coating system for a period of five years from the date of written acceptance by Owner.

The Contractor shall warrant his work to be free from all defects in material and workmanship for a period of five years from the date of written acceptance by the Owner.

The warranty shall cover the prepared existing coatings and new coatings, i.e., from the steel (or other base material) substrate out. The warranty shall be based on zero percent (0%) failure rate. Warranties based on percentage failure per year, or which are prorated or conditional warranties shall be deemed unacceptable.

As a portion of the contract covering the work of this specification, the Contractor shall be responsible for correction of all coatings defects and failures. All repairs shall be scheduled and completed within 4 months of written Contractor notification of required repairs.

All required repairs shall be in accordance with the provisions of the original coatings work.

Contractor's warranty obligations shall include, but not be limited to, equipment, materials, and labor to remove, repair, and reinstall defective coatings provided by the Contractor. The Owner shall provide the Contractor with reasonable access to perform its warranty obligations, provided that such access does not interfere with operation of the total facilities.

Coating damage, either physical, chemical or temperature related, that is the responsibility of the Owner shall not be covered under the Contractor's warranty.

09900.2 Products

09900.2.1 Materials
All field applied coating materials shall be delivered to the job in original, unopened containers, with labels intact. Coating materials shall be maintained during transportation, storage, mixing and application within the temperature range required by the coating manufacturer. No adulterant, unauthorized thinner, or other material not included in the coating formulation shall be added to the coating for any purpose.

All coatings shall conform to the air quality regulations applicable at the location of use. Coating materials that cannot be warranted by the manufacturer to conform, whether or not specified by product designation, shall not be used.

Coatings used in successive field coats shall be produced by the same manufacturer. The first field coat over shop coated or previously coated surfaces shall cause no wrinkling, lifting, or other damage to underlying coats.

09900.2.2 Approved Manufacturers
Except as otherwise acceptable to the Owner, coatings shall be manufactured, formulated, and compounded by coating manufacturers named herein.

09900.2.2.1 Approved Manufacturers - Paint.

Table 09900-4 Shop Paint Exterior Steel (new)				
Shop Coatings	Prime Coat		Carbozinc 859	
	First Coat		Carboguard 893 SG	
	Finish Coat		Carbothane 134 HG	
Areas and Items to Be Painted	**Prime Coat**	**First Coat**	**Finish Coat**	**Color**
All new structural steel, including miscellaneous plates, angles, etc.; portions of steel ductwork extending outside of the insulation and lagging NOTE: All back-to-back angles shall be blasted and primed prior to fabrication and full primer application.	3-5 mils DFT	4-5 mils DFT	2-3 mils DFT (exterior only)	Gray
Bumper posts	3-5 mils DFT	4-5 mils DFT	2-3 mils DFT (exterior only)	ANSI Safety Yellow
Limestone silo and support steel	3-5 mils DFT	4-5 mils DFT	2-3 mils DFT	White

Table 09900-5 Field Touchup Paint Structural Steel				
Field Touch-Up	Prime Coat		Carboguard 893 SG	
	First Coat		Carboguard 893 SG	
	Finish Coat		Carbothane 134 HG	
Areas and Items to Be Painted	**Prime Coat**	**First Coat**	**Finish Coat**	**Color**
Touch-up for field welded connections and other damaged areas.	5 mils DFT	5 mils DFT	2-3 mils DFT (exterior only)	Match colors as applicable

Table 09900-6 Field Paint Exterior Structural Steel (existing, rusted)				
Field Coatings	Prime Coat		Rustbond or Rustbond FC	
	First Coat		Carboguard 893 SG or Carboguard 893 SGLT	
	Finish Coat		Carbothane 134 HG	
Areas and Items to Be Painted	**Prime Coat**	**First Coat**	**Finish Coat**	**Color**
All existing exterior structural steel, including miscellaneous plates, angles, etc.	1.5 mils DFT	5 mils DFT	2-3 mils DFT	Match colors as applicable

Table 09900-7 Galvanized Steel (touchup)

Carboline		
Field Coatings	Prime Coat	Rustbond or Rustbond FC
	Finish Coat	Carbomastic 90

Table 09900-8 Interior Steel (new)				
Carboline				
Shop Coatings	Prime Coat	Carbozinc 859		
	Finish Coat	Carboguard 890		
Field Touch-Up	Prime Coat	Carbozinc 890		
	Finish Coat	Carboguard 890		
Areas and Items to Be Painted	**Prime Coat**	**First Coat**	**Finish Coat**	**Color**
All new structural steel, including miscellaneous plates, angles, etc.; NOTE: All back-to-back angles shall be blasted and primed prior to fabrication and full primer application.	3-5 mils DFT	4-5 mils DFT	2-3 mils DFT (exterior only)	Gray
Ladders, railings, bumper posts & toe plates	3-5 mils DFT	4-5 mils DFT	2-3 mils DFT (exterior only)	ANSI Safety Yellow

Table 09900-9 Field Paint Concrete Block Walls				
Carboline				
Hole Repair	Repair Mortar	Carboguard 510		
Field Coatings	Prime/Fill Coat	Sanitile 600		
	First Coat	Sanitile 555		
	Second Coat (if required)	Sanitile 555		
Areas and Items to Be Painted	**Prime Coat**	**First Coat**	**Second Coat**	**Color**
All new concrete block walls	20 mils DFT	3-4 mils DFT	3-4 mils DFT (if required for full hiding)	As selected by Owner

Table 09900-10 Field Paint Concrete				
Concrete				
Carboline				
Field Coatings	Prime Coat*	Carboguard 1340		
	Finish Coat	Sanitile 555		
Areas and Items to Be Painted	**Prime Coat**	**First Coat**	**Second Coat**	**Color**
All new floors and basewalls	6-8 mils DFT	3-4 mils DFT	NA	As selected by Owner

Other manufacturers shall be submitted for Owner approval.

Contractor shall indicate weight of VOC compounds per gallon as well as percent of zinc in dry film thickness on substitutions (any substitution shall have a minimum of 80 percent zinc). Products must be VOC compliant.

09900.3 Execution

09900.3.1 Inspection
Surfaces scheduled to be painted shall be thoroughly examined prior to commencement of work. The Contractor shall report in writing to the Owner, any condition that may potentially affect proper application. Such defects shall have been corrected before commencement of the work.

The Contractor shall have a full time NACE inspector on site during all protective coating applications on site, including, but not limited to, the chimney exterior painting application, lined field fabricated tanks, sumps, trenches, etc. The Contractor shall provide the name of the inspector to the Owner for the Owner's approval prior to start of protective coating application in the field.

The Contractor shall provide inspection reports for all shop applied protective coatings for items and components.

Defects and deficiencies in surfaces that may adversely affect work of this section shall be corrected.

New structural steel shall be shop finished, except around field welded connections.

Upon delivery of steel to the site, all surfaces shall be free of defects. Surfaces shall be inspected by the Owner upon receipt and unloading. If defects are found, the Owner shall determine the extent of the touch-up work to be done at the Contractor's expense.

For field touch-up work the Contractor shall notify the Owner and allow him to inspect surfaces after cleaning and before primer or paint is applied.

09900.3.2 Surface Preparation
Coating work shall include the protection of surfaces not to be coated and surface preparation, furnishing and applying materials, and other work incidental to coating that is required to properly execute the work. All exposed surfaces of the equipment shall be coated in accordance with the coating manufacturer's recommendations.

All surfaces to be coated shall be clean and dry, free of grease, rust, scale, dirt, and dust and shall meet the recommendations of the coating manufacturer for surface preparation. Oil and grease shall be completely removed by using techniques described in SSPC-SP 1 before mechanical cleaning is started. Surfaces to be field painted shall be prepared to a hand or power tool cleaning in accordance with SSPC-SP-2 or 3. Contractor shall ensure that steel surfaces are at the specified preparation level immediately prior to paint application.

Surfaces shall be free of cracks, pits, projections, or other imperfections that would interfere with the formation of a smooth, unbroken coating film.

Freshly coated surfaces shall be protected from dust and other contaminants. The gloss on previously coated surfaces shall be dulled if necessary for proper adhesion of topcoats.

When applying touchup coating or repairing previously coated surfaces, the surfaces to be coated shall be cleaned as recommended by the coating manufacturer and the edges of the repaired area shall be feathered by sanding or wire brushing to produce a smooth transition that will not be noticeable after the

coating is applied. All coatings made brittle or otherwise damaged by heat of welding shall be completely removed.

The quality of compressed air shall be verified in accordance with ASTM D4285 prior to performing abrasive blasting. The test will be carried out at the beginning of each shift and witnessed by the coating inspector.

Electrical plates, hardware, light fixture trim, and fittings shall be removed prior to preparing surfaces or finishing.

All mill finish aluminum or items not to be painted shall be masked-off or shielded.

Impervious Surfaces: Mildew shall be removed by scrubbing with solution of tri-sodium phosphate and bleach. The surface shall be rinsed with clean water and allowed to dry.

Pervious (concrete block) Surfaces: Old paint shall be removed and surface cleaned by 5,000 psi vacuum water blast method. Paint chips and blasting water shall be collected for proper disposal. Disposal of existing lead based paints shall be coordinated with the Plant EHS representative. Surface shall be allowed to dry. Holes shall be filled with repair mortar prior to paint application.

09900.3.2.1 Galvanized Surfaces. Galvanized surfaces shall be prepared for coating according to the instructions of the coating manufacturer. Any chemical treatment of galvanized surfaces shall be followed by thorough rinsing with clean water.

09900.3.2.2 Ferrous Metal Surfaces. Ferrous metal surfaces shall be prepared for coating by using one or more of the following cleaning procedures as specified: solvents (SSPC-SP1); hand tools (SSPC-SP2); power tools (SSPC-SP3 or -SP11); abrasive blasting (SSPC-SP5, -SP6, -SP7, or -SP10); or water jetting (-SP12). Oil and grease shall be completely removed in accordance with SSPC-SP1 before beginning any other cleaning method. Surfaces of welds shall be scraped and ground as necessary to remove all slag and weld spatter.

All cut or sheared edges shall be ground smooth to a 1/8 inch minimum radius for all material 1/4 inch thickness and larger. For material thickness less than 1/4 inch all cut or sheared edges shall be ground smooth to a radius equal to 1/2 the material thickness. Grinding of rolled edges on standard shapes with a minimum radius of the 1/16 inch will not be required.

All ferrous metal surfaces shall have all welds ground smooth and free of all defects in accordance with NACE Standard RP0178, Appendix C, Designation D.

All blasting residue, waste, and accumulation shall be removed before coating application.

Cleaned surfaces shall be coated or lined with the specified coating, primer, or touchup coat within 6 hours of cleaning, or before rust bloom occurs. No blast cleaned surfaces shall stand overnight before coating.

The surface preparation specified herein are minimums, and if the requirements printed in the coating manufacturer's data sheets exceed the limits specified, the value printed on the data sheets shall become the minimum requirement

09900.3.3 Mixing and Thinning

Coating shall be thoroughly mixed each time any is withdrawn from the container. Coating containers shall be kept tightly closed except while coating is being withdrawn.

Coating shall be factory mixed to proper consistency and viscosity for hot weather application without thinning. Thinning will be permitted only as necessary to obtain recommended coverage at lower application temperatures. In no case shall the wet film thickness of applied coating be reduced, by

addition of coating thinner or otherwise, below the thickness recommended by the coating manufacturer. Thinning shall be done in compliance with all applicable air quality regulations.

Uniform suspension of coating pigments shall be maintained during application.

Jobsite tinting will not be permitted.

09900.3.4 Application

Coating shall be applied in a neat manner that will produce an even film of uniform and proper thickness, with finished surfaces free of runs, sags, ridges, laps, and brush marks. In no case shall coating be applied at a rate of coverage greater than the maximum rate recommended by the coating manufacturer.

A skid resistant additive shall be incorporated into the top layer of coating systems which are applied to permanent walking surfaces.

Each layer of the coating system shall be of a visibly different color or shade from the preceding coat. Coatings shall be factory tinted.

A minimum of 80 foot-candles of illumination shall be provided for surfaces to be coated.

Ventilation in the work area shall be adequate to remove all particulates and solvent vapors. Where natural ventilation is inadequate, a mechanical ventilation system shall be employed. The ventilation system shall provide a clean air supply during all phases of coating operations.

Coating failures will not be accepted and shall be entirely removed down to the substrate and the surface recoated. Failures include but are not limited to checking, cracking, teardrops, fat edges, fisheyes, or delamination.

Coating materials shall be applied in accordance with the manufacturer's recommendations by competent and experienced applicators.

The Contractor shall be responsible for review and acceptance of the prepared surface. The application of coating material to a surface shall constitute acceptance of that surface by the Contractor. If the surface is not acceptable for coating, the Contractor shall notify the Owner in writing before starting application of the coating material.

Finishes shall not be applied to surfaces that are not dry. Applied coat shall be allowed to dry before next coat is applied.

The application of each coat of paint will be inspected by the Owner and/or a technical representative from the painting manufacturer.

The materials stated pot life shall be strictly observed. Mixed materials beyond their pot life shall be discarded.

09900.3.5 Protection of Surfaces

Throughout the work, proper dropcloths, masking tapes, and other protective measures shall be provided to protect surfaces from accidental spraying, splattering, or spilling of coatings. Damage resulting from coating operations shall be corrected and repaired. Coatings deposited on surfaces not being coated shall immediately be removed.

The Contractor shall remove and reinstall, or provide adequate in-place protection for, valve and equipment identification tags, gauges, installed hardware, accessories, lighting and electrical components, factory finished materials, plumbing fixtures and fittings, and other materials that may become splattered or damaged by coating materials.

09900.3.6 Cleaning
As work proceeds, all paint shall be promptly removed where spilled, splashed, or spattered.

During the progress of the work. the premises shall be maintained free of unnecessary accumulation of tools, equipment, surplus materials, and debris.

All cotton waste, cloths, and material which may constitute a fire hazard shall be collected and , placed in closed metal containers and removed daily from the site.

09900.3.7 Environmental Conditions
Coatings shall not be applied, except under environmentally controlled conditions, during wet, damp, or foggy weather, or when windblown dust, dirt, debris, or insects will collect on freshly applied coating.

The Contractor shall ensure surface temperatures or the surrounding air temperature is above 50° F, below 100° F, and a minimum of 5° F above dewpoint before applying finishes, unless manufacturers product data sheet allows for low temperature cure conditions. Coating or lining material shall not be installed if the relative humidity is greater than 95 percent.

Coatings shall not be applied at temperatures lower than the minimum temperature recommended by the coating manufacturer, or to metal surfaces where conditions are likely to cause condensation, regardless of the air temperature. When necessary for proper application, a temporary enclosure shall be erected and the environment properly conditioned until the coating has fully cured. Adequate continuous ventilation and sufficient heating facilities to maintain temperatures above 50° F for 24 hours before, during and 48 hours after application of finishes shall be provided, unless required otherwise by manufacturer's instructions

Coatings shall not be applied at temperatures higher than the maximum temperature recommended by the coating manufacturer. Where coatings are applied during periods of elevated ambient temperatures, the Contractor shall ensure that proper application is performed including adherence to all re-coat window requirements. Precautions shall be taken to reduce the temperature of the surface application, especially for metal, at elevated temperatures above 100° F including shading the application area from direct sunlight, applying coating in the evening or at night, and ventilating the area to reduce the humidity and temperature.

09900.3.8 Quality Control
The following inspection and testing shall be performed: visual inspection, surface profile, wet and dry film thickness, spark testing, and adhesion testing. The Owner will be responsible for review of all Contractor testing documentation and will also establish hold points indicating periodic onsite review of the Contractor's test procedures.

The Contractor shall provide daily documented atmospheric condition reports to the Owner including temperature and humidity every four hours during application and temperature monitoring during cure of the coating system.

Personnel performing or supervising the inspection of surface preparation, coating application and quality control testing shall be qualified as a Certified Coating Inspector in accordance with the requirements of NACE International or previously approved equivalent program.

09900.3.8.1 Surface Profile Testing. The surface profile for ferrous metal surfaces shall be measured for compliance with the specified minimum profile in accordance with ASTM D4417. The surface profile for concrete shall comply with SSPC-SP 13, Table 1, for severe service.

09900.3.8.2 Visual Inspection. The surface of the protective coatings shall be visually inspected.

09900.3.8.3 Film Thickness. Coating film thickness shall be verified by measuring the film thickness of each coat as it is applied and the dry film thickness of the entire system. Dry film thickness shall be

measured in accordance with SSPC-PA 2. Wet film thickness shall be measured with a gauge that will measure the wet film thickness within an accuracy of ±0.5 mil in accordance with ASTM D4414.

09900.3.8.4 Spark Testing. Spark testing shall be conducted for coatings on metallic surfaces that will be in immersion service or underground buried service. Coatings shall be spark tested using an acceptable electrical spark tester set at the recommended voltage. The Owner shall observe the spark testing and shall verify the testing equipment is working properly before the spark testing of the coating is started. The electrode movement shall be continuous and shall proceed in a systematic manner that will cover 110 percent of the coated surface.

Spark testing for coatings on metal shall be done in accordance with NACE RPO188.

All detected holidays and pinholes shall be marked and repaired as recommended by the coating manufacturer.

09900.3.8.5 Adhesion Testing. An adhesion test shall be conducted on a properly prepared and coated steel, concrete or concrete masonry surface that is acceptable to the Contractor and the Owner. The test area shall be at least 2 square feet or larger to allow a minimum of three tests to be conducted. The test area shall be coated with the specified system and cured as recommended by the coating manufacturer. Pull-off strength adhesion tests of the coating shall be conducted in accordance with ASTM D4541 using an Elcometer tensile adhesion tester. At least three adhesion tests shall be conducted and the results averaged. Adhesion strength shall equal or exceed the minimum adhesion strength recommended by the coating manufacturer and shall exceed the tensile strength of the substrate.

If the coating fails the adhesion test, the cause of the failure shall be determined and corrected before reconducting the test.

09900.3.9 Not Used

09900.3.10 Cleanup
All project and plant generated wastes/debris shall be, and remain, unmixed and separate.

Blast and coating residue shall be removed from the enclosure to the appropriate waste storage containers on a daily basis unless otherwise directed by the Owner.

The Contractor shall provide prompt removal and proper disposal of all debris and trash generated in doing the work; at least on a weekly interval.

All tools, surplus materials, equipment, scrap, debris and waste shall be removed from the plant site immediately upon completion of the project.

Blast wastes may remain onsite until proper waste classifications are determined. Blast/paint residue shall be removed within one week of the receipt of analytical data.

Contractor generated solvent wastes and coatings application waste is the sole responsibility of the Contractor. All such wastes shall be managed by the Contractor.

The Contractor shall correct and restore to original condition any property and equipment damaged as a result of project operations.

SECTION 13300
PRE-ENGINEERED METAL BUILDING SYSTEMS

13300.1 General

13300.1.1 Related Documents

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

13300.1.2 Summary

13300.1.2.1 The extent of the building is shown on the drawings. Items to be furnished and installed include, but are not limited to the following:

Thermal wall and roof insulation.

Anchor bolts for building columns, beams and embedded items installed under other sections ofthe specifications.

Boots for sealing and flashing roof penetrations.

Snowjacks over entrance doors.

Shop drawings, erection plans, column and bracing reactions, certifications.

Anchor bolt design.

Design drawings and calculations wet sealed and signed by a Professional Engineer licensed in the state of Missouri.

13300.1.2.2 Design Loads: Basic design loads, as well as auxiliary and collateral loads, are indicated below.

Basic design loads include live load, wind load, and seismic load in addition to the dead load.

Collateral loads include additional dead loads over and above the weight of the metal building system such as monorail systems hanging from the roof.

Roof

Dead Load:
Weight of all structures/materials incorporated into roof construction
Uniformly distributed hanging dead load of 10 psf (lighting+misc. mechanical loads)

Live Load:
Roof load - 20 psf (non-reducible)
Monorail loads (include 15% impact)if required

Snow Load:
Ground Snow Load – 20 psf + plus snow drift where required
Exposure C (Exposure Factor = 1.0)
Importance Factor = 1.00

Wind Load:

Design and engineer metal building systems capable of withstanding the effects of wind loading per IBC 2006. The effects of wind loading as follows:

Basic Wind Speed:	90 mph
Importance Factor:	1.00
Exposure:	Exposure C
Building / Story Drift Limitation:	h/180 building under wind and service load, i.e. DL + WL
Building type – Low-rise	

Seismic Load:

Design and engineer metal building systems capable of withstanding the effects of earthquake motions determined according to IBC 2006 Seismic Loads

Labadie
S_1 = 0.1442
Ss= 0.4451

Meramec
S_1 = 0.1771
Ss= 0.6194

Rush Island
S_1 = 0.1991
Ss= 0.7013

Sioux
S_1 = 0.1452
Ss= 0.4625

Seismic Use Group II
Importance Factor 1.0
Site Class D
Lateral Force Resisting System:
Concentrically Braced Steel Frame: R = 5
Cd = 4½
Ordinary Moment Frames of Steel: R = 3½
Cd = 3

Seismic Design Category to be the most severe as determined per IBC 2006 Section 1616.3.

Drift: Building design will comply with the amplified drift section of IBC 2006. True deflection is taken from using the elastic drift and factoring that drift with the amplification factor.

Maximum Deflection Criteria:

Purlins and Rafters: Vertical deflection of 1/150 of the span
Girts: Horizontal deflection of 1/120 of the span
Roof Panels: Vertical deflection of 1/180 of the span
Wall Panels: Horizontal deflection of 1/180 of the span

Design secondary framing system to accommodate deflection of primary building structure and construction tolerances, and to maintain clearances at openings.

13300.1.2.3 Structural Framing and Roof and Siding Panels: Design primary and secondary structural members and exterior covering materials for applicable loads and combinations of loads in accordance with the IBC 2006 including all supplements.

Structural Steel: Comply with the American Institute of Steel Construction's (AISC) "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" for design requirements and allowable stresses.

Light Gage Steel: Comply with the American Iron and Steel Institute's (AISI) "Specification for the Design of Cold Formed Steel Structural Members" and "Design of Light Gage Steel Diaphragms" for design requirements and allowable stresses.

Welded Connections: Comply with the American Welding Society's (AWS) "Standard Code for Arc and Gas Welding in Building Construction" for welding procedures.

13300.1.3 System Performance Requirements

13300.1.3.1 General: Engineer, design, fabricate and erect the pre-engineered metal building system to withstand loads from winds, gravity, structural movement including movement thermally induced, and to resist in-service use conditions that the building will experience, including exposure to the weather, without failure.

Design each member to withstand stresses resulting from combinations of loads that produce the maximum allowable stresses in that member as prescribed in the IBC 2006 including all supplements.

13300.1.3.2 Air Infiltration for Roof Panels: Provide roof panel assemblies with permanent resistance to air leakage through assembly of not more than 0.09 cfm/sq. ft. of fixed roof area when tested according to ASTM E 1680 at a static-air-pressure difference of 4 lbf/sq. ft.

13300.1.3.3 Air Infiltration for Wall Panels: Provide wall panel assemblies with permanent resistance to air leakage through assembly of not more than 0.09 cfm/sq. ft. of fixed wall area when tested according to ASTM E 283 at a static-air-pressure difference of 4 lbf/sq. ft.

13300.1.3.4 Water Penetration for Roof Panels: Provide roof panel assemblies with no water penetration as defined in the test method when tested according to ASTM E 1646 at a minimum differential pressure of 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. and not more than 12 lbf/sq. ft.

13300.1.3.5 Water Penetration for Wall Panels: Provide wall panel assemblies with no water penetration as defined in the test method when tested according to ASTM E 331 at a minimum differential pressure of 20 percent of inward-acting, wind-load design pressure of not less than 6.24 lbf/sq. ft. and not more than 12 lbf/sq. ft.

13300.1.3.6 Wind-Uplift Resistance: Provide roof panel assemblies that meet requirements of ASTM E 1592 using design coefficients established in accordance with the current IBC code in effect under the Authority having Jurisdiction.

13300.1.4 Submittals

13300.1.4.1 General: Submit the following in accordance with Conditions of the Contract, Appendix J, and Section 1A, 5.0.

13300.1.4.2 Product data consisting of metal building system manufacturer's product information for building components and accessories, including insulation.

13300.1.4.3 Shop drawings for metal building structural framing system, roofing and siding panels, and other metal building system components and accessories.

Structural Framing: Furnish complete erection drawings signed and sealed by a Professional Engineer legally authorized to practice in the State of Missouri. Include details showing

fabrication and assembly of the metal building system. Show anchor bolts settings and sidewall, endwall, and roof framing. Include transverse cross-sections.

Roofing and Siding Panels: Provide layouts of panels on walls and roofs, details of edge conditions, joints, corners, custom profiles, supports, anchorages, trim, flashings, closures, and special details. Include transverse cross-sections.

Building Accessory Components: Provide details of metal building accessory components to clearly indicate methods of installation including the following:

Sheet Metal Accessories: Provide layouts at ¼ inch scale. Provide details of ventilators, louvers, gutters, downspouts, and other sheet metal accessories at not less than 1½ inch scale showing profiles, methods of joining, and anchorages.

13300.1.4.4 Samples for initial selection purposes in form of manufacturer's color charts or chips showing full range of colors, textures, and patterns available for metal roofing and siding panels with factory-applied finishes.

13300.1.4.5 Samples for verification purposes of roofing and siding panels. Provide sample panels 12-inch long by actual panel width, in the profile, style, color, and texture indicated. Include clips, battens, fasteners, closures, and other panel accessories.

13300.1.4.6 Reactions: Submit column and bracing reactions to be resisted by foundation system. Forces shall be broken down separately by dead load, collateral load, live load, wind load, and seismic load. **Reactions shall be submitted within 2 weeks of award of contract to allow verification of foundation design.**

13300.1.4.7 Professional Engineer's certificate prepared, signed and sealed by a Professional Engineer, legally authorized to practice in the State of Missouri, verifying that the structural framing and covering panels meet indicated loading requirements and that the roof assembly meets the UL-90 wind uplift rating requirements.

13300.1.4.8 Four (4) sets of drawings and design calculations signed and wet sealed by a Professional Engineer legally authorized to practice in the State of Missouri to be used by Ameren to obtain building permits.

13300.1.5 Quality Assurance

13300.1.5.1 Design Criteria: The drawings indicate sizes, profiles, and dimensional requirements of the pre-engineered metal building system. Metal building systems having equal performance characteristics with deviations from indicated dimensions and profiles may be considered, provided deviations do not change the design concept or intended performance. The burden of proof for equality is on the Proposer.

13300.1.6 Delivery, Storage, and Handling

13300.1.6.1 Deliver prefabricated components, sheets, panels, and other manufactured items so they will not be damaged or deformed. Package wall and roof panels for protection against transportation damage.

13300.1.6.2 Handling: Exercise care in unloading, storing, and erecting wall and roof covering panels to prevent bending, warping, twisting, and surface damage.

13300.1.6.3 Stack materials on platforms or pallets, covered with tarpaulins or other suitable weathertight ventilated covering. Store metal wall and roof panels so that water accumulations will drain freely. Do not store panels in contact with other materials that might cause staining, denting or other surface damage.

13300.1.7 Warranty

13300.1.7.1 Roofing and Siding Panel Finish Warranty: Furnish the roofing and siding panel manufacturer's written warranty, covering failure of the factory-applied exterior finish on metal wall and roof panels within the warranty period. This warranty shall be in addition to and not a limitation of other rights the Owner may have against the Contractor under the Contract Documents.

Warranty period for factory-applied exterior finishes on wall and roof panels is 20 years after the date of Substantial Completion.

13300.1.8 Extra Materials

13300.1.8.1 Maintenance Stock: Furnish at least 5 percent excess over required amount of nuts, bolts, screws, washers, and other required fasteners for each metal building. Pack in cartons labeled to identify the contents and store on the site where directed.

13300.2 Products

13300.2.1 Manufacturers

13300.2.1.1 Manufacturer: Subject to compliance with specified requirements, provide metal building systems provided by one of the following (or approved equal):

American Buildings

Butler Manufacturing Co.

Ceco Buildings Division

Metallic Building Co.

Varco-Pruden Buildings

Star Manufacturing Co.

13300.2.2 Materials

13300.2.2.1 For all Steel items related items refer to Section 05120, Structural Steel and Section 05500, Metal Fabrication.

13300.2.2.2 Insulation:

Thermal Insulation: Glass-fiber blanket. Comply with Thermal Insulation Manufacturer's Association Standard TIMA 202 MBI, ASTM C 991,0.5 lb per cu. ft. density, thickness indicated, with UL flame spread classification of 25 or less.

Vapor Barrier: Exposed insulation shall be faced on one side with a white metalized polypropylene / scrim / kraft vapor barrier consisting of a .0015" white metalized polypropylene film over a 4" x 4" tri-directional fiberglass scrim reinforcement backed with a 15 lb./ream kraft paper.

Fire Hazard Classification: Flame spread 25 or less with smoke developed 50 or less per UL 723 and ASTM E-84.

Water Vapor Transmission Rate: 0.02 Perms per ASTM E -96.

Light Reflectivity: 80 percent per ASTM C-523.

Roof Insulation: Provide R30 system consisting of either 6" faced batts placed between purlins and topped with 3½" unfaced batts placed across purlins or 8" faced batts placed between purlins and topped with 2" unfaced batts placed across purlins. Lap edges of facing over purlins and seal to provide continuous vapor barrier. Support insulation using a banded system consisting of 2" wide galvanized steel straps spaced 24" on centers with white enamel coating screw attached to underside of purlin. Screw heads to have matching color.

Wall Insulation: 4" faced batts placed between girts and siding.

13300.2.3 Structural Framing

13300.2.3.1 Rigid Frames: Fabricated from hot-rolled structural steel shapes or provide factory-welded, shop-painted, built-up "I-beam"-shape consisting of tapered or parallel flange beams and tapered columns. Furnish frames with attachment plates, bearing plates, and splice members. Holes for field-bolted connections to be factory-drilled.

13300.2.3.2 Primary Endwall Framing: Provide the following primary endwall framing members fabricated for field-bolted assembly:

Endwall Columns: Manufacturer's standard shop-painted, built-up factory-welded "I"-shape with parallel flanges or hot-rolled structural steel shapes.

Endwall Beams: Manufacturer's standard shop-painted "C"-shape roll-formed sections.

13300.2.3.3 Secondary Framing: Provide the following secondary framing members:

Roof Purlins, Sidewall and Endwall Girts: "C"-or "Z"-shaped sections fabricated from shop-painted roll-formed steel. Purlin spacers shall be fabricated from cold-formed galvanized steel sections.

Eave Struts: Unequal flange "C"-shaped sections formed to provide adequate backup for both wall and roof panels. Fabricate from shop-painted roll-formed steel.

Flange and Sag Bracing: Fabricate from shop-painted roll-formed steel.

Base or Sill Angles: Fabricate from cold-formed galvanized steel sections. Secondary endwall structural members, except columns and beams, shall be the manufacturer's standard sections fabricated from cold-formed galvanized steel.

13300.2.3.4 Wind Bracing: Provide adjustable wind bracing using cables or threaded steel rods; comply with ASTM A 36 or ASTM A 572, Grade D.

13300.2.3.5 Bolts: Provide shop-painted bolts except when structural framing components are in direct contact with roofing and siding panels. Provide zinc-plated or cadmium-plated bolts when structural framing components are in direct contact with roofing and siding panels.

13300.2.3.6 Paint and Coatings: Provide Manufacturer’s standard shop primer.

13300.2.4 Roofing, Siding, and Liner Panels

13300.2.4.1 Wall Panel Face Sheets: Fabricate wall panel face sheets from 24-gage (0.0239-inch) minimum, structural quality, Grade C, zinc-coated steel sheets.

Color: Final color to be selected by Engineer.

13300.2.4.2 Fluoropolymer Finish: Provide shop-applied fluoropolymer (containing 70% Kynar 500® or Hylar 5000® resin) finish to interior and exterior galvanized steel siding panels and related trim and accessory elements.

Clean galvanized steel with an alkaline compound, then treat with a zinc phosphate conversion coating and seal with a chromic acid rinse.

Apply a 2-coat fluoropolymer coating system to pretreated steel. Coating shall consist of a specific formulated inhibitive primer applied to a dry film thickness of 0.15 mil to 0.25 mil and a fluorocarbon color coat containing not less than 70% polyvinylidene fluoride resin by weight applied to a dry film thickness of 0.80 mils to 1.3 mils.

13300.2.4.3 Standing Seam Roof Panels: Manufacturer's standard factory-formed standing-seam roof panel system designed for mechanical attachment of panels to roof purlins using a concealed clip. Form panels of 24-gage (0.0239-inch), steel sheets with 0.5 ounce Galvalume coating per ASTM A 792.

Clips: Provide 16-gage (0.0598-inch) panel clips.

Cleats: Factory-caulked, mechanically seamed cleats formed from 24-gage (0.0239-inch), Grade C, zinc-coated steel sheets.

Thermal Blocks: 1" high density polystyrene thermal blocks between purlin and roof clip.

Color: Final color to be selected by Engineer.

13300.2.4.4 Fasteners: Self-tapping screws, bolts, nuts, self-locking rivets, self-locking bolts, end-welded studs, and other suitable fasteners designed to withstand design loads. All fasteners shall be extended life type.

Provide metal-backed neoprene washers under heads of fasteners bearing on weather side of panels.

Use aluminum or stainless steel fasteners for exterior application and galvanized or cadmium-plated fasteners for interior applications.

Locate and space fastenings in true vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of neoprene washer.

Provide fasteners with heads matching color of roofing or siding sheets by means of plastic caps or factory-applied coating.

13300.2.4.5 Accessories: Provide sheet metal accessories factory-formed of the same material in the same finish as roof and wall panels.

13300.2.4.6 Flexible Closure Strips: Closed-cell, expanded cellular rubber, self-extinguishing flexible closure strips. Cut or premold to match configuration of roofing and siding sheets. Provide closure strips where indicated or necessary to ensure weathertight construction.

13300.2.4.7 Sealing Tape: Pressure-sensitive 100% solids gray polyisobutylene compound sealing tape with release paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape ½" wide and ⅛" thick.

13300.2.4.8 Joint Sealant: One-part elastomeric polyurethane, polysulfide, or silicone rubber sealant as recommended by the building manufacturer.

13300.2.4.9 Snowjacks: Snowjacks as manufactured by SNOWJAX, Inc. or approved equal.

13300.2.5 Sheet Metal Accessories

13300.2.5.1 General: Provide coated steel sheet metal accessories with coated steel roofing and siding panels.

13300.2.5.2 Gutters: Furnish gutter as required, complete with end pieces and other special pieces as required; and sized in accordance with BOCA National Plumbing Code. Join sections with riveted and soldered or sealed joints. Provide expansion-type slip joint at center of runs. Furnish gutter supports spaced 36" on center, constructed of same metal as gutters. Provide bronze, copper, or aluminum wire ball strainers at outlets. Finish to match rake.

Color: Final color to be selected by Engineer.

13300.2.5.3 Downspouts: Furnish complete with elbows and offsets. Join sections with 1½" telescoping joints. Provide fasteners designed to hold downspouts securely 1" away from walls; locate fasteners at top and bottom and at approximately 5 feet on center in between.

Color: Final color to be selected by Engineer.

13300.2.6 Fabrication

13300.2.6.1 General: Design prefabricated components and necessary field connections required for erection to permit easy assembly and disassembly.

Fabricate components in such a manner that once assembled, they may be disassembled, repackaged, and reassembled with a minimum amount of labor.

Clearly and legibly mark each piece and part of the assembly to correspond with previously prepared erection drawings, diagrams, and instruction manuals.

13300.2.6.2 Structural Framing: Shop-fabricate framing components to indicated size and section with base plates, bearing plates, and other plates required for erection, welded in place. Provide holes for anchoring or connections shop-drilled or punched to template dimensions.

Shop Connections: Provide power riveted, bolted, or welded shop connections.

Field Connections: Provide bolted field connections.

13300.3 Execution

13300.3.1 Erection

13300.3.1.1 Framing: Erect framing true to line, level, plumb, rigid, and secure. Level base plates to a true even plane with full bearing to supporting structures, set with double-nutted anchor bolts. Use a non-shrink, non-metallic grout to obtain uniform bearing and to maintain a level base line elevation. Moist cure grout for not less than 7 days after placement.

13300.3.1.2 Purlins and Girts: Provide rake or gable purlins with tight-fitting closure channels and fascias. Locate and space wall girts to suit door and window arrangements and heights. Secure purlins and girts to structural framing and hold rigidly to a straight line by sag rods.

13300.3.1.3 Bracing: Provide diagonal cable, rod or angle bracing in roof and sidewalls as indicated. See drawings for bracing location.

13300.3.1.4 Framed Openings: Provide shapes of proper design and size to reinforce openings and to carry loads and vibrations imposed, including equipment furnished under mechanical and electrical work. Securely attach to building structural frame.

Coordinate with mechanical contractor.

13300.3.2 Roofing and Siding

13300.3.2.1 General: Arrange and nest sidelap joints so prevailing winds blow over, not into, lapped joints. Lap ribbed or fluted sheets one full rib corrugation. Apply panels and associated items for neat and weathertight enclosure. Avoid "panel creep" or application not true to line. Protect factory finishes from damage.

Field cutting of exterior panels by torch is not permitted.

Provide weatherseal under ridge cap. Flash and seal roof panels at eave and rake with rubber, neoprene, or other closures to exclude weather.

13300.3.2.2 Standing-Seam Roof Panel System: Fasten roof panels to purlins with concealed clip in accordance with the manufacturer's instructions.

Install clips at each support with self-drilling fasteners.

At end laps of panels, install tape calk between panels.

Install factory-calked cleats at standing-seam joints. Machine-seam cleats to the panels to provide a weathertight joint.

13300.3.2.3 Wall Sheets: Apply elastomeric sealant continuously between metal base channel (sill angle) and concrete and elsewhere as necessary for waterproofing. Handle and apply sealant and backup in accordance with the sealant manufacturer's recommendations.

Align bottom of wall panels and fasten panels with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws. Fasten window and door frames with machine screws or bolts. When building height requires two rows of panels at gable ends, align lap of gable panels over wall panels at eave height.

Install screw fasteners with power tools having controlled torque adjusted to compress neoprene washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.

Provide weatherproof escutcheons for pipe and conduit penetrating exterior walls.

13300.3.2.4 Sheet Metal Accessories: Install gutters, downspouts, and other sheet metal accessories in accordance with manufacturer's recommendations for positive anchorage to building and weathertight mounting.

13300.3.2.5 Thermal Insulation: Install insulation concurrently with installation of roof panels in accordance with manufacturer's directions. Install blankets straight and true in one-piece lengths with both sets of tabs sealed to provide a complete vapor barrier.

13300.3.2.6 Snowjacks: Secure to roof with adhesive and install in accordance with manufacturer's instructions.

13300.3.2.7 Cleaning and Touch-Up: Clean component surfaces of matter that could preclude paint bond. Touch up abrasions, marks, skips, or other defects to shop-primed surfaces with same type material as shop primer.

SECTION 16101
MEDIUM-VOLTAGE SWITCHING DEVICES

16101.1 General

16101.1.1 Scope of Supply

Scope of supply shall include furnishing medium voltage switching devices as specified herein and on the Medium Voltage Switching Devices Specification Sheets included at the end of this section.

Medium voltage equipment included in the scope of supply is as follows:

Table 16101-1 Medium Voltage Equipment
Item
34.5 kV Switchgear

16101.1.2 Not Used

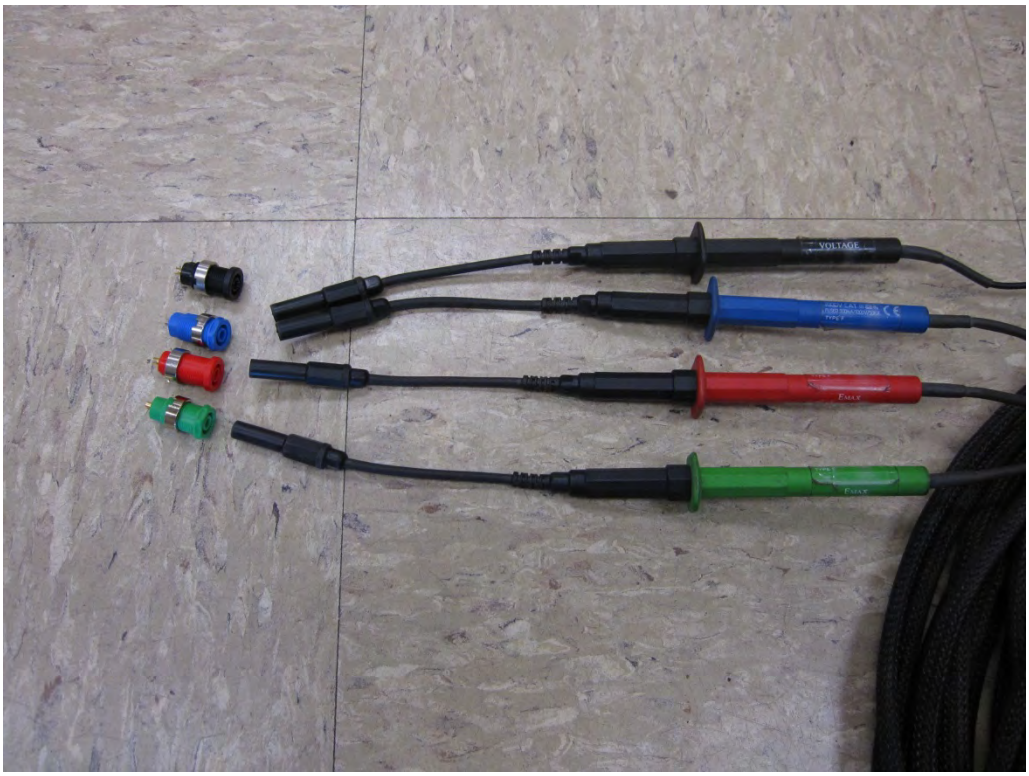
16101.1.3 Performance and Design Requirements

Performance and design requirements for the medium voltage switching devices are indicated on the Medium Voltage Switching Devices Specification Sheets included at the end of this section and as follows.

MV Switchgear shall be single-high design, with the control compartment on top and the power compartment on bottom.

For all switchgear provide infrared (IR) viewing windows in the back of each cubicle so on-line temperature monitoring can take place for cable and bus connections without having to open panels. IR windows shall have a bolted and hinged cover over the windows. IR windows shall be designed and installed as to not compromise the rating or integrity of arc resistant switchgear.

For breakers feeding motors, provide PdMA M-TAP Amphenol® connector plug receptacle on outside of control compartment with PdMA® circuit board box for on-line motor testing. The motor testing plugs shall be accessible from outside the switchgear without opening any doors. For on-line motor testing purposes, a jack panel shall be provided (one for each bus) to connect the PdMA voltage test cable connectors to the secondary of the bus potential transformers for voltage measurements. Reference photo below:



If the Contractor elects to provide the medium voltage and other electrical equipment in prefabricated power distribution centers, the equipment specified on the Medium Voltage Switching Devices Specification Sheets shall be furnished installed in a factory-fabricated building as specified in Section 13125. Design and layout of prefabricated power distribution center shall be reviewed and approved by the Owner. If furnished in the prefabricated power distribution center, there shall be no steps and there shall be no change in elevation to remove breakers from the power distribution center unless an appropriately sized elevator is available for use. The design life of the equipment supplied shall not be less than 30 years subject to proper operations and maintenance in accordance with industry standards.

The entire switchgear shall be completely enclosed and inside of the prefabricated building with adequate distance around the rear of the switchgear for completely opening doors. The rear of the switchgear shall not be exposed to ambient conditions.

The depth of the finished equipment shall be sufficient to allow for entrance, bending, and termination of power cables. A minimum of 26 inches of clearance between terminal points and cable entrance shall be provided.

Spare cubicles shall be fully equipped with circuit breaker/contactor, relays, indication equipment, etc.

All breakers/contactors shall be operated and controlled from the plant control system. Breaker/contactor control power available or status shall be monitored by the plant control system.

All breaker/contactor cubicles shall be provided with local controls on the front of the cubicles for maintenance purposes. The breaker in non-operable conditions (test position, etc) shall be indicated in the DCS. The local controls shall incorporate LED indication lights and pistol grip switches. Lamps shall be replaceable from the front of the switchgear without opening the cubicle door.

All medium voltage motor feeder cables shall have shielded cable and a separate ground conductor run for each circuit. The shields of the motor cables shall be tied together at both ends but only grounded at the motor end and left ‘floating’ at the switchgear end. The shield shall be run through the zero sequence CT as part of the cable assembly but not be run back through the zero sequence CT. The shield of the cable shall only pass through the zero sequence CT once.

16101.1.4 Codes and Standards

Work performed under these specifications shall be done in accordance with the codes and standards specified on the Medium Voltage Switching Devices Specification Sheets included at the end of this section, and all codes and standard referenced by those codes and standards. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards specified shall be interpreted to be the jurisdictionally approved edition and addenda. If a code or standard is not jurisdictionally mandated, then the latest edition and addenda in effect at the date of this document shall apply. These references shall govern the work except when they conflict with the Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference.

16101.1.5 Not Used

16101.1.6 Approved Manufacturers of Components

For the following components, only the listed manufacturers are recognized by Owner as maintaining the level of quality of workmanship required by these specifications.

The manufacturer shall be ISO 9001 certified.

Table 16101-3 Approved Manufacturers

Component	Manufacturer
Medium voltage switchgear	In accordance with Approved Suppliers List
Medium voltage controllers	Same as MV switchgear
Medium voltage power switching centers	Same as MV switchgear
Power Distribution Centers	In accordance with Approved Suppliers List
MV Protective relays	Refer to Tables 16101- 6 thru 16101-15 for relay types and test devices.

16101.1.7 Test Requirements

Testing shall be conducted in accordance with the standards specified on the Medium Voltage Switching Devices Specification Sheets included at the end of this section. The testing is to be considered part of the defined Scope of Work. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure.

16101.1.7.1 Production Tests. After the equipment has been completely fabricated, it shall be tested in accordance with the manufacturer's standard tests. The production (routine) tests shall include the following items as minimum in accordance with all applicable standards:

High voltage tests for all main and control circuits.

Mechanical operation and interlocks.

Circuit breaker operation tests, including local and remote trip/close, with a minimum of 100 mechanical operations.

Each vacuum interrupter shall receive a vacuum integrity test by means of the system ac high potential test prior to shipment.

Each circuit breaker shall have contact timing and contact motion velocity test.

Each circuit breaker shall be uniquely identified with an individual serial number permanently mounted on the breaker by means of a metal nameplate.

Current transformer and voltage transformer ratio and polarity check. All current transformer saturation and performance curves shall be provided to the Owner during detail design phase.

Equipment shall be subjected to primary voltage injection procedures to determine proper operations of all voltage sensitive components.

Equipment shall be subjected to primary current injection procedures to determine proper operations of all current sensitive components.

Complete wiring check. Full operational tests of the control schemes and equipment to verify correct operation.

Overall fit and finish.

Accuracy of calibrated pickup and drop-off levels over the range of relay settings.

Wiring continuity tests and a complete wiring check shall be performed for all equipment.

Confirm that the bus bars are properly aligned and appropriately torqued across shipping splits and power distribution center shipping splits. Ensure insulation integrity of all bus.

Physical dimensions shall be checked against approved drawings.

The complete assembly shall have a low frequency withstand (AC high potential) test performed to assure insulation system integrity.

The arc resistant design testing shall be performed in accordance with IEEE C37.20.7 using the maximum short circuit current available for the system or device rating as the perspective current available at the incoming bus terminals of the test sample.

If the equipment is provided in a power distribution center, a complete checkout of all building auxiliaries such as the HVAC, paging system, fire detection, power distribution system, etc shall take place. Current Transformer and Voltage Transformer wiring shall not go through shipping splits and have splices. Final Power Distribution Center designs shall be reviewed and approved by the Owner.

16101.1.8 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. The equipment shall be provided as indicated on the one-line diagrams. The equipment units shall be numbered as indicated on the drawings in Appendix L – Project Specific Drawings.

16101.1.9 Not Used

16101.2 Products

16101.2.1 General

The Contractor shall provide a standard design for items within the scope of this specification that are not covered in detail in the specification. The standard design shall be in accordance with accepted industry practices.

Where conflicting specification information is provided, the order of precedence is: 1) one-line diagrams; 2) Medium Voltage Switching Devices Specification Sheets and articles; and 3) technical supplemental specifications.

16101.2.1.1 Definitions. The following are descriptions of selected terms used within this specification and on the Medium Voltage Switching Devices Specification Sheets.

16101.2.1.1.1 Equipment assembly (lineup). One or more contiguous enclosures containing subassembly units and associated equipment that may in addition have an overall weatherproof housing.

16101.2.1.1.2 Subassembly unit. A group of equipment, which may include one (for most types of applications) or more (for certain motor starting applications) switching devices, that forms part of an equipment assembly.

16101.2.1.1.3 Switching device. A device capable of opening and closing one or more electrical power circuits.

16101.2.1.1.4 Spare. When used in reference to a subassembly unit, it is a fully-equipped and fully-functional subassembly unit of the designated type, including switching device, designated for future use. Spare subassembly units shall be furnished completely equipped and wired.

16101.2.1.1.5 Equipped space. Identical to a fully-equipped and fully-functional subassembly unit of the designated type, excluding the switching device. A switching device installed in an equipped space shall be immediately operable.

16101.2.1.1.6 Drawout. When used in reference to a device, it is a device that can be isolated from the supply (and load, if applicable) and removed without the use of tools other than the racking tool provided with the switchgear.

16101.2.2 Ratings

All equipment supplied under these specifications shall be provided in accordance with the ratings specified on the Medium Voltage Switching Devices Specification Sheets.

16101.2.3 Medium Voltage Switchgear

This article provides requirements specific to medium voltage switchgear. Medium voltage switchgear shall consist of an assembly of medium voltage power circuit breakers and other associated equipment as specified herein and on the Medium Voltage Switching Devices Specification Sheets. Each switchgear lineup shall have a test station local to the switchgear or shall have a means of testing each device with the appropriate control voltage.

16101.2.3.1 Power Circuit Breakers. Medium-voltage switchgear shall be furnished with electrically operated, 3-pole, single-throw, draw out type, medium voltage power circuit breakers complete with operating mechanisms and other required devices. The interrupting medium shall be vacuum.

The breakers shall be operated by a motor-charged, spring-type stored energy mechanism. The electric motor shall be rated at 125 VDC and shall operate from 100 to 140 VDC. The stored energy closing springs shall be suitable for manual as well as electrical charging, and a front operated manual spring charging handle shall be furnished for emergency charging. Trip and close levers for manual operation shall be furnished on the circuit breaker element.

Closing and Trip coils shall operate at the following specified voltage ranges:

Nominal Voltage – 125 VDC.or 48VDC

Closing Mechanism Operating Range – 100 to 140 VDC.

Tripping Mechanism Operating Range – 70 to 140 VDC.

The closing springs shall be discharged automatically when the breaker is rolled into the compartment or is moved from the "Connected" to the "Test" position. The closing springs shall also be discharged when the breaker is removed from the "Test" position-either between the "Test" and "Disconnected" positions or between the "Disconnected" and "Withdrawn" positions.

The continuous current capacity of each power circuit breaker shall be 1200A, 2000A, or 3000A.

The primary line and load connections shall be self-aligning. The draw out mechanism shall be configured to operate with the compartment door closed. The draw out mechanism shall require less than 25 turns to move the circuit breaker from the connected to the disconnected positions.

The circuit breakers shall have an ANSI rating structure based on a K factor of 1.0.

The basic insulation level (BIL) of the circuit breakers shall be not less than 95kV for 8.25kV applications.

The breakers shall not be forced cooled. If forced cooling is required to meet the desired ratings, the Contractor shall obtain approval from the Owner before design begins. .

The operating mechanism shall be of the stored energy type with a closing coil and with the number of tripping coils as specified on the Medium Voltage Switching Devices Specification Sheets. The closing devices, tripping devices, and charging motor shall be designed and rated for operation on the specified control voltage as specified on the Medium Voltage Switching Devices Specification Sheets. The operating mechanism shall be both mechanically and electrically trip-free in any position and shall be anti-pumping. Mechanical tripping of a closed circuit breaker shall be possible with the front cubicle door closed. The mechanical trip device shall be covered with a hinged door to avoid accidental tripping of the breaker. 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.

The breaker shall be provided with provisions to be padlocked in the disconnected position.

The circuit breaker ground connection shall be capable of carrying the short circuit rating of the circuit breaker for a minimum of 2 seconds and must also be capable of withstanding the peak current value (or 2.6 times the rated short circuit) of the circuit breaker.

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

Each breaker shall be furnished with a mechanical operations counter that shall be readable from the front of the switchgear unit (with doors closed) with the breaker in the connected position.

Each circuit breaker shall have an easily accessible means for contact wear indication.

All breakers shall have the following three positions; "Disconnect," "Test," and "Connect" clearly visible on the front of the switchgear. The circuit breaker shall be furnished with mechanical indicators for Open/Closed positions and breaker closing spring charged or discharged.

Draw out breakers shall be furnished complete with four (4) wheels to provide easy removal from the enclosure. Draw out breakers shall be designed such that the breakers can be rolled out onto the plant floor without having to use auxiliary means such as a cart or a lift to remove the breakers. Cart or lift will be used to remove the draw out contactor if the switchgear assembly is located on a housekeeping pad. The cart or lift shall be designed accordingly such that no manual lifting is required to move the draw out contactors onto the cart or lift.

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

A dummy breaker shall be provided for each switchgear lineup. Appropriate interlocking shall be provided for the use of the dummy circuit breaker.

16101.2.3.2 Automatic Shutters. Compartments containing drawout breakers shall be furnished with automatically-operated shutters to allow or block access to the stationary primary disconnecting contacts. The shutters shall be grounded, constructed of metal and automatically opened by the circuit breaker as it moves toward the connected position, allowing access to the stationary line and load primary disconnecting contacts. Access to the primary line and load disconnecting contacts shall automatically be blocked as the

circuit breaker is racked away from the connected position. The shutters shall be pad-lockable in the closed position. All cubicle shutters shall be labeled as "BUS" or "LOAD" Shutter. Tie Breakers shall have Warning Labels indicating that both stabs are hot. Bus Tie Breaker Shutters shall be labeled as "BUS" and "TIE" shutters.

16101.2.5 Medium Voltage Power Switching Centers

This article provides requirements specific to medium voltage power switching centers. Medium voltage power switching centers shall consist of an assembly of load interrupter switches, power fuses, and other equipment as specified herein and on the Medium Voltage Switching Devices Specification Sheets.

Windows or guarded openings shall be provided for visual inspection of the position of each disconnect switch.

Doors shall be interlocked with the associated switch such that the door cannot be opened with the disconnect switch in the closed position and the disconnect switch cannot be closed with the door opened.

16101.2.5.1 Load Interrupter Switches. All load interrupter switches shall be group-operated, load-break, 3-pole, single-throw, utilizing a stored-energy, direct-acting, spring-charged, quick-make/quick-break mechanism for both opening and closing functions. Switches shall have main and arcing contacts and be designed to provide maximum endurance for load interrupting and fault closing. All switches shall be arranged with the hinged end of the switch blade de-energized when the switch is in the open position.

The switches shall be capable of interrupting transformer magnetizing currents as well as switch continuous current equal to the continuous (normal) current rating.

Switches shall have provisions for padlocking in the open position.

Switches shall not be capable of being positioned in any intermediate position between fully-opened and fully-closed.

16101.2.5.2 Operating Mechanism. Each load interrupter switch shall be opened and closed by means of an externally mounted manual operating mechanism and, if specified on the Medium Voltage Switching Devices Specification sheets, a motor operator. The speed of operation of the switch shall be quick-make, quick-break, that is independent of the speed of the manual or motor operator.

The manual operating handle shall be non-removable, self-levering, and padlockable.

The open and closed position shall be indicated on each switch.

Motor operators shall be operable with the voltage supply specified on the Medium Voltage Switching Devices Specification Sheets.

16101.2.5.3 Fuses. 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 power switching center components.

Fuses shall be located on the load or de-energized side of the load interrupter switch.

Easy identification of blown fuses shall be provided by positive action indicators.

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.

16101.2.6 Enclosures

Each equipment assembly shall be furnished with enclosures as specified on the Medium Voltage Switching Devices Specification Sheets. The enclosure shall be metal-clad construction using welded, industrial-riveted, or bolted sheet steel. The enclosures shall consist of vertical sections that are fabricated of steel and assembled to provide rigid self-supporting structures.

Switching devices that are removable shall be removable from the front. Any auxiliary device that may require access, removal, or replacement during normal maintenance or operation shall also be accessible and/or removable from the front.

All compartments within an equipment assembly not furnished with contactors or designated as an equipped space shall be furnished as an equipped space complete with front door and barriers isolating the inside of the compartment from the bus, and a backplane for mounting future devices.

The switchgear lineup shall be capable of extension from the end opposite compartment containing the main bus tie compartments without modification to existing structural members.

16101.2.7 Doors

Each compartment shall be furnished with a hinged front door. Doors shall be designed and adequately constructed for rigidity for the mounting of instruments, meters, relays, switches, indicating lights, and other specified devices, as required. Front compartment doors shall contain a view window for observing circuit breaker position. The doors shall be capable of withstanding the effects of an internal arcing fault as proven by successful testing per IEEE C37.20.7. A single handle mechanism shall be provided to operate all required latching. Tie down bolts shall not be used unless approved by the Owner. No special tools shall be required to latch the front compartment door or engage the arc resistant function. Stops and latches shall be provided to hold each door in the open or closed position.

Front Door Interlocks:

The front doors shall have interlocks to prevent racking a circuit breaker into a compartment with the door in the open position. This interlock may be manually circumvented for maintenance purposes by a deliberate act on the part of the operator.

The front doors shall have interlocks to prevent opening the compartment door unless the circuit breaker is in the disconnected position and safety shutters are closed. This interlock shall also include an indication of shutter position on the front of the compartment door. This interlock may be manually circumvented for maintenance purposes by a deliberate act on the part of the operator. This interlock shall reset if the compartment door is closed following maintenance after circumvention.

The front door must be closed before racking of the circuit breaker between the connected and disconnect positions.

Rear Door Interlocks:

The rear doors shall have interlocks to prevent opening of the rear door(s) unless the removable element (circuit breaker or contactor) in the front compartment of the vertical section is in the disconnected position

All accessible rear compartments shall be provided with hinged steel doors. Each rear compartment door shall be capable of withstanding the effects of an internal arcing fault as proven by successful testing per IEEE C37.20.7.

16101.2.8 Arc-Resistant Equipment

Arc-resistant equipment shall be supplied that meets the requirements of the latest revision of the standard specified, for the accessibility type specified, with a rated internal arcing short circuit current and rated arcing duration that meet or exceed the values specified on the Medium Voltage Switching Devices Specification Sheets. The use of a device that intentionally creates a three-phase short-circuit is not acceptable. The Contractor shall furnish all vents, chutes/ductwork, and supports required to vent material and gasses associated with arcing faults away from the equipment and away from locations where personnel may be present. The vents shall be tested as part of the equipment in accordance with IEEE C37.20.7. Proper insulation shall be provided for arc chute plenums when transitioning from air-conditioned spaces, such as PDC buildings, to avoid condensation build-ups. If the switchgear is provided

in PDC buildings or enclosures, all materials required for the complete arc chute plenum as required to safely vent the materials and gasses outside the PDC shall be provided and shall not be directed toward any equipment. The gasses and materials shall not be vented to locations such as platforms or stairways where personnel may be present when an arc occurs.

Arc resistant equipment shall meet the requirements of and shall be rated in accordance with ANSI/IEEE C37.20.2 - Standard for Metal-Clad Switchgear.

Arc resistant equipment shall be designed so that personnel may perform closed door racking or switching of breakers from the front of the switchgear in Category 0 Personal Protective Equipment (PPE, as defined by NFPA 70E). This includes design to provide safe protection for personnel in Category 0 PPE should an arcing event occur anywhere in the switchgear including the rear bus compartment or in any breaker cubicle.

Arc resistant switchgear shall be designed to allow personnel open door access inside of the top control/relay/instrument compartments of any cubicle in Category 0 PPE, as long as the bottom breaker compartment doors are closed.

Arc resistant equipment shall be designed so that personnel in Category 0 PPE located at the front, sides, or back of the equipment are protected from an arc event, as long as breaker doors and rear compartments are closed.

All cable penetrations, transitions from bus duct, and other attachments shall be designed as to not compromise the arc rating of the switchgear.

16101.2.9 Main and Tap Bus

The main and tap buses shall be constructed of solid copper tin plated busbar in accordance with the material and plating as specified on the Medium Voltage Switching Devices Specification Sheets. The tin shall be lead-free. All bus, except the ground bus and power connections, shall be electrically insulated and covered to prevent accidental contact by personnel.

The busbar shall be capable of continuously carrying the current specified on the Medium Voltage Switching Devices Specification Sheets under the ambient temperature conditions specified without exceeding the temperature requirements specified in the applicable standards.

The bus shall be installed with rigid, non-tracking, fire-resistant, and non-hygroscopic insulating supports that are capable of withstanding the mechanical forces imposed by short-circuit currents equal to the close and latch and short-time current ratings (short-circuit making current and short-time withstand current ratings) of the equipment as specified on the Medium Voltage Switching Devices Specification Sheets.

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

All power current carrying connections shall be bolted connections. All connections shall have minimum contact resistance. Bus bar bolts shall be torqued appropriately at the factory and shall be identified with paint markings. Bolts shall be rated at Grade 5 and plated for corrosion resistance.

The Contractor shall furnish all material required for field connections of equipment bus and terminals.

Provisions shall be made for bus expansion to prevent undesirable or destructive mechanical strains in the bus supports and connections, through the full ambient temperature range as specified in the Medium Voltage Switching Devices Specification Sheets. Expansion joints shall be furnished where required.

Buses shall be coated with epoxy type insulating material or acceptable equal molded around and bonded to the bus. All bolted joints; expansion joints; bus connections, factory or field; and all terminals, cable connectors, or bus connectors for attachment of conductors of instrument transformer circuits and external circuits shall be insulated with removable boots. Removable boots shall be designed to overlap permanent bus or cable insulation a minimum of 1 inch upon each conductor in the connection insulated by the boot.

Removable boots shall also be supplied for all medium voltage feeder cables entering or exiting the equipment. The insulation rating of bus, joint, connection, and termination insulation shall be not less than the voltage rating of the equipment. Any materials required for insulation of field connections shall be provided. Molded cycloaliphatic epoxy inserts are required whenever bus passes through a barrier of any type of 15kV gear.

16101.2.10 Ground Bus

An uninsulated solid copper ground bus shall be furnished through the entire length of each equipment assembly. All equipment requiring grounding shall be connected to this grounding bus. The ground bus shall be bolted to each vertical section and to each breaker ground contact. Both ground bus and ground cable connections shall be easily accessible from the cable compartment. The minimum bus size shall be suitable for carrying the maximum ground fault current for the rated short-circuit duration but shall not be smaller than 0.25 inch by 2 inches.

16101.2.11 External Connections

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

16101.2.11.1 Entrance. Adequate openings shall be furnished for all conductors entering the equipment from top or bottom, as indicated on the Medium Voltage Switching Devices Specification Sheets. Power and ground conductor as well as control cable entrance to the equipment will be as indicated on the Medium Voltage Switching Devices Specification Sheets. Openings shall be properly sealed once conductors are installed.

16101.2.11.2 Terminal Connectors. Terminal connectors for power cable and grounding cable entering the equipment shall be furnished and shall be as listed in the following table, or an acceptable equal. Solder type terminals are not acceptable.

Table 16101-4 Terminal Connectors for Power and Grounding Cable		
	Burndy Terminal Connector for Copper Conductors	
Cable Size	Bolted Clamp Type, Grounding Cable	Compression Type, Power Cable
8 AWG and smaller	N/A	YAV
6 AWG through 1/0 AWG	VA-2N	YA-2N
2/0 AWG and larger	VVA-2N	YA-2N

16101.2.11.3 Stress Cones. 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.

16101.2.11.4 Bus Duct. When bus duct is specified on the Medium Voltage Switching Devices Specification Sheets for power conductors, the Contractor shall ensure that all materials required to complete the interface are provided.

16101.2.11.5 Ground Bus Connections. Ground cable connectors shall be furnished for the attachment of stranded copper cable to the grounding bus for external connection to the station grounding system. Connectors shall be furnished at each end of the equipment assembly grounding bus.

Connectors shall be furnished for attaching all power cable shields directly to the equipment assembly grounding bus. Provisions shall be made for connecting the bus duct grounding bus to the equipment assembly grounding bus.

16101.2.11.6 Not Used.

16101.2.12 Current Transformers

Current transformers shall be supplied as specified on the Medium Voltage Switching Devices Specification Sheets, and in accordance with the requirements as specified herein.

Current transformers shall be installed so that they can be easily maintained or replaced. The secondary termination of current transformers shall be on a shorting terminal. Current transformers shall have a rated 5 Amp secondary unless otherwise specified.

Current transformer mechanical and thermal limits shall be coordinated with the momentary and short-time ratings of the switching device with which they are used. The thermal ratings shall be based on a short-circuit duration of 1 second or greater.

Window type current transformers shall have a sufficient diameter circular window, or the oval equivalent, to accommodate the cable as needed. Window current transformers shall be mechanically braced to withstand the same momentary current as the switching device with which they are used. The product of the ratios of the window current transformer and the auxiliary current transformer shall be equal to the specified ratio. Auxiliary current transformers shall not be used for metering and relaying.

Zero sequence current transformers shall be sized to accommodate all power conductors entering the cubicle or 5.25 inches in diameter, whichever is greater.

16101.2.12.1 Current Transformers Used in Relaying Applications. Unless otherwise specified, the accuracy ratings of current transformers used in relaying applications shall meet the following minimum requirements for the specific application as listed below. The minimum thermal rating factor of a current

transformer shall be 1.33 preferred rating of 1.5 or 2.0. As an alternative to meeting these requirements for a particular current transformer, the Contractor may provide, subject to Owner approval specific guidance published by the manufacturer(s) of relay(s) connected to that particular current transformer providing minimum current transformer performance requirements that assure no delay in relay operation, and provide current transformers that meet or exceed those published recommendations.

All current transformers used in a bus differential scheme shall be identical to each other and shall have the relaying accuracy as stated below.

Unless otherwise specified or directed by the Owner to maximize current transformer performance, the Contractor shall provide current transformers as stated below. The secondary rating on current transformers shall be 5A.

The accuracy class of the CTs shall be specified and stated on all drawings, including but not limited to schematics, one-line diagrams, and three-line diagrams.

Single ratio current transformers shall be provided unless otherwise specified by the Owner to be multi-ratio (such as those denoted with an "MR" next to ratio).

Below are the minimum accuracy classes that shall be used for current transformers used in relaying applications:

Zero sequence CTs: minimum C20, preferred C50.

Phase CTs for 38kV feeder breakers: C200.

Phase CTs for 38kV main breakers: C400.

Phase CTs for 38 kV bus differential relaying: C400.

16101.2.12.2 Current Transformers used in Metering Applications. Unless otherwise specified, the accuracy ratings of current transformers used in metering applications shall have an accuracy class of 0.6 or better (for IEEE C57.13 current transformers) with a minimum burden rating equal to a minimum of 150 percent of the connected burden. Unless otherwise specified, the ratio of current transformers used solely for metering purposes shall be approximately equal to the load current with a minimum continuous thermal rating equal to 150 percent of rated current.

16101.2.13 Voltage Transformers

Voltage transformers shall be provided as specified on the Medium Voltage Switching Devices Specification Sheets. Unless otherwise specified on the Medium Voltage Switching Devices Specification Sheets, voltage transformers shall have a rating of not less than 200 volt-amperes on a thermal basis and a capability of withstanding a secondary short-circuit for not less than 1 second. The voltage transformers shall be rated for 100 percent of rated primary voltage across the primary winding when connected line-to-line or line-to-ground. The voltage ratings shall be suitable for the type of system grounding employed and shall, at a minimum, be capable of operating at 110 percent of rated voltage continuously and 125 percent of rated voltage on a short-time basis without loss of life.

The voltage transformer BIL or Lightning Impulse Withstand voltage shall meet or exceed the equipment rated BIL or Lightning Impulse Withstand Voltage.

Unless otherwise specified, the voltage transformer accuracy at the applied burden shall be 0.6 or better (for IEEE C57.13 voltage transformers).

Each voltage transformer shall be provided with current limiting primary fuses and secondary fuses. The primary fuses shall protect the voltage transformer damage curve. The primary fuses shall be adequately rated for the voltage transformer inrush and load current, and shall have an interrupting capacity equal to or greater than the maximum short-circuit momentary current rating of the equipment assembly. The

secondary fuses shall coordinate with the primary fuses. The connections from the main buses to the primary of each voltage transformer shall be capable of carrying the rated short-circuit current of the equipment for a minimum of 1 second.

Each device fed by the voltage transformer shall be fused and the fuses shall coordinate with the secondary fuses on the voltage transformer.

Voltage transformer assemblies shall be draw out construction to provide maximum operator safety. Voltage transformer drawers shall be capable of being racked out with a handle or ratchet system. The voltage transformers and primary fuses shall be mounted on a draw outtype removable unit designed to isolate and ground the secondary potential circuits when the unit is in the fully withdrawn position. Visible indication of a positive ground is required. Provisions shall be made to prevent an arc on the primary disconnecting contacts of each voltage transformer by arranging to open the secondary circuits before the primary disconnecting contacts part. Provisions shall be made to prevent personnel from coming into contact with the voltage transformer primary fuses until after the primary disconnecting devices are separated by a safe distance and grounded.

Voltage transformers shall have a 120 VAC secondary.

Bus voltage transformers shall be provided with a switch (VTCI) to monitor the position of the voltage transformer's draw out type removable unit (carriage).

16101.2.14 Surge Mitigation Equipment

The Contractor shall furnish any surge mitigation equipment specified on the Medium Voltage Switching Devices Specification Sheets and as required to provide equipment protection. Arrestors need to be provided on the main breakers at minimum. The Contractor shall provide an evaluation to determine which other breaker positions require arresters. Typically any equipment subject to lightning strikes shall be provided with a surge arrester.

In addition, the Contractor shall furnish surge mitigation equipment in accordance with the switching device manufacturer's recommendations and to protect equipment subject to damaging overvoltages caused by switching device operation. This equipment includes transformers, small motors, and no-load conditions on cable.

Contractor shall provide an arrestor coordination study to ensure surge equipment is properly rated and applied. Owner will review this study and approval of arrestor types.

16101.2.15 Protective Relays

Protective relays shall be furnished in accordance with the Medium Voltage Switching Devices Specification Sheets and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection. Where there are discrepancies between this specification and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection, the requirements in and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection shall take precedence. Unless otherwise specified, protective relays shall be microprocessor-based, have trip indication on the front of the relay, have an alarm contact that provides relay health status, be flush-mounted on the front of the equipment assembly, and be operable from the 125 VDC control power source. The power supply for each protective relay shall be fused. Separate power supply circuits shall be provided for primary and secondary protection from the DC panel. Protective relays shall be furnished with the latest firmware available at the time of equipment shipment. Immediately following installation of the protective relays in the Equipment Assembly, the Contractor shall submit a list to the Owner showing the firmware revision number for each relay. All protective relays shall be furnished with test switches per the acceptable types listed in this specification.

Terminal blocks and jumpers shall be provided between the protective relay and all field wires. No field wiring or field devices (such as RTDs or TCs) shall be wired directly to the protective relays.

A 125 VDC lockout relay shall be supplied for every breaker/contactor in addition to an overall bus lockout relay. All lockout relays shall be Electroswitch brand and shall be equipped with a coil monitoring circuit. Lockout relays shall provide tripping and circuit lockout functions. A minimum of four (4) spare N.O. and four (4) spare N.C. contacts shall be wired to terminals and shall be provided for the Owner's use in addition to the contacts used within the switchgear lineup.

All protective relays and other solid-state electronics equipment shall be protected from the effects of electromagnetic interference in accordance with ANSI/IEEE Standard C37.90.2.

Test switches on switchgear shall have each individual test switch labeled with a white phenolic nameplate with black lettering. Nameplates shall meet the requirements of Section 17302-Phenolic Nameplates.

The Contractor shall use the following relay types and test device types as applicable.

Table 16101-9 Relays for Station Service Transformers (MV-MV)

Relay Type	Relay Name	Relay Model	Station Service Transformer Position (MV-MV)
SEL 551C	11H-Xfmr Name	0551C0BX5X3X R504	Backup Transformer Protection
Test Devices ABB FT1	Cubicle#-TD#xx Cubicle#-TD#xx	129A517G01 129A501G01	8 current poles 10 potential poles
Basler BE1 50/51	51NT-Xfmr Name	BE1-50/51B-207	Transformer Neutral O/C Protection
Electroswitch	86-Xfmr Name	78PB05D	Lockout
Test Devices ABB FT1	Cubicle#-TD#xx	129A501G01	10 potential poles

Table 16101-14 Test Device

Meter/Transducer Test Device	Test Device Name	Test Device Model	Test Device Description
Test Devices ABB FT1	Cubicle#-TD#xx		2 potential poles, 8 current poles

Table 16101-15 Relay Communications

Relay Type	Relay Name	Relay Model	Relay Communications
SEL 3332	Comm Network-Bus Number	333235X7X223038GF00	Communication processor
GE Multilin		ML2400-F-HI-HI-A4-A4-A2-XX-X	Network router switch

16101.2.15.1 Auxiliary System Protection. Protective relays shall be furnished in accordance with the Medium Voltage Switching Devices Specification Sheets and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection. Where there are discrepancies between this specification and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection, the requirements in and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection shall take precedence. Auxiliary system protection shall be designed with primary and secondary systems. The relaying needs to detect all bolted faults and coordinate under all single contingency outages of protective relay, CT circuit, PT circuit, dc circuit, or major equipment. Minimum bolted fault detection margin is 1.5 with a margin of 2.0 preferred. System design and primary relaying shall limit all arc flash levels to 25 Cal/cm^2. Primary and secondary relays shall allow equipment loading up to its nameplate or calculated normal and emergency ratings with margin of 1.15 or greater.

As a minimum, primary protection shall include transformer and bus differential relaying and instantaneous overcurrent protection on feeder and motor positions. In addition secondary protection shall include time coordinated over-current relaying. Minimum time over-current coordination is 0.3 seconds at maximum fault levels.

Primary and backup ground over-current relays are required to detect ground faults.

All equipment shall have primary and secondary protection. The protection must be set to detect all fault conditions with adequate margin. Separate power supply circuits shall be provided for primary and secondary protection from the DC panel.

All protective relays shall be equipped with targets that can be externally reset.

16101.2.15.2 Auxiliary System - CT Selection. Feeder breaker CTs shall be selected to exceed FLA by 115 percent to 200 percent. Neutral and differential flux balance window CTs shall be selected to provide less than 100A secondary for a bolted ground fault. Typical neutral CTs are 50/5 to 100/5.

Main and tie breaker CTs shall be sized for maximum bus load ratings, and to provide less than 100A secondary for maximum fault levels.

Transformer CTs shall be sized for maximum transformer emergency ratings, and to provide less than 100A secondary for maximum fault levels.

In all cases the maximum accuracy class shall be based on Article 16101.2.12.1, Current Transformers Used in Relaying Applications.

16101.2.15.3 Relay Communications. All auxiliary system multifunction relays shall be connected to a SEL-3332 communications processor for remote communications capability and connection to the plant DCS. The remote communications must meet NERC cyber security standards to the maximum extent possible. Communications shall be for indication only (no control).

Multifunction relay data shall be sent to the plant DCS through the communications processor using OPC protocol. Analog and digital data required from the multifunction relays shall be based on individual plant operating requirements and shall be determined by the Contractor with input from the Owner during detailed design.

Standard protective relaying schemes for the auxiliary system and auxiliary motors are shown on the following figures.

FIGURE 1 STANDARD AUXILIARY SYSTEM MEDIUM VOLTAGE PROTECTION

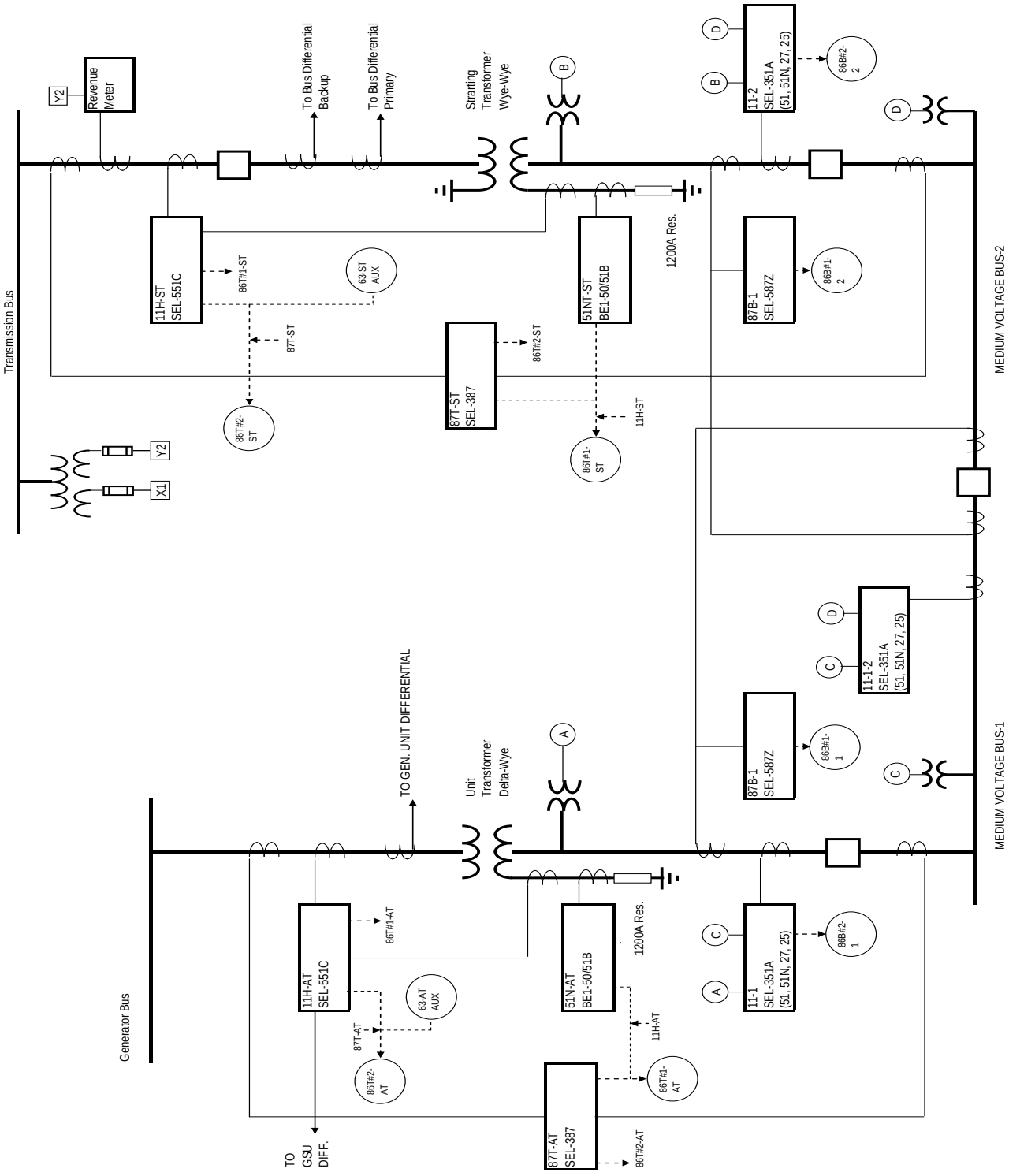

Transmission Bus
Y2
Revenue Meter
To Bus Differential Backup
To Bus Differential Primary
Starting Transformer Wye-Wye
B
D
11-2 SEL-351A (51, 51N, 27, 25)
86B#2-2
11H-ST SEL-551C
86T#1-ST
63-ST AUX
87T-ST
86T#2-ST
87T-ST SEL-387
51NT-ST BE1-50/51B
1200A Res.
87B-1 SEL-587Z
86B#1-2
86T#2-ST
86T#1-ST
11H-ST
Y2
X1
MEDIUM VOLTAGE BUS-2
D
C
11-1-2 SEL-351A (51, 51N, 27, 25)
87B-1 SEL-587Z
86B#1-1
C
MEDIUM VOLTAGE BUS-1
TO GEN. UNIT DIFFERENTIAL
Unit Transformer Delta-Wye
A
Generator Bus
11H-AT SEL-551C
86T#1-AT
63-AT AUX
87T-AT 1
86T#2-AT
51N-AT BE1-50/51B
1200A Res.
11H-AT
86T#1-AT
C
A
11-1 SEL-351A (51, 51N, 27, 25)
86B#2-1
87T-AT SEL-387
86T#2-AT
TO GSU DIFF.

FIGURE 2 STANDARD MOTOR FEEDER PROTECTION - WITHOUT DIFFERENTIAL

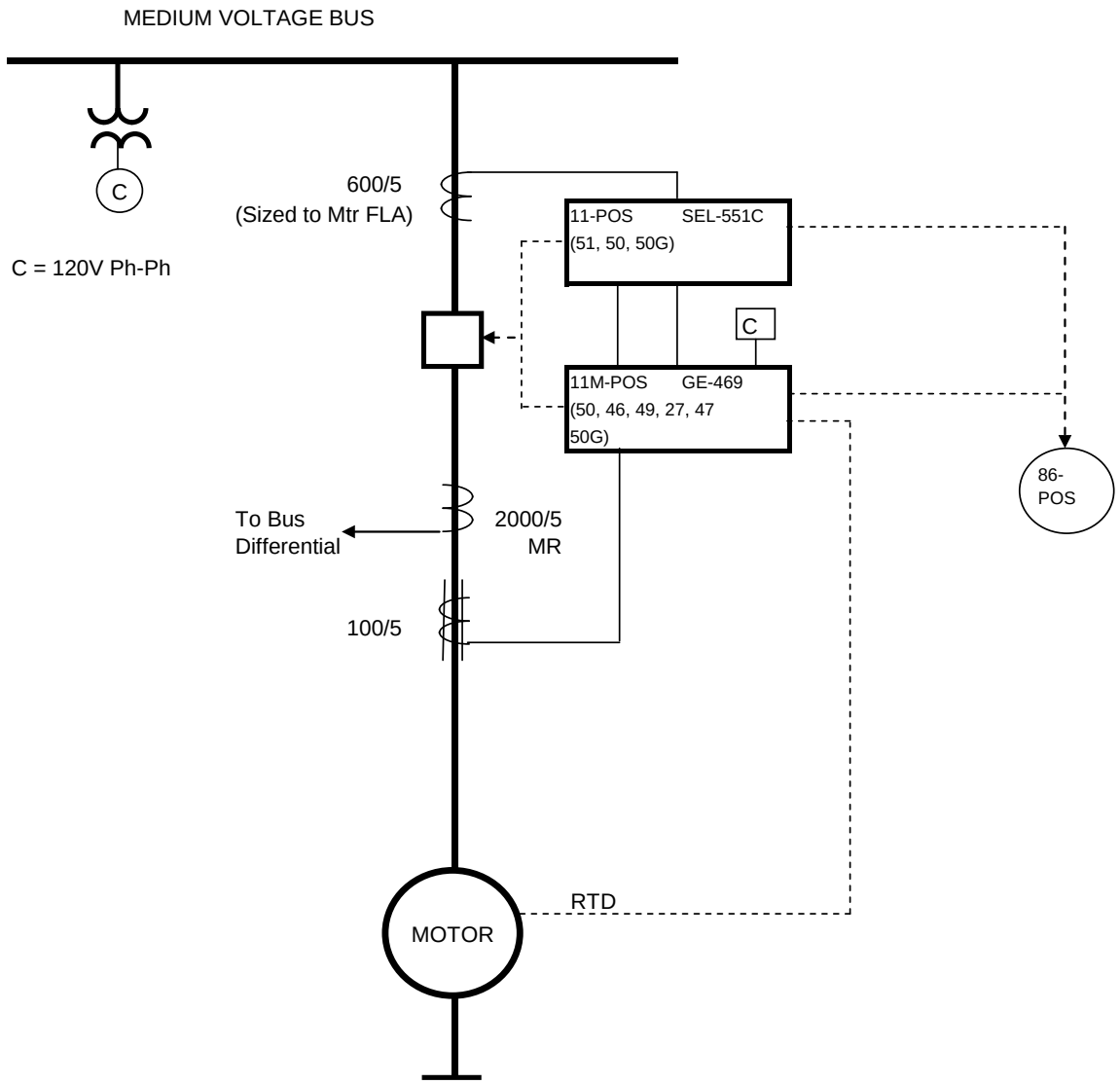


FIGURE 3 STANDARD MOTOR FEEDER PROTECTION – WITH DIFFERENTIAL

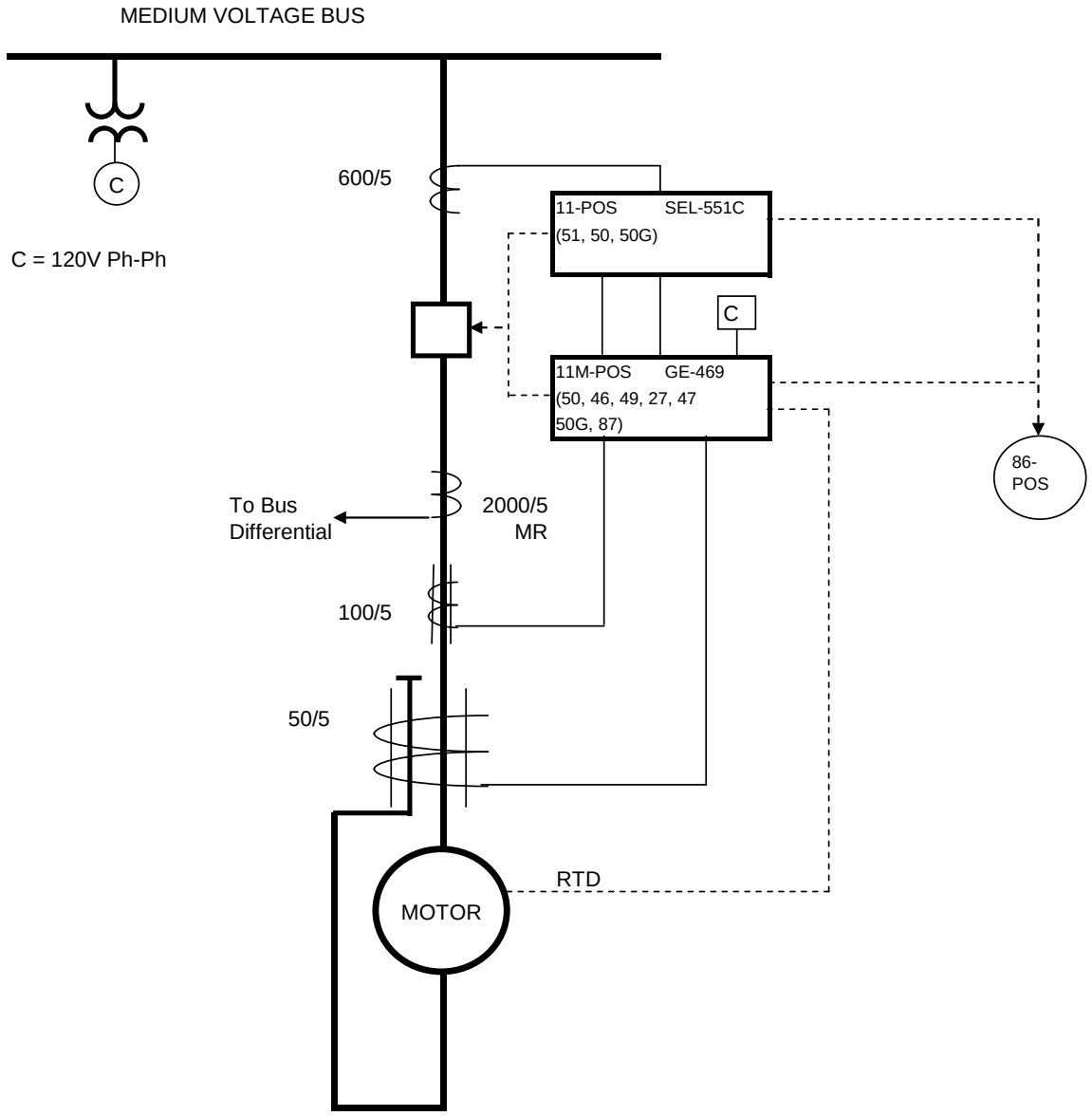


FIGURE 4 STANDARD 480V TRANSFORMER FEEDER PROTECTION

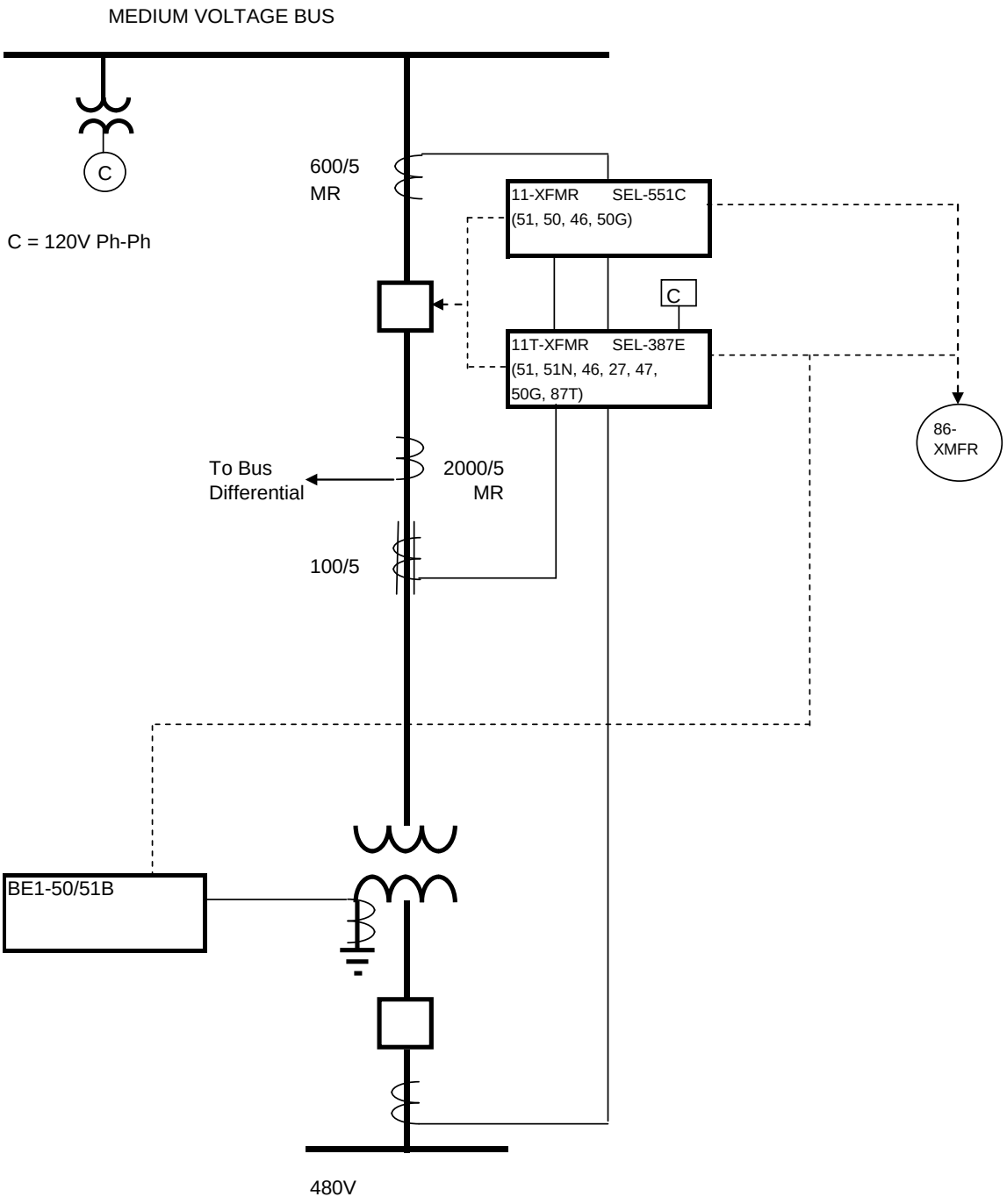
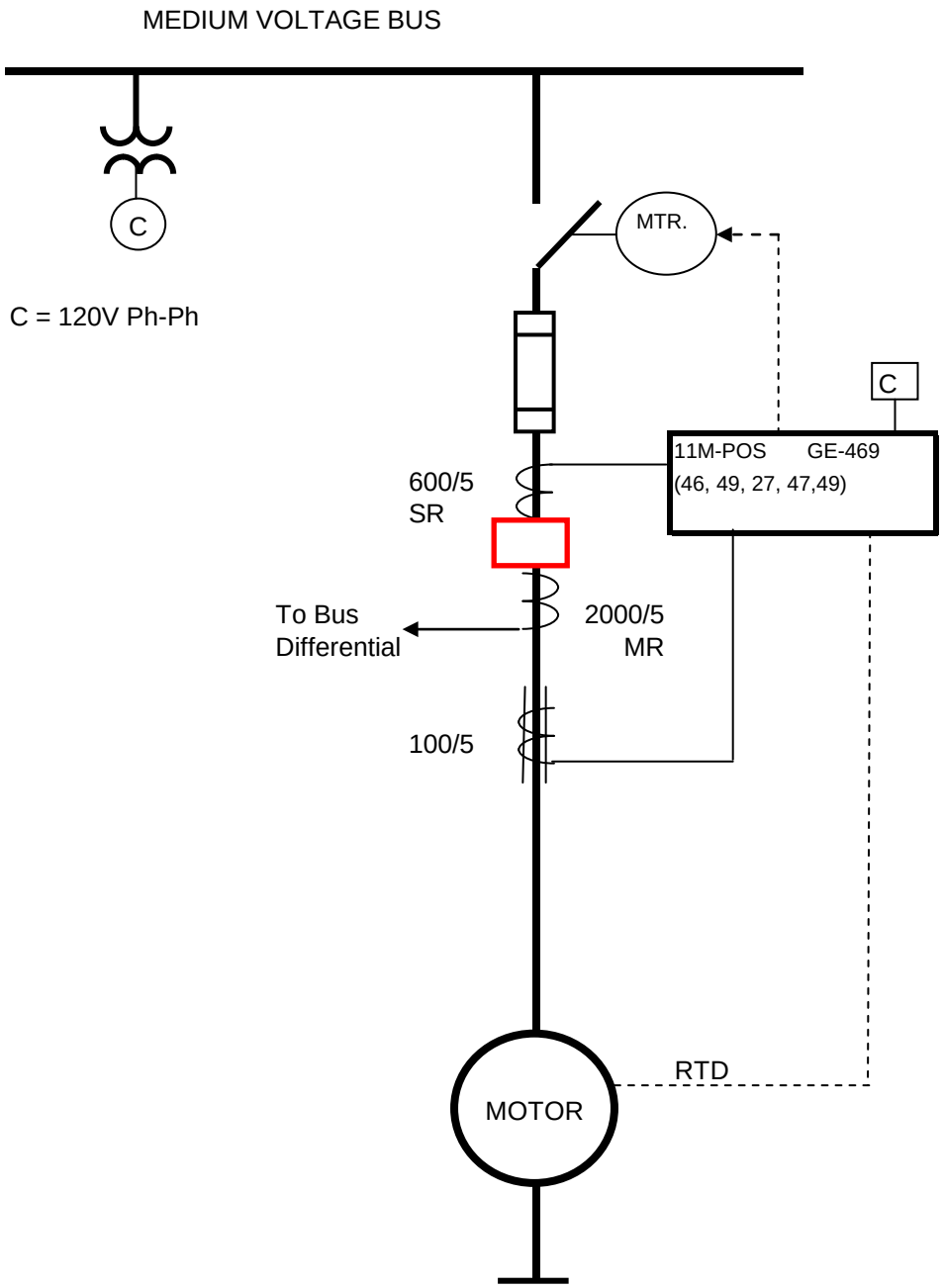


FIGURE 5 STANDARD MOTOR CONTACTOR FEEDER POSITION



16101.2.16 Meters

Meters shall be furnished in accordance with the Medium Voltage Switching Devices Specification Sheets. Unless otherwise specified, meters shall be microprocessor-based, capable of providing local indication of metered quantities, and capable of remote communication for all functions using the specified protocol. Watt-Hour meters shall have an accuracy of +/- 0.3 percent. Meters shall have the capability of

communicating to the Owner's DCS. Watt-hour meters shall be installed on each Medium Voltage Switchgear bus mains. The watt-hour meters shall be tied into the relay network via the SEL-3332 device.

16101.2.17 Test Switches

Test switches shall be furnished in accordance with the Medium Voltage Switching Devices Specification Sheets.

16101.2.18 Equipment Assembly Communication Networks

The Contractor shall provide each equipment assembly with the equipment, wiring, and accessories necessary to implement the means of data exchange with the facility DCS, as specified on the Medium Voltage Switching Devices Specification Sheets included at the end of this section. No DCS soft link to breaker/contactor control shall be used. Only communication to relays through the SEL-3332 shall be used as noted in Section 16101.2.15.3.

16101.2.18.2 Not Used.

16101.2.18.3 Not Used.

16101.2.18.4 Data Communication Network for both Control and Data Collection. The communication network from the DCS to the equipment in the equipment assembly shall be comprised of a fully-redundant communication network Modbus or OPC over Ethernet TCP/IP. The information exchanged on the redundant communication network shall be in accordance with the list provided by the Owner. All hardwired points shall be in accordance with the typical schematics provided by the Owner. The Contractor shall include any exceptions or comments to requirements shown on the list and schematics with their bid.

The Contractor shall be responsible for providing all equipment, configuration, wiring, connections, etc. necessary to interface the redundant communication network with the equipment in the equipment assembly.

The fully redundant Contractor-provided communication network equipment shall be designed so that no single point of failure will prevent the DCS from receiving the information. The Contractor shall submit a network architecture drawing to describe the level of redundancy included. This document shall be issued as a formal submittal after contract award.

16101.2.19 IRIG-B Signal Distribution

The IRIG-B signal will not be used.

16101.2.20 Electrical Accessory Devices

Electrical accessory devices, such as control switches, auxiliary relays, push buttons, fuses, fuse blocks, indicating lights shall be in accordance with the requirements of the technical supplemental.

Unless otherwise explicitly specified, control devices mounted on the Equipment Assembly with the switching device shall not control the switching device when the switching device is in the "connected" position. The breaker control switch on the cubicle door should operate the breaker when it is in the "Test" or "Connected" position.

LED indicating lights shall be provided for status of each switching device. Lights shall be LED style (same manufacturer/model of LED lights shall be supplied for all switchgear and control panels). The indication lights shall have a 2000 Ohm resistor to be included in the socket.

LED indicating lights shall also be provided to indicate when the breaker is connected to the bus and energized.

16101.2.21 Maintenance Switch Schemes for Arc-Flash Hazard Reduction

Maintenance switch schemes shall be furnished as specified herein – these are only required for non-arc resistant equipment with an open door rating of more than 25cal/cm^2. Each maintenance switch scheme shall include an arming switch. An indicating light shall be furnished adjacent to each arming switch used to activate a particular maintenance switch scheme to provide positive indication that the maintenance

switch scheme is armed. The light shall be driven by an output contact from the relay containing the overcurrent protection for the maintenance switch scheme and powered by the same control power source supplying the relay. A contact from each arming switch shall be wired to an input on that same relay to arm the overcurrent protection for the scheme. The arming switch contacts and lights shall be wired to terminal blocks to allow paralleling of switches and lights. If the overcurrent protection is located external to the equipment then the maintenance switch and indicating light shall be wired to terminal blocks for external connection. Unless otherwise specified, a normally-open contact (closed when armed) from each arming switch shall be wired out to terminal blocks for external (DCS) indication and installed back to the DCS by the Contractor as an alarm.

16101.2.22 Remote Racking Devices

The Contractor shall provide each equipment assembly containing that switching device with a remote racking system in accordance with the following requirements.

The system shall either be an integral part of the equipment assembly or an externally attached device that can be moved from switching device to switching device. The remote racking mechanism shall be capable of being connected and operating with the switching device enclosure door closed at all times. Any power required for the remote racking devices shall be supplied from the equipment assembly.

The remote racking devices shall include a racking mechanism and a control pendant with cords of sufficient length to allow the operator to stand with the pendant outside of the room or outside of the flash protection boundary. The racking operation shall be controlled from the control pendant and the control pendant shall include visual indication of the racking position of the switching device.

The remote racking mechanism and the control pendant shall be provided with a storage bracket attached to one end of the equipment lineup. Alternatively, at the direction or consent of the Owner, the storage bracket may be wall mounted.

16101.2.23 Enclosure Space Heaters

If specified on the Medium Voltage Switching Devices Specification Sheets, each vertical section shall be furnished with space heaters to prevent condensation of moisture within the equipment. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored. The space heater supply buses shall all be connected together and factory wired through each continuous assembly (including, for example, medium voltage controllers and switchgear located in a common equipment assembly). The Contractor shall furnish contactors, all required internal wiring, suitable branch circuit protection for each space heater circuit, and space heater power bus conductor through the equipment assembly. The Contractor shall balance the current loading on multiphase space heater buses.

Space heater capacity shall be as required to maintain the enclosure internal temperature above the dew point. Space heaters shall be controlled by an adjustable thermostat or a fixed humidistat. Space heater sheaths shall be of a corrosion-resistant, non-oxidizing material.

16101.2.25 Hazard Warning Labels

Prior to equipment energization, the Contractor shall furnish, on each accessible side of each vertical section, labels warning of arc flash and shock hazard and requiring that appropriate PPE be worn. The labels shall meet the Owner's standard and requirement for warning labels as specified in AUE-ADM-5002 Energized Equipment Electrical Safety Program,.

16101.2.26 Hardwired External DCS I/O Equipment Provided and Installed by Contractor

When the Medium Voltage Switching Devices Specification Sheets specify that an equipment assembly shall provide data exchange through hardwired external DCS I/O equipment provided and installed by the Contractor, the Contractor shall wire the appropriate points to terminal blocks where they can be connected to external cables to the externally-mounted DCS equipment.

16101.2.27 Power Sources

Electrical power for control, instrumentation, and space heaters shall be furnished as indicated on the drawings and as specified on the Medium Voltage Switching Devices Specification Sheets.

The Contractor shall furnish all internal devices and wiring required to distribute power to each subassembly unit as required. The power used in each individual subassembly unit shall be furnished with a disconnecting and protective device for each individual power circuit (including separate devices for the closing circuit and one for each tripping circuit).

A 125 VDC control power breaker shall be mounted on the door to disconnect the close power to the breakers. However, this breaker shall not disconnect the power the protective relaying devices or the trip circuit. The trip circuit power and protective relay power shall be powered from a separate 125 VDC disconnect switch that is not rated as a protective device such as fuses, circuit breakers, etc. The trip, close, and relaying power shall come from the same 125 VDC branch circuit for each cubicle.

The typical disconnecting and protective devices shall be as shown on the typical schematics provided by the Owner on the drawings included in Appendix L – Project Specific Drawings.

16101.2.27.1 External Contractor-Provided Power Source. When the power source is specified as being external by Contractor, the Contractor shall provide one set of terminals for external connection of that power source. The terminals shall be on a terminal block in an accessible location within the equipment assembly. The Contractor shall then wire from that set of terminals to all equipment within the equipment assembly that is specified to use that power source. The wiring shall extend, if necessary, through the entire length of the equipment assembly. This includes, for example, extension from medium voltage switchgear to attached medium voltage controllers in a common equipment assembly. Primary and secondary (back-up) devices shall be fed from different power sources, following the "train" methodology of no single point of failure.

16101.2.27.2 Not Used.

16101.2.27.3 Not Used.

16101.2.28 Internal Wiring

Control wiring shall be SIS type #14 AWG, 41 strand, extra flexible, stranded copper or larger.

Current transformer secondary wiring shall be SIS type #10 AWG, stranded copper and shall terminate on shorting type terminal blocks.

Control wiring must be a continuous length from terminal to terminal. Each control wire shall be marked at both terminations with "from-to designations" as shown on the wiring diagrams.

All wiring between devices in the same equipment assembly (including those that cross shipping splits) or between equipment in the PDC assemblies shall be installed by the Contractor and tested at the factory.

All wiring that crosses shipping splits shall be terminated on terminal blocks at one side of each shipping split. Wiring that crosses a shipping split shall be determinated from the terminal blocks and coiled in the adjacent cabinet for shipping. All cables that are coiled shall be clearly marked and assigned circuit numbers and shown on drawings from the Contractor.

All wires shall be one continuous length from terminal to terminal. Splicing is not permitted.

All interior wiring shall be neatly and carefully installed in wiring gutters, tray, or conduit and shall be terminated at terminal blocks plainly lettered or marked in accordance with the Contractor's connection diagrams. Extra flexible SIS type wire shall be furnished at hinge points and suitably covered and protected to prevent wear. Exposed wiring shall be suitably protected against contact with sharp edges.

All wiring leaving an enclosure shall leave from terminal blocks, located for convenient connection of external circuits, and not from other devices within the enclosure.

Unless otherwise specified, all relay inputs and outputs shall be wired to terminal blocks, including voltage transformer input circuits, current transformer input circuits (through shorting-type terminal blocks), relay output contacts, relay inputs, relay trouble alarms, RTD inputs, and analog outputs.

Unless otherwise specified, all spare contacts on control switches, limit switches, or similar devices shall be wired to accessible terminal blocks for the Owner's future connections.

All instrument transformer secondary leads shall be wired out to terminal blocks.

16101.2.29 Auxiliary Switches

A sufficient quantity of auxiliary switches and contacts shall be provided as specified on the Medium Voltage Switching Devices Specification Sheets, and the typical schematics provided by the Owner.

16101.2.29.1 Position Status Auxiliary Switches. These auxiliary switches are mounted on the switching device mechanism to provide 'a' contacts (contact is closed when the switching device is closed and open when the switching device is open) and 'b' contacts (contact is closed when the switching device is open and open when the switching device is closed). For draw out switching devices, the electrical connection between the switches on the switching device mechanism and the secondary connections in the equipment assembly enclosure shall be such that external indication of open or closed status from these switches are active when the switching device is in both the "connected" and "test" positions. The Contractor shall furnish each switching device with a sufficient number of position status auxiliary switch contacts to meet all control and status indication requirements plus the quantity of spare position status auxiliary switch contacts as specified on the Medium Voltage Switching Devices Specification Sheets or shown on the typical schematics furnished by the Owner.

16101.2.29.2 Stationary Position Status Auxiliary Switches. These auxiliary switches are not mounted on the switching device mechanism but are mounted in the equipment assembly enclosure and operated by linkage to the switching device mechanism. These auxiliary switches provide 'a' contacts (contact is closed when the switching device is closed and open when the switching device is open) and 'b' contacts (contact is closed when the switching device is open and open when the switching device is closed). For draw out switching devices, these switches shall be actuated only when the switching device is in the "connected" and "test" position. The Contractor shall furnish each switching device with a sufficient number of stationary position status auxiliary switch contacts to meet all control and status indication requirements plus the quantity of spare stationary position status auxiliary switch contacts as specified on the Medium Voltage Switching Devices Specification Sheets or shown on the typical schematics furnished by the Owner.

If stationary position status auxiliary switches are not available for the switching device type, then an equivalent arrangement shall be provided by wiring connection status auxiliary switches in series or parallel, as appropriate, with position status auxiliary switches to provide the required quantity of equivalent stationary position status auxiliary switches. If interposing relays must be used to achieve that equivalency, the method used by the Contractor to achieve this equivalency shall be subject to the Owner's approval. The connection status auxiliary switches and position status auxiliary switches used in this arrangement shall not count toward the quantity of spare contacts required for each of those types.

All auxiliary contacts, stationary or position status contacts, and connection status auxiliary contacts shall be wired out to terminal blocks in the control enclosure for each circuit, not to terminal blocks in the medium voltage enclosure, unless approved by Owner.

16101.2.29.3 Connection Status Auxiliary Switches. These auxiliary switches are mounted in the equipment assembly enclosure to provide indication that a draw out switching device is in the "connected" ("in-service") or not in the "connected" ("test" or "disconnected") position. These auxiliary switches provide normally-closed (N.C. - closed when the switching device is in the connected position and open when not in the connected position) and normally-open (N.O. - open when the switching devices is in the connected position and closed when not in the connected position) contacts. The Contractor shall furnish each switching device with a sufficient number of connection status auxiliary switch contacts to meet all control and indication requirements plus the quantity of spare connection status auxiliary switch contacts as specified on the Medium Voltage Switching Devices Specification Sheets or shown on the typical schematics furnished by the Owner.

Because these contacts are utilized as permissives for closing control of the drawout switching devices, the Contractor shall ensure, either by mechanical interlocks or the design of the connection status position auxiliary switch, that the switching device cannot be closed unless the switching device is in the fully-connected position or it is sufficiently racked out that closure of the switching device will not cause arcing.

16101.2.30 Contractor-Furnished Drawings

The Contractor shall furnish a complete set of drawings to fully document the equipment provided. These drawings shall meet the requirements below.

After completion of the inspection and testing procedures and factory acceptance test the manufacturer shall submit a complete set of 'as-built' drawings. These drawings shall function as a record of the final construction of the equipment at the time it left the factory.

16101.2.30.1 One-Line and Three-Line Diagrams. The Contractor shall submit one-line diagrams for acceptance by the Owner. The Contractor shall submit three-line diagrams after receiving approval of one-line diagrams. These drawings shall be based on, and identical in function to, typical one-line diagrams, three-line diagrams, and metering/relaying diagrams furnished by the Owner included in Appendix L – Project Specific Drawings.

Typical one-line diagrams for the Medium Voltage Switching Devices and three-line diagrams are included in Appendix L – Project Specific Drawings.

The three-line diagrams shall be drawn similar to the three-line diagrams included in Appendix L – Project Specific Drawings. The Contractor shall submit sample three-lines for Owner review. The three line diagrams shall be submitted to the Owner for review and approval.

All diagrams shall maximize the sheet as much as possible up to ANSI Size D drawings.

16101.2.30.2 Schematic and Wiring Diagrams. Equipment schematic and wiring diagrams shall be provided by the Contractor. These drawings shall be based on, and identical in function to, typical schematic (elementary) diagrams and connection diagrams furnished by the Owner. Typical schematic diagrams for the Medium Voltage Motors are included in Appendix L – Project Specific Drawings. All devices, including auxiliary contacts, shall be shown on the schematics and cross-reference the appropriate schematics where they are used.

All diagrams shall maximize the sheet as much as possible up to ANSI Size D drawings.

After receiving the Owner's diagrams, the Contractor shall prepare their schematic (elementary), connection, and wiring diagrams, which shall indicate the same terminal designations and the same terminal arrangement as indicated on the Owner's diagrams.

The complete connection diagram of each switchgear breaker, contactor, or metering compartment shall be on an individual sheet. Information on each wiring and 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. All diagrams shall maximize the sheet as much as possible up to ANSI Size D drawings

Each item of equipment shall be identified by item designation and name. Each schematic and wiring diagram from the Contractor shall clearly indicate the equipment assembly ID number and switching device by name and tag number, as shown on the drawings provided by the Owner.

When the Contractor's standard terminal designations differ from those required by the schematic and connection diagrams furnished by the Owner, or from those marked on the Contractor's connection drawings submitted for acceptance and returned by the Owner, the Contractor shall revise terminal designations in accordance with the Owner's requirements on both the Contractor's drawings and the terminal blocks.

16101.2.31 Infrared Inspection Ports

For all switchgear permanently installed infrared (IR) viewing windows shall be provided for all switchgear in the back each cubicle so on-line temperature monitoring of all medium voltage busbar and cable and bus connections can take place without having to open panels.

IR windows shall have a bolted and hinged cover over the windows. IR windows shall be designed and installed as to not compromise the rating or integrity of arc resistant switchgear. Each port shall have a reinforced lens suitable for application with the thermography means being used and capable of withstanding the pressures produced by an arcing fault without allowing passage of hot gasses or material.

For breakers feeding motors, provide PdMA M-TAP 2 Amphenol® connector plug receptacle on outside of control compartment with PdMA® circuit board for on-line motor testing. The motor testing plugs shall be accessible from outside the switchgear without opening any doors. For on-line motor testing purposes, a jack panel shall be provided (one for each bus) to connect the PdMA voltage test cable connectors to the secondary of the bus potential transformers for voltage measurements. Reference photo below:

16101.2.32 Nameplates

Engraved nameplates shall be furnished for the front and rear of each equipment assembly and front and rear (where accessible) of each cubicle. An equipment assembly nameplate shall be located on the front top center of each equipment assembly. In addition, each cubicle shall be identified with its function designation engraved on laminated plastic tags. Each device installed in the cubicles, each plug assembly and terminal strip, and each indicating and operating element shall be identified with permanently attached nameplates. Nameplates shall meet the requirements of Section 17302 - Phenolic Nameplates. All nameplates shall be clearly visible. Inscriptions on these nameplates shall coincide with those used on the drawings approved by the Owner. Unless otherwise indicated or modified by the Owner during formal review of the supplier shop drawings, all nameplate inscriptions shall match the Contractor's final one-line and schematic drawings, descriptions, or lists, and the nameplates and tags. A list of nameplates shall be provided to the Owner for approval. Caution nameplates used shall be yellow with black letters, and warning labels shall be red with white letters.

16101.2.33 Channel Sills

Where specified on the Medium Voltage Switching Devices Specification Sheets, channel sills shall be furnished with specified equipment. These sills shall be arranged to provide for track welding to the equipment base on the inside of the units, and shall be shipped sufficiently in advance to the project site for installation in the concrete base which will support the equipment.

16101.2.34 Mimic Bus

A mimic bus is not required.

16101.2.35 Tightening of Connections

On the erection and assembly drawings, the Contractor shall include complete information for the 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.

16101.2.36 Outsourcing of Components

The Contractor shall include a list of all equipment components that will be sourced from outside the final assembly plant with lead times longer than 30 days with the Proposal. This list shall give a detailed description of the component, its manufacturer, and the location it will be shipped from.

Medium Voltage Switching Devices Specification Sheets

General Requirements	
Standards for manufacturing and testing	
Medium voltage switchgear:	IEEE C37.20.2 and C37.20.7 and other relevant ANSI and IEEE C37 series standards
Medium voltage controllers:	NEMA ICS3
Current transformers:	IEEE C57.13
Voltage transformers:	IEEE C57.13
Cable gland plates to be furnished with the equipment:	No
Cable glands to be furnished with the equipment:	No
Mimic bus:	Not Required
Site elevation:	
Seismic requirements:	

Accessories		
The following accessories shall be provided (one set per island, remote electrical room, or PDC)		
Quantity	Unit	Item
4	LOT	Remote racking device of each type and local racking device handles/tools. One device per MV bus (4 remote racking devices per FGD Island)
1	EA	Wall-mounted test cabinet with test jumper for testing breakers out of housing or alternate method of testing each breaker in the disconnected position.
1	EA	Grounding and test device for switchgear cubicle
1	EA	Transfer truck/lifting trolleys to move drawout switching devices into and out of the equipment housings
1	LOT	Special tools if required
1	LOT	Spare protective relay for each type furnished
1	EA	Spare lockout relay coil

Additional Requirements:
Two sets of cables, signal converters, Microsoft Windows compatible software, and any other equipment/software required for programming each type of relay, meter, or other device furnished under this contract shall be provided for interfacing with a personal computer USB port (computer furnished by the Contractor). The programming cables/converters/equipment/software shall be shipped with the first equipment shipment to the site. A third set of programming software if not available on the internet shall be shipped to the Contractor for use in providing relay settings to the site. The Contractor shall turn all software over to the Owner at the end of the Project.

Equipment Assembly Details	
Equipment assembly designation:	BUS XX
Equipment assembly tag:	TBD
Install in factory-fabricated building:	As required by Contractor's design
General Ratings	
Nominal operating voltage:	34.5 kV
Maximum operating voltage:	38 kV
Nominal power system frequency:	60 Hz
Minimum rated short-circuit and short-time current:	Determined by Contractor
Minimum rated short-circuit duration/permissible tripping delay:	2 seconds
Rated voltage range factor, K, for circuit breakers:	1.0
Minimum rated closing and latching (making) current:	As required by standards
Minimum rated continuous (normal) current:	Determined by Contractor
Minimum neutral bus rated continuous (normal) current:	Neutral bus not required
Medium voltage breakers:	
Maximum rated interrupting (break) time:	3 cycles
Maximum rated closing time:	Manufacturer's standard
Number of trip coils per breaker:	One (1)
Controllers: maximum rated closing time:	Manufacturer's standard
Configuration/Construction Requirements	
Configuration:	3-phase, 3-wire, low-impedance grounded
Construction:	Single-high construction, drawout
Classification:	Metal-clad switchgear and metal-enclosed controllers
Arc-resistance construction:	Required
Standard:	IEEE C37.20.7
Accessibility type:	IEEE C37.20.7 Type 2B
Minimum rated internal arcing current:	Equal to specified short-circuit current
Minimum rated arcing duration:	0.5 seconds
Busbar material and plating:	Copper with tin plating
Insulated busbar:	Required
Surge Arrester	Required; Contractor to determine location and rating of each surge arrester.
Enclosure Degree of Protection	
Medium voltage switchgear	ANSI Indoor
Medium voltage controllers:	NEMA 12 dust-tight
Medium voltage power switching center	ANSI Indoor

Installation environment:	Not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapors or salt
Installation location ambient temperature range:	
Equipment assembly communication network:	Hardwired DCS I/O equipment (with data communication network to relays and meters)
DCS data communication network to relays/meters protocol:	TCP/IP over 1000BASE-SX multi-mode fiber-optic cable with ST connector
DCS data communication network to Equipment Assembly protocol:	Not applicable
Data communication network fail mode:	Fail "in place"
Voltage Transformer Requirements	
Bus voltage transformers	
Number of sets:	One (1)
Mounting:	Draw out
Ratio:	Determined by Contractor (120 VAC on secondary)
Connection:	Determined by Contractor
Secondary grounding:	Neutral
Minimum accuracy rating:	0.3 WXYZ
Minimum thermal rating:	Equal to maximum rated standard burden
Line-side voltage transformers	
Number of sets connected to incoming side of each main breaker:	One (1)
Mounting:	Draw out
Ratio:	Determined by Contractor(120 VAC on secondary)
Connection:	Determined by Contractor
Secondary grounding:	Neutral
Minimum accuracy rating:	0.3 WXYZ
Minimum thermal rating:	Equal to maximum rated standard burden

Auxiliary Contacts

As a minimum, the following quantity of spare auxiliary switch contacts shall be provided and wired out to terminal blocks:

Type	**Switchgear**	**Controllers**	**Power Switching Centers**
Auxiliary contacts	6 'a' and 6 'b'	6 'a' and 6 'b'	6 'a' and 6 'b'
Stationary auxiliary contacts	5 'a' and 5 'b'	4 'a' and 4 'b'	4 'a' and 4 'b'
Position auxiliary contacts (connected/test position indication)	4 N.O. and 4 N.C.	2 N.O. and 2 N.C.	2 N.O. and 2 N.C.

Miscellaneous Requirements	
Provide IRIG-B signal distribution:	No
Control cable entrance:	Both top and bottom
Infrared inspection ports:	Required
Rear doors:	Required
Lockable doors:	No
Enclosure space heaters:	Required
Enclosure space heater minimum rated voltage:	120/240 VAC
Exterior paint color:	Manufacturer's standard
External ground cable size:	Determined by Contractor
Provide channel sills, if required:	Yes

Power Sources

Description	Source	Circuit Description	Code	Nominal Voltage
Enclosure space heaters:	External by Contractor		LV-1	120 VAC
Motor space heaters:	External by Contractor		LV-1	120 VAC
Normal control power:	External by Contractor		DC-1	125 VDC
Medium voltage breakers				
Spring charging motor:	External by Contractor		DC-1	125 VDC
Trip coil:	External by Contractor		DC-1	125 VDC
Close coil:	External by Contractor		DC-1	125 VDC
Controller control power:	External by Contractor		DC-1	125 VDC
Disconnect switch control power:	Required.			

Reference Drawings

This equipment assembly shall be designed and wired in accordance with the following reference drawings:

Drawing Number	Revision	Drawing Title
8440-X-172504	0	ELECTRICAL ONE LINE

Additional Requirements:

The Contractor shall use the One-Lines attached as a reference. All loads including load size, switching device current rating, power factor, phase CT ratio and power/ground conductor entry shall be determined by the Contractor during detail design.

Subassembly Unit Type Details	
Subassembly unit type designation:	SWG-MAIN
Subassembly unit type description:	Switchgear main and reserve breakers
Switching device(s) type:	Medium-voltage switchgear breaker
Application:	Bus switching device
Switching device(s) mounting:	Draw out
Insulating medium for switching device interrupter:	Vacuum

Internally-Mounted Equipment

This subassembly unit contains the following equipment that shall be furnished, mounted within the equipment assembly, and fully connected:

Quantity	Unit	Description
1	LOT	Equipment as shown on reference drawings listed below
1	EA	Phase current transformer for protection application, bus side, per phase, for connection to upstream transformer differential protection. Breaker should be included in the differential zone.
2	EA	Phase current transformer for protection application, line side, per phase. One phase CT for shall be provided for primary protection and another phase CT shall be provided for secondary/back-up protection.
1	EA	Phase current transformer for metering application, line side, per phase
1	EA	Trip coil monitoring relay
1	EA	Lockout coil monitoring relay
1	EA	Control power monitor relay
2	EA	Interposing auxiliary relay
1	LOT	Set of shorting type terminal blocks for all current transformer circuits – per CT
		Switchgear shall be provided with GE EB-25 or Marathon 1500 Series terminal blocks.
1	LOT	Set of control power fuses
1	LOT	All other devices required for a fully-functioning unit and to meet the specified application

Protective Relays

This subassembly unit contains the following protection relays that shall be furnished, mounted, and connected on the front of the equipment assembly:

Quantity	Unit	Description
1	EA	Schweitzer Engineering Laboratories SEL-351-7

Front-Mounted Equipment

This subassembly unit contains the following equipment that shall be furnished, mounted on the front of the equipment assembly, and fully connected:

Quantity	Unit	Description
1	LOT	Equipment as shown on Reference Drawings listed below
1	EA	Control switch, three-position, open-neutral-close, spring return to neutral

1	EA	Maintenance switch scheme arming switch, enabled-disabled, maintained in each position
1	LOT	Indicating lamp set
1	EA	Lockout relay, manual reset, six normally-open and six normally-closed contacts
1	LOT	Test switches - connected to each relay and meter current and voltage input, each relay trip output, and each lockout relay normally-open contacts
1	LOT	All other devices required for a fully-functioning unit and to meet the specified application

SECTION 16110
LOW-VOLTAGE SWITCHING DEVICES

16110.1 General

16110.1.1 Scope of Supply

Scope of supply shall include furnishing the low voltage switching devices as specified herein and on the Low Voltage Switching Devices Specification Sheets. The low voltage equipment items included in the scope of supply are as follows:

Table 16110-1 Low Voltage Equipment
Item
Low Voltage Switchgear (Metal-Enclosed Circuit Breakers)
Low Voltage MCCs

16110.1.2 Not Used

16110.1.3 Performance and Design Requirements

Performance and design requirements for the low voltage switching devices are indicated on the Low Voltage Switching Devices Specification Sheets and as follows:

If the Contractor elects to provide the low voltage switchgear and MCCs and other electrical equipment in prefabricated power distribution centers, the equipment specified in the Low Voltage Switching Devices Specification Sheets shall be furnished in a factory-fabricated building as specified in Section 13125. If furnished in the prefabricated power distribution center, there shall be no steps and there shall be no change in elevation to remove breakers from the power distribution center.

Table 16110-2 Low Voltage Switching Devices Design Requirements	
Low voltage switchgear	The switchgear shall be designed and constructed for use on a 480 volt, 3-phase, 60 hertz, 3 wire, solidly grounded system. All tie breakers shall be live bus manual transfer. The switchgear trip units shall be specified with metering capabilities and zone selective interlocking (ZSI). The trip units shall be networked together and taken via an Ethernet router and cable back to the DCS so status and metering can be viewed. LED indicating lights on front of each switchgear cubicle containing breaker or contactor. The same manufacturer/ model of LED lights shall be supplied for all switchgear and control panels. The indication lights shall have a 2000 ohm resistor to be included in the socket. Spare cubicles shall be fully equipped with circuit breaker/contactor, relays, indication equipment, etc. All breakers/contactors shall be operated and controlled from the DCS. "Breaker/contactor control power available" shall be monitored by the DCS. All positions with breaker/contactor shall be provided with local controls on the front of the switchgear for maintenance purposes. The breaker/contactor in non-operable conditions

Table 16110-2 Low Voltage Switching Devices Design Requirements	
	(test position, etc.) shall be indicated in the DCS. The local controls shall incorporate LED indicating lights and pistol grip switches. For all switchgear provide infrared (IR) viewing windows in the back of the equipment (each cubicle) so online temperature monitoring can take place for cable and bus connections without having to open panels. IR windows shall have a bolted and hinged cover over the windows. IR windows shall be designed and installed as to not compromise the rating or integrity of arc resistant switchgear. For breakers that feed motors of 50hp or greater, provide M-tap-2 PdMA® Amphenol plug and circuit board for closed door online motor test.
Low voltage MCCs	The low voltage motor control equipment shall be designed and fabricated complete with all accessories for use on a 480 volt, 3-phase, 60 hertz, 3 wire, solidly grounded system and shall be coordinated to fully protect motors over the complete range of overload through-fault conditions of 65 kA symmetrical at 480 volts. Provisions shall be made so that each low voltage MCC can be extended to include additional vertical sections in the future. Future extension provisions shall be made at the right end of the MCC when viewed from the front. For breakers and MCC buckets that feed motors 50 hp or greater, provide PdMA MTAP2 circuit board, CT's and test connector for closed door online motor testing.
Site elevation	Less than 3,300 ft

16110.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16110-3 Codes and Standards	
Work	**In Accordance With**
Low voltage switching devices	Latest revision of applicable ANSI C37, NEMA ICS2, and UL Standards

16110.1.5 Materials

The following materials shall be used:

Table 16110-4 Materials	
Component	**Material**
As determined by the Contractor's design	

16110.1.6 Approved Manufacturers of Components
For the following components, only the listed manufacturers are recognized by the Owner as maintaining the level of quality of workmanship required by these specifications.

Table 16110-5 Approved Manufacturers	
Component	**Manufacturer**
Low voltage switchgear (metal-enclosed circuit breakers)	Ameren Missouri Approved Suppliers
Low voltage MCCs (motor control gear assemblies)	Ameren Missouri Approved Suppliers
UL/NEMA low voltage switchboards	Same as LV switchgear
Power Distribution Centers	In accordance with Approved Suppliers List

16110.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16110-6 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Factory testing	Latest revision of applicable ANSI C37 and UL Standards	Factory, manufacturer
Production tests	ANSI/IEEE C37.20	Factory, manufacturer

Production Tests. After the equipment is completely fabricated, it shall be tested at the factory in accordance with the applicable standards and the manufacturer's standard practices. The production tests shall include the following minimum items in accordance with all applicable standards:

Voltage withstand tests (switchgear only).

Mechanical operation and interlocks.

Circuit breaker operation tests including local and remote trip/close.

Current transformer and voltage transformer ratio and polarity check.

Complete wiring check.

Overall fit and finish.

Accuracy of electronic tripping devices (switchgear only).

Wiring continuity tests and a complete wiring check shall be performed for all equipment installed.

Confirm that the bus bars are properly aligned across shipping splits and power distribution center shipping splits.

If the equipment is provided in a power distribution center, a complete checkout of tall building auxiliaries such as the HVAC, paging system, fire detection, power distribution systems, etc shall be performed.

Type Tests and Certification. The Contractor shall perform the type tests for major components as required and in accordance with all applicable standards. Type test certificates from identical components are acceptable in lieu of the individual type test. Type test certificates shall be made available to the Owner at no extra charge upon request.

16110.1.8 Not Used

16110.1.9 Not Used

16110.2 Products

16110.2.1 Low Voltage Switchgear (Metal-Enclosed Circuit Breakers)
This article specifies information for the procurement of low voltage metal-enclosed switchgear. The Contractor shall provide a standard design for items within the scope of this specification that are not covered in detail herein. The standard design shall be in accordance with accepted industry practices for electrical power generation.

Design and construction of metal-enclosed switchgear shall be in accordance with the Low Voltage Switching Devices Specification Sheets and the following requirements.

16110.2.1.1 Descriptions and Definitions.

16110.2.1.1.1 Device. A device is a fully functional piece of equipment that is described and specified on the Low Voltage Switching Devices Specification Sheets. It shall be installed in a completely equipped and wired compartment. The quantity of each device shall be furnished as specified on the Low Voltage Switching Devices Specification Sheets.

16110.2.1.1.2 Spare. A spare is a fully functional device for future use. The spare shall be installed in a completely equipped and wired compartment. All hardware and materials necessary to permit storage of the spare device shall be furnished. The quantity of spare devices shall be designated on the Low Voltage Switching Devices Specification Sheets. Spares shall be equally distributed throughout the assembly.

16110.2.1.1.3 Equipped space. An equipped space shall be furnished complete with all bus separators, terminals, connectors, wiring, control and indication devices, doors, and other hardware required for a space containing a functional device. Equipped spaces shall be identical to compartments containing operating breakers of the designated type, except that the functional unit shall not be furnished. A functional unit installed in an equipped space shall be immediately operable. The quantity of equipped spaces shall be designated on the Low Voltage Switching Devices Specification Sheets. Equipped spaces shall be equally distributed throughout the assembly.

16110.2.1.1.4 Blank space. All compartments not furnished with functional devices or designated as blank space shall be furnished as a blank space complete with front door and barriers isolating the inside of the compartment from the bus, and a backplane for mounting future devices. Blank spaces shall be located where required throughout the assembly.

16110.2.1.1.5 Air circuit breaker units. Air circuit breakers (ACBs) shall be provided with the ratings shown on the Low Voltage Switching Devices Specification Sheets and shall be mounted on drawout type carriages. ACB units having the same options and the same current and voltage ratings shall be mechanically and electrically interchangeable. Physical interlocks shall also be provided to prevent ACBs of different current and voltage ratings from being interchangeable. Each removable breaker shall be furnished with facilities for padlocking the breaker in either the disconnect or the open position.

The ACB main contact surfaces and all secondary device contact surfaces shall have silver-to-silver contact. The contact surfaces shall be designed and fabricated to be self-aligning and to resist burning and deterioration. Arc quenching and extinguishing devices (deion grids, baffles, and magnetic arc chutes) shall be fabricated from a nonhygroscopic material.

Circuit breakers shall be either electrically or manually operated as indicated on the Low Voltage Switching Devices Specification Sheets. The operating mechanism shall be of the stored energy type. The operating mechanism shall be trip-free in any position and shall be antipump. The breaker main contacts shall not move to the closed position or arc across into a faulted circuit when a breaker close signal is received while a trip signal is being applied. Electrically operated breakers shall be operated from the DCS.

Each electrically and manually operated breaker shall be furnished with a manual TRIP push button that 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 for the final breaker release device. Each manually operated breaker shall be furnished with a manual CLOSE push button that mechanically closes the breaker. If electrically operated breakers cannot be furnished without a manual CLOSE push button that mechanically closes the breaker, the CLOSE push button shall operate independently of any electrical close coil and a sealed cover shall be provided over the CLOSE push button to inhibit accidental manual closing of the breaker. A means shall be provided to allow an operator to defeat the sealed cover.

Each breaker shall be furnished with an operations counter.

Each breaker shall be furnished with a sufficient number of auxiliary switch contacts to provide all necessary interlocks and spares as shown on the typical breaker schematics included with this specification or as specified on the Low Voltage Switching Devices Specification Sheets. A minimum of 6 N.O. and 6 N.C. spare auxiliary contacts shall be provided.

A breaker position switch shall be furnished with each breaker. The switch shall change state between the DISCONNECTED, TEST and CONNECTED positions. The number of contacts and the wiring of the contacts shall be provided as shown on the typical breaker schematics included with this specification. The front door must close in all positions. Mechanical indication shall be provided for position and also to denote if the breaker closing spring is CHARGED or DISCHARGED.

Each electrically operated breaker shall be furnished with a local control station mounted on the front of its associated cubicle to permit testing of the breaker in the TEST position. The configuration of the control station shall be as shown on the typical breaker schematics.

When specified on the Low Voltage Switching Devices Specification Sheets, circuit breakers shall be furnished with coordinated current limiting fuses integrally mounted on the removable breaker element. Series rated breakers shall not be permitted.

All breakers shall be capable of closed door racking and switching. A remote racking device shall be provided for each island, electrical room, or PDC if the switchgear is non-arc resistant.

Breaker trip system shall be capable of tripping the breaker without external power connection.

An interlock shall be provided such that if the breaker trips upon overload, the breaker cannot be closed until a local reset or trip pushbutton has been operated (mechanical interlock). An interlock shall also be provided to discharge any stored energy springs before the breaker can be removed from its cell.

Breakers racking mechanism shall have provision for padlocking in the withdrawn and open positions.

Breakers shall have interlocks in place which prevent racking in or out unless the breaker is open. The interlock shall also prevent closing of the breaker by any means while it is being racked in or out.

16110.2.1.1.6 Short-circuiting switches. When short-circuiting and/or ground switches are specified on the Low Voltage Switching Devices Specification Sheets, a suitably interlocked removable switch shall be provided. The short-circuiting and grounding switch shall be complete with conducting paths, stored energy operating mechanism and accessories, but without overcurrent releases. The switch shall be capable of being shorted at either the top or bottom contact blades. Capability of remote closing and tripping shall be provided. The grounding contact shall be mounted on the side of the switch casing and shall establish the connection to the guide frame when the grounding device is inserted into the grounding drawer. Auxiliary contacts and cell position contacts shall be provided for remote indication and interlocks for the grounding switch.

16110.2.1.1.7 Not Used.

16110.2.1.2 Switchgear Assembly Design and Construction. Low voltage switchgear arrangements and dimensions shall be submitted to the Owner for approval.

The low voltage switchgear shall be of the free-standing, self-supporting, and dead-front design with all equipment installed inside vertical steel structures. Steel cubicles with front access doors shall be used to house circuit breakers, power buses, cable connecting facilities, and auxiliary devices. Each vertical section shall be the same height and have the same busbar position. Lifting angles shall be furnished on the top of each shipping section.

Terminal blocks shall be grouped in the same vertical section that contains the devices to which they are connected. Terminal blocks shall be mounted either vertically or horizontally on the switchgear frame. Terminal blocks for control and instrumentation shall be located no less than 12 inches away from power bus or power cable. Terminal blocks shall not be located in a manner that would require a worker to reach under, over, around, or through the power bus or cable while performing maintenance on the control circuit terminal blocks. Terminal blocks and wiring within a cubicle shall be designed and installed to not allow potential interference with racking, removal, or insertion of breakers within the cell.

Switchgear construction shall include barriers to isolate energized busbars from the front of the switchgear cubicles when the breakers are racked in and cubicle door opens.

Each compartment shall be completely isolated from adjacent compartments by means of grounded steel panels.

Barriers shall also be furnished to isolate all main bus, vertical or horizontal, from the cable entrance and wiring compartments. Isolation shall be by metal barriers, insulation, or a combination of the two. Metal barriers shall be grounded. Uninsulated cable, terminals, or other ungrounded conductors not isolated by metal barriers shall be insulated with prefabricated covers coordinated with the switchgear insulation. The Contractor shall furnish all materials for field applied insulation.

Doors with door latches and concealed hinge construction shall be provided on the front of each compartment and on the rear of each vertical section. No hinge shall be visible from outside when the doors are closed. Hinged panels shall be furnished with panel guards and stops designed to prevent damage to panel mounted equipment. Door interlocks that trip the breaker when a door is opened shall not be furnished. Each rear door shall be furnished with screwdriver operated, quarter-turn cam, captive fasteners. The rear doors shall be easily removable and hinged. Doors shall not require special keying or tools to open (all doors shall be capable of being opened with a standard flat head screwdriver).

Adequate openings shall be furnished for all conductors entering the switchgear.

Provide option for arc resistant 480V switchgear to help reduce the effects of arc flash and blast. At minimum, maintenance switches (or maintenance modes integral to the circuit breaker shall be provided for each breaker) to reduce arc flash energy upon activation.

16110.2.1.2.1 Automatic shutters. When specified on the Low Voltage Switching Devices Specification Sheets, automatically operated grounded steel shutters shall block access to the stationary primary disconnects when the breaker is in the disconnected position. The shutters shall automatically open as the

breaker is racked into the connected position to allow it to make a solid connection to the primary disconnects. Mechanical interlocks shall block access to the primary disconnects when the breaker is racked away from the connected position.

16110.2.1.2.2 Current transformers. All current transformer leads shall be brought out to shorting type terminal blocks arranged to provide the required combination of connections and polarity. Current transformer thermal and mechanical limits shall be coordinated with the short-time rating of the circuit breaker or bus with which they are associated.

CT's shall be provided at the load side (secondary) of each main breaker to allow for the breaker to be part of the upstream transformer differential zone. CT's shall be wired to the upstream transformer differential relay.

16110.2.1.2.3 Voltage transformers. The ungrounded phase of each transformer primary winding shall be provided with primary fuses. Transformer secondary winding fuses and connections to terminal blocks shall be provided as required during detailed design or as indicated on the drawings or on the Low Voltage Switching Devices Specification Sheets. The primary fuses shall be adequately rated for the transformer inrush and load current, and shall have an interrupting capacity equal to or greater than the maximum short-circuit momentary current rating of the switchgear assembly. The connections from the switchgear main buses to the voltage transformer primary fuses shall be capable of carrying the rated short-circuit current of the switchgear for a minimum of 1 second.

16110.2.1.2.4 Enclosure space heaters. If space heaters are required on the Low Voltage Switching Devices Specification Sheets, a space heater bus shall be wired throughout the switchgear assembly, and each vertical section of the low voltage switchgear shall be furnished with space heaters to prevent condensation of moisture. 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 section internal temperature above the dew point. Space heaters shall be controlled by an adjustable thermostat or a fixed humidistat.

The space heater bus shall be provided with incoming power terminal blocks for connection of the space heater power field cables. The incoming power feed voltage and space heater voltage ratings shall be as indicated on the Low Voltage Switching Devices Specification Sheets. Close-coupled switchgear buses shall have independent power to the heater bus. The Contractor shall furnish all wiring internal to the low voltage switchgear and suitable branch circuit protection.

16110.2.1.2.5 Motor space heater wiring. Selected motors will have their space heaters energized (switched on and off) from an independent power supply and each motor should be from independent branch circuits. The space heater power source shall provide space heater power to each individual motors. The selection of motors to be supplied with heaters shall be determined during detailed design and approved by the Owner.

16110.2.1.2.6 Nameplates. Engraved nameplates shall be furnished for each switchgear lineup and for each compartment in each lineup. A switchgear lineup nameplate shall be located on the front top center of each switchgear. Each circuit breaker, combination starter unit, and fused switch shall be identified with its feeder designation engraved on laminated plastic tags. Each device installed in the compartments, each plug assembly and terminal strip, and each indicating and operating element shall be identified with permanently attached plastic tags or nameplates. All tags or nameplates shall be clearly visible. Inscriptions on these tags shall coincide with those used on the drawings approved by the Owner.

In the case of low voltage switchgear, all wiring terminal blocks mounted on the rear of the switchgear which are associated with a given circuit breaker shall be distinguishable from the wiring terminal blocks used for another breaker through use of an appropriate nameplate engraved with the compartment number of the breaker they are associated with. The nameplate bearing the breaker compartment number shall be located near the terminal blocks it serves, and shall be clearly visible to an electrician in the field.

The Contractor shall submit the list of nameplate engraving for Owner review. Unless otherwise indicated or modified by the Owner during formal review of the supplier shop drawings, all nameplate inscriptions

shall match the one-line and schematic drawings, descriptions, or lists, and the nameplates and tags shall meet the requirements of Section 17302 - Phenolic Nameplates.

16110.2.1.2.7 Transducers. When specified on the Low Voltage Switching Devices Specification Sheets, transducers shall be provided and wired as shown on the typical breaker schematics listed in Article 16110.1.8.

16110.2.1.3 Power and Control Conductors. Switchgear power and control conductors shall be furnished in accordance with the requirements of the following articles. 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 as specified on the Low Voltage Switching Devices Specification Sheets. Expansion joints shall be furnished when required.

The main bus, bus taps, and bus plating shall be furnished as specified on the Low Voltage Switching Devices Specification Sheets.

All conductors shall have minimum 600V insulation.

16110.2.1.3.1 Main bus. The switchgear main buses shall be designed to continuously carry the current specified on the Low Voltage Switching Devices Specification Sheets without exceeding temperature rise requirements specified in the applicable standards.

The bus shall be installed with rigid, nontracking, fire-resistant, and nonhygroscopic insulating supports that are capable of withstanding the mechanical forces imposed by short-circuit currents equal to or greater than the specified values indicated on the Low Voltage Switching Devices Specification Sheets.

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

Design of the busbars shall be so that future expansion of the switchgear to either side is possible unless close-coupled between transformers.

The Contractor shall furnish all material required for field connections and, if specified on the Low Voltage Switching Devices Specification Sheets, insulation of switchgear bus and terminals.

All bus shall be insulated with 600V minimum rated insulation. Bus shall be tin plated copper.

Bus bars shall be bolted together and Contractor shall ensure they are clean and free of corrosion, welding slag, and other foreign matter.

16110.2.1.3.2 Ground bus. An uninsulated ground bus shall run through the entire length of the low voltage switchgear with provisions for terminating ground conductors at each feeder point and at each end of the low voltage switchgear assembly. When a secondary unit substation transformer is integral to the low voltage switchgear assembly, the Contractor shall connect the switchgear ground bus to the power transformer neutral (solidly grounded).

The ground bus material shall be as indicated on the Low Voltage Switching Devices Specification Sheets. All switchgear equipment requiring grounding shall be connected to this ground bus. Two ground connectors shall be furnished for the attachment of a Contractor supplied 1/0 AWG to a 300 kcmil stranded copper cable at each end of the switchgear assembly protective ground bus.

16110.2.1.3.3 Neutral bus. When a 4 wire system is specified on the Low Voltage Switching Devices Specification Sheets, a neutral bus shall extend the entire length of the low voltage switchgear assembly. The neutral bus shall be insulated from the switchgear enclosure, the switchgear phase bus system, and the ground bus. The neutral bus shall extend into each feeder cable or bus connection compartment. A means of disconnection (such as a bolted link) shall be provided to isolate the neutral bus from the power source neutral for testing purposes. When a unit substation transformer is integral to the low voltage

switchgear, the switchgear neutral bus shall be connected by busbar to the neutral of the transformer. The neutral bus shall have the same bracing as the phase bus and shall be made of the same material.

16110.2.1.3.4 Not Used.

16110.2.1.4 External Connections. Facilities for the entrance, support, termination, and connection of power and control conductors shall be furnished in accordance with the requirements in the following articles.

16110.2.1.4.1 Terminal connectors. Terminal connectors for power cables and ground cables entering the switchgear shall be furnished and shall be as listed in the following table or an acceptable equal. Solder type terminals are not acceptable. Bolted clamp type connectors are only acceptable for ground connections. Phase connections shall be compression type connections. The Contractor shall determine sizes for the power and ground cables:

Table 16110-7 Terminal Connectors for Power and Ground Cables

Cable Size	Burndy Terminal Connector for Copper Conductors	
	Bolted Clamp Type	**Compression Type**
8 AWG and smaller		YAV
6 AWG through 1/0 AWG (50 mm^2)	VA-2	YA-2N
2/0 AWG and larger	VVA-2N	YA-2N

16110.2.1.4.2 Station Service Transformer (480V SST). When a Station Service transformer (SST) is specified on the Low Voltage Switching Devices Specification Sheets, the Contractor shall furnish all the materials and integral parts required for the connection/interface of the unit substation transformer to the low voltage switchgear assembly in accordance with the requirements of Section 16153 - Station Service Transformers.

The Station Service Transformers for the LV Switchgear shall be close-coupled to the Switchgear Load Centers. The Station Service Transformers shall have an isolation switch adjacent to the transformer on the high side of the transformer.

16110.2.1.4.3 Bus duct. When bus duct is specified on the Low Voltage Switching Devices Specification Sheets for power conductors, the Contractor shall furnish all materials required to complete the connection/interface with the bus duct.

Each switchgear unit that contains terminals for connection of metal-enclosed bus duct shall have provisions for connecting the bus duct ground bus to the switchgear ground bus.

Bus duct and other penetrations to the switchgear shall be designed as to not compromise the NEMA or arc resistant rating of the enclosure.

16110.2.1.5 Control Power. Control power for each electrically operated breaker shall be as specified on the Low Voltage Switching Devices Specification Sheets and the typical breaker schematics.

The Contractor shall furnish all internal devices and wiring required to distribute control power to each electrically operated breaker. 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. Control power breakers shall be mounted so they are accessible through the enclosure, without having to open any breaker compartment doors. A 125V DC control power breaker shall be provided to disconnect the close power to the breakers. However, this breaker shall not disconnect the power the protective relaying devices or the trip circuit. The trip circuit

power and protective relay power shall be powered from a separate 125 VDC disconnect switch that is not rated as a protective device such as fuses, circuit breakers, etc. The 125 VDC source shall be the same for each cubicle and breaker.

16110.2.1.6 Electronic Tripping Devices and Relays. Circuit breakers shall be equipped with the latest microprocessor based electronic tripping devices and shall be furnished in accordance with the Low Voltage Switching Devices Specification Sheets.

If conflicting specification information is provided, the order in which the conflict will be resolved from first to last is as follows:

Typical Breaker Schematics.

Low Voltage Switching Devices Specification Sheets and text articles.

Auxiliary relays that are mounted internally to the switchgear shall be surface mounted and front connected.

The generalized tripping device descriptions included on the Low Voltage Switching Devices Specification Sheets are for bidding purposes. The Contractor shall furnish characteristic curves for all available tripping devices in the various ranges available for the types of tripping devices specified. After receiving the characteristic curves and relay instruction manuals, the Contractor shall select the specific characteristics and current sensor ratings required to be furnished.

16110.2.1.6.1 Electronic tripping devices. Breakers shall be equipped with microprocessor based overcurrent tripping protection. The Contractor shall set the trip settings to provide coordinated selective tripping of overcurrent protection devices. The Contractor shall furnish tripping devices with characteristics and trip ranges that will permit this coordination with both upstream and downstream through the entire associated system.

All solid-state tripping devices furnished shall be identical to devices that have been completely tested in actual service. They shall be certified to operate within plus or minus 5 percent of set point throughout a temperature range of -22° F to 122° F. The Contractor shall immediately replace any tripping devices which, when tested in service, do not meet this requirement.

Unless specified otherwise, the electronic trip devices shall be integral with the breaker. A bell alarm device that operates whenever the breaker trips due to a protective function of the electronic tripping device shall be provided. A DCS alarm shall be provided in the event of a trip. Tripping via the breaker manual trip push button, shunt trip, undervoltage device or open fuse lockout shall not operate the bell alarm. The bell alarm shall be furnished with a mechanical lockout feature that prevents the breaker from being manually mechanically closed until the lockout is manually reset at the breaker. The bell alarm device shall also be provided with 2 N.O. and 2 N.C. spare contacts in addition to the number of contacts required by the Contractors design. If a breaker display unit is specified on the Low Voltage Switching Devices Specification Sheets, the display and the display controls shall be visible and available from the front of the switchgear assembly with the breaker door closed. The Contractor shall provide any power supplies required by the breaker display unit. Power supplies shall be fed from the main control power DC circuit within the same cubicle, but may pass through a transformer if required.

A test set for testing breaker electronics shall be provided to the Owner.

16110.2.1.6.2 Protective relays. Protective relays shall be flush mounted and furnished as indicated on the Low Voltage Switching Devices Specification Sheets and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection. Where there are discrepancies between this specification and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection, the requirements in and T&D Design Standard No. 16G and 16G Supplemental-Design Guide for Generator and Generator Auxiliary System Protection shall take precedence.

Terminal blocks and jumpers shall be provided between the protective relay and all field wires. No field wiring or field devices (such as interlocks, RTDs or thermocouples) shall be wired directly to the protective relays.

16110.2.1.6.2.1 Auxiliary system protection. Auxiliary system protection shall be designed with primary and secondary systems. The relaying needs to detect all bolted faults and coordinate under all single contingency outages of protective relay, CT circuit, PT circuit, DC circuit, or major equipment. Minimum bolted fault detection margin is 1.5 with a margin of 2.0 preferred. System design and primary relaying shall limit all arc flash levels to 25cal/cm^2. Primary and secondary relays shall allow equipment loading up to its nameplate or calculated normal and emergency ratings with margin of 1.15 or greater.

As a minimum, primary protection shall include transformer and overcurrent protection on feeder and motor positions. In addition, secondary protection shall include time coordinated over-current relaying. Minimum time over-current coordination is 0.3 seconds.

At a minimum, neutral overcurrent relays shall be specified for the secondary of each transformer which supplies the bus.

Primary and backup ground over-current relays are required to detect ground faults. High-impedance bus differential relays are usually sensitive enough to detect 1200 A ground faults with margin.

16110.2.1.6.2.2 Auxiliary system - CT selection. Feeder breaker CTs shall be selected to exceed FLA by 115 percent to 200 percent. Neutral and differential flux balance window CTs shall be selected to provide less than 100 A secondary for a bolted ground fault.

Main and tie breakers CTs shall be sized for maximum bus load ratings, and to provide less than 100 A secondary for maximum fault levels.

Transformer CTs shall be sized for maximum transformer emergency ratings and to provide less than 100 A secondary for maximum fault levels.

16110.2.1.7 Diagrams and Lists. The Contractor shall furnish internal switchgear wiring, transformer wiring, connections, and diagrams in accordance with the requirements of the following articles.

16110.2.1.7.1 One-line diagrams and three-line diagrams. The Contractor shall submit one-line diagrams for approval by the Owner. The one-line diagrams shall be based on documentation provided by the Owner. The Contractor shall submit three-line diagrams for approval by the Owner after receiving the one-line diagrams, approved by the Owner. These drawings shall be based on, and identical in function to, typical one-line diagrams, three-line diagrams, and metering/relaying diagrams furnished by the Owner.

The three-line diagrams shall be drawn similar to the three-line diagrams. The Contractor shall submit sample three-lines for Owner review. The three line diagrams shall be submitted to the Owner for review and approval.

16110.2.1.7.2 Wiring and Interconnection Diagrams. Wiring and Interconnection diagrams shall be in accordance with the requirements specified herein. Switchgear schematic, connection, and interconnection diagrams furnished by the Contractor shall be based on typical schematic (elementary) diagrams and connection diagrams furnished by the Owner as a basis for the Contractor's detailed design. The Contractor shall provide detailed schematic (elementary) diagrams and connection diagrams for each breaker and compartment.

After receiving the Owner's typical schematics and wiring diagrams, the Contractor shall prepare his schematic (elementary), connection, and interconnection diagrams, which shall indicate the same terminal designations and the same terminal arrangement as indicated on the Owner's diagrams.

The complete connection diagram of each switchgear breaker, contactor, or metering compartment 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. All diagrams shall maximize the sheet as much as possible up to ANSI Size D drawings

Each item of switchgear mounted equipment indicated on the diagrams shall be identified by an item number and description in accordance with the Owner's nomenclature.

The Contractor's terminal block designations shall match the terminal block designations shown on the schematic and connection diagrams furnished by the Owner.

16110.2.1.8 Tightening of Connections. On the erection and assembly drawings, the Contractor shall include 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.

16110.2.1.9 Control and instrument wiring. All wiring shall be 600V, 90° C rated, at minimum SIS wire shall be used for internal switchgear control, instrument, and control power 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 Contractor'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 and terminal blocks required to interconnect the switchgear units after they are set in place in the field. However, Current and voltage transformer wiring shall not go through the shipping splits.

If installed in a Power Distribution Center (PDC), all wiring between devices in the same Equipment Assembly (including those that cross shipping splits) or between equipment in the PDC assemblies shall be installed by the Contractor and tested at the factory for continuity and accuracy.

All wiring that crosses shipping splits shall be terminated on terminal blocks at one side of each shipping split. Wiring that crosses a shipping split shall be de-terminated from the terminal blocks and coiled in the adjacent cabinet for shipping. All cables that are coiled shall be clearly marked and assigned circuit numbers and shown on drawings from the Contractor.

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

Table 16110-8 Minimum Wire Size for Control and Instrumentation

Minimum Wire Service	**Size, AWG**
Power supplies	12
Current and voltage transformer circuits	10
Indicating lights and annunciator circuits	14
Instrumentation circuits	14
All other wiring	14 or sized as required

16110.2.2 Low Voltage Motor Control Centers (MCCs)
This article specifies information for the procurement of low voltage MCCs. The Contractor shall provide a standard design for items within the scope of this specification that are not covered in detail herein. The standard design shall be in accordance with accepted industry practices for electrical power generation.

Design and construction of low voltage MCCs shall be in accordance with the Low Voltage Switching Devices Specification Sheets and the following requirements.

A local voltmeter shall be placed on each MCC for main bus voltage indication.

MCCs shall be sized for 20 percent space for positions available for future expansion. 20% spare buckets of each type and size at each building minimum and two spare breaker positions minimum shall be supplied on each MCC.

An option shall be provided for arc resistant 480V MCCs to help reduce the effects of arc flash and blast.

16110.2.2.1 Descriptions and Definitions.

16110.2.2.1.1 Device. A device is a fully functional piece of equipment that is described and specified on the Low Voltage Switching Devices Specification Sheets. It shall be installed in a completely equipped and wired compartment. The quantity of each device shall be furnished as specified on the Low Voltage Switching Devices Specification Sheets.

16110.2.2.1.2 Spare. A spare is a fully functional device for future use. The spare shall be installed in a completely equipped and wired compartment. All hardware and materials necessary to permit storage of the spare device shall be furnished. The quantity of spare devices shall be designated on the Low Voltage Switching Devices Specification Sheets. Spares shall be equally distributed throughout the assembly.

16110.2.2.1.3 Equipped space. An equipped space shall be furnished complete with all bus separators, terminals, connectors, wiring, control and indication devices, doors, and other hardware required for a space containing a functional device. Equipped spaces shall be identical to compartments containing operating breakers or starters of the designated type, except that the functional unit shall not be furnished. A functional unit installed in an equipped space shall be immediately operable. The quantity of equipped spaces shall be designated on the Low Voltage Switching Devices Specification Sheets. Equipped spaces shall be equally distributed throughout the assembly.

16110.2.2.1.4 Blank space. All compartments not furnished with functional devices or designated as blank space shall be furnished as a blank space complete with front door and barriers isolating the inside of the compartment from the bus and a backplane for mounting future devices. Blank spaces shall be located where required throughout the assembly.

16110.2.2.1.5 Insulated case circuit breaker with electronic tripping device. If applicable, insulated case circuit breakers (ICCB) shall be fixed mounted and provided with the ratings shown on the Low Voltage Switching Devices Specification Sheets. The ICCBs shall have a molded case made of a glass-reinforced insulating material. The breakers shall be rated to be applied at 100 percent of their continuous current rating when installed within the MCC assembly.

Each breaker shall be provided with manual OPEN and CLOSE mechanical push buttons located on the face of each ICCB. The OPEN and CLOSE push buttons shall operate independently of any electrical trip or close coils. If electrically operated breakers cannot be furnished without a manual CLOSE push button, a sealed cover shall be provided over the CLOSE push button to inhibit accidental manual closing of the circuit breaker. A means shall be provided to allow an operator to defeat the cover. The operating handle shall have the means to padlock the breaker device in the OPEN position.

The operating mechanism shall be of the stored energy type and shall be trip-free. All poles shall have common tripping and closing mechanisms. A circuit breaker main contact position indicator shall be provided on the face of each ICCB. Circuit breakers shall be either electrically or manually operated as indicated on the Low Voltage Switching Devices Specification Sheets. Each manually operated breaker shall be complete with a spring charging handle. Each electrically operated breaker shall be complete with spring charging motor, trip coil, and closing coil. The operating voltage of the electrically operated breakers shall be as specified on the Low Voltage Switching Devices Specification Sheets.

Each breaker shall be furnished with four field configurable auxiliary switch contacts that change state with the breaker main contacts. Unless otherwise specified, the auxiliary switch contacts shall be factory configured as two NO and two NC contacts. Automatic tripping caused by overcurrent tripping device action shall be monitored with an alarm switch having one NO and one NC electrically isolated contact. The alarm switch shall reset when the circuit breaker is manually reset. All auxiliary and alarm contacts shall be wired out to terminal blocks.

The ICCB shall be furnished with a microprocessor based overcurrent tripping device to provide interchangeable and independently adjustable overcurrent, and short-circuit (instantaneous) protection. The Contractor shall set the trip settings to provide coordinated selective tripping of overcurrent protection devices of both phase and ground fault functions. The Contractor shall submit characteristic curves and relay instruction manuals. The Contractor shall select the specific characteristics and current sensor ratings required. The Contractor may supply a tripping device that has more functions than those indicated; however, it shall be possible to disable the extra functions.

ICCBs may only be used for MCC main breakers. The use of ICCBs and MCC main breakers shall be approved by the Owner.

All solid-state tripping devices furnished shall be identical to devices that have been completely tested in actual service. They shall be certified to operate within plus or minus 5 percent of set point throughout a temperature range of -22° F to 122° F. The Contractor shall immediately replace, at his own expense, any tripping devices which, when tested in service, do not meet this requirement.

Unless specified otherwise, the electronic trip devices shall be integral with the breaker. Following automatic tripping of the breaker by the electronic tripping device, manual closure of the circuit breaker shall be prevented until the protective device is manually reset at the breaker. If a breaker display unit is specified on the Low Voltage Switching Devices Specification Sheets, the display and the display controls shall be visible and available from the front of the MCC assembly with the breaker door closed. The Contractor shall provide any power supplies required by the breaker display unit.

16110.2.2.1.6 Molded case circuit breaker (Thermal Magnetic). The molded case circuit breakers (MCCB) shall be fixed mounted and provided with the ratings as shown on the Low Voltage Switching Devices Specification Sheets. The circuit breakers shall consist of a molded case manufactured from glass-reinforced insulating material. The breakers shall be rated to be applied at 100 percent of their continuous current rating when installed within the MCC assembly.

The MCCB shall be furnished with a microprocessor based overcurrent tripping device to also provide interchangeable and independently adjustable overcurrent, and short-circuit (instantaneous) protection.

The circuit breaker operating handle shall indicate ON, OFF, and TRIPPED positions. The operating mechanism shall be trip free. All poles shall have common tripping and closing mechanisms. The operating handle shall have the means to lock the breaker device in the OPEN position.

16110.2.2.1.7 Feeder tap units. Feeder tap units shall be complete with molded case circuit breakers. Circuit breaker trip elements shall be as specified on the Low Voltage Switching Devices Specification Sheets.

Manual operating handles shall be furnished on the access doors of feeder tap units to operate the circuit breakers. The operating handle of the disconnect device shall be door mounted and interlocked to prevent the opening of the compartment door when the breaker/switch is in the CLOSED position. For maintenance purposes, the interlock mechanism shall be able to be defeated by means of a tool. Handles shall be clearly marked to indicate the positions of the breaker/switch. The circuit breaker operating handle shall indicate ON, OFF, and TRIPPED positions. The operating handle shall have the means to lock the disconnect device in the OPEN position. Each operating handle shall indicate when the breaker has tripped automatically.

16110.2.2.1.8 Combination starter units. All combination magnetic starter units shall include disconnecting and branch circuit overcurrent protection devices, 3-phase contactors with manual reset

electronic solid-state overload relays, and operating coils. Control transformer leads, starter overload relay contacts, contactor operating coils, and starter auxiliary contacts shall be wired to marked unit terminal blocks as indicated on the Owner's typical schematics for MCC's. Selection and coordination of disconnect devices and overload relays shall be performed by the Contractor.

The disconnect device shall be a molded-case, magnetic-only circuit breaker with adjustable trip settings. All devices shall be NEMA rated, no exceptions. Molded-case, magnetic-only circuit breakers shall have a minimum adjustable range of between 800 and 1700 percent of motor full-load current. Where a molded-case magnetic-only circuit breaker with an adjustable range cannot be provided to encompass the full 800 to 1700 percent range, the Contractor shall provide a molded-case magnetic-only circuit breaker with a minimum adjustable range of between 1100 and 1700 percent for energy efficient motors unless directed otherwise by the Owner. Any circuit breakers which are verified to be of the correct range selection (based upon motor efficiency category) yet do not allow motors to be started shall be replaced as directed by the Owner.

The disconnect device shall withstand and interrupt the maximum symmetrical (rated short-circuit breaking current) available at the main bus. The operating handle of the disconnect device shall be door mounted and interlocked to prevent the opening of the compartment door when the breaker is in the CLOSED position. For maintenance purposes, the interlock mechanism shall be able to be defeated by means of a tool. Handles shall be clearly marked to indicate the positions of the breaker ON, OFF, and TRIPPED. The operating handle shall have the means to padlock the disconnect device in the OPEN position.

Each starter shall be supplied from a control power transformer with each ungrounded phase fused in both the primary and secondary circuits. Minimum size for the control power transformer shall be 150VA. One of the secondary circuit leads shall be grounded. The transformer shall be designed with 100 volt-amperes of spare capacity. Each control transformer shall maintain the minimum potential for the operating coil at its secondary terminals during starter coil inrush, while simultaneously serving an additional load of 100 volt-amperes at 50 percent power factor. Each control transformer shall be mounted as part of the removable combination starter unit.

On motor starters through NEMA Size 3 the contractor operating coil shall be 120 VAC operation.

For NEMA 4 and larger starters, the operating coil shall be for use on 480 VAC and there shall be a 120 VAC interposing relay in the control circuit (only contactor coil to be 480 V, all other controls to be 120 VAC).

Contactor dropout voltage shall be no more than 80 percent of rated voltage.

Contactor short circuit withstand shall be non-welding under all normal conditions including locked rotor current.

The main contactor operating coils, shall be equipped with auxiliary contactors (relays) for use in the operating coil circuit. Each auxiliary contactor (relay) shall be operated from the circuit of the control transformer. The auxiliary contactors (relays) shall be mounted with the removable combination starter unit. Each contactor shall have at least two spare NO and 2 spare NC aux contacts at the end of the FAT.

Two-speed starters and reversing starters shall be mechanically and electrically interlocked so that only one set of contactors shall be energized at any one time.

Electronic solid-state relay(s) shall monitor each ungrounded phase of the primary circuit in each combination motor starter. The overload capacity of the relays shall be manually adjustable through a range of 85 to 115 percent of the normal trip rating. The relays shall be temperature compensated. Provisions shall be made for manually resetting the thermal relays without opening the starter door. Actuation of the reset feature of the thermal relays while the combination motor starter is energized shall not de-energize the motor starter. Normally open and normally closed (Form C) alarm contacts shall be provided on the overload protection relay which operate on an alarm condition. The normally closed contact shall be wired to the DCS.

When specified on the Low Voltage Switching Devices Specification Sheets, combination starters shall be furnished with a fourth thermal overload relay for use as an overload alarm if alarm contacts are not available from the solid state relays specified in the previous paragraph. This overload relay shall monitor the combination starter center phase. Normally open and normally closed (Form C) alarm contacts from the fourth thermal overload relay shall be wired to the starter terminal block.

Overload relay(s) shall operate within a range of plus or minus 5 percent of the overload relay trip setting. Overload relay(s) or assemblies that do not meet this requirement, both when field tested and when in actual operation, shall be replaced by the Contractor.

Overload relay(s) shall be solid state type relays with provisions for ModBus over TCP/IP communications. O/L relays shall contain ground fault current sensing and trip.

Each starter shall be furnished with mechanically operated auxiliary contacts. Auxiliary contacts shall be mounted on the main contactor.

A minimum MCC starter size shall be NEMA Size 1.

16110.2.2.1.9 Dry type transformers. Transformers shall be dry type and shall be manufactured and installed in accordance with the applicable standards.

Winding insulation shall be rated for temperature rise by resistance above the ambient temperature specified on the Low Voltage Switching Devices Specification Sheets. Transformer heat transferred to the surrounding area shall not adversely affect the operation of the associated panelboard breakers or adjacent MCC starters or breakers.

Transformer installations having sound levels in excess of the noise levels specified on the Low Voltage Switching Devices Specification Sheets shall be replaced.

16110.2.2.1.10 Not Used.

16110.2.2.1.11 Not used.

16110.2.2.1.12 Future additions and modifications. The ends of each vertical section shall include provisions for the future installation of similar sections. Each section shall be arranged to allow the removal, addition, interchange, or replacement of individual units.

16110.2.2.2 MCC Assembly Design and Construction. All starter units and feeder tap units shall be readily interchangeable with units of the same type and size. For example, any size 2 FVNR starter bucket shall have the ability to be swapped with any other size 2 FVNR starter bucket.

16110.2.2.2.1 Arrangement. To minimize cable congestion in vertical wireways, combination starters, circuit breakers, and other accessories shall be arranged such that higher ampacity devices are located nearest the point of cable entry within each vertical section. For top-entry MCCs, higher ampacity devices shall be installed towards the top of the vertical sections. For bottom-entry MCCs, higher ampacity devices shall be installed towards the bottom of the vertical sections. The Contractor shall arrange the remaining devices to minimize heat buildup in the top of the cubicles and to facilitate accessibility. Operating handles, in their highest position, shall not be located more than 79 inches above the bottom of the MCC assembly. If an equipment base is required, this maximum height should be adjusted down accordingly. The minimum bucket size shall be 9 inches. No 9 inch bucket shall be arranged at the top or bottom of any vertical section. Wireways shall be sized to adequately handle installed cabling and also allow provisions for future cabling to spare/space cubicles.

16110.2.2.2.2 Enclosures. The MCC enclosure shall be of the type specified on the Low Voltage Switching Devices Specification Sheets. MCC equipment shall be mounted in compartmentalized vertical sections fabricated of steel and assembled to provide a rigid self-supporting structure. Each vertical section shall be the same height and have the same busbar position. Lifting angles shall be furnished on the top of each MCC shipping section. Removable metallic barriers shall be provided for the cable access

openings on top of the enclosure to prevent accidental contact with the bus work. The removable metallic barrier shall be designed to be installed either with a junction box or top hat or without a junction box or top hat.

16110.2.2.2.3 Wire troughs. Horizontal wireways shall be located at the top and bottom of each section, and aligned and located to provide a continuous wireway of the same cross-sectional dimensions throughout the length of the assembled MCC. Vertical wire troughs shall be provided between each horizontal section. Horizontal top troughs shall be minimum 12" high and bottom troughs shall be 6" minimum height.

16110.2.2.2.4 Doors. Gasketed hinged doors shall be provided on the front of each starter unit and feeder tap unit. Doors shall be designed to allow easy maintenance or replacement of all starters, disconnecting and branch circuit overcurrent protection devices, transformers, panelboards, and similar devices from the front. A separate hinged and gasketed full height door shall be furnished on the front of each section to allow access to the vertical wire trough without opening any other door.

The Contractor shall align all compartment doors at the factory so that rubbing will not occur between adjacent units and the MCC structure. Provisions shall be included in the door hinges to allow field adjustment after the MCCs have been set.

16110.2.2.2.5 Compartments. Removable assemblies shall move smoothly along guides. For the removal of assemblies weighing more than 55 pounds gross weight, suitable equipment shall be provided to facilitate the removal and installation of the assembly. Details of such equipment shall be provided with the Proposal.

16110.2.2.2.6 Enclosure space heaters. When specified on the Low Voltage Switching Devices Specification Sheets, space heaters shall be furnished at the bottom of each vertical section of MCCs to prevent condensation of moisture within the enclosure. The heaters shall be located and thermally insulated so that no painted surface will be damaged or discolored. Space heater location shall not interfere with the normal entrance of cables into the sections.

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

The Contractor will furnish a single power feed to each MCC assembly for the space heater service. The incoming power feed voltage and space heater voltage ratings shall be as indicated on the Low Voltage Switching Devices Specification Sheets. The Contractor shall furnish all wiring internal to the MCC and suitable branch circuit protection.

16110.2.2.2.7 Motor space heater wiring. Selected motors will have their space heaters energized (switched on and off) from an independent power supply and each motor should be from independent branch circuits. The space heater power source shall provide space heater power to each individual motors. The selection of motors to be supplied with heaters shall be determined during detailed design and approved by the Owner.

The Contractor shall furnish motor space heater power supplies to each individual motor with a space heater, including all motor space heater wiring integral to the switchgear equipment assembly and suitable branch circuit protection for each motor space heater feed. The motor space heaters shall be powered from a dedicated 120/208V power panel with each motor space heater having its own dedicated power circuit. The 120/208V power panel shall not be built into the switchgear and shall be stand alone. The motor space heater shall be energized while the motor feeder circuit is de-energized. Each motor heater shall be fed from an independent power supply branch circuit. Each motor space heater circuit shall include auxiliary contacts from the switching device(s) to turn motor space heaters on when main power is not being provided to the motor, individual molded case circuit breakers, and connections to terminal blocks for external connections as shown on the typical schematics for motor feeders provided by the Contactor. For withdrawable switching devices, unless otherwise specified, the ability of the supply circuit to provide power to the motor space heater shall not be dependent upon the switching device being in the connected position. The Contractor shall balance the current loading on multiphase space heater buses.

16110.2.2.2.8 Nameplates. An engraved nameplate shall be furnished for each MCC and for each unit door acceptable to the Owner. A list of nameplates shall be provided for Owner approval. The nameplates shall meet the requirements of Section 17302- Phenolic Nameplates.

16110.2.2.2.9 Circuit breakers. All breakers shall be manually operated with quick-make, quick-break, trip-free mechanisms of the toggle type. The breakers shall be equipped with suitable arc quenching devices. Main current carrying contacts shall be silver-plated and shall be capable of carrying their rated current without exceeding the specified temperature rise in accordance with the applicable standards. All circuit breakers shall be of the same manufacture.

16110.2.2.2.10 Current transducers. When specified on the Low Voltage Switching Devices Specification Sheets, current transducers shall be mounted on the removable starter unit or feeder tap unit.

16110.2.2.3 Power and Control Conductors. All power and control conductors shall be 600V, 90 degree C rated minimum. Internal wiring shall be SIS wire. The MCC power and control conductors shall be furnished in accordance with the requirements of the following articles. 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 as indicated on the Low Voltage Switching Devices Specification Sheets. Expansion joints shall be furnished where required.

The main bus taps shall be made of the same material as the phase bus. All joints shall have silver-to-silver contact surfaces with minimum contact resistance.

16110.2.2.3.1 Main bus. The bus shall be installed with rigid, nontracking, fire-resistant, and nonhygroscopic insulating supports with high dielectric strength and high creepage surface capable of withstanding the mechanical forces imposed by short-circuit currents of the magnitude specified on the Low Voltage Switching Devices Specification Sheets. 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 specified on the Low Voltage Switching Devices Specification Sheets. Expansion joints shall be furnished where required.

The MCC main horizontal and vertical bus shall be designed to continuously carry the current specified on the Low Voltage Switching Devices Specification Sheets without exceeding temperature rise requirements specified in the applicable standards. The main and neutral horizontal bus shall be isolated from the horizontal wiring trough by means of removable barriers. All joints shall have silver-to-silver contact surfaces with minimum contact resistance.

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

Design of the busbars shall be so that future expansion of the MCC at the right hand end of the MCC when viewed from the front.

Bus shall be insulated and tin plated copper.

16110.2.2.3.2 Ground bus. An uninsulated protective ground bus shall be furnished through the entire length of the MCC. All MCC equipment requiring grounding shall be connected to this ground bus.

16110.2.2.3.3 Neutral bus. If specified on the Low Voltage Switching Devices Specification Sheets to furnish a neutral bus, the bus shall be furnished insulated from the MCC enclosure. Unless specified otherwise on the Low Voltage Switching Devices Specification Sheets, the bus shall be furnished limited to the vertical section containing the incoming power connections only. The continuous current rating of the neutral bus shall be as specified on the Low Voltage Switching Devices Specification Sheets. All MCC equipment requiring connection to the neutral shall be connected to this bus.

16110.2.2.3.4 Aluminum bus material. Aluminum bus is not allowed.

16110.2.2.4 External Connections. Facilities for the entrance, support, termination, and connection of power, control, and ground conductors shall be furnished.

When the MCC is to be integrally connected to low voltage switchgear, all flanges, flexible connectors, bolting, and other materials required to complete the connection shall be furnished.

When an incoming line termination compartment is specified on the Low Voltage Switching Devices Specification Sheets, the Contractor shall extend the main bus into a compartment of a vertical section for termination of the incoming line. Each incoming line termination compartment shall be not less than 18 inches high and shall be located at the top or bottom of the vertical section to coordinate with the direction of the incoming line cable entrance specified.

16110.2.2.5 Terminals. The Contractor shall furnish terminals for all power, control, and ground conductors entering the MCCs. Solder type terminals are not acceptable.

Terminal connectors shall be furnished for all incoming line cables as follows:

Table 16110-9 Terminal Connectors for Power, Control, and Ground Conductors

	Burndy Terminal Connector for Copper Conductors	
Cable Size	**Bolted Clamp Type**	**Compression Type**
8 AWG and smaller		YAV
6 AWG through 1/0 AWG (50 mm^2)	VA-2	YA-2N
2/0 AWG and larger	VVA-2N	YA-2N

Either bolted clamp type or compression type terminal connectors shall be furnished for all incoming power cables, except that the load feeder cable may terminate on the overload relays for the two smallest single-speed nonreversing starter unit types or the smallest, single-speed reversing starter unit types.

Incoming power cable feeding the MCC shall be terminated using compression type connectors. Load feeder cables may be terminated directly on breaker lugs of feeder taps. Motor feeder cables shall terminate directly on overload relay terminals using compression lugs if screw terminals are provided on the OL relay. Motor feeder cables shall connect directly to box lugs on larger OL relays. Control and signal wiring shall be terminated using ring type terminals.

Each starter unit shall be furnished with terminal blocks located adjacent to the vertical wireway for termination of control cable.

Connectors for attachment of ground and neutral buses to the external system shall be bolted clamp type suitable for 1/0 AWG to 300 kcmil copper conductors. One connector shall be provided at each end of each MCC ground bus. One connector shall be provided at the incoming line end of the MCC neutral bus. A load ground connector shall be furnished on the ground bus for each combination starter unit and each feeder tap unit. The Contractor shall determine terminal connector size during detailed design.

16110.2.2.6 Wiring, Wiring Diagrams, and Databases. MCCs shall not be furnished with labeling of auxiliary devices nor opposite end destination identification of conductors. Diagrams for other components such as panelboards and transformers shall be the Contractor's standard subject to Owner's approval.

16110.2.2.7 Tightening of Connections. On the erection and assembly drawings, the Contractor shall include 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.

16110.2.2.8 Outsourcing of Components. The Contractor shall include, with the Proposal, a list of all equipment components that will be sourced from outside the final assembly plant with lead times longer than 30 days. This list shall give a detailed description of the component, its manufacturer, and the location from which it will be shipped.

Low Voltage Switching Devices Specification Sheet

Low Voltage Switching Equipment - General Requirements	
Standards for manufacturing and testing	ANSI/NEMA/UL
Nominal operating voltage	480 VAC
Nominal power system frequency	60 Hz
Bus configuration	3-phase, 3 wire, solidly grounded
Current transformer rated secondary current	5 amps
Voltage transformer turns ratio, line-to-line	480 V - 120 V
Cable gland plates to be furnished with the equipment	Not applicable
Cable glands to be furnished with the equipment	Not applicable
Busbar material and plating	Copper with tin plating
Exterior paint color	ANSI 61 Gray
Altitude	Less than 3,300 ft
Environment	Not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapors, or salt
Low Voltage Switchgear (Metal-Enclosed Circuit Breakers)	ANSI/NEMA
Busbar insulation	Required Manufacturer's standard
Grounding metal barrier separation configuration	
Arc resistant	Yes (as option)
Low Voltage MCC (Motor Control Center Assemblies)	ANSI/NEMA
Grounding metal barrier separation configuration	
Additional Requirements	
Two sets of cables, signal converters, Microsoft Windows compatible software (if not Internet available), and any other equipment/software required for programming each type of relay, meter, overload, or other device furnished under this Contract shall be provided for interfacing with a personal computer USB port (computer furnished by others). The programming cables/converters/equipment/software shall be shipped with the first switchgear shipment to the site. A third set of programming software, if not available on the Internet, shall be shipped to the Owner for use in providing relay settings to the site.	

Low Voltage Circuit Breakers					
Item	**800 A ACB ANSI**	**1600 A ACB ANSI**	**2000 A ACB ANSI**	**3200 A ACB ANSI**	
Type					
800 A ACB ANSI	Draw-out air type with microprocessor based trip unit.				
1600 A ACB ANSI	Draw-out air type with microprocessor based trip unit.				
2000 A ACB ANSI	Draw-out air type with microprocessor based trip unit.				
3200 A ACB ANSI	Draw-out air type with microprocessor based trip unit.				
Rated continuous current	800 A	1,600 A	2,000 A	3,200 A	
Sensor rating (amps)	Later	Later	Later	Later	
(Sensor rating indicated as "Later" to be determined during detailed design)					
Rated voltage	480 V	480 V	480	480 V	
Operating mechanism					
800 A ACB ANSI	Electrically operated (EO)				
1600 A ACB ANSI	Electrically operated (EO)				
2000 A ACB ANSI	Electrically operated (EO)				
3200 A ACB ANSI	Electrically operated (EO)				
Breaker mounting	Draw-out	Draw-out	Draw-out	Draw-out	
Number of poles	3-pole	3-pole	3-pole	3-pole	
Interrupting rating, symmetrical (minimum)	65 kA rms	65 kA rms	65 kA rms	65 kA rms	
Short-time rating (minimum)	65 kA rms	65 kA rms	65 kA rms	65 kA rms	
Current-limiting fuse	No	No	No	No	
Control voltage					
Spring charging motor	125 VDC	125 VDC	125 VDC	125 VDC	
Close coil	125 VDC	125 VDC	125 VDC	125 VDC	
Trip coil	125 VDC	125 VDC	125 VDC	125 VDC	
Protection					
Long-time pickup	X	X	X	X	
Long-time delay	X	X	X	X	
Short-time pickup	X	X	X	X	
Short-time delay	X	X	X	X	
Instantaneous pickup	X				
Automatic trip alarm contact	X	X	X	X	

Low Voltage Circuit Breakers					
Item	**800 A ACB ANSI**	**1600 A ACB ANSI**	**2000 A ACB ANSI**	**3200 A ACB ANSI**	
Breaker display unit-trip	X	X	X	X	
Metering and display					
Breaker display unit-metering	X	X	X	X	
Phase currents	X	X	X	X	
Ground (Earth) fault current					
Line voltages				X	
Kilowatts				X	
Kilovars				X	
Power factor				X	
Additional requirements	Synch checking relays for tie breakers. Synch check relays shall be Basler.				
Reference Drawings					
Drawing Number	**Drawing Title**				**Revision**
	480V Metal Frame Swgr Motor Standard				

Molded Case Circuit Breakers	Additional molded circuit breaker sizes shall be added based on Contractor's final design. Features of molded case circuit breakers of additional sizes shall match requirements of MCCBs shown in this table.)				
Item	**225 A Frame ANSI**	**400 A Frame ANSI**	**600 A Frame ANSI**		
Standards for manufacturing and testing	ANSI/NEMA/UL				
Dual feed	No	No	No		
Continuous current rating at 40° C	225 amperes	400 amperes	600 amperes		
Rated voltage	480 VAC	480 VAC	480 VAC		
Breaker mounting	Fixed	Fixed	Fixed		
Number of poles	3-pole	3-pole	3-pole		
Interrupting rating at:					
480 VAC (minimum)	65 kA rms	65 kA rms	65 kA rms		
125 VDC (minimum)	10 kA	10 kA	10 kA		
Trip system type					
225 A Frame ANSI	Thermal and fixed magnetic trip				
400 A Frame ANSI	Thermal and adjustable magnetic trip				
600 A Frame ANSI	Thermal and adjustable magnetic trip				
Accessories					
Undervoltage trip, xxx volts dc					
Shunt trip, xxx volts dc					
Auxiliary switch					
Mechanical interlock		X	X		
Alarm switch					
Electric motor operator, xxx volts dc					
Plug-in mounting assembly					
Fungusproofing	X	X	X		
Additional Requirements					

MCC Starters					
Item	**NEMA FVNR**	**NEMA FVR**	**NEMA FV2S2W**		
Standards for manufacturing and testing	ANSI/NEMA/UL				

MCC Starters							
Item			**NEMA FVNR**	**NEMA FVR**	**NEMA FV2S2W**		
Starter type							
NEMA FVNR			Full voltage, nonreversing (FVNR)				
NEMA FVR			Full voltage, reversing (FVR)				
NEMA FV2S2W			Full voltage, two-speed, two-winding (FV 2S2W)				
Rated voltage			480 VAC	480 VAC	480 VAC		
Required sizes							
Size	**Tolerance**	**Mounting**					
NEMA 1	N/A	Drawout	X	X	X		
NEMA 2	N/A	Drawout	X	X			
NEMA 3	N/A	Drawout	X	X			
NEMA 4	N/A	Drawout	X	X			
NEMA 5	N/A	Drawout	X				
Starter options							
Control transformer			X	X	X		
CPT primary fuses			X	X	X		
CPT secondary fuses			X	X	X		
Push buttons - start/stop							
Timing relays					X		
Fixed control TB			X	X	X		
Selector switch				X	X		
Disconnecting device							
Adjustable instantaneous molded case circuit breaker			X	X	X		
Thermal magnetic molded case circuit breaker					Motor Starter bucket breakers shall be magnetic trip only. Provide thermal magnetic for panel breakers.		
Fused load break switch							
Interrupting rating, symmetrical (minimum)			65 kA rms	65 kA rms	65 kA rms		
Overload type							

MCC Starters					
Item	**NEMA FVNR**	**NEMA FVR**	**NEMA FV2S2W**		
Solid-state overload relay	X	X	X		
Manufacturer's standard					
Ground fault protection relay	No	No	No		
Additional Requirements					

Assembly Details				
Assembly ID Number				
Assembly name	480 V switchgear XX			
Location	Indoors (If mounted in Electrical Equipment Rooms)			
Equipment arrangement	Front and rear access			
Incoming power connections	Throat connected to 480 V Station Service Transformer			
Load feeder connections	Top			
Control cable connections	Top			
Degree of protection	ANSI/NEMA			
	NEMA 1 (Gasketed)			
External power sources by Owner	Power System			
	Description		**Code**	**Voltage**
Control power source			DC-1	125 VDC
Cubicle space heater power source			LV-1	120 VAC
Space heater power source			LV-1	120 VAC
Space heater rated voltage				120 V
Special wiring trough				
Automatic shutters	Yes			
Horizontal bus ampacity (minimum)	ANSI/NEMA			
	3200 A, or as contractor design requirements.			
Vertical bus ampacity (minimum)	As required			
Neutral bus ampacity (minimum)	N/A			
Bus bracing (short-time withstand) (symm, rms)	65 kA minimum			
Wiring method	NEMA Class 1, Type B			
Switching Devices	**Quantity**	**Spare Quantity**	**Equipped Space Quantity**	**Blank Space Quantity**
3200 A ACB ANSI	Determined by Contractor			
2000 A ACB ANSI	Determined by Contractor			
Switching Devices	**Quantity**	**Spare Quantity**	**Equipped Space Quantity**	**Blank Space Quantity**

1600 A ACB ANSI	Determined by Contractor			
800 A ACB ANSI	Determined by Contractor			

SECTION 16125
DRY TYPE GENERAL PURPOSE TRANSFORMER UP TO 112.5 KVA

16125.1 General

The dry type transformers up to 112.5 kVA described herein shall be furnished and installed under these specifications.

16125.2 Codes and Standards

Transformers shall be designed and fabricated in accordance with applicable ANSI, NEMA, and UL standards. Transformers shall bear the UL label.

All materials and devices shall be in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards."

16125.3 Description

In accordance with the Contractor's detailed design, dry type transformers suitable for indoor or outdoor mounting shall be furnished in the quantity, voltage, phase, kVA rating, tap rating, and method of mounting indicated herein.

All 3-phase transformers shall have three-winding primaries and three-winding secondaries with insulation class as shown in the following table. Three-phase transformers shall have 480 volt delta primaries with 480Y/277 volt or 208Y/120 volt secondaries.

Transformers shall be bonded to the ground ring at opposing corners of the equipment.

Transformers shall be Class AA.

Transformer enclosures shall be ventilated and rated for indoor or outdoor use as defined by the Contractor's detailed design.

Transformers shall have a minimum of four 2.5 percent taps, two full capacity above normal (FCAN) and two full-capacity below normal (FCBN). The Contractor shall specify and set all taps.

The Contractor shall provide standard ANSI impedance ranges of transformers being proposed.

K-rated transformers for nonlinear loads shall be as required by the Contractor's detailed design. At a minimum all UPS system transformers shall be K-rated.

Winding average temperature rise by resistance in degrees Celsius shall be in accordance with the following table:

Table 16125-1 Winding Average Temperature Rise by Resistance

Rated kVA	Degree Celsius Rise by Resistance		Insulation Class
	Single-Phase	3-Phase	
2	115	-	185C
3	115	-	185C
5	115	-	185C
7.5	115	-	185C
9	-	115	185C
10	115	115	185C
15	115	150	185C

Table 16125-1 Winding Average Temperature Rise by Resistance			
	Degree Celsius Rise by Resistance		Insulation Class
Rated kVA	Single-Phase	3-Phase	
30	-	150	220C
45	-	150	220C
75	-	150	220C
112.5	-	150	220C

Transformers shall have a sound level of 45 decibels or below when measured in accordance with NEMA standards. Transformers or transformer installations with sound levels in excess of 45 decibels shall be replaced or relocated as directed by the Owner.

Vibration isolating pads shall be provided at each transformer support point to reduce the transmission of sound resulting from transformer vibration. The pads shall be in accordance with the pad manufacturer's recommendations for the appropriate transformer weight.

Wall hanger brackets especially designed to accommodate the transformers shall be furnished with all wall mounted transformers.

Transformers shall be thoroughly cleaned, then given a rust resisting primer coat and two or more finish coats of enamel. Transformers which are to be mounted outdoors shall be finished with ANSI 24 dark gray outdoor enamel. Transformers which are to be mounted indoors shall be finished with ANSI 61 light gray indoor enamel.

16125.3.1 Nameplates

An engraved nameplate shall be furnished for each transformer in accordance with Section 17302 - Phenolic Nameplates. The transformer nameplates shall be as listed in the Contractor's detailed design drawings. Nameplate inscription shall consist of the "Abbreviated Description" with the "Contractor's ID Number" inscribed below the abbreviated description.

16125.4 Manufacturers

The transformers shall be by Ameren Missouri Approved Suppliers.

16125.5 Not Used

16125.6 Installation

Transformers shall be installed in accordance with the requirements of NEC and as indicated on the Contractor's detailed design drawings.

Installation of the transformers shall include accurately aligning and leveling the transformer.

SECTION 16153
STATION SERVICE TRANSFORMERS

16153.1 General

16153.1.1 Scope of Supply
Scope of supply shall include furnishing the Station Service Transformers (SSTs) as specified herein and on the Station Service Transformers Specification Sheets included at the end of this section.

16153.1.2 Not Used

16153.1.3 Performance and Design Requirements
Performance and design requirements for the station service transformers are indicated on the Station Service Transformers Specification Sheets (included at the end of this section).

16153.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16153-1 Codes and Standards

Work	In Accordance With
Transformer	ANSI C57

16153.1.5 Not Used

16153.1.6 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.

Table 16153-2 Approved Manufacturers

Component	Manufacturer
	In accordance with Ameren Missouri Approved Suppliers

16153.1.7 Test Requirements
Factory testing shall be conducted in accordance with the standards specified in Article 16153.1.4. This testing is to be considered part of the defined Scope of Work. The Owner and/or Owner’s representatives shall be given the opportunity to attend all transformer FAT’s. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16153-3 Test Requirements

Tests	In Accordance With	Conducted By
Factory testing	Latest revision of the applicable ANSI C57	Manufacturer

16153.1.8 Not Used

16153.1.9 Not Used

16153.2 Products

Station service transformers for the 34.5 kV medium voltage switchgear and for the 480V low voltage switchgear shall be furnished as specified on Station Service Transformers Specification Sheets. Each transformer shall be suitable for continuous operation at 100 percent of nameplate rating, with normal life expectancy, based on the specified ambient conditions.

Refer to the Station Service Transformers Specification Sheets for the type of design and construction. Furthermore, the data sheets will specify whether the dry type transformer is to be conventional or cast coil. The Contractor may propose alternate designs for consideration, provided that the base bid is met first.

16153.2.1 Not Used

16153.2.2 Dry Type Transformers

The insulating materials used shall be suitable for operation at a temperature of 428° F with a temperature rise limited to 266° F for conventional dry type transformers. Cast coil epoxy insulated transformers with an operating temperature of 365° F shall have a temperature rise limited to 212° F. Cast coil epoxy insulated transformers designed for an operating temperature of 311° F shall be limited to 176° F rise regardless of the allowable rise shown on the Station Service Transformers Specification Sheets.

16153.2.2.1 Conventional Dry Type. The windings shall be sealed and protected using a Vacuum Pressure Impregnation (VPI) or encapsulation process. The preheated windings shall be subjected to a dry vacuum cycle, followed by a wet vacuum cycle during which time the windings will be impregnated with an electrical grade varnish resin, polyester resin, or silicone resin. A pressure cycle shall then force the resin throughout the insulation. The windings shall then be cured to bind the resin to the insulation material, while eliminating voids which could create hot spots, partial discharge, or cause corona formation. This process shall completely seal and protect the windings from moisture, dust, dirt, salt air, and other industrial contaminants.

16153.2.2.2 Cast Coil Type. The high voltage windings shall be cast in a mold using fiberglass reinforced epoxy materials. The coil/mold assembly shall be filled with the epoxy formulation under vacuum. Then, using overpressure, the epoxy shall be forced into all voids and cured. The final product shall be a void free winding design, hermetically sealed, with smooth external surfaces and optimum dielectric, mechanical, and thermal strength. The insulation system shall be non-explosive, nonflammable, and self-extinguishing. A partial discharge test shall be performed to assure void free construction.

16153.2.3 Mechanical Construction

16153.2.3.1 Not Used.

16153.2.3.2 Dry Type Transformers. All transformer enclosures, incoming sections, and outgoing sections shall have completely enclosed sheet metal bottoms. All side panels shall be removable. The ventilated enclosure shall be of heavy gauge sheet steel and shall be suitable for outdoor or indoor operation, as specified on the Station Service Transformers Specification Sheets.

Each transformer enclosure shall be gasketed and shall be provided with tops and shields required to prevent falling or dripping water from entering the enclosure. Each transformer enclosure, both interior and exterior, shall be thoroughly cleaned, then given rust resisting primer coat and two or more finish coats of enamel. The Proposal shall include a complete description of the paint system.

External lifting eyes, or other means acceptable to the Owner for handling of the complete transformer assembly, shall be furnished as part of each enclosure framework so that during movement of the unit its core and coils remain completely protected from damage or shifting. External lifting eyes shall be certified and shall be stamped for the lifting rating of the eye. The unit(s) shall also be constructed and supported such that movement in any direction on rollers will not damage or permanently distort the enclosure, frame, or internal apparatus.

If ladders are provided to access the top of the transformers, self-closing swing gates shall be used instead of chains and clips at all personnel access openings.

Nonslip "Mebac" ladder rung covers shall be used on all fixed access ladders.

Fall protection tie-offs shall be provided at the top of the transformer.

Provide a copper ground bus connecting each surge arrestor, neutral bushing, and transformer ground pad located at base level.

16153.2.4 Core and Coils

The core and coil assembly shall be adequately braced to withstand short-circuit forces without damage or displacement, limited only by the transformer impedance. It shall also withstand normal moving and handling without the use of special shipping braces. Verification that short-circuit withstand tests have been performed on a prototype or identical transformer design shall be submitted. All winding conductors, including all connections to tap changers and bushings shall be copper.

For dry type transformers, the core and coil assembly shall rest on vibration dampers designed to isolate core vibration from the enclosure.

The core shall be constructed of high grade grain oriented silicon steel. It shall be securely grounded to the frame. Magnetic flux densities shall be kept well below the saturation point.

Impedance shall be specified by the Contractor based on system design taking into consideration the following (minimum) requirements: short circuit, load flow voltage support, motor starting.

The basic impulse insulation level shall be inherent to the design and is to be obtained without the use of supplemental surge arresters.

Impedance shall be specified by the Contractor and shall be within ANSI tolerances (7.5 percent of base value).

16153.2.5 De-Energized Taps

Unless otherwise specified on the Station Service Transformers Specification Sheets, the high voltage winding shall have four approximately 2-1/2 percent rated full-capacity, de-energized taps, two above and two below rated primary voltage. The tap connections shall be bolted, flexible jumper, or rigid bar type, easily accessible by removal of one of the enclosure side panels. The tap position indicator and terminal markings shall be clearly visible and identical with those used on the transformer nameplate. The Contractor shall specify and set taps as part of the design scope based on power system analysis results.

16153.2.6 Forced Cooling

If a forced cooled rating is specified on the Station Service Transformers Specification Sheets, the transformer shall be furnished with a complete forced air-cooling system, including cooling fans, fan support brackets, winding temperature controls, fan power supply transformers, circuit protective devices, wiring, terminal blocks, and control panel. The fan power supply transformers shall be factory wired to the low voltage side of the unit substation transformer. All current carrying parts shall be sized for the maximum FA rating. Manual control switches shall be made available to allow for testing and maintenance of cooling fan groups. Make provisions for de-energizing cooling units on operation of remote protective relaying.

If a forced cooled rating is not specified on the Station Service Transformers Specification Sheets, the transformer shall be furnished with all the components above that must be installed at the time of manufacture. Adding the remaining components at a later date shall be easily accomplished. The only work necessary for future addition of forced air-cooling shall be to mount the fans on existing brackets and connect the motor leads to existing terminal blocks. All current carrying parts shall be sized for the maximum future FA rating.

A spare/back-up installed fan shall be provided on all units with forced cooling. The spare fan shall be designed to automatically turn on should the primary fan fail.

Provide filters for all cooling air openings of enclosures.

If a control panel is provided, it shall meet the requirements set forth in other sections of this specification. All devices shall be wired to terminal blocks for field connections, per requirements in this spec.

16153.2.7 Accessories

Each dry type transformer shall be furnished with the manufacturer's standard accessories, including the following:

Two grounding pads.

Stainless steel diagrammatic nameplate.

Provisions for lifting and jacking.

Digital winding temperature indicator.

Refer to Ameren Missouri Approved Suppliers for the temperature monitoring and control unit, including DCS points (installed back to DCS by Contractor) for temperature, fan status, and alarms for over-temp and fan trouble.

All alarm contacts shall be wired to clearly labeled terminal points in the control compartment.

All accessories shall be clearly identified and described in the Proposal.

16153.2.8 Termination Compartments

Each transformer shall include high voltage (HV) and low voltage (LV) termination compartments in accordance with the following paragraphs.

16153.2.8.1 HV Compartments. HV termination compartments shall be metal-enclosed, air-insulated terminal chambers with gasketed and bolted covers. The compartments shall be large enough to accommodate working space for field installation of stress cones on HV cables that are shielded and to house other accessories specified, such as surge arresters. Enclosures shall be fabricated of electrogalvanized sheet steel or aluminum and painted in accordance with these specifications.

Indoor enclosures shall be dust-tight and impervious to dripping or falling water. Hardware shall be stainless steel or cadmium plated steel.

All exterior hardware for units located outdoors shall be stainless steel.

16153.2.8.2 LV Compartments. LV termination compartments shall be of the type specified on the Station Service Transformers Specification Sheets and in accordance with the following paragraphs.

The compartments shall be metal-enclosed, air-insulated terminal chambers with gasketed and bolted covers. Enclosures shall be fabricated of electrogalvanized sheet steel or aluminum and painted in accordance with these specifications.

Indoor enclosures shall be dust-tight and impervious to dripping or falling water. Hardware shall be stainless steel or cadmium plated steel.

All exterior hardware for units located outdoors shall be stainless steel. Transformers shall not be located directly outdoors. Transformers shall have a weatherproof, dustproof, enclosure.

Terminal compartments that are specified to be "throat" connected to LV equipment shall be designed to connect directly to the specified equipment to form a complete assembly. All required hardware, bus splice plates, flexible connectors, etc., shall be provided.

Terminal compartments that are specified to be connected to LV bus duct shall be designed to connect directly to the specified bus duct to form a complete assembly. All required flanges, gaskets, hardware, bus splice plates, flexible connectors, etc., shall be provided.

Terminal compartments that are specified to be connected to LV cables shall be designed to accommodate field installation of the size and number of cables specified from the direction indicated on the Station Service Transformers Specification Sheets.

16153.2.9 Resistance Grounding Equipment

When specified on the Station Service Transformers Specification Sheets, each transformer shall be supplied with resistance grounding equipment, in accordance with the following paragraphs.

16153.2.9.1 Not Used.

16153.2.10 Factory Testing

Each transformer shall be completely assembled and tested at the factory in accordance with applicable standards (ANSI) and the manufacturer's standard practices, using materials and equipment that will be a part of the final assembled unit and receive the routine and design tests as dictated by the latest revision of the applicable standard. Certified test reports shall be supplied, summarizing the results of all tests. In particular, the calculated hottest spot temperature rises of the primary and secondary windings shall be shown.

Hottest spot temperature rises shall conform to the appropriate standard, and shall be calculated using mathematical models verified by thermal tests on test windings and/or a prototype transformer representative of the design family. Tests shall have been conducted at conditions of full load or conditions simulating full load. Complete data shall be available for Owner's review.

The Owner reserves the right to witness factory testing and shall be informed in writing at least 30 days prior to the scheduled starting date of tests so that arrangements can be made for a representative to be present.

Minimum testing shall be required for the following:

Impulse testing.

Temperature rise test.

Sound level test.

Ratio test.

No-load losses and current.

Impedance voltage, short circuit impedance, and load losses.

Partial discharge.

Insulation resistance and power factor.

Functional check of control cabinet and all controls, indications, instrument, and alarms.

Provide and install secondary CTs for neutral grounding relaying.

Shop Drawings shall include the following:

Electrical Characteristics.

Specified ratings.

Connection requirements.

Outline drawing with dimensions.

Weight.

Center of gravity.

Connection and support points.

Bill of Materials.

Nameplate drawing.

Wiring diagrams.

Schematic diagrams.

Ratio correction factor curves with B-2 burden and secondary current from .25 to 22 times normal secondary current for each type of current transformer furnished.

Excitation curve for each type and ratio current transformer furnished.

Station Service Transformers Specification Sheet

Station Service Transformers		
These specification sheets are applicable to the following transformers:		
Transformer Name	**ID Number**	
Station Service Transformers		
Standard for manufacturing and testing	ANSI C57	
Transformer type	Dry Type	
Cooling class	AA/FA	
Self-cooled rating capacity, kVA	To be determined by the Contractor	
Force-cooled rating capacity, kVA	To be determined by the Contractor	
Frequency, Hz	60	
Number of phases	3	
Average winding rise, °C	80	
Vector relationship	Dyn1	
Impedance, percent Z at self-cooled rating	Manufacturer's standard	
	Primary	**Secondary**
Voltage ratings, volts	34,500	TBD# and 480
Insulation BIL, kV	*	*
HV de-energized taps	±2 x 2.5 percent	

Winding connections		Delta	Wye-grounded
Termination compartments		Cables or bus	Throat
Grounding			
Grounding type		Solidly Grounded for 480V	
Items marked with (*) shall be determined by Contractor during detailed design. Items marked with (#) shall be determined by output of DC-AC inverter.			

SECTION 16201
PROTECTIVE RELAYING PANELS

16201.1 General

16201.1.1 Scope of Supply
Scope of supply shall include furnishing the protective relaying panels as specified herein and on the Protective Relaying Panels Specification Sheet included at the end of this section.

16201.1.2 Not Used

16201.1.3 Performance and Design Requirements
Performance and design requirements for the protective relaying panels are indicated on the Specification Sheet included at the end of this section.

16201.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16201-1 Codes and Standards

Work	In Accordance With
Protective relaying panels	The applicable ANSI, NEMA, and UL standards

16201.1.5 Approved Manufacturers
For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications.

Table 16201-2 Materials

Component	Manufacturer
Protective Relaying Panels	Ameren Missouri Approved Suppliers

16201.1.6 Not Used

16201.1.7 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.

The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16201-3 Test Requirements

Tests	In Accordance With	Conducted By
Production test	NEMA, IEEE, UL	Contractor
Type test/Functional test	Contractor standard	Contractor

Table 16201-3 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Point-to-point wiring checking	Contractor standard	Contractor

16201.1.8 Not Used

16201.1.9 Not Used

16201.2 Products

16201.2.1 General
This section covers the furnishing of protective relaying panels as specified herein and on the drawings.

16201.2.2 Arrangement
Protective relaying panels shall be arranged in accordance with the arrangement drawing(s) included with these specifications and as specified herein.

16201.2.3 Vertical Panel Structures
The vertical panel structure shall be an assembly of standard fixed vertical panels. Panels shall be fabricated from not less than 11 USS gauge leveled steel sheets and reinforced as required to form a rigid structure.

An open vertical panel will be supported by wall braces. An enclosed vertical switchboard shall have an overall sheet metal enclosure (not grille) covering the back, top, and ends of the entire assembly. Access to the interior of the enclosure shall be provided by doors or by removable covers.

Each panel shall be formed with edges bent back and joints welded and ground smooth and shall be designed to be readily removable from the structure without disturbing the remaining panel assembly or existing control or cross panel wiring. Finished panel surfaces shall be free of waves, bellies, and other imperfections. Exterior panel surfaces shall be sandblasted, ground smooth, filled, primed, and enamel finished.

Instruments, meters, lockout relays, and protective relays shall be mounted on the front of the panels. Panel cutouts, mounting studs, and support brackets shall be accurately located as indicated on the drawings.

Mounting brackets, as required, shall be arranged for mounting and wiring auxiliary equipment and devices and terminal blocks. Where required, brackets shall be hinged and located to allow access to the back of the equipment mounted on the front of the panels.

Panel space not used by equipment shall remain clear for the addition of possible future equipment.

Blank panels shall be provided with standard wiring gutters for future wiring.

The interior of each panel shall be illuminated with a light, mounted inside the top of the panels and controlled from a switch mounted inside the door.

Wiring for lights and receptacles shall be run to one common 15 ampere fuse or circuit breaker for the voltage specified on the Specification Sheets, Performance and Design Requirements, as an external connection.

16201.2.4 Not Used

16201.2.5 Not Used

16201.2.6 Nameplates
Engraved nameplates shall be furnished per Section 17302-Phenolid Nameplates. Inscriptions on these tags shall coincide with those used on the drawings and shall be approved by the Owner. Nameplates shall be furnished on the front of the panel and on the inside of the panel next to each relay or component. The nameplates shall be located such that they are easily readable after the wiring installation is complete and shall be acceptable to the Owner.

16201.2.7 Wiring and Wiring Diagrams
The Contractor shall provide internal panel wiring, connections, and diagrams in accordance with the following requirements.

16201.2.7.1 Panel Wiring. All wiring used within the panel shall be installed and tested at the factory.

All wiring shall be neatly and carefully installed in wiring gutters or raceway

16201.2.7.2 Diagrams. The Contractor's wiring diagrams shall be in accordance with the requirements specified herein. One-Line, three-line, panel schematic, complete connection, and interconnection wiring diagrams shall be furnished by the Contractor.

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

The complete interconnection and connection wiring diagrams of each panel 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 panel. Elementary diagrams of control and instrument circuits, contact arrangement of switches, and internal wiring of relays and instruments for each panel shall be on additional sheets as required. Interconnection diagrams shall be on separate sheets. All sheets shall be the same size.

16201.2.7.3 Terminal Blocks. Furnish and install 20 percent spare control terminal blocks in each panel. In addition, one lot of terminal blocks (with 20 percent spares) shall be provided for the current transformers, potential transformers, and analog wiring interface circuits as shown on the one-line diagrams included with these specifications.

16201.2.8 Buses
Control, potential, and alarm buses of 10 AWG or larger panel wire shall be furnished and installed as required.

A continuous 1/4 inch by 1 inch cross-section bare copper ground bus, with copper/bronze compression or clamp type connectors at each end, shall be provided in the panel. All panel equipment requiring grounding shall be connected to this ground bus with copper/bronze compression or clamp type connectors.

16201.2.9 Power Supply Disconnects
Each panel mounted device requiring ac or dc supply shall have in its supply circuit a panel mounted fuse to allow isolation of the device from the power supply.

When required by the Contractor's design, power supplies for special devices shall be wired to a separate supply circuit for connection to the Owner's preferred ac power supply. Isolation fuses shall be furnished for each power supply.

16201.2.10 Relays, Meters, Controls, and Instruments
Meters, relays, instruments, and controls shall be installed and wired on the front panels with the exception of auxiliary relays, transducers, and instrument transformers that may be mounted inside of the panel or on sub-panels. Unless otherwise noted, instruments and meters including transducers shall be suitable for operation from instrument transformers with nominal 5 ampere and 120 volt secondary. Scale ranges and dial constants shall be provided to match the primary current and voltage ratings.

16201.2.10.1 Indicating Lights. Indicating lights shall be light-emitting diode (LED) type sized for the supply voltage. The Contractor shall furnish indicating lights as noted per Ameren Missouri Approved Suppliers or an Owner-approved equal. Lamps and lenses shall be replaceable from the front of the panel. Shields shall be provided to prevent short circuits. Indicating lights in outdoor panels shall be weatherproof. Resistor type lights shall be used when lights are in trip circuits (for breakers, contactors, lockout relays, etc).

16201.2.10.2 Potential Transformer Circuit Fuses. Each potential transformer (PT) circuit entering the panel shall be provided with incoming fuses provided by the Contractor. Typically PTs are fused at 30A. Each device connected to the PT circuit shall be fused separately. Typically each device is fused at 3A.

16201.2.11 Raceway
An adequate raceway system shall be provided for all wiring on each side of each panel and between panels. The horizontal raceway for interpanel wiring shall be furnished complete as specified herein.

A complete system of separate vertical wiring raceways shall be provided for all factory and field wiring. This shall include vertical raceways along both sides of each panel.

The raceways for factory wiring shall be sized so that fill does not exceed 30 percent. Vertical raceways for field wiring shall be twice as large as those provided for factory wiring or shall have a minimum cross-sectional area of 20 in^2, whichever is larger.

Vertical raceways for field wiring shall be so constructed as to be accessible to conductors entering from the bottom or the top of the panel.

Wiring raceways shall be plastic wiring duct with covers. Wiring raceways shall meet the testing requirements shown in Article 16201.1.7, Test Requirements.

The manufacturer's standard raceway may be considered, provided the Proposal includes sufficient information to evaluate the raceway system offered.

16201.2.12 Space Heater
A thermostatically controlled space heater shall be furnished and installed in the panel. Space heaters shall be controlled by an adjustable thermostat or fixed humidistat.

16201.2.13 Receptacles
Receptacles shall be furnished, mounted, and wired in a convenient location at each end of the panel. The receptacles for portable tools and droplights will be supplied from a single-phase ac source furnished by the Contractor.

16201.2.14 Factory Tests
After the panel has been fabricated and all parts assembled, the complete gear, including instruments and devices, shall be factory tested. Factory tests shall include the following:

Tests that verify correct assembly and operation.

High potential tests.

Applicable standard tests.

16201.2.15 Type Tests and Certification
The Contractor shall perform the type tests for major components if specified in Article 16201.1.7, Test Requirements, and will be in accordance with all the applicable standards.

Type test certificates from identified components are acceptable in lieu of the individual type test. Type test certificates shall be made available to the Owner at no extra charge upon request.

16201.2.16 Special Shipping Requirements
The equipment shall be shipped by air cushioned van.

Protective Relaying Panels Specification Sheet

General Requirements			
Standards for manufacturing and testing	ANSI/NEMA		
Item			
Description			
Location	Indoor		
Panel type	Enclosed vertical		
Enclosure type	NEMA 12, or per the environment installed		
Power supply			
Circuit Description	**Code**	**Voltage**	**Entry**
Two 2 wire circuit for DC power to relays One single-phase 1 wire/ground circuit for receptacles and space heaters.	LV-3 or DC-1	120 VAC or 125 VDC as determined by the Contractor	Top
Space heater	Yes		
Receptacles	Yes-1 per panel		
Wiring Method			
For terminal blocks interfacing with the Owner's field cabling, one side of the terminal block shall be used by the equipment manufacturer for factory wiring and the other side of the terminal block shall be reserved for the Owner's field cabling terminations.			
Additional requirements			
Accessories			
The panels shall be furnished with the following maintenance and operating equipment:			
Quantity	**Unit**	**Item**	
1	Lot	100 percent replacement of fuses	
1	Each	Lockout relay coil spare	

SECTION 16210
SOLAR INVERTER EQUIPMENT

16210.1 General

16210.1.1 Scope of Supply

Scope of supply shall include furnishing and installation of the solar inverter equipment as specified herein to be connected to photovoltaic panels as described in Section 16240.

16210.1.2 Not Used

16210.1.3 Performance and Design Requirements

Performance and design requirements for the material and components to be furnished under these specifications are indicated herein and on the Specification Sheets included at the end of this section.

16210.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16210-1 Codes and Standards	
Work	**In Accordance With**
Power Conversion Equipment	UL508C
IEEE Harmonic Control in Electrical Power Systems	IEEE519
Enclosures for Electrical Equipment	UL50E
Seismic Zones	IBC
Ground Fault Indicator	UL1741
Surge Location Categories	IEEE C62.41.2
Interconnecting Distributed Resources with Electric Power Systems	UL1547

16210.1.4 Testing Requirements

Table 16210-2 Codes and Standards	
Work	**In Accordance With**
Surge Testing for Low Voltage AC Circuits	IEEE C62.45-2002
Surge Withstand Capability Tests	IEEE C37.90.1
With exception of anti-islanding and grid disturbance behavior.	IEEE 1547

16210.1.5 Technical Details

Solar inverters shall be sized to the full continuous capacity of the PV array and at maximum peak output and based on the panel manufacturer's information on Solar Ckt. Preliminary sketch provided. String voltage shall not exceed 1000V DC.

Solar inverters shall be supplied in a weather-proof enclosure with a hinged door and seamless door gaskets. NEMA 12 enclosure shall be required for option where inverters are supplied in a temperature controlled building.

Enclosure must have a door interlock system to prohibit the doors from being opened while energized.

Inverters shall incorporate a no-load, two (2)-pole, lockable disconnect switch for main DC power disconnect for maintenance personnel safety.

Equipment enclosure shall have a suitable means for dissipation of heat suitable to the environment where located.

Inverter output shall be protected by a circuit breaker with short and long time adjustable over current protection. This circuit breaker shall be locally and remotely operated from the PLC.

Inverters shall employ a maximum power point tracking scheme to optimize inverter efficiency over the entire range of photovoltaic panel output for the given Site design conditions.

Inverters shall be equipped with all hardware for data collection and communication to the central PLC server. Data collection points integrated into the inverter monitoring and communications package.

Inverters shall be equipped with multiple fused, disconnectable, DC inputs with built in current and fault monitoring for input to the PLC system.

Inverter shall have integral protection devices and standard alarms for trouble in the form of dry contacts, local indication, and communications including volts, amps, etc…

Inverters shall have all the necessary equipment to monitor and communicate loss of a PV array. It shall have the option to monitor combiner zone current.

Local indication and remote indication of status, communications, and metering shall be included. Remote indication involves Modbus/TCP monitoring and a conduit to transferring those signals to PLC for distribution through Ameren Missouri.

Surge protection withstand shall be included for equipment protection from over-voltage caused by lightning strikes or other conditions.

Inverters shall include flicker mitigations.

A 480VAC output breaker shall be provided for local disconnecting means to completely disconnect AC power from the inverter for protection. The breaker symmetrical short circuit current fault analysis shall be used to determine requirements.

Multiple inverter devices if connected in parallel shall be rated for such as well as balanced load sharing.

Inverter shall have space heaters controlled by a thermostat for condensate control.

Receptacles shall be provided in the inverter compartment for maintenance and the source shall be provide from an alternative source other than the control power for the inverter.

Inverter shall have redundant relay protection utilizing **Schweitzer** (SEL) relays to trip the output breaker of the inverter.

Inverters shall have 10% spare terminal blocks for interconnect wiring.

Inverter displays shall face north and be protected from the sun.

Engraved nameplates shall be furnished for the front and rear of each inverter and for equipment and devices within each inverter. Inverter equipment and devices shall be identified on 3" plastic laminate engraved nameplates with white background with black lettering. Nameplate inscriptions will be furnished by the Company. Name plates shall be mechanically fastened to equipment.

16210.1.6 Design Basis Details

DESCRIPTION	PARAMETER
Environmental:	
Location	Outdoor 3R
Ambient Temperature	0° C - 50° C
Altitude	441ft (0 – 3300ft)
Cooling	TBD by Vendor
Humidity	0-95% Non-Condensing
Noise Level	<85dB
Mechanical:	
Mounting	Floor Mount
Enclosure Type	NEMA 4
Finish	Galvanized Steel
Electrical:	
Rated Input DC Voltage	1000VDC, Single Phase
Voltage Ripple	< 3%
Protected DC inputs	Yes
Nominal AC Output Voltage	480VAC, 3 Phase
Nominal Output Frequency	60Hz
Minimum Power Factor @ Full Load	0.99
Minimum Efficiency @ Full Load	96%
Power Factor Compensation	Yes
AC Output Grounding Switch	Yes
Cabinet Heating	Yes
Remote Connection Type	Ethernet (Modbus over TCP)
Grid Support & Compliance	
Reactive power compensation	Yes
Power reduction	Yes
Low voltage ride through	Yes
Grid Tie Capabilities	Yes
Protection	
AC Short Circuit and Over-current Protection	Yes
DC Short Circuit and Over-current Protection	Yes
AC Overvoltage and Temperature Protection	Yes
DC Overvoltage and Temperature Protection	Yes
DC reverse polarity	Yes
Grid Monitoring	Yes
Ground Fault Monitoring	Yes

SECTION 16220
PHOTOVOLTAIC STRING COMBINER BOXES

16220.1 General

16220.1.1 Scope of Supply

Scope of supply shall include furnishing and installation of the solar inverter equipment as specified herein to be connected to photovoltaic panels as described in Section 16240.

16220.1.2 Not Used

16220.1.3 Performance and Design Requirements

Performance and design requirements for the material and components to be furnished under these specifications are indicated herein and on the Specification Sheets included at the end of this section.

16220.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16220-1 Codes and Standards

Work	**In Accordance With**
Standard for Distributed Generation	UL1741
National Electric Code	Article 690

16220.1.4 Not Used

16220.1.5 Technical Details

PV string combiner boxes shall be supplied in a weather-proof NEMA 4X enclosures with a hinged door and seamless door gaskets. The door tops shall have a viewing window over the fuse blown indication so that the operator does not have to open door to check for blown fuses.

Equipment enclosure shall have a suitable means for dissipation of heat suitable to the environment where located.

Each series string of PV modules shall be independently protected by an isolation fuse before it is connected in parallel with the other string on that PV output circuit.

The isolation fuse or breaker shall be less than the de-rated ampacity of the wiring that it is protecting and greater than 1.56 times the short circuit current rating of the PV modules in that PV source circuit. All other conductors and overcurrent devices shall be sized per the requirements of National Electric Code (NEC) Article 690. Contractor shall supply PV string combiner boxes with the appropriate sized and rated PV fuses and number of input circuits based on the panel manufacturer’s information on Solar Ckt. Preliminary sketch provided.

PV fuses shall be installed in finger-safe fuse holders in the PV string combiner box. The fuse holder shall have a blown indicator.

Surge protection withstand shall be included for equipment protection from over-voltage caused by lightning strikes or other conditions.

Power Distribution blocks shall be finger-safe and installed in the PV string combiner box.

PV string combiner boxes shall have an integrated disconnect switch for Company lockout/tagout compliance. Disconnect shall be load break DC rated operated on the outside of the box.

Combiner boxes shall have power distribution blocks rated for the voltage and current for the application. Finger safe covers shall be applied were applicable.

PV combiner boxes shall have negative input and ground terminal blocks.

Combiner box shall withstand rating short circuit rating of 10kA @ 1000 Volts DC rated.

Engraved nameplates shall be furnished for the front of each PV string combiner box and for equipment and devices within each PV string combiner box. PV string combiner box equipment and devices shall be identified on plastic laminate engraved nameplates with white background with black lettering. Nameplate inscriptions will be furnished by the Company. Name plates shall be mechanically fastened to equipment.

16220.1.6 Not Used

SECTION 16230
PHOTOVOLTAIC ARRAY DISCONNECT

16230.1 General

16230.1.1 Scope of Supply

Scope of supply shall include furnishing and installation of the solar inverter equipment as specified herein to be connected to combiner boxes as described in Section 16220.

16230.1.2 Not Used

16230.1.3 Performance and Design Requirements

Performance and design requirements for the material and components to be furnished under these specifications are indicated herein and on the Specification Sheets included at the end of this section.

16230.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16230-1 Codes and Standards

Work	In Accordance With
Standard for Distributed Generation	UL1741

16230.1.4 Not Used

16230.1.5 Technical Details

An appropriate amount of array disconnect shall be supplied for each inverter.

Array disconnects shall be supplied in a weather-proof NEMA 4X enclosures with a hinged door and seamless door gaskets.

Equipment enclosure shall have a suitable means for dissipation of heat suitable to the environment where located.

Contractor shall supply array disconnect with the number of input circuits based on the panel manufacturer’s information on Solar Ckt. Preliminary sketch provided.

Array disconnect configuration shall be designed with string isolation capability to allow for individual string maintenance without need to de-energize the inverter. Finger safe covers shall be applied were applicable.

Array disconnects shall have an integrated disconnect switch for Company lockout/tagout compliance. Disconnect shall be load break DC rated and operated outside the box.

Array disconnect shall have power distribution blocks rated for the voltage and current for the application. Finger safe covers shall be applied were applicable.

Engraved nameplates shall be furnished for the front of each array disconnect and for equipment and devices within each array disconnect. Array disconnect equipment and devices shall be identified on plastic laminate engraved nameplates with white background with black lettering. Nameplates shall be mechanically fastened to equipment.

SECTION 16240
PHOTOVOLTAIC PANELS

16240.1 General

16240.1.1 Scope of Supply

Scope of supply shall include furnishing and installation of the photovoltaic panels specified herein to be installed on a racking system described in Section 05900.

16240.1.2 Not Used

16240.1.3 Performance and Design Requirements

Performance and design requirements for the material and components to be furnished under these specifications are indicated herein and on the Specification Sheets included at the end of this section.

16240.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16240-1 Codes and Standards	
Work	**In Accordance With**
Crystalline Silicon Terrestrial PV Modules	IEC61215
Photovoltaic Module Safety Qualification	IEC61730

16240.1.4 Testing Requirements

Table 16240-2 Codes and Standards	
Work	**In Accordance With**
Temperature Testing and analysis of PV Modules	UL1703
Recommended Practice for Qualification of PV Modules	IEEE1262
Crystalline silicon photovoltaic (PV) array - On-site measurement of I-V characteristics	IEC 61829

16240.1.5 Technical Details

Panels shall be rated 300 watts or higher.

Cell type shall be polycrystalline. No thin film photovoltaic panel will be accepted.

Module wiring shall be a minimum of #12 AWG type stranded copper with 1000 volt 90 degree C insulation. Locking MC4 connectors or Company Approved equivalent shall be installed on the panel wiring and mating connectors provided. The connectors shall comply with UL 498 and 1977. Grounding terminals shall be provided for customer's ground wire.

The panels shall have a linear performance warranty period of no less than 20 years. In addition the PV Panel shall not exhibit power output less than 90% of peak power after 10 years as specified on the data sheet and 80% of peak power after 20 years as specified on the data sheet.

The panels shall have a limited product warranty period of no less than 10 years.

Modules shall have a class C fire rating.

Modules shall have a junction box that complies with IP65.

Modules shall be free of defects between panel and glass, failure of materials, cracking of glass due to foreign objects inside the glass will not be accepted.

16240.1.5 Not Used

SECTION 16410
JUNCTION BOXES

16410.1 General
The junction boxes described herein shall be furnished and installed under these specifications.

16410.1.2 Not Used

16410.2 Description
The junction boxes shall be provided as required by the Contractor.

16410.2.1 Nameplates
Each junction box shall be identified with an engraved nameplate at the top of the front cover. Each nameplate shall be engraved with the junction box identification as determined by the Contractor. Nameplates shall be in accordance with Section 17302 - Phenolic Nameplates.

16410.3 Construction
NEMA type, size, identification, and additional devices, if required, shall be provided as required by the Contractor's design.

Terminal blocks mounted in junction boxes shall be mounted on a sheet steel mounting backplate. The mounting plate shall be finished with gloss white enamel or a white epoxy coating. Terminal blocks and other devices, if required, shall be mounted by screws with drilled and tapped mounting holes. Mounting of the backplate within the junction box shall be by nuts on a welded stud. No mounting holes may penetrate the outside surface of the box. Wiring, if required, shall be as specified in Section 16510 - Conductors and Accessories.

16410.4 Manufacturers
Junction boxes and enclosures shall be manufactured Ameren Missouri Approved Suppliers.

SECTION 16430
1000V DISCONNECT SWITCHES

16430.1 General

The disconnect switches described herein shall be furnished and installed under these specifications.

16430.1.2 Not Used

16430.2 Codes and Standards

All equipment provided under these specifications shall conform to the applicable standards of ANSI, NEMA, UL, and IEEE and shall be in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards."

The switches shall be designed and fabricated in accordance with the requirements of NEMA KS 1 for heavy-duty (Type HD) enclosed switches.

16430.3 Description

The disconnect switches shall be nonfused or of the fused heavy-duty type, single-throw, rated 1000 volts ac. The switches shall be safety type with quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Watertight hubs shall be provided for all NEMA 4 and 4X enclosures.

All power isolators shall have flange mounted disconnect switches.

Disconnect switches shall be furnished in the quantities, enclosure type, with voltage ratings, ampere ratings, short-circuit interrupting rating, number of poles, and fusible or nonfusible, as determined by the Contractor. The fusible disconnect switches shall be furnished with one set of fuses installed in each switch. Fuses shall be Bussmann Type FRS-R or acceptable equal, as referenced on the Approved Suppliers List.

Unless specified otherwise, each switch shall be mounted in a sheet steel enclosure. Each switch enclosure shall be finish painted.

An engraved nameplate shall be furnished mounted on the front of each switch enclosure in accordance with Section 17302-Phenolic Nameplates. The disconnect switch nameplates shall be as determined by the Contractor. Nameplate inscription shall consist of the "Abbreviated Description" with the "ID Number" inscribed below the abbreviated description.

Switches shall be horsepower rated when used as a motor or motor controller disconnect switch.

16430.4 Installation

The Contractor shall install the switches complete as indicated on the drawings.

16430.5 Manufacturers

Disconnect switches shall be as manufactured by Ameren Missouri Approved Suppliers.

SECTION 16470
AC/DC PANELBOARDS

16470.1 General

16470.1.1 Scope of Supply
Scope of supply shall include furnishing the ac/dc panelboards as specified in Article 16470.2.

16470.1.2 Not Used

16470.1.3 Performance and Design Requirements
Performance and design requirements for the equipment to be furnished under this section of these specifications are indicated on the AC/DC Panelboards Specification Sheets included at the end of this section.

Main dc panels or switchgear shall have a mimic bus.

Panels shall have at least 20 percent spare capacity at end of project.

16470.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16470-1 Codes and Standards

Work	In Accordance With
AC/DC panelboards	The latest revision of the applicable ANSI, NEMA, or UL standards

16470.1.5 Materials
The following materials shall be used:

Table 16470-2 Materials

Component	Material
None identified	

16470.1.6 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.

Table 16470-3 Approved Manufacturers

Component	Manufacturer
Panelboards	Ameren Missouri Approved Suppliers

16470.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16470-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
As required by ANSI, NEMA, and UL for low voltage panels	ANSI, NEMA, UL Standards	Panel Manufacturer

16470.1.8 Not Used

16470.1.9 Not Used

16470.2 Products

16470.2.1 General
This article covers the furnishing of ac and dc panelboards as specified herein. Panelboards shall be furnished in the quantities and with components, devices, and materials meeting the requirements indicated on the drawings.

16470.2.2 Arrangement
Ac and dc panelboards shall be arranged in accordance with the Contractor's detailed design drawing(s) and as approved by the Owner.

16470.2.3 Construction
Panelboards shall be designed and fabricated in accordance with the applicable standards specified in Article 16470.1.4.

16470.2.3.1 Cabinets. Each panelboard shall be enclosed in a cabinet. Indoor panelboards in dry areas shall be NEMA 1 mounted in a dust-resistant cabinet enclosure, with a full gasket between the box and cabinet front and between the cabinet door and the cabinet front. Outdoor panelboards or panelboards installed in areas subject to hosedown shall be NEMA 4 mounted in a weatherproof cabinet enclosure. Panelboards mounted in wet corrosive areas shall be provided in NEMA 4X cabinet enclosures.

Each cabinet shall be sheet steel and shall consist of a box with a removable front, complete with hinged door, and latch. The box shall be flanged galvanized sheet steel, galvanized either before or after fabrication. If galvanized before fabrication, all locations where the galvanized coating is damaged or bare steel is exposed during fabrication shall be cleaned to white metal and repaired with a zinc rich coating. The repair coating shall deposit no fewer than 2 ounces of zinc per square foot. Boxes shall be fabricated with straight edges and square corners. Surfaces shall be free of waves, bellies, and other imperfections. Warped or distorted boxes will not be acceptable.

Prime and finish painting of surfaces shall be performed using the manufacturer's standard paints, paint colors, and paint processes. The complete description of prime and finish painting, including paint manufacturers and types, paint colors, paint processes, and dry film thickness, shall be submitted for Owner review.

The panelboard interior shall be equipped with a dead-front shield separate from the cabinet front.

A circuit directory cardholder and card with a clear plastic covering shall be provided on the inside cabinet door. The directory card shall have a space to identify each circuit in the panelboard. The Contractor shall provide typed circuit directory cards for each panel, supplied upon panel turn-over to the Owner.

16470.2.4 Buses
Rigid buses of tin plated copper shall be installed to provide consecutive phasing of branch circuit connections and adequately braced for the interrupting capacity specified on the specification sheets. Bolt-in branch circuit devices shall be installed to allow replacement of any device without disturbing the operation or mounting of other devices in the panelboard.

A solid copper neutral bus shall be provided in all ac panelboards designated on the drawings to supply phase-to-neutral loads. The neutral bus shall have solderless connectors, numbered to agree with the branch circuits. The bus shall be insulated from the cabinet with provisions for grounding.

All ac panelboards shall be furnished with an equipment grounding bus. The equipment grounding bus shall be copper and have a main lug and solderless connectors, numbered to agree with the branch circuits.

All dc panelboards designated as main battery panelboards shall have insulated buses. In addition, a non-conductive barrier shall be provided between the positive and negative line terminals.

16470.2.5 Branch Circuit Protective Devices

16470.2.5.1 DC System Branch Circuit Protective Devices. Branch circuit protective devices shall be thermal magnetic type circuit breakers unless otherwise specified in specification sheets or the Contractor's design drawings. The devices shall be double-, triple-, or quadruple-pole, as required by maximum system voltage and panelboard interrupting capacity as specified in the specification sheets.

16470.2.5.2 UPS System Branch Circuit Protective Devices. Branch circuit protective devices shall be fast acting semiconductor protection fuses in series with manually operated thermal magnetic type circuit breakers.

16470.2.5.3 General AC System Branch Circuit Protective Devices. Branch circuit protective devices shall be either thermal magnetic type circuit breakers designed for automatic tripping, or replaceable dual element fuses arranged in series with manually operated quick-make quick-break switches. The devices shall be single-, double-, or triple-pole, bolt-on type, as specified in the specification sheets or on the drawings.

Panels designated for heat trace systems shall utilize ground leakage equipment protection type circuit breakers.

All panels shall have a main breaker to isolate the panel. The main breaker shall be the same frame size as the panel bus rating.

Panelboard branch circuit breakers shall be bolt-in, individually front replaceable type and shall indicate ON, OFF, and TRIPPED. Circuit breakers indicated as multiple-pole shall be common trip.

All branch circuit breakers in lighting panelboards shall be marked as HID and shall be suitable for switching fluorescent or high-intensity discharge lighting circuits. Panelboard drawings will identify lighting panelboards.

For distribution panelboards, the circuit breakers shall be 100 or 225 ampere frame size molded case circuit breakers.

Circuit breakers shall include ground-fault circuit-interrupter (GFCI) protection for personnel (4-6 mA trip) if indicated on the Contractor's panelboard design drawings and approved by the Owner.

Branch circuit breakers installed in the panelboard shall be identified with odd numbers on the left and even numbers on the right.

All circuit breakers shall be supplied with provisions to lock the handles to accommodate tag out per Owner’s WPA Tags Plus program. This can be accomplished either integral to the breaker handle design or with manufacturer supplied standard handle locking accessories

16470.2.6 Nameplates
Engraved nameplates shall be furnished on laminated plastic tags of at least 1.5 inches by 4 inches. Nameplates shall have black letters with a white background. Nameplate inscriptions on these tags shall

coincide with those used on the drawings. Nameplate inscriptions will be furnished by the Owner at a later date.

16470.2.7 Cardholders
Circuit identification for each breaker shall be typewritten on cards mounted in cardholders.

16470.2.8 Ground Detection and Tracing System
The DC panelboard shall be furnished as seen in Ameren Missouri Approved Suppliers or Owner-approved acceptable equal per panel. All of the output contacts of the Arga meter/relay shall be wired out to terminal blocks within the panel for input to the Owner's DCS.

Main DC panelboards shall have a Ground Meter, and a Positive and Negative Volt Meter.

When a ground circuit tracing system is specified for the DC panelboard, refer to Ameren Missouri Approved Suppliers or Owner-approved acceptable equal shall be provided with pulsing system and handheld pulse receiver for locating the ground fault.

16470.2.9 Voltage Dropping Diode System
When a voltage dropping diode system is specified for a panel, the panel shall be furnished with a set of voltage dropping diodes which are connected in series, a set of series connected bypass contactors, and voltage sensing circuitry. The circuitry shall maintain the output of the dc panel to the dc loads to no more than 10 percent above the nominal battery voltage. During equalizing or boost charging by the battery chargers, the diodes shall maintain the output of the dc panel to no more than 10 percent above the nominal battery voltage. Upon loss of the battery chargers, the diodes shall be bypassed by the contactors to allow the full battery voltage to be passed onto the various dc loads.

16470.2.10 Not Used

16470.2.11 Alarm Contacts for DC Panelboards
When a battery disconnect switch or battery breaker is specified on the specification sheets or drawings, each battery disconnect switch or battery breaker shall be furnished with a contact for use by the plant DCS that opens to alarm when the disconnect switch or battery breaker is not closed (battery disconnected from the DC bus).

When fuses are specified with the battery disconnect switch on the specification sheets or drawings, the fuses shall be furnished with a contact for use by the plant DCS that opens to alarm when the fuses are blown.

When a battery charger circuit breaker is specified on the specification sheets or drawings, each battery charger circuit breaker shall be furnished with a contact for use by the DCS that opens to alarm when the circuit breaker is not closed.

When a battery discharged test connection circuit breaker is specified on the specification sheets or drawings, each battery discharge test connection circuit breaker shall be furnished with a contact for use by the DCS that opens to alarm when the circuit breaker is not closed.

Contractor shall install each alarm to the DCS.

16470.2.12 Factory Tests
After the panel has been fabricated and all parts assembled, the complete gear, including instruments and devices, shall be factory tested. Factory tests shall include the following:

Tests required verifying correctness of assembly and operation.

High potential tests.

Applicable standard tests.

16470.2.13 Type Tests and Certification

The Contractor shall perform the type tests for major components, if required in Article 16470.1.7, and these tests will be in accordance with all the applicable standards specified in Article 16470.1.4.

Type test certificates from identified components are acceptable in lieu of the individual type test. Type test certificates shall be made available to the Owner at no extra charge upon request.

16470.3 Execution

16470.3.1 General

All panelboards shall be installed so that branch circuit protective devices are not more than 6 feet above the finished floor or grade. Measure the steady state load currents at each panelboard feeder. Should the difference at the any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent.

Panelboards shall be installed in accordance with the following articles.

16470.3.2 Cabinets

The cabinets shall be leveled and securely fastened to the mounting surface, utilizing all of the mounting holes provided in the panelboard cabinets. The mounting surfaces shall be adjusted as required to maintain the cabinets in a true vertical plane.

16470.3.3 Panel Interior

Each cabinet shall be installed, conduits connected, and wires pulled before the panel interior is installed. Each panel interior shall be carefully inspected, and all connections shall be tightened. The panel interior shall then be mounted in the cabinet using all of the mounting provisions furnished. The panelboard interior shall then be connected, with wires tightly secured in the terminals provided and with unnecessary lengths or wire eliminated. Wiring shall be neatly arranged in the gutters. A heavy cardboard panel front shall be temporarily secured to the panelboard to protect the interior from dirt or damage until the permanent metal front is installed.

All panels shall be cleaned of dust, dirt, debris, and other foreign matter prior to turn-over to the Owner.

16470.3.4 Panelboard Fronts

Each panelboard front shall be carefully aligned and adjusted until its edges are parallel to the panelboard interior and the building lines, and then shall be firmly secured with the fasteners provided.

The directory shall be accurately and neatly completed to permit ready location of the protective devices controlling circuit loads.

AC/DC Panelboards Specification Sheets

General Requirements	
The following types of equipment shall be furnished	AC panelboards or DC panelboards
Standards for manufacturing and testing	ANSI/NEMA/UL
Type of cabinet finish	Painted ANSI 61 Gray
Busbar material (phases)	Tin plated copper
Busbar material (neutral and ground)	Copper
Exterior paint color	Manufacturer's standard
Design ambient temperature	104° F
Additional requirements	600 V Rated Panels
AC Panelboard Requirements	
Item	
Description	
Nominal operating voltage, volts ac	120/208 or 120/240 or 277/480 or 480
Nominal power system frequency, hertz	60
Bus configuration	3-phase, 4 wire, with neutral or 3-phase, 3 wire, no neutral or Single-phase, 3 wire, with neutral or Single-phase, 2 wire, no neutral
Panel type	Enclosed Vertical
Location	Indoor or Outdoor
Enclosure type	NEMA 1 in dry clean electrical rooms or NEMA 4 in wet areas, NEMA 4X in wet corrosive areas
Type of branch circuit protective devices	Circuit breakers
Interrupting capacity of panelboards, kA (as required to meet fault study criteria)	50 for 240 V or 480 V distribution panelboards
Minimum Interrupting capacity of lighting and appliance panelboards, kA (as required to meet fault study criteria)	10 for 240 V panelboards, 14 for 480 V distribution panelboards
Type of panelboard protection	Main circuit breaker
Device rating, amperes	100 or 200 or 225 or 400 as required by design

Branch Breakers		
Ampere Rating	**Number of Poles**	**Quantity**
Determined by Contractor		

Receptacle	No
Quantity required per panel	
The following devices shall be furnished with the panel:	
Device	**Quantity**
Determined by Contractor	
Wiring method	
Additional requirements	
DC Panelboard Requirements	
Item	
Description	
Nominal operating voltage, volts dc	125
Maximum system voltage, volts dc	140
Bus configuration	Ungrounded 2 wire 125 VDC
Panel type	Enclosed vertical
Location	Indoor
Enclosure type	NEMA 1 in clean, dry electrical rooms, NEMA 4 in wet areas, and NEMA 4X is corrosive areas.
Type of branch circuit protective devices	Circuit breakers
Interrupting capacity of panelboards, kA	Determined by Contractor
Type of panelboard protection	Main circuit breaker
Device rating, amperes	Determined by Contractor
Ground detection system is required	Yes
Ground circuit pulsing and tracing system is required	Yes
Voltage dropping diode system is required	Determined by Contractor

Branch Breakers		
Ampere Rating	**Number of Poles**	**Quantity**
Determined by Contractor		

The following devices shall be furnished with the panel:	
Device	**Quantity**

Determined by Contractor	
Wiring method	
Additional requirements	The main 125 VDC panels shall be provided with mimic panel features.

SECTION 16502
LIGHTING

16502.1 General

16502.1.1 Scope of Supply

Scope of supply shall include designing, furnishing, and installing the building lighting and convenience receptacle system as specified herein. Illumination levels for the building spaces shall be in accordance with the National Electric Safety Code (NESC) and the NFPA Life Safety Code 101. Illumination calculations shall be provided to the Owner for all spaces. Calculations shall be average maintained values determined from a working plane height of 30 inches above the floor or platform. Light loss factors shall be determined as recommended by the Illumination Engineering Society of North America (IESNA).

16502.1.2 Not Used

16502.1.3 Performance and Design Requirements

Performance and design requirements for the equipment and materials to be furnished under this section of these specifications are indicated herein.

For lighting system materials, the following requirements shall also apply in addition to the requirements of this section:

Section 16510 - Conductors and Accessories.

Section 16910 - Electrical Equipment Installation.

Section 16920 - Raceway Components and Installation.

Section 16925 - Conductors Installation.

Section 16941 - Lighting System Installation.

16502.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16502-1 Codes and Standards

Work	**In Accordance With**
Luminaires	
Fluorescent	UL 542, 935, 1598
High intensity discharge	UL 496, 1029, 1598
Incandescent	UL 496, 1088, 1574, 1598
Light emitting diode (LED)	UL 8750
Emergency and emergency power equipment	UL 924
Hazardous area	UL 844
Duplex and single receptacles	UL 498, 943, 1010, 1449, 1682, 1686

Table 16502-1 Codes and Standards	
Work	**In Accordance With**
Switches, dimmers, contactor, and photocells	UL 20, 508, 773, 894, 1472
Device plates and outlet boxes (unfinished areas)	UL 514

16502.1.5 Materials

The following materials shall be used:

Table 16502-2 Materials	
Component	**Material**
Switches	
Housing and operating levers	Phenolic compound
Device plates	
Finished areas (metal)	Type 430 satin stainless steel
Unfinished areas	Formed sheet steel coated with zinc of cadmium
Weatherproof receptacle and switches	
Plates and lift cover	Cast aluminum
All other metal parts	Stainless steel or Monel metal

16502.1.6 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. Note that "finished areas" are defined as rooms with a suspended ceiling system and "unfinished areas" are all other indoor locations:

Table 16502-3 Approved Manufacturers	
Component	**Manufacturer**
Luminaires	
Enclosed and gasketed pulse start metal halide with glass refractors	Appendix C - Ameren Missouri Approved Suppliers
Hazardous area pulse start metal halide with glass refractors	Appendix C - Ameren Missouri Approved Suppliers
Interior high bay applications pulse start metal halide	Appendix C - Ameren Missouri Approved Suppliers
Interior low bay applications pulse start metal halide with prismatic lens reflector	Appendix C - Ameren Missouri Approved Suppliers
Enclosed and gasketed pulse start metal halide cutoff wallpack	Appendix C - Ameren Missouri Approved Suppliers
Industrial fluorescent with white reflectors, end caps, and 20 percent uplight	Appendix C - Ameren Missouri Approved Suppliers

Table 16502-3 Approved Manufacturers	
Component	**Manufacturer**
Industrial enclosed and gasketed fluorescent suitable for damp and wet locations	Appendix C - Ameren Missouri Approved Suppliers
Industrial hazardous area fluorescent	Appendix C - Ameren Missouri Approved Suppliers
Recessed fluorescent troffers with aluminum parabolic reflectors	Appendix C - Ameren Missouri Approved Suppliers
Recessed fluorescent troffers with KSH 0.125 inch acrylic diffuser	Appendix C - Ameren Missouri Approved Suppliers
Emergency incandescent wall mounted units with integral lead acid batteries suitable for 90 minute operation	Appendix C - Ameren Missouri Approved Suppliers
Emergency incandescent recessed ceiling mounted units with integral lead acid batteries suitable for 90 minute operation	Appendix C - Ameren Missouri Approved Suppliers
Emergency LED exit lighting units with a black aluminum enclosure, brushed stencil face, and integral batteries suitable for 90 minute operation for finished areas	Appendix C - Ameren Missouri Approved Suppliers
Emergency LED exit lighting units with white steel enclosure and integral batteries suitable for 90 minute operation for interior unfinished areas	Appendix C - Ameren Missouri Approved Suppliers
Emergency LED exit lighting units with white metal enclosure without integral batteries	Appendix C - Ameren Missouri Approved Suppliers
Emergency remote incandescent light with NEMA 4 enclosure for outdoor areas	Appendix C - Ameren Missouri Approved Suppliers
Convenience receptacles	
Duplex (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Single (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Special purpose outlets, such as kitchen range, ac unit, and clock outlet	Appendix C - Ameren Missouri Approved Suppliers
Isolated ground	Appendix C - Ameren Missouri Approved Suppliers
Ground fault interrupting (ivory)	Appendix C - Ameren Missouri Approved Suppliers

Table 16502-3 Approved Manufacturers	
Component	**Manufacturer**
Hazardous rated (Class I, Group D and Class II, Group F areas)	Appendix C - Ameren Missouri Approved Suppliers
Switches	
Single-pole (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Three-way (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Four-way (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Momentary contact (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Two-pole (ivory)	Appendix C - Ameren Missouri Approved Suppliers
Three-way, four-way (Class I, Group D and Class II, Group F areas)	Appendix C - Ameren Missouri Approved Suppliers
Fluorescent and incandescent dimmers	Appendix C - Ameren Missouri Approved Suppliers
Device plates	
Device plates (unfinished areas)	Appendix C - Ameren Missouri Approved Suppliers
Device plates (ivory - finished areas)	Appendix C - Ameren Missouri Approved Suppliers
Weatherproof single receptacle device plates	Appendix C - Ameren Missouri Approved Suppliers
Weatherproof duplex receptacle device plates	Appendix C - Ameren Missouri Approved Suppliers
Weatherproof switch device plates	Appendix C - Ameren Missouri Approved Suppliers
Miscellaneous	
Lamps	Appendix C - Ameren Missouri Approved Suppliers
Fluorescent dimming system	Appendix C - Ameren Missouri Approved Suppliers
Photoelectric controller	Appendix C - Ameren Missouri Approved Suppliers
Lighting contactors	Appendix C - Ameren Missouri Approved Suppliers

16502.1.7 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.

Table 16502-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Operational test	Article 16502.1.4	Contractor

16502.1.8 Not Used

16502.1.9 Not Used

16502.2 Products

16502.2.1 Luminaires

Luminaires shall be as specified in this specification section.

Office area luminaires shall be 2 foot by 4 foot recessed static enclosures with aluminum parabolic reflectors that are in accordance with ANSI/IESNA RP-1 recommendations. Luminaires in corridors, restrooms, locker rooms, and similar spaces may use 1 foot by 4 foot recessed static enclosures with minimum 0.125 inch thick prismatic acrylic diffuser lens. Surface mounted fluorescent luminaires shall be baked white enamel steel enclosures with prismatic acrylic diffusers. Recessed fixture bodies shall not exceed a depth of 6 inches, including yokes and bridges.

Industrial fluorescent luminaires shall be steel enclosures with baked white enamel, end caps, center V reflector, and 20 percent minimum uplight. No fluorescent fixtures shall be used in damp or wet locations.

All fluorescent ballasts shall be energy efficient electronic programmed rapid start. The ballasts shall have less than 10 percent harmonic content. All fluorescent fixtures shall be provided with only one ballast per fixture for one, two, three, or four lamp fixtures.

High bay and low bay pulse start metal halide lights shall be steel and cast aluminum enclosures with a power hook assembly. High bay luminaires shall have glass or glass coated reflectors. Low bay pulse start metal halide luminaires shall have prismatic acrylic diffusers. Pulse start metal halide wallpack luminaires shall be suitable for wet locations and shall include a black or dark bronze cast aluminum enclosure and cutoff flat glass lens.

Unless otherwise approved, all pulse start metal halide luminaires shall have mogul or medium base sockets and a constant wattage auto-regulating ballast.

Plugs for lighting may be used but only for light fixtures powered with 120 VAC and below.

16502.2.2 Luminaire Supports

All required luminaire supports, hangers, clamps, hardware, and fasteners shall be furnished and installed as required for a rigid support. Supports shall be from the building structure support steel or walls. Chain supported luminaires are not acceptable. Supports shall be designed for the project seismic criteria.

16502.2.3 Plugs and Receptacles

One matchup hazardous rated plug shall be furnished for each three hazardous rated receptacles.

Ground fault current interrupter receptacle outlets shall be provided as required by the NEC. All other receptacles shall be grounded straight-blade NEMA 5-20R type.

Each receptacle shall be marked with its source circuit.

16502.2.4 Switches

Switches shall be totally enclosed tumbler type with single mounting yoke design. Single- and double- pole switches shall be position indicating.

16502.2.5 Device Plates

Device plates shall be furnished for all device boxes. Unless otherwise indicated by the Owner, galvanized stamped steel shall be provided for unfinished areas and smooth plastic for finished areas. Outdoor location device plates shall be suitable for wet locations with the plug installed.

16502.2.6 Lamps

Lamps shall be furnished for all luminaires. All fluorescent lamps shall be energy efficient T8, unless otherwise required by the dimming system equipment supplier. Fluorescent lamps shall be 32 watt, 3000 K, 4 foot type. Fluorescent lamps shall be compliant with Toxicity Characteristic Leaching Procedure (TCLP) standards. Pulse start metal halide lamps shall be clear with mogul (preferred) or medium bases. All metal halide lamps shall have a 3000 K correlated color temperature (CCT), unless otherwise required due to being a higher wattage lamp.

16502.2.7 Lighting Contactors

Lighting contactors shall be as specified in this specification section and shall be based on total lighting demand load. Lighting contactors shall be electrically or mechanically held as required by the design and shall include an enclosure suitably rated for the installation environment (NEMA 12 minimum), hand-off-auto control switch, control fuse, and contacts rated for the application. Multiple lighting branch circuits that are to be controlled from a photoelectric controller shall use a multiple pole electrically held contactor.

16502.2.8 Emergency Lighting Uninterrupible Power Supply

The emergency lighting uninterrupible power supply (UPS) system shall be as specified in Section 16180. Emergency lighting with battery backup may only be used in remote areas and must be approved by the Owner.

16502.2.9 Lighting and Convenience Receptacle Conductors

The following conductor types for use in the lighting and convenience receptacle circuits shall be provided in accordance with the Cable Specification Sheets included in Section 16510.

Table 16502-5 Conductor Types

Cable Type	Circuit Use
THHN	For 120 volt circuits in heated areas
XHHW-2	All 277 volt circuits and all 120 volt circuits in unheated areas
SF-2	For incandescent luminaire connections

16502.2.10 Lighting and Convenience Receptacle Raceway

The following raceway and raceway fittings for use in lighting and convenience receptacle circuits shall be provided

Table 16502-6 Raceway

Raceway Type	Use
Electrical preassembled and prewired cable assemblies	Installed in indoor finished environments only
Rigid galvanized steel	All areas
Flexible metallic tubing	Luminaire taps in finished areas

16502.2.11 Not Used

16502.3 Execution

If lighting installation is included in the Scope of Supply (Article 16502.1.1), the installation shall be in accordance with Section 16941- Lighting System Installation.

SECTION 16510
CONDUCTORS AND ACCESSORIES

16510.1 General

16510.1.1 Scope of Supply

Scope of supply shall include conductors and accessories as indicated in the attachments listed in Article 16510.1.8 and as specified herein as required for Contractor's design of field cabling to interconnect equipment.

16510.1.2 Not Used

16510.1.3 Performance and Design Requirements

Performance and design requirements for the material and components to be furnished under these specifications are indicated herein and on the Conductors and Accessories Specification Sheets included at the end of this section. Additional requirements include the following:

Table 16510-1 Performance and Design Requirements (Additional Requirements)	
Assignment of cable to reels	Contractor to assign cable to reels based on routed cable lengths

16510.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16510-2 Codes and Standards	
Work	**In Accordance With**
ANSI/IEEE/ICEA/UL/NEC	
Power, Control, Instrumentation, Thermocouple, And Specialty Cables	The codes and standards indicated in indicated on the cable data sheets at the end of this section.
Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies	IEEE 1202
Short-Circuit Performance of Metallic Shields and Sheaths on Insulated Cable	ICEA P-45-482
Electrical Power and Control Tray Cables with Optional Optical-Fiber Members	UL 1277
UL Standard for Safety - Power Limited Circuit Cables	UL 13
UL Standard for Safety - Flexible Cord and Fixture Wire	UL 62
UL Standard for Safety - Electrical Wires, Cables, and Flexible Cords	UL 1581
Cable Accessories	AEIC CS8, IEEE 404, IEEE 48

16510.1.5 Materials

The following materials shall be used:

Table 16510-3 Materials	
Component	**Material**
Power, Control, Instrumentation, Thermocouple, And Specialty Cables	As indicated on the cable data sheets
Cable Accessories	As indicated in Article 16510.2.3

16510.1.6 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 Contractor wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be pre-approved by Owner thirty (30) days prior to submitting bids. Acceptance of the manufacturer as a substitute is at the discretion of the Owner:

Table 16510-4 Approved Manufacturers	
Component	**Manufacturer**
ICEA/AEIC medium voltage power cable	Ameren Missouri Approved Suppliers
ICEA/UL low voltage power cable	Ameren Missouri Approved Suppliers
ICEA/UL control cable	Ameren Missouri Approved Suppliers
ICEA/UL instrumentation and thermocouple cable	Ameren Missouri Approved Suppliers
ICEA/UL insulated ground cable	Ameren Missouri Approved Suppliers
Fiber-optic cable	Ameren Missouri Approved Suppliers
Accessories	As indicated in Article 16510.2.3

16510.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16510-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Standard	Applicable ANSI, IEEE, ICEA, AEIC and UL Standards	Manufacturer
ICEA/AEIC medium voltage power cable qualification tests	AEIC CS8 and ICEA S-97-682	Manufacturer
Cable type tests, production tests, routine tests, and flame tests	The codes and standards indicated in Article 16510.1.8	Manufacturer
Cable flame tests	The codes and standards indicated in Article 16510.1.8	Manufacturer

Table 16510-5 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Post-installation testing, hi-pot for MV cables, megger for low voltage cables. PD testing needed.		Contractor

16510.1.8 Technical Attachments

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

Table 16510-6 Technical Attachments		
Document Number/Description	**Title**	**Revision**
5 kV AND 8 kV	5 kV AND 8 kV POWER CABLE SPECIFICATION SHEET	
15 kV	15 kV POWER CABLE SPECIFICATION SHEET	
#CC1	600 V SHIELDED MULTICONDUCTOR CONTROL CABLE SPECIFICATION SHEET	
#CC2	600 V UNSHIELDED MULTICONDUCTOR CONTROL CABLE SPECIFICATION SHEET	
#IC1	600 V INSTRUMENTATION CABLE SPECIFICATION SHEET	
#PC1	600 V SINGLE CONDUCTOR POWER CABLE SPECIFICATION SHEET (see Note 1)	
#PC2	600 V MULTI-CONDUCTOR POWER CABLE SPECIFICATION SHEET (see Note 1)	
#TEC1	600 V THERMOCOUPLE EXTENSION CABLE SPECIFICATION SHEET	

Note 1: Per NFPA 70-2014, conductors can be rated up to 1000 V if listed and marked.

16510.1.9 Not Used

16510.1.10 Certification Requirements

Certified test reports for each type of power cable furnished under this Contract shall be provided in accordance with the requirements of AEIC CS8 and ICEA S-97-682 (ICEA/AECI MV power cable) and in accordance with the requirements of ICEA S-95-658 (ICEA/UL LV power cable) and other applicable standards as indicated in Article 16510.1.8.

16510.2 Products

16510.2.1 Conductors and Accessories - General Requirements

The design and construction of insulated conductors shall be in accordance with manufacturer and utility industry standard practices, except as modified in accordance with these specifications. All insulated cable, conductors, and accessories shall meet the operating conditions and requirements as specified herein and on the Conductors and Accessories Specification Sheet.

The term "Type" used in these specifications refers to the letter identification indicated on each Cable Specification Sheet.

16510.2.1.1 Design Life. All equipment, components, and materials shall have a useful design life of 40 years, accounting for corrosion, erosion, and material degradation.

16510.2.1.2 Engineering Data. The Contractor shall submit his product specification drawings for all specified cable and accessories to the Owner in accordance with the Schedule of Contract Submittals. The drawings shall include dimensions and materials of construction for all materials. Material furnished shall be in accordance with the product specification drawings that receive approval by the Owner.

16510.2.1.3 Splicing. Splicing is prohibited. All pigtail conductors shall be terminated in a local junction box.

16510.2.1.4 Stripping Requirements. Any material in contact with the conductor shall be free-stripping. Cables which require wire brushing of the conductor or dipping of the conductor into molten solder to facilitate termination are not acceptable. If the material in contact with the conductor is not free-stripping, the entire cable reel may be rejected at the option of the Owner.

16510.2.1.5 Not Used.

16510.2.1.6 Not Used.

16510.2.1.7 Conductor Identification. The means of identifying single insulated conductors of a multiple conductor cable rated above 2000 volts (ICEA/UL) shall be by the use of color coded tapes which are applied between the extruded insulation shield and the metallic tape portion of the insulation shield.

Conductor identification of cables rated 2000 volts (ICEA/UL) and less shall be as specified on the Cable Specification Sheets.

16510.2.1.8 Not Used.

16510.2.1.9 Field and Post Installation Tests. Upon receipt at the site, a dc high voltage will be applied to shielded power cable rated greater than 2000 volts (ICEA/UL) to determine that the cable was not damaged during shipment. The Contractor shall bear all costs of replacing defective cable including costs for making and delivering new cable, as well as removing and disposing of defective cable. Cable shall be shipped such that it may be tested on the reel. After installation, a dc high voltage will be applied to shielded power cable rated greater than 2000 volts (ICEA/UL) to demonstrate that the cable was not damaged during installation.

16510.2.1.10 Packaging. All cable shall be shipped on industry standard nonreturnable reels except where cable size, length, or weight requires the use of returnable reels. The radius of each flange shall be at least 2 inches greater than the distance from the axis of the reel to the outside of the outermost layer of cable on the reel.

Cable ends, whether exposed or concealed, shall be sealed with heat shrinkable caps. Cap sizes shall be as recommended by the cap manufacturer for the cable diameter and insulation. Caps shall contain sufficient adhesive so that shrinkage of the cap during application results in the formation of a positive watertight seal capable of withstanding complete immersion or totally exposed storage over a period of several months without permitting the entrance of moisture.

Each reel shall be shipped resting on the edges of the reel flanges.

Each reel shall have a legible waterproof metal or plastic tag marked to include the following identification:

Cable type, conductor size, and number of conductors (cores).

The individual reel numbers in the total group of reels having cable of the same type, conductor (core) size, and number of conductors (cores); and the total number of reels in the group.

Net length of cable on the reel in feet (meters).

Gross and net weight of cable on the reel in pounds (kg).

Sequential foot (meter) marking at the reel drum end and at the exposed end.

16510.2.1.11 Not Used.

16510.2.2 AEIC/ICEA/UL Cable - Technical Requirements

16510.2.2.1 Conductors. Conductor material, construction, and stranding shall be as specified on the Cable Specification Sheets. If copper conductors are specified, either coated or uncoated copper conductors shall be supplied. Uncoated copper conductors may be supplied if the Contractor warrants that the material in contact with the conductor will not corrode the copper. The Contractor may supply either round or compressed conductors. The conductor diameter and dc resistance shall meet the tolerance requirements of the applicable standards referenced in Article 16510.1.4 and on the Cable Specification Sheets.

16510.2.2.2 Conductor Shield (Screen). When a conductor shield (screen) is specified, it shall be in accordance with applicable AEIC and ICEA requirements. If compact conductors are supplied, the thickness of the conductor shield shall be determined as if round conductors were being used. The conductor shield shall be an extruded thermosetting, semiconducting material.

16510.2.2.3 Insulation. The insulation material shall meet the requirements as specified herein and as indicated on the Cable Specification Sheets. Core identification shall be by numbers printed on the insulation or by coloring of insulation as specified on the Cable Specification Sheets. Multiconductor cable shall use the ICEA S-73-532, Appendix E, Method 1, Table E-2 (K2) color code. The conductor insulation shall be a high quality, heat and moisture-resisting compound. The insulation shall fit tightly to the conductor or conductor shield (screen). The insulation shall be applied so that it can be cleanly stripped in the field with conventional stripping tools. Cable strand and insulation shall be free of water and water vapor. The Contractor shall fully describe his methods and procedures for drying and testing cables.

16510.2.2.4 Insulation Shield (Screen). When an insulation shield (screen) is specified, it shall consist of an extruded, thermosetting semiconducting material in combination with a metallic tape. The semiconducting material shall be in accordance with the requirements of AEIC and ICEA. Concentric neutral cables are not acceptable.

16510.2.2.5 Not Used.

16510.2.2.6 Not Used.

16510.2.2.7 Not Used.

16510.2.2.8 Jacket (Outer Sheath). When specified, an overall jacket (outer sheath) shall be extruded onto the cable assembly. The material of the jacket shall meet the ICEA requirements indicated on the Cable Specification Sheets. If single conductor shielded cables are supplied, the thickness of the jacket shall be in accordance with the table titled Single-Conductor Metallic Shielded Cables (ICEA cables).

Jackets (outer sheaths) shall consist of an abrasion, moisture, oil, heat, weather, sunlight, and flame-resistant compound. The cable jacketing interstitial spaces within the jacket (outer sheath) shall be free of water or water vapor.

The jacket (outer sheath) shall be smooth, free-stripping, and free from surface damage and irregularities. Severe damage or recurring irregularities may be cause for rejection of the cable by the Owner.

The halogen content of chlorinated polyethylene and chlorosulfonated polyethylene cable assembly jackets (sheaths) shall not exceed 19 percent by weight.

16510.2.2.9 Inspection and Testing. Cables shall be inspected and tested in accordance with the appropriate codes and standards as indicated in Article 16510.1.4, 16510.1.7, and on the Cable Specification Sheets. The Contractor shall be responsible for all examinations, inspections, and tests, including recording of results and maintenance of records. The Owner shall be given full factory access, including Contractor's shops, during normal working hours while cables are being manufactured and tested, and access to all fabrication and testing documents.

Upon request, the Owner shall be given engineering samples of the cable types specified herein.

The Contractor shall submit an Inspection and Test Procedure to the Owner for review and approval in accordance with the Schedule of Contract Submittals. The Owner shall be notified in advance prior to the start of fabrication for conducting general inspections.

16510.2.2.9.1 Qualification tests (ICEA/AEIC medium voltage shielded power cable). Qualification tests shall be performed for each cable type furnished. Qualification tests shall be performed in accordance with ICEA S-97-682 and the additional requirements of AEIC CS 8. A certified copy of the Qualification Test report (and evidence of on-going testing) which represents the cable being furnished shall be provided by the Contractor. The following qualification tests shall be included, as a minimum:

Table 16510-7 Qualification Tests	
Qualification Test Requirements	
Core Material Qualification Tests (Conductor Shield, Insulation, and Insulation Shield)	High Voltage Time Tests Hot Impulse Tests Accelerated Water Treeing Tests Resistance Stability Tests Conductor Shield Protrusions, Convolutions and Voids Insulation Voids and Contaminants
Jacket Qualification Tests	Sunlight Resistance (PVC and CPE) Environmental Stress Cracking (PE) Abrasion Resistance Halogen Content
Other Tests	Thermomechanical Qualification Test CV Extrusion Qualification Test Insulation Resistance Accelerated Water Absorption Resistance Stability Brittleness Test for Semiconducting Shields Dissipation Factor Characterization Test Other Tests As Required By The Applicable Codes And Standards

16510.2.2.9.2 Not used.

16510.2.2.9.3 Production tests (ICEA/AEIC Cables). Where applicable, the following tests shall be provided for each cable manufactured. Tests shall be made on all cable in accordance with the applicable standards as indicated on the Cable Specification Sheets. A certified copy of the Production Test Report shall be provided by the Contractor when requested by the Owner:

Table 16510-8 Production Tests	
Production Test Requirements	
Medium Voltage (MV) Power Cable	All production tests on cable components and the completed cable shall be performed in accordance with ICEA S-97-682 and AEIC CS 8

Table 16510-8 Production Tests	
Production Test Requirements	
Conductor Tests	
All cables	Conductor wire prior to stranding, elongation, finish, continuity, stranded conductor elongation tests, dc resistance determination, cross-sectional area determination, and diameter determination
Thermocouple extension cables	Initial calibration tolerance
Insulation Tests (all cables)	
Physical requirements	Tensile strength, elongation, and elongation at rupture
Aging requirements	Tensile strength and elongation at rupture after aging
Other tests (all cables)	Hot creep tests, insulation resistance constant, ozone resistance, and accelerated water absorption
Other tests (MV cable only)	Voids, contaminants, and protrusions
Nonmetallic Shield Tests (MV cable)	Elongation after air oven tests, brittleness temperature, volume resistivity, thickness, wafer boil, voids and contaminants, stripping tests, and diameter tests
Metallic Shield Tests	Shield isolation, shield continuity, and dimensions
Jacket Tests	
Physical requirements	Tensile strength, tensile stress, heat distortion, and elongation at rupture
Aging requirements	Tensile strength and elongation at rupture after aging
Oil immersion requirements	Tensile strength and elongation at rupture after oil immersion
Other tests	Heat shock, heat distortion, and cold blend
Electrical Tests	
All cables	Ac voltage withstand, insulation resistance, conductor continuity, and spark tests for nonshielded single conductor cables
MV cables	Partial discharge and jacket spark
Other tests as required by the applicable codes and standards	

16510.2.2.9.4 Not used.

16510.2.2.9.5 Not used.

16510.2.2.9.6 Flame tests. Certified flame test reports shall be submitted to the Owner for all cable types listed in accordance with the codes and standards referenced on the Cable Specification Sheets.

16510.2.2.9.7 Networking cables. Cables used for control system network loops and LAN communication cables shall be provided with the jackets with the colors as noted in the following table:

Table 16510-9 Networking Cables Jacket and Color Requirements						
Plant	**Operator Console Network**	**KVM Extenders**	**Bailey Loop**	**PLC Network**	**Corporate LAN**	**Crossover Cables**

	Primary	Secondary		(COAX)			
Labadie	Red Jacket	Pink Jacket	White Jacket	Orange Jacket	Orange Jacket	Blue Jacket	Black Jacket
Rush Island	Orange Jacket	Pink Jacket	White Jacket	Orange Jacket	Orange Jacket	Blue Jacket	Black Jacket

16510.2.3 Accessories

16510.2.3.1 General. This article covers conductor accessories. All conductor accessories shall be provided as indicated in Article 16510.1 and as specified herein.

16510.2.3.2 Terminal Connectors.

16510.2.3.2.1 Terminal connectors for conductors 8 AWG and larger. Terminal connectors for conductors 8 AWG and larger shall be compression type, as indicated Ameren Missouri Approved Suppliers. Mechanical lugs are not acceptable. Compression type lugs only shall be used.

Reducing pin compression connectors (if required and approved for use by Owner) shall be as shown in Ameren Missouri Approved Suppliers. or acceptable equal for cables that are oversized due to voltage drop or derating that will not fit into equipment lugs.

16510.2.3.2.2 Terminal connectors for conductors smaller than 8 AWG. Terminal connectors for conductors smaller than 8 AWG shall be compression type connectors properly sized for the conductor and the terminal. The connectors shall be constructed of fine grade high conductivity copper and shall be tin-plated. The interior surface of the connector wire barrel shall be serrated, and the exterior surface of the connector wire barrel shall be provided with crimp guides.

Noninsulated terminal connectors shall be provided on conductors terminated on devices equipped with individual fitted covers, as indicated on Ameren Missouri Approved Suppliers. Preinsulated ring type terminal connectors shall be used on all current and potential transformer circuits. All other terminal connectors for conductors smaller than 8 AWG shall be preinsulated ring type.

Preinsulated terminal connectors shall include a vinyl insulating sleeve, color coded to indicate conductor size. Preinsulated terminal connectors shall include a metallic support sleeve bonded to the vinyl insulating sleeve and designed to grip the conductor insulation.

Ring type connectors shall be manufactured by as shown in Ameren Missouri Approved Suppliers.

Ferrules shall be provided on all stranded conductors that are to be terminated to compression type IEC terminal blocks.

16510.2.3.3 Not Used

16510.2.3.4 Not Used.

16510.2.3.5 Crimping Tools. Crimping tools used to secure conductors in compression type connectors or terminal lugs shall be those made for that purpose and for the conductor sizes involved. The crimping tools shall accurately crimp the connector barrel and shall accurately crimp the conductor insulation support sleeve where provided. Crimping tools shall be provided with guides to position connectors in the tool, shall be provided with stops to prevent overcrimping, and shall be of a type which prevents the tools from opening until the crimp action is completed. Crimping tools shall be a product of the connector manufacturer or shall be as recommended by the connector manufacturer and acceptable to the Owner for use with the connectors.

Mechanical crimps are extremely critical on these projects. A crimping class will be conducted by the contractor's supervision with all appropriate contractors employees that will be performing these crimps in the field. This will be done in the presence of Ameren Missouri's Construction Supervisor and or Ameren Missouri's Engineer. During this class, the Contractor at a minimum, will demonstrate the appropriate procedure that will be used for the project. This will include the crimps for all wire sizes, all types of crimps, and the matching tools including wire stripping tools that will be used. All crimps and tools will be submitted for approval before any will be used in the class and field. Generic crimping tools will not be allowed. Specific ratcheting tools, with identifying engraving that identify the dies will be used. All attendees in the class will demonstrate that they can perform the crimps. A 100 percent pull test will be used in the class and for all crimps in the field. The contractor must submit a list of recent projects indicating that the specific employees have had experience in terminating in these types of panels and cabinets.

16510.2.3.6 Insulating Materials. Insulating materials for splice and termination insulation shall be in accordance with the following.

16510.2.3.6.1 1000 volt (or less) cable. Insulating materials for terminal connections in motor terminal housings shall be as shown in Ameren Missouri Approved Suppliers.

Insulating materials for terminal connections to busbar shall be as shown in Ameren Missouri Approved Suppliers where they can be applied to obtain an environmental seal where multiple cables enter a single sleeve.

Where heat shrink insulating sleeves and boots cannot be used, insulating materials for terminal connectors or compression type splicing connectors shall consist of varnished cambric tape, rubber tape, and vinyl tape. Taping materials shall be as listed in

16510.2.3.6.2 Shielded cable rated 5 kV and above. Insulating materials for terminal connectors in motor terminal housings with direct cable connection to the motor leads **(for cable rated up to 8 kV)** shall be as referenced in Ameren Missouri Approved Suppliers high voltage motor connection kits or acceptable equal. After installation of the cable termination kit as specified in Article 16510.2.3.11, the terminal connectors in motor terminal housings shall be insulated with material as indicated in Ameren Missouri Approved Suppliers high voltage motor connection kits or acceptable equal.

Connections to insulated switchgear buses shall be insulated with removable boots furnished with the switchgear or acceptable equal.

Other indoor terminal connectors, including those located in air insulated terminal chambers (bus type terminations), shall be insulated using materials as shown in Ameren Missouri Approved Suppliers for high voltage bus connection kits or shall be insulated by using a taped system. The HVBC or taped system shall be applied after application of the termination kit specified in Article 16510.2.3.11. Taping materials shall be as listed below or acceptable equal as shown on the table in Ameren Missouri Approved Suppliers.

Splicing connectors for 5 kV and 15 kV cable shall be insulated using items identified in the Ameren Missouri Approved Suppliers.

Material for insulation of splices for cable rated above 15 kV and for motor terminal connectors for cable rated above 8 kV shall be as specified on the drawings.

16510.2.3.7 Support Grips. Cable support grips shall be either split or closed woven wire type as manufactured by suppliers shown in the Ameren Missouri Approved Suppliers.

16510.2.3.8 Wire and Cable Markers. Brady self-laminating vinyl labels with 1/4" text shall be used for wire and cable markers. The marker board shall not be less than 0.75 inch by 2.5 inches and shall be as contained in Ameren Missouri Approved Suppliers or acceptable equal. Identification shall be permanent and waterproof. The holding device shall be designed to allow the fastening tail to pass around the cable through the holding device and prevent the removal of the tail without cutting it loose from the marker.

Markers for individual wires and conductors shall be machine generated. From-to designations shall be denoted on the marking on the individual conductors.

16510.2.3.9 Cable Ties. Lacing materials for field installed cable shall be nonreleasing weather-resistant black nylon ties manufactured by the Ameren Missouri Approved Suppliers.

16510.2.3.10 Arcproofing Material. Material for the arcproofing of nonflame retardant cable shall be an unsupported intumescent self-extinguishing elastomer tape, and a pressure sensitive silicone adhesive backed glass cloth holding tape, as listed in Ameren Missouri Approved Suppliers," or an acceptable equal.

16510.2.3.11 Cable Termination Kits for Shielded Cable Rated 5 kV and Above. All cable termination kits for shielded cable rated 5 kV and above shall be in accordance with the requirements of IEEE 48 for Class 1 terminations.

Cable termination kits for 5 kV and 15 kV shielded cable in motor terminal housings shall be as shown in Ameren Missouri Approved Suppliers.

Outdoor cable termination kits and indoor cable termination kits for cable of voltage classes above 15 kV shall be as specified on the drawings.

Stress cones shall be provided for all MV cable terminations.

16510.2.3.12 Not Used.

16510.2.3.13 Pulling Lubricant. Pulling lubricant shall be provided as recommended by the cable manufacturer.

16510.2.3.14 Fiber-Optic Cable Accessories.

16510.2.3.14.1 Inner duct. Inner ducts for fiber-optic cable shall be no smaller than 1 inch, flame-resistance, corrugated, orange colored, with measuring/pull tape, and shall be as shown in Ameren Missouri Approved Suppliers or an acceptable equal for plenum, riser and general purpose applications in accordance with NEC Articles 770 and 800. The actual size of the inner duct shall be coordinated with the fiber-optic manufacturer's requirements by the Contractor. The pulling tape shall have a recommended maximum working load of at least 1,200 pounds.

16510.2.3.14.2 Pulling equipment. Pulling equipment for fiber-optic cable shall include a recording running line dynamometer graph to measure and record the pulling tension, as manufactured by the list in Ameren Missouri Approved Suppliers or an acceptable equal. The pulling equipment shall have "slip load" capability to allow the winch to maintain a constant pulling force without taking up the winch line. The pulling equipment shall also be equipped with a hydraulic bypass which shall be set so that a maximum tension of 150 pounds is not exceeded. A reliable, nonfreezing swivel shall be provided for insertion between the pulling line and the cable pulling grip to prevent twisting under strain. The swivel shall be equipped with shear or tension pins with a breaking strength of 150 pounds. Swivels shall be by manufacturers as shown in Ameren Missouri Approved Suppliers or an approved equal. Woven wire grips shall be provided to pull the cable unless not allowed by the manufacturer of the fiber-optic cable. Woven wire grips shall be chosen from Ameren Missouri Approved Suppliers or an acceptable equal, with a minimum length of 18 inches. The grips shall have provisions for tying the Kevlar jacket to the grip.

16510.2.3.14.3 Pulling lubricants. Pulling lubricants shall be provided for pulling both the inner duct and the fiber-optic cable. Pulling lubricants for installation of the inner duct shall be as noted in Ameren Missouri Approved Suppliers or acceptable equal. Pulling lubricants for installing the cable shall be in the Ameren Missouri Approved Suppliers.

16510.2.3.14.4 Fiber-optic cable terminations. Fiber-optic cable terminations and optical connectors shall be approved by the cable manufacturer for use with the type of fiber-optic cable specified. Utilize ceramic ferrule, field installed and polished, anaerobic cure connectors. Quick connect crimp type

connectors shall not be used. As an option, pre-terminated pigtail connectors may be used where they are fusion spliced to the fiber-optic cables and heat shrink tubes and suitable splice trays are utilized.

Utilize ST type connectors for DCS system fiber-optic cables and SC type connectors for Facility LAN system fiber-optic cables unless otherwise noted on the drawings.

Any special tools and materials required to install the fiber-optic cable connectors shall be provided by the Contractor.

16510.3 Execution

If installation is included in the scope of work, installation shall be in accordance with the requirements of Section 16925 - Conductors Installation.

16510.4 PV Panel Additions

a. DC cable shall be 90°C (wet or dry) power cable type XHHW with UL 1581, VW-1 rating at the appropriate voltage rating

b. PV Panel interconnect DC cable shall be type USE-2 cable, or approved equal with XLP jacket capable of meeting DC collection system design current requirements

c. Externally installed cables shall be sunlight resistant, suitable for direct burial and conform with NEC 300.5 underground installation, minimum cover requirement is thirty-six inches (36”) including voltage classes not covered in NEC 300.5

d. PV panel interconnect connectors shall be latching, polarized, and non-interchangeable with receptacles in other systems. Grounding member shall be first to make and last to break contact with mating connector and shall be rated for interrupting current without hazard to operator.

e. PV panel interconnect connectors shall be tee tap branch connectors and multi-contact termination connectors.

f. Cables shall be listed and identified as PV wire in accordance with NEC Article 690.

g. If a cable tray is utilized, Supplier shall submit cable tray design for Company Review.

h. All medium voltage underground cable shall be mapped and identified along their entire run with hazard tape and tracing, 18” above the cable elevation and 18” below finish grade elevation.

i. All risers shall be galvanized, rigid steel conduit.

j. All ninety degree (90°) bends shall be long sweeps installed in accordance with NEC, Chapter 9, Table 2.

k. All underground conduit within the PV array footprint shall be installed in conduit per NEC. Conduits shall be a minimum schedule 40 PVC conduit. Conduit above 18 inch depth shall be schedule 80 PVC.

l. Underground cable outside of the PV array footprint can be direct buried at a minimum of three feet (3’) of below finish grade elevation.

m. No underground cable splicing shall be acceptable under any circumstances. All cable splices shall be brought above ground and housed in a suitable enclosure.

5 kV AND 8 kV POWER CABLE
SPECIFICATION SHEET

A. DESCRIPTION: 5kV/8 kV single conductor cable UL listed as Type MV-90, NEC Type TC.

B. CONDUCTOR: Annealed bare copper Class B stranded in accordance with ASTM B-8.

C. INSULATION: Ethylene Propylene Rubber (EPR) or cross-linked polyethylene (XLPE) in accordance with ICEA S-97-682.

D. INSULATION LEVEL: 133% for 5 kV, 100% for 8 kV.

E. JACKET: Chlorinated Polyethylene (CPE) or Chlorosulfonated Polyethylene (Hypalon) in accordance with ICEA S-97-682.

F. SHIELDING: Strand shield - Extruded semi-conducting material applied directly to the insulation in accordance with ICEA S-97-683, Part 3.

Insulation shield - Extruded semi-conducting material applied directly over the insulation in accordance with ICEA S-97-683, Parts 5 and 6.

Metallic shield - 5 mil bare copper tape helically wrapped with a 10% minimum overlap to provide 100% coverage.

G. TEMPERATURE:

Normal Continuous	90°C
Emergency	130°C
Short Circuit	250°C

H. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-97-682, AEIC CS8, and IEEE-1202.

I. CERTIFICATION: All cables shall be certified to be in conformance with all applicable requirements of ICEA S-97-682, AEIC CS8, and IEEE 1202.

15 kV POWER CABLE
SPECIFICATION SHEET

A. DESCRIPTION: 15 kV single conductor cable UL listed as Type MV-90, NEC Type TC.

B. CONDUCTOR: Annealed bare copper Class B stranded per ASTM B-8.

C. INSULATION: Ethylene Propylene Rubber (EPR) or cross-linked polyethylene (XLPE) in accordance with ICEA S-97-682.

D. INSULATION LEVEL: 220 mil or 133% insulation level.

E. JACKET: Chlorinated Polyethylene (CPE) or Chlorosulfonated Polyethylene (Hypalon) in accordance with ICEA S-97-682.

F. SHIELDING: Strand shield - Extruded semi-conducting material applied directly over the insulation in accordance with ICEA S-97-683, Part 3.

Insulation shield – Extruded semi-conducting material applied directly over the insulation in accordance with ICEA S-97-683, Parts 5 and 6.

Metallic shield – 5 mil bare copper tape helically wrapped with a 10% minimum overlap to provide 100% coverage.

G. TEMPERATURE:

Normal Continuous	90°C
Emergency	130°C
Short Circuit	250°C

H. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-97-682, AEIC CS8, and IEEE-1202.

I. CERTIFICATION: All cables shall be certified to be in conformance with all applicable requirements of ICEA S-97-682, AEIC CS8, and IEEE 1202.

600 V SHIELDED MULTICONDUCTOR CONTROL CABLE
SPECIFICATION SHEET #CC1

A. DESCRIPTION: 600 volt, shielded, multiconductor, control cable, NEC Type TC.

B. CONDUCTOR: Class B, stranded bare or tinned soft annealed copper in accordance with ASTM B-3 or B-33 for 14, 12 or 10 AWG.

C. INSULATION: Cross-linked polyethylene "XLPE" or ethylene-propylene rubber "EPR" in accordance with
ICEA S-73-532, Part 3; Not less than 30 mils average insulation thickness.
Color coding shall be in accordance with ICEA S-73-532, Appendix E, Method 1, Table E-2. The color of the conductor shall also be printed on the conductor.

D. JACKET: Chlorosulfonated polyethylene "Hypalon" or chlorinated polyethylene (CPE) (ICEA S-73-532, Part 4) of the following thicknesses (ICEA S-73-532, Table 4-1):

1. 45 mils: 14 AWG, 2 to 7 conductors; 12 AWG, 2 to 5 conductors; 10 AWG, 2 to 3 conductors
2. 60 mils: 14 AWG, 9 to 12 conductors; 12 AWG, 7 to 12 conductors; 10 AWG, 4 to 9 conductors
3. 80 mils: 10 AWG, 12 conductors

Include rip cord under the jacket to facilitate stripping.

E. SHIELD: Aluminum mylar with drain wire.

F. IDENTIFICATION: Surface printing on the cable shall show the manufacturer's name, insulation type, jacket type, number and size of conductors, voltage rating, and numbered footage markers.

G. TEMPERATURE: Cable shall be suitable for continuous use at 90°C wet or dry in accordance with ICEA S-73-532.

H. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-73-532 and IEEE 1202.

I. CERTIFICATION: All cables shall be certified to be in conformation with all applicable requirements of ICEA S-73-532 and IEEE 1202.

600 V UNSHIELDED MULTICONDUCTOR CONTROL CABLE
SPECIFICATION SHEET #CC2

A. DESCRIPTION: 600 volt, unshielded, multiconductor, control cable, NEC Type TC.

B. CONDUCTOR: Class B, stranded bare or tinned soft annealed copper in accordance with ASTM B-3 or B-33 for 14, 12, or 10 AWG.

C. INSULATION: Cross-linked polyethylene "XLPE" or ethylene-propylene rubber "EPR" in accordance with ICEA S-73-532, Part 3; not less than 30 mils average insulation thickness. Color coding shall be in accordance with ICEA S-73-532, Appendix E, Method 1, Table E-2.

D. JACKET: Chlorosulfonated polyethylene "Hypalon" or chlorinated polyethylene (CPE) (ICEA S-73-532, Part 4) of the following thicknesses (ICEA S-73-532, Table 4-1):

1. 45 mils: 14 AWG, 2 to 7 conductors; 12 AWG, 2 to 5 conductors; 10 AWG, 2 to 3 conductors.
2. 60 mils: 14 AWG, 9 to 12 conductors; 12 AWG, 7 to 12 conductors; 10 AWG, 4 to 9 conductors.
3. 80 mils: 10 AWG, 12 conductors.

Include rip-cord under the jacket to facilitate stripping.

E. IDENTIFICATION: Surface printing on the cable shall show the manufacturer's name, insulation type, jacket type, number and size of conductors, voltage rating, and numbered footage markers.

F. TEMPERATURE: Cable shall be suitable for continuous use at 90°C wet or dry in accordance with ICEA S-73-532.

G. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-73-532 and IEEE 1202.

H. CERTIFICATION: All cables shall be certified to be in conformation with all applicable requirements of ICEA S-73-532 and IEEE 1202.

600 V INSTRUMENTATION CABLE
SPECIFICATION SHEET #IC1

A. DESCRIPTION: 600 volt, instrumentation cable, with individually shielded, twisted pairs or triads, as specified. NEC type TC.

B. CONDUCTOR: Class B, stranded bare or tinned coated soft annealed copper in accordance with ASTM B-3 or B-33, conforming to ASTM B-8, 16 AWG.

C. INSULATION: Cross-linked polyethylene "XLPE" (ICEA S-82-552) or ethylene-propylene rubber "EPR" (ICEA S-82-552); thickness: 25 mils (ICEA S-82-552). Color coding shall be by ICEA S-82-552, Appendix E, Method 9A, using the color-pigmented compounds. Each pair shall have one (1) white and one (1) black conductor with printed numbers for pair identification.

D. PAIR/TRIAD SHIELD: Aluminized mylar tape with a 7 strand tinned-copper drain wire. Shields to be isolated from all other assemblies.

E. CABLE SHIELD: Aluminized mylar tape with tinned-copper drain wire.

F. JACKET: Chlorosulfonated polyethylene "Hypalon" or chlorinated polyethylene (CPE) in accordance with ICEA S-82-552 of the following thicknesses:

1. 60 mils: 1, 2, 4, 6, or 8 pairs
2. 80 mils: 12 pairs

Include rip cord under the jacket to facilitate stripping.

G. IDENTIFICATION: Surface printing on the cable show the manufacturer's name, insulation type, jacket type, number of pairs, size of conductors, voltage rating, and numbered footage markers.

H. TEMPERATURE: Cable shall be suitable for continuous use at 90°C wet or dry (ICEA S-82-552).

I. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-82-552 and IEEE 1202.

J. CERTIFICATION: All cables shall be certified to be in conformance with all applicable requirements of ICEA S-82-552, and IEEE 1202.

600 V SINGLE CONDUCTOR POWER CABLE
SPECIFICATION SHEET #PC1

A. DESCRIPTION: 600 volt, single conductor, power cable. NEC type CT for sizes #1/0 and larger, and type CT for sizes below #1/0 where the cable is to be installed in tray.

B. CONDUCTOR: Class B stranded bare or tinned coated soft annealed copper per ASTM B-3 or
B-33 or Class K, G, or I flexible stranding per ASTM B-8.

C. INSULATION: Ethylene propylene "EPR" or "XLPE" per ICEA S-95-658 of the following thicknesses (ICEA S-95-658 Table 3-4, Column A for cables without an overall jacket covering, or Column B for cables with a jacket meeting the requirements in "Part D. JACKET" on this spec sheet):

Insulation w/o Jacket		Insulation w/Jacket	
1.	45 mils: 14 to 10 AWG	30 mils:	14 to 10 AWG
2.	60 mils: 8 to 2 AWG	45 mils:	8 to 2 AWG
3.	80 mils: 1 to 4/0 AWG	55 mils:	1 to 4/0 AWG
4.	95 mils: 250 to 500 MCM	65 mils:	250 to 500 MCM
5.	110 mils: 750 to 1000 MCM	80 mils:	750 to 1000 MCM

Color coding shall be ICEA Method 1 and shall be black, unless noted otherwise using color pigmented compounds.

D. JACKET: For NEC type CT for sizes #1/0 and larger (or smaller cables to be installed in tray), jacket shall be as follows: Chlorosulfonated polyethylene "Hypalon" (ICEA S-95-658, Section 4, Para. 4.1.11) or chlorinated polyethylene (CPE) (ICEA S-95-658, Section 4, Para. 4.1.12). Thicknesses per ICEA S-95-658, Table 4.3:

1. 15 mils: 14 to 8 AWG
2. 30 mils: 6 to 2 AWG
3. 45 mils: 1 to 4/0 AWG
4. 65 mils: 250 to 500 MCM
5. 80 mils: 750 to 1000 MCM

E. IDENTIFICATION: Surface printing on the cable shall show the manufacturer’s name, insulation type, conductor size, voltage rating, and numbered footage markers.

F. TEMPERATURE: Cable shall be suitable for operation under the following maximum conductor temperatures:

1. 90° C: Continuous wet or dry locations

2. 130° C: Emergency

3. 250° C: Short Circuit

G. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-95-658, and IEEE 1202.

H. CERTIFICATION: All cables shall be certified to be in conformance with all applicable requirements of ICEA S-95-658, and IEEE 1202.

600 V MULTI-CONDUCTOR POWER CABLE
SPECIFICATION SHEET #PC2

A. DESCRIPTION: 600 volt, 2, 3, or 4 conductor, power cable, NEC Type TC.

B. CONDUCTOR: Class B stranded bare or tinned coated soft annealed copper in accordance with ASTM B-3 or B-33.

C. INSULATION: Cross-linked polyethylene "XLPE" or ethylene propylene "EPR" (ICEA S-95-658) of the following thicknesses (ICEA S-95-658, Table 3-4, Column B):

1. 30 mils: 14 to 10 AWG; 2, 3, or 4 conductors
2. 45 mils: 8 to 2 AWG; 2, 3, or 4 conductors
3. 55 mils: 1 to 4/0 AWG; 2, 3, or 4 conductors
4. 65 mils: 250 to 500 kCMIL; 2, 3, or 4 conductors
5. 80 mils: 750 kCMIL; 2, 3, or 4 conductors

Color coding for 14-10 AWG shall be ICEA Method 1, Table E2 and for 8 AWG-750 kCMIL colors shall be ICEA Method 4.

D. JACKET: Chlorosulfonated polyethylene "Hypalon" (ICEA S-95-658, Section 4, Para. 4.1.11) or chlorinated polyethylene (CPE) (ICEA S-95-658, Section 4, Para. 4.1.12) of the following thicknesses (ICEA S-95-658, Table 4-5):

1. 45 mils: 14 AWG, 2 to 4 conductors; 12 AWG, 2 to 4 conductors; 10 AWG 2 or 3 conductors
2. 60 mils: 10 AWG, 4 conductors; 8 AWG, 2 to 4 conductors; 6 AWG 2 to 4 conductors; 4 AWG, 2 or 3 conductors
3. 80 mils: 4 AWG, 4 conductors; 4/0 AWG 3 conductors; Include rip cord under the jacket to facilitate stripping.
4. 110 mils: 4/0 AWG, 4 conductors; 500 kCMIL 4 conductors; Include rip cord under the jacket to facilitate stripping.
5. 140 mils: 750 kCMIL, 3 to 4 conductors; Include rip cord under the jacket to facilitate stripping.

E. IDENTIFICATION: Surface printing on the cable shall show the manufacturer's name, insulation type, jacket type, number and size of conductors, voltage rating, and numbered footage markers.

F. TEMPERATURE: Cable shall be suitable for operation under the following maximum conductor temperatures:

90° C: Continuous wet or dry locations

130° C: Emergency

250° C: Short Circuit

G. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-95-658 and IEEE 1202.

H. CERTIFICATION: All cables shall be certified to be in conformance with all applicable requirements of ICEA S-95-658 and IEEE 1202.

600 V THERMOCOUPLE EXTENSION CABLE
SPECIFICATION SHEET #TEC1

A. DESCRIPTION: 600 volt, thermocouple extension cable, with individually shielded twisted pairs. NEC type TC.

B. CONDUCTOR: 16 AWG, solid:

Type	Positive Wire	Negative Wire
JX	Iron	Constantan
KX	Chromel	Alumel
TX	Copper	Constantan
EX	Chromel	Constantan

C. INSULATION: Cross-linked polyethylene "XLPE" or ethylene propylene rubber "EPR" ICEA S-82-552, Part 3; not less than 25 mils average thickness. Color coding shall be by ANSI-MC96.1, using color pigmented compounds. Each pair shall have one (1) positive wire and one (1) negative wire (ANSI). Multiple pairs shall be printed with numbers for pair identification.

D. PAIR SHIELD: Aluminized mylar tape with a 7 strand tinned-copper drain wire. Shields to be isolated from all other assemblies.

E. CABLE SHIELD: Aluminized mylar tape with tinned-copper drain wire.

F. JACKET: Chlorosulfonated polyethylene "Hypalon" or chlorinated polyethylene (CPE) in accordance with ICEA S-82-552 of the following thicknesses:

1. 45 mils: 1 pair
2. 60 mils: 2, 4, 6, or 8 pairs
3. 80 mils: 12 pairs

Jacket color shall be black (ANSI). Include rip cord under the jacket to facilitate stripping.

G. IDENTIFICATION: Surface printing on the cable shall show the manufacturer's name, insulation type, jacket type, number of pairs, size of conductors, voltage rating, and numbered footage markers.

H. TEMPERATURE: Cable shall be suitable for continuous use at 90°C wet or dry (ICEA S-82-552).

I. TESTING: All cables shall be tested in accordance with the requirements of ICEA S-82-552 and IEEE 1202.

J. CERTIFICATION: All cables shall be certified to be in conformance with all applicable requirements of ICEA S-82-552 and IEEE 1202.

SECTION 16910
ELECTRICAL EQUIPMENT INSTALLATION

16910.1 General

The Contractor shall provide schematics, interconnection, and wiring drawings before that phase of the electrical construction begins which requires the use of these drawings.

16910.1.1(1) Scope of Supply

Scope of supply shall include the electrical equipment installation as defined in the Contract.

16910.1.1(2) Scope of Supply

Scope of supply shall include the electrical equipment installation as defined herein.

16910.1.1.1 Scope of Erection/Installation. The scope of erection/installation shall include the following:

Table 16910-1 Scope of Erection/Installation	
Item	**Installation Requirements Article**
Transformer	16910.3.2
Batteries and Battery Chargers	16910.3.4
Continuous AC Power Equipment	16910.3.8
Panelboard	16910.3.5
Cable Bus	16910.3.7
Nonsegregated Phase Bus Duct	16910.3.7
Medium Voltage Switchgear and Controllers	16910.3.8
Low Voltage Equipment	16910.3.8
Metering and Relaying Cabinets	16910.3.8

16910.1.2 Not Used

16910.1.3 Not Used

16910.1.4 Not Used

16910.1.5 Not Used

16910.1.6 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.

Table 16910-3 Approved Manufacturers	
Component	**Manufacturer**
None.	

16910.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure.

Table 16910-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Battery Capacity Discharge Testing	IEEE 450	Contractor

16910.1.8 Not Used

16910.1.9 Not Used

16910.2 Not Used

16910.3 Execution

16910.3.1 Installation Requirements Applicable to All Equipment

16910.3.1.1 General. This article covers installation work for all electrical equipment installed or furnished and installed under these specifications.

Installation work shall include receiving, unloading, storage, removal from storage, hauling, cleaning, installation on foundations, and other work necessary to place all equipment into successful operation.

In addition, installation work shall include complete assembly of equipment shipped unassembled; dismantling and reassembly of equipment to make adjustments; and provision of personnel, equipment, and assistance in testing and placing the equipment into operation.

Installation procedures not specified herein shall be in accordance with the instructions, recommendations, and/or drawings of the equipment manufacturer. Contradictions between these specifications and the manufacturer's instructions, recommendations, and drawings shall be resolved by the manufacturer's recommendations taking precedence.

The Contractor shall submit detailed installation procedures and schedule for approval by the Owner prior to starting installation work.

All installation work on this equipment shall be performed under these specifications. Work under these specifications shall include the installation of all wiring that is included under the scope of equipment installed under these specifications.

All electrical equipment shall be inspected and cleaned to be free of foreign materials including dirt, dust, shaving, wrappings, and other miscellaneous foreign matter introduced during assembly and construction. The Contractor shall confirm that all filters, such as on the inverter cabinets, are in place. Cleaning shall be completed prior to equipment turn-over to the Owner.

16910.3.1.2 Miscellaneous Material. All miscellaneous materials shall be furnished as required for the complete installation, startup testing, and operation of the equipment. These materials shall include, but shall not be limited to, grout, shims, wedges, dowels, anchors, supports, bolting, gaskets, packing, welding rod, and consumable gases.

Anchors as required by the equipment manufacturer shall be furnished and installed by the Contractor.

16910.3.1.3 Location Tolerances. Equipment shall be located within 1/8 inch of the dimensional location indicated on the drawings unless otherwise permitted by the Engineer. Some equipment is indicated schematically without dimensions. The Contractor shall coordinate the location of this equipment with all other equipment or materials to be installed.

16910.3.1.4 Alignment. Rigid components such as bus, bus duct, throat connections, and enclosures shall be aligned and connected with special care to prevent excessive stress in joints, supports, and connections.

Equipment with moving parts and safety interlocks, such as switches, circuit breakers, and switch operating mechanisms shall be carefully aligned to assure free mechanical operation.

The Contractor shall confirm the alignment of all bus bar across equipment shipping splits.

16910.3.1.5 Bolted Electrical Connections. Where bolted electrical connections are made to aluminum, the aluminum surface shall be thoroughly cleaned with a wire brush, then coated with joint compound and thoroughly brushed again through the compound. Additional compound shall then be added and the joint bolted together.

Where bolted connections are made between copper or brass surfaces, the metal surfaces shall be thoroughly cleaned and coated with a suitable antioxidizing compound.

It shall be the Contractor's responsibility to certify that the tightness of each bolt in all bolted electrical connections is in accordance with the manufacturer's recommendations. Factory bolt torques shall be verified as part of the equipment checkout and test procedures.

Bolted electrical connections shall be tightened with manual torque wrenches. Torque wrenches shall be constructed so that they will visually or audibly indicate when the proper torque is reached. The accuracy of each torque wrench shall be checked by a testing laboratory acceptable to the Owner immediately prior to its use on equipment installed under these specifications, and every 6 months thereafter, or sooner if the calibration of the wrench becomes suspect.

16910.3.1.6 Torque Values. If the equipment manufacturer's installation instructions do not include recommended torque values for bolt tightening, torque values shall be in accordance with those listed in the following table:

Table 16910-5 Torque Values For Dry, Unplated, Nonlubricated Bolts

Torque Values For Dry, Unplated, Nonlubricated Bolts					
Bolt Size	**18-8 Stainless Steel (in.-lb)**	**Brass (in.-lb)**	**Silicon Bronze (in.-lb)**	**Aluminum 24ST-4 (in.-lb)**	**316 Stainless Steel (in.-lb)**
1/4" - 20	75.2	61.5	68.8	45.6	78.8
1/4" - 28	94.0	77.0	87.0	57.0	99.0
5/16" - 18	132	107	123	80	138
5/16" - 24	142	116	131	86	147
3/8" - 16	236	192	219	143	247
3/8" - 24	259	212	240	157	271
7/16" - 14	376	317	349	228	393
7/16" - 20	400	327	371	242	418
1/2" - 13	517	422	480	313	542
1/2" - 20	541	443	502	328	565
9/16" - 12	682	558	632	413	713
9/16" - 18	752	615	697	456	787

Table 16910-5 Torque Values For Dry, Unplated, Nonlubricated Bolts					
Torque Values For Dry, Unplated, Nonlubricated Bolts					
Bolt Size	**18-8 Stainless Steel (in.-lb)**	**Brass (in.-lb)**	**Silicon Bronze (in.-lb)**	**Aluminum 24ST-4 (in.-lb)**	**316 Stainless Steel (in.-lb)**
5/8" - 11	1,110	907	1,030	715	1,160
5/8" - 18	1,244	1,016	1,154	798	1,301
3/4" - 10	1,530	1,249	1,416	980	1,582
3/4" - 16	1,490	1,220	1,382	958	1,558
7/8" - 9	2,328	1,905	2,140	1,495	2,430
7/8" - 14	2,318	1,895	2,130	1,490	2,420
1" - 8	3,440	2,815	3,185	2,205	3,595
1" - 14	3,110	2,545	2,885	1,995	3,250

16910.3.1.7 Connection Bolt Tightness Check. The tightened bolts in electrical connections shall be checked at random. The Contractor shall be responsible for coordinating the checking of bolt tightness so that minimum interference with equipment installation and connection will be experienced. Removal of covers and similar dismantling of equipment to permit the Owner to witness the checking of bolt tightness of enclosed connections shall be part of the work included under these specifications.

The number of bolts checked shall be acceptable to the Owner, based upon his observance of the quality and completeness of the tightening operations. A minimum of 10 percent of the bolts in each connection, but not less than two bolts in each connection, shall be checked.

Checking of tightness of electrical connections in the presence of the Owner is intended to assist the Contractor in avoiding the expense of repairing costly connection failures. This check shall not relieve the Contractor of complete responsibility for the integrity of the electrical connections.

16910.3.1.8 Welding. All workmen performing ferrous welding of any kind shall be qualified according to the codes and standards indicated in the applicable supplemental specification.

16910.3.1.9 Equipment Finish. Surfaces of most electrical equipment, such as panels, switchgear, transformers, and circuit breakers, are finished at the factory. Great care shall be exercised to prevent damage to this original finish during equipment installation and during construction work.

If the factory finish is damaged during the course of construction, the damaged component shall be touched up or refinished to the satisfaction of the Owner by the Contractor.

Refinishing paint, if furnished with the equipment, may be used; otherwise, the paint shall be obtained from the equipment manufacturer.

16910.3.2 Transformer Erection

16910.3.2.1 General. The transformers shall not be unloaded until the transformer has been inspected for evidence of load shifting, and until any impact recorder data has been examined for evidence of high impacts and a megger test and internal inspection have been performed. A concealed damage claim shall be filed with the carrier if such evidence is found. Impact recorders shall be used during loading, shipment, and unloading/placement of SSTs.

Transformers shall be installed in accordance with the manufacturer's instructions, recommendations, and drawings.

Movement of each transformer tank with core and coils to its permanent foundation shall be done in accordance with manufacturer's instructions and recommendations.

Transformers shall be securely grounded prior to the start of any installation work or inspections.

All instruments, gauges, and switches and other parts subject to damage shall be carefully protected during construction. All bushings and insulators shall be thoroughly cleaned of paint, dirt, or any other contaminating material with a nonresidue type solvent. All valves for oil filling and draining, and for vacuum connections, shall use standard pipe threads.

All bushings on the transformer and all other component parts disassembled for shipment, shall be mounted. Conduits and wiring connections for all components shall be completed as required. The entire installation shall be done in accordance with the manufacturer's instructions.

16910.3.3 Not Used

16910.3.4 Batteries and Battery Chargers Installation

16910.3.4.1 General. The Contractor shall install and connect the batteries and battery chargers and prepare them for operation, in accordance with the battery manufacturer, immediately upon their arrival at the jobsite.

A temporary power supply shall be connected to each battery charger and shall be maintained in service until permanent power supplies are installed and ready for continuous energization. The source for the temporary power supply shall be reliable. A freshening charge shall be given to each battery within 90 days after its shipment from the factory.

16910.3.4.2 Assembly. The assembly of each battery and battery rack shall be in accordance with the manufacturer's recommendations and assembly instructions.

The individual cells or modules shall be lifted using the lifting equipment recommended by the battery manufacturer. Cells or modules shall be lifted by the channels or the bottom of the case and not by the cell posts. Cell polarity shall be checked for positive to negative connections throughout the battery.

Prior to installing intercell connectors, the Contractor shall inspect all terminal posts and connecting hardware. Any area showing evidence of corrosion, dirt, or acid shall be cleaned, exercising care to prevent removal of lead plating. A thin film of corrosion inhibiting grease shall be applied to all contact surfaces. Intercell connections shall be completed with connectors and associated hardware supplied by the battery manufacturer. Where more than one intercell connector per cell post is required, the connectors shall be mounted on opposite sides of the post for maximum surface contact. Both ends of the connection bolts shall be tightened to the manufacturer's recommended torque values.

All cell covers and containers shall be cleaned. A water moistened clean wipe shall be used for the removal of dust and dirt. A bicarbonate of soda and water moistened wipe shall be used for cleanup of electrolyte spillage. All wipes used shall be free of oil distillates. Explosion resistant vent plugs shall be installed where provided. Individual cell numbers in sequence with No. 1 at the positive end of the battery shall be applied for permanent identification.

The voltage of the battery shall be measured to ensure that individual cells are connected correctly. If the measured voltage is less than approximately the number of cells multiplied by the measured voltage of one cell, the individual cell polarities shall be rechecked.

Intercell connection resistance shall be measured and recorded. Any connection with a resistance measurement exceeding 10 percent above the average shall be remade and remeasured.

Final connections from the battery to the charger and dc system shall be installed after assembly of the battery has been completed.

After the battery assembly is complete to the stage of intercell connections, the battery shall be protected from construction dirt and debris.

16910.3.4.3 Freshening Charge and Testing. A freshening charge shall be applied to each battery after installation. Freshening charges shall be applied in accordance with the manufacturer's instructions and recommendations.

16910.3.4.3.1 Flooded cell batteries. The temperature, voltage, and specific gravity of each cell shall be measured and recorded prior to applying the charge. The cell with the lowest specific gravity shall be selected as a pilot cell. All cells shall be inspected and water shall be added as necessary to bring the electrolyte to the "Low Level" line. The quality of all water added to the battery cells shall be in accordance with the manufacturer's instructions and recommendations. The specific gravity and temperature of the electrolyte of the pilot cell shall be measured and recorded at least once daily. After pilot cell specific gravity readings become constant (with correction for temperature), distilled water shall be added to all cells to bring electrolyte up to the "High Level" line. The charge shall be continued for 3 hours at which time the charge voltage shall be returned to normal float voltage. After an additional 72 hours of floating charge, all individual cell voltages, temperatures, and specific gravities shall be measured and recorded as specified in this section under the article entitled Records. If the specific gravity of any cell, corrected to a temperature of 77° F, measures less than 1.200 or more than 1.220, or the voltage of any cell measures more than 0.04 volt below the average, the Contractor shall notify the Owner, who will inform him as to how he shall proceed.

The Contractor shall furnish any temporary ventilation equipment necessary to exhaust any explosive gases generated by flooded cell batteries during charging of the batteries. The Contractor shall maintain this temporary ventilation system until the permanent ventilation system is placed into service.

16910.3.4.3.2 Not used.

16910.3.4.4 Capacity Discharge Test. A capacity discharge test shall be conducted in accordance with IEEE Standard 450. Testing equipment and test load shall be furnished as specified in Article 16910.1.

16910.3.4.5 Records. Data obtained from receiving, storage, and assembly is pertinent to the maintenance and operational life of the battery. Listed below, as applicable, are the data that shall be recorded and submitted to the Owner:

Date of receipt of battery. Cells should not be stored for more than the time period recommended by the manufacturer without applying a charge to the battery. In all cases, a period of 3 months' storage is allowable between charges if the cells are stored in a clean, dry, cool location without exposure to extremely low ambient temperatures or localized sources of heat.

Initial resistance values of the intercell connections measured as specified in this section under the article entitled Assembly.

Charging current, individual cell voltage, temperature, and specific gravity (corrected to a temperature of 77° F) measurements as specified in this section under the article entitled Freshening Charge and Testing.

Capacity discharge test data obtained as specified in this section under the article entitled Capacity Discharge Test (if required).

16910.3.5 Panelboard Installation

The panelboards shall be installed in accordance with the requirements of Article 16120.3.

16910.3.6 Not Used

16910.3.7 Nonsegregated Phase Bus Duct or Cable Bus Installation

16910.3.7.1 General. The Contractor shall provide experienced technical supervisory personnel for the installation of the nonsegregated phase bus duct or cable bus system. Technical supervision shall include interpretation of the manufacturer's assembly and installation drawings and instructions.

If specified in Article 16910.1, the Contractor shall furnish a complete support system for the nonsegregated phase bus duct or cable bus. The support system shall include galvanized threaded steel hanger rods, beam clamps, anchors, and cross member material as follows:

Hanger rods shall be 1/2 inch diameter threaded steel rods.

Where hanger rods will be supported from building steel, they shall be attached with strut, miscellaneous support steel, or beam clamps.

Where hanger rods will be supported from concrete surfaces, they shall be fastened with self-drilling tubular expansion shell anchors with externally split expansion shells, single cone expanders, and annular breakoff grooved chucking cones.

Strut material shall be hot-dip galvanized after fabrication. Minimum channel size shall be 1-5/8 inch wide by 1-5/8 inch high, 12 gauge steel.

The Contractor shall install the bus support system in accordance with these specifications and the manufacturer's instructions, recommendations, and drawings.

Termination of the bus duct or cable bus at equipment shall be in accordance with the manufacturer's drawings and instructions and with these specifications.

The bus duct or cable bus housing sections shall be connected with bolts and hardware designed for that purpose. At each bus duct or cable bus housing section connection, the Contractor shall install one Everdur bolt or Owner-acceptable equal and star washer using a torque wrench. The Everdur bolt shall be installed with a minimum torque of 25 foot-pounds and a maximum torque of 35 foot-pounds. The bolt and washer shall be installed at each joint in the bus duct or cable bus housing in such a manner that the housing will provide an electrically continuous path for ground current.

16910.3.7.2 Nonsegregated Phase Bus Duct. The Contractor shall furnish molded boots for insulation of bus terminations. The Contractor shall also furnish all bus duct bolts, straps, and plates for connection of the bus to equipment. The Contractor shall install termination and termination insulating materials required for a complete bus duct system.

16910.3.7.3 Cable Bus. The Contractor shall install cable within the cable bus system in accordance with the manufacturer's recommendations and instructions.

Cable termination materials, including stress relief devices, shall be furnished and installed by the Contractor.

16910.3.8 Electrical Distribution and Control Equipment Installation

16910.3.8.1 General. Extreme care shall be taken in the storage, handling, and installation of all electrical distribution and control equipment containing solid-state devices or electrical contacts to prevent the entrance of dust, dirt, moisture, or other contaminants. Equipment shall be kept covered and doors shall be kept closed until the equipment is placed into operation and turned over to the Owner. All space heaters inside the equipment shall be energized during storage and construction, as required. Any equipment damaged by contamination or condensation after receipt of the equipment shall be repaired or replaced.

Upon the removal of the electrical equipment from its storage location, the equipment shall immediately be set or installed in its permanent location. Equipment shall be protected from rain or dripping water with waterproof coverings until the structure in which the equipment has been set has proven the integrity of its roof and drainage system through substantial rainfall.

Free standing electrical equipment, such as switchgear, electrical cabinets and enclosures, low voltage switchgear, etc. mounted on concrete floors shall be installed on housekeeping pads. The housekeeping pads shall have a minimum height of 4 inches. Leveling channels shall be provided for switchgear and MCCs and multisection panels where leveling of the panels may be required. Equipment, such as breaker trucks, shall be provided for switchgear and MCCs to safely remove and reinstall breakers or contactors from their enclosures. When equipment is located on housekeeping pads, the truck shall be designed to remove and reinstall the breakers without having to manually lift the breakers or contactors when removing or inserting the breakers or contactors into the switchgear compartment.

16910.3.8.2 Electrical Cabinets and Enclosures. Electrical cabinets shall be set in place, shimmed level, and anchored so that all doors operate freely throughout their entire travel. Cabinets that are split for shipping shall be aligned, shimmed, and fastened together in accordance with the manufacturer's recommendations. Wiring across shipping splits shall be terminated in accordance with the manufacturer's drawings or instructions.

16910.3.8.3 Medium Voltage Switchgear and Controllers. Medium voltage switchgear and controllers shall be installed as specified herein and as detailed on the manufacturer's drawings and instructions.

If the equipment is to be supported on steel channels embedded in the floor or concrete housekeeping pad, the channels shall be checked for levels and the concrete checked for high or low spots. The equipment shall then be set, bolted together, level verified, and door swing checked before welding the equipment to the channels. Switchgear shall be installed on minimum 4 inch high concrete housekeeping pads.

Wiring harnesses shall be provided for connections across shipping splits. The Contractor shall clean and bolt together all bus connections, install bus insulation over these connections by taping or by use of molded insulating boots, remove all shipping braces, install the breakers and motor starters, terminate the wiring harness, etc., to completely assemble the equipment into continuous lineups.

The drawout circuit breakers and controllers shall be properly installed in their housings, with any rails adjusted as required for smooth travel. Main and secondary contacts on the removable and stationary sides shall be checked for tightness and adjusted if loose. Covers or enclosures shall be securely bolted in place.

After each item of switchgear and controllers is installed and connected, a thorough inspection of the installation shall be made. All insulators which are exposed and all cubicles and compartments shall be cleaned of debris and foreign matter, etc. Prior to energization, the equipment shall be cleaned of all construction dust and dirt.

The Contractor shall exercise the breakers and assure that all front panels form a straight true line, units are correctly spaced from center-to-center and plumb, all mechanical interlocks are installed and operational, the breakers roll freely into and out of the switchgear units, all barriers are installed, and all stab type contacts are aligned and functional.

Where drawout type potential transformers are furnished, the potential transformers shall be installed on their drawout carriages, proper mechanical operation of the carriage shall be checked, and any automatic grounding device shall be checked to assure that it actually grounds the "live" equipment at the proper point of travel of the carriage.

All required power and control connections shall be completed.

16910.3.8.4 Low Voltage Equipment. This equipment consists of low voltage 13800 V:480 V Station Service Transformers (SSTs), low voltage MCCs, separately mounted motor starters and contactors, reliable power supply equipment, and other low voltage ac switchboards and panels.

All low voltage equipment and medium voltage to low voltage transformers shall be installed according to the manufacturer's recommendations and instructions and local code requirements.

Installation of this equipment shall include accurately aligning each unit on its foundation and securing it in place; making up the transformer throat connections; installing the drawout circuit breakers, starters, and devices in their respective housings; and checking all main and secondary connections and tightening them where found loose. All covers or enclosures which have been removed for shipment or removed during installation shall be securely bolted in place. Each enclosure shall be installed so that it is level and all doors freely swing full travel.

The Contractor shall assemble enclosures that are split for shipping, make bus and control wire shipping split connections, and assure that mechanical and safety interlocks are installed and functional, all stabs and disconnect devices are properly aligned, isolation barriers are in place, and the drawout units move freely in and out of their compartments. Contractor shall install and exercise all breakers, starters, and miscellaneous devices and assure that the equipment is suitable for electrical energization.

All circuit breakers, fused switches, motor starters, etc., shall be checked for proper mechanical and electrical operation.

All space heaters inside equipment shall be energized during storage and construction, as required.

16910.3.8.5 Miscellaneous Equipment. Any miscellaneous electrical distribution equipment not specified above shall be installed in accordance with the manufacturer's instructions and recommendations.

SECTION 16920
RACEWAY COMPONENTS AND INSTALLATION

16920.1 General

This section covers the furnishing and field installation of all electrical raceway systems and components. The raceway system and installation shall be in accordance with the Contractor's design and these specifications.

The raceway system is defined to include conduit, flexible conduit, cable tray, below grade conduit, duct bank, wireway, junction boxes and pull boxes, and all materials and devices required to install, support, secure, and provide a complete system for support and protection of electrical conductors.

16920.1.1 Scope of Supply

Any materials which are required for a complete raceway installation for the equipment being furnished under this contract shall be furnished.

16920.1.2 Not Used

16920.1.3 Performance and Design Requirements

Performance and design requirements for the equipment to be furnished under this section of these specifications are indicated herein and as follows:

Size conduit one size larger than required for conductor type installed; 3/4 inch minimum size.

16920.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference.

Raceway systems and components furnished with these specifications shall be manufactured in accordance with applicable standards of the American National Standards Institute (ANSI), the National Electrical Manufacturers Association (NEMA), and Underwriters' Laboratories, Inc. (UL). Raceway systems and components shall be installed in accordance with the applicable requirements of the National Electrical Code (NEC) and the Occupational Safety and Health Administration (OSHA) standards.

Areas subject to conditions classified in the NEC as hazardous areas shall be indicated on the drawings provided by the Contractor. Raceway systems and components furnished and installed in these areas shall meet the requirements of the NEC for the hazardous condition indicated.

16920.1.5 Not Used

16920.1.6 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 Contractor 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 Owner:

Table 16920-1 Approved Manufacturers

Component	Manufacturer
Post-installed mechanical anchor bolts	Ameren Missouri Approved Suppliers
Fire stops	Ameren Missouri Approved Suppliers

Table 16920-1 Approved Manufacturers	
Component	**Manufacturer**
Conduit - Steel	Ameren Missouri Approved Suppliers
Conduit-PVC Coated Steel	Ameren Missouri Approved Suppliers
Conduit - Aluminum	Ameren Missouri Approved Suppliers
Conduit - Plastic	Ameren Missouri Approved Suppliers
Conduit - Flexible	Ameren Missouri Approved Suppliers
Conduit bodies and fittings - Metal	Ameren Missouri Approved Suppliers
Conduit bodies and fittings - Plastic	Ameren Missouri Approved Suppliers
Support channels and fittings	Ameren Missouri Approved Suppliers
Conduit supports	Ameren Missouri Approved Suppliers
Wireway	Ameren Missouri Approved Suppliers
Boxes and enclosures - Metal	Ameren Missouri Approved Suppliers
Boxes and enclosures - Plastic	Ameren Missouri Approved Suppliers
Cable tray and accessories - Metal	Ameren Missouri Approved Suppliers
Cable tray and accessories - Fiberglass	Ameren Missouri Approved Suppliers

16920.1.7 Not Used

16920.1.8 Not Used

16920.1.9 Not Used

16920.2 Not Used

16920.3 Execution

16920.3.1 General Installation Requirements

The installation specifications included in this article apply to all raceway system components.

16920.3.1.1 Routing of Above Grade Raceway. Electrical cable tray and wireway shall be routed as indicated on the Contractor's drawings. Conduit shall be field routed according to the general routing to be indicated on the drawings. The location of field routed raceway and all raceway supports shall be coordinated with other equipment and structures. Conduit supports shall be arranged to prevent distortion of alignment by wire pulling operations. The location and material used for the cable tray and conduit shall be designed for the identified hazards for that specific location.

Conduit and cable tray routes shall be walked down with the Owner before installation to identify hazards such as tripping, headroom, thermal, chemical, etc. Conduit and cable tray routes may be revised where possible to minimize or eliminate hazards at no additional cost to the Owner.

Field routed raceway shall be routed so that, except where it is changing floor elevations or being lowered to enter equipment, the lowest part of the raceway, including its associated supports and appurtenances, is at least 8' above the closest floor or walking surface beneath it. Elevations of the raceway may need to be increased in areas where equipment removal, disassembly, or maintenance requires it. Field routed raceway and its associated supports and appurtenances, located at least 8', above the closest walking surface, may be routed a reasonable distance away from the supporting wall, ceiling, or structural member so long as the specified support is provided and interference with other equipment and structures is avoided. Field routed raceway and its associated supports and appurtenances, which must be routed

closer than 7'-6" above the closest walking surface, shall be routed as close as possible to surfaces of walls, columns, and the equipment served.

Field routed raceway and all raceway supports shall be located at least 12 inches from the final outside surface of all steam piping, including insulation, flues, and heating appliances, and 6 inches from the final outside surface of all other conduit and piping, including insulation if provided. Consideration shall be given to the thermally expanded position of piping when field routing raceway.

Field routed raceway and all raceway supports shall be located so that they do not interfere with equipment which expands, vibrates, or moves under normal operation such as a steam generator, flue gas ductwork, or overhead crane. Raceway shall be routed to avoid open bays and not block removable grating.

Low to roof and floor electric conduits and raceway shall be minimized in order to not create a tripping hazard. Conduits and raceway on top of flat roofs or floors shall be routed along the walls as much as possible in order to minimize the amount of conduit and raceway routed on the top of roofs or along floors that are exposed and could cause a tripping hazard. Conduits or raceway routed in walkways on roofs or floors is in a walkway, there shall be steps or ramps over the raceway and conduits. A 6 inch strip of yellow and black striped sticker shall be placed on both sides of conduit or raceway along rooftops or on the floors. Routing of raceway and conduit on the top of roofs and along floors shall be acceptable to the Owner.

Cable trays shall be routed to be accessible by the Owner after the completion of the project.

16920.3.1.2 Brackets. Bracket supports shall be used where specifically indicated and may be substituted for other types of hangers where acceptable to the Owner.

16920.3.1.3 Raceway Attached to Concrete. Where raceways are supported from concrete surfaces or floors, the anchorage shall be in accordance with the manufacturers as contained in Ameren Missouri Approved Suppliers while still meeting Federal Specification A-A-1923A, IBC, and ACI 318, Appendix D. Raceways mounted on concrete or masonry walls shall be mounted so that there is a minimum of 1/4 inch of air space between the raceway and the concrete or masonry wall.

Raceway supports attached to concrete floors shall be installed such that they are elevated and grouted above the finished floor a minimum of 1 inch to prevent corrosion caused by exposure to standing water.

16920.3.1.4 Raceway Attached to Building Steel. Except as otherwise specified or acceptable to the Owner, raceway or all raceway supports attached to building steel shall be secured by welding, by powder activated devices and fasteners, or by beam clamps. No drilling and tapping is permitted.

Raceway and raceway supports shall not be attached to grating.

Raceway and raceway supports shall not be attached to the flanges of the cold-formed support steel in pre-engineered buildings. Instead, raceway and raceway supports shall be attached to the web of the cold-formed support steel by using bolts installed through holes field drilled in the web.

16920.3.1.5 Insulation. Raceway and all supports for raceway connected to equipment, piping, raceways, etc., that have been electrically insulated from contact with other structures shall be properly installed to prevent shunting of the insulation. Particular attention shall be given to bearings on large motors and insulated piping flanges.

16920.3.1.6 Sleeves and Openings. Sleeves and openings for the passage of electrical raceways or conductors will be located beneath major pieces of electrical equipment and in certain locations where raceway or conductors will pass through floors or walls.

The Contractor shall be responsible for all required openings. Required openings not provided during structure fabrication shall be provided by the Contractor. Openings shall be finished, fire-stopped, sealed, and approved by the Owner.

16920.3.1.6.1 Openings through steel beams. Conduit may be routed through building steel only when the routing is reviewed for structural integrity by the Owner and approved. Holes required for conduit passages shall be drilled or sawed, or flame cut with subsequent reaming and/or grinding to prevent ragged edges, notches, cuts, or cracks. The Contractor shall minimize routing conduit through structural members to the greatest extent possible.

16920.3.1.6.2 Openings through grating. Where openings through grating are required, the openings shall be made at divisions or ends of grating sections, if possible. These openings shall be square and shall be neatly finished by installing a kickplate around the entire opening and welding it to the cut grating bars. All rough spots shall be ground smooth, and welds and cuts shall be regalvanized. Penetrations in grating shall be sawed or flame cut with subsequent grinding to ensure smooth and straight cut appearance.

16920.3.1.6.3 Openings through concrete and masonry. Openings in concrete floors and concrete or masonry walls for single conduits or minimum quantities of conductor shall be cut using a core drill. Larger openings required for multiple conduits, conductors or cable tray shall be cut using multiple core drills chiseled out to the appropriate size, or by saw cutting. The Contractor shall be responsible for providing all necessary materials to protect equipment and personnel from falling debris and water while making the opening.

Required field cut openings larger than 12 inches in any direction shall be approved by the Owner prior to cutting.

Openings cut through concrete floors and concrete or masonry walls for the passage of conduit shall be finished by either grouting or by sealing around the conduit. Openings in concrete floors for the passage of electrical conductors shall be sealed. Openings in concrete floors and concrete or masonry walls for the passage of cable tray shall be sealed.

Exposed openings between the edge of raceway components and the edge of field cut concrete floor openings exceeding 1-1/2 inches in width shall have kickplate installed around the entire opening.

16920.3.1.6.4 Openings through metal wall panel. Single conduit openings in metal wall panel shall be hole punched or drilled the minimum size to allow passage of the conduit through the wall panel. Openings for multiple conduits or cable tray shall be neatly saw cut 2 inches larger than required on all four sides to allow passage of the raceway components.

Insulation removed to clear the opening for the passage of raceway components through metal insulated wall panel shall be reinserted around the outside edges of the opening.

Openings through metal wall panel shall be finished and sealed as indicated on the drawings.

16920.3.1.6.5 Openings through roof. No roof openings shall be allowed for raceway components. Where raceway components must access equipment located on a roof, the opening shall be made on vertical portions of walls or parapets as specified herein. Openings shall be finished and sealed after the installation of the raceway components is complete.

16920.3.1.6.6 Openings into equipment. All openings beneath equipment and all openings into the top or sides of equipment in non-air-conditioned areas, including pull boxes, shall be sealed to prevent the entry of dust and liquids. All sealing materials and installations shall be watertight and flame retardant, and shall be installed in accordance with the manufacturer's recommendations. The sealing installation shall be finished to provide a smooth, neat appearance. Openings shall not be sealed until all the cables passing through the opening have been installed and tested.

All sealing materials and installation methods shall be acceptable to the Owner prior to installation.

All openings beneath equipment shall be sealed. The seal shall provide for a minimum fire rating equal to the floor being penetrated. The cut edge of openings through metal decking beneath concrete floors for the passage of cables not enclosed in conduit shall be smooth to prevent damage to the cable.

All openings into the top or sides of equipment in non-air-conditioned areas allowing for the passage of cable shall be sealed as indicated on the drawings. The seal shall provide a minimum fire rating of 2 hours.

Unused openings into the top or sides of equipment planned for the passage of cable shall be sealed by installing a gasketed plate over the unused opening and securing it to the equipment with stainless steel screws. The gasket and plate shall extend beyond the edges of the opening a minimum of 3/4 inch all around the entire opening. Unused openings into the top or sides of equipment planned for conduit shall be sealed by installing a threaded gasketed conduit hub over the conduit opening and inserting a threaded plug into the hub. The conduit hub shall be sized for the opening in the equipment and securely fastened to the equipment. Rubberized knockout plugs and snap-in steel blanks shall not be allowed.

16920.3.1.6.7 Fire stops. Sleeves and openings for the passage of cable and raceway through walls and floors shall be sealed with UL or Factory Mutual approved fire stops having a fire rating not less than that of the wall or floor penetrated.

All fire stops shall be installed in accordance with the manufacturer's recommendations, including installation by trained personnel when so recommended by the manufacturer.

All seals shall be finished to provide a smooth, neat appearance.

16920.3.1.7 Extensions of Building Steel to Support Raceway. Extensions of building structures to support raceway shall be of the same material as the structure being extended and shall be finished to match the finish of the extended structure.

16920.3.1.8 Beam Clamps. Beam clamps for attachment of hanger rods to structural steel beams shall be electrogalvanized steel and shall be provided with safety beam anchor straps. Swivels shall be provided where required to prevent bends in the hanger rods.

16920.3.1.9 Welding. Tack welds shall either be incorporated into, or removed from, the final assembly. Temporary welds used for erection, lifting lugs, etc., shall be removed and the area ground flush.

Weld spatter, including tightly adherent spatter, shall be removed from weld areas and the areas shall be prime painted or regalvanized.

All temporary supports which have been welded to the building shall be removed as promptly as possible. After removal, the roughened surface of the building steel shall be ground smooth and a protective primer paint applied equal to that which was initially applied.

16920.3.1.10 Use of Unfinished Conduit. Conduit runs including supports and connections shall be completed prior to the pull-in of conductor where the potential for conductor damage exists.

16920.3.1.11 Repair of Galvanized Surfaces. All galvanized surfaces on which the galvanizing is removed or damaged by cutting, drilling, or any other operation shall be regalvanized in accordance with ASTM A780.

16920.3.2 Raceway Installation Records

The Contractor shall complete a Raceway Installation Record form for each raceway installed. Forms used shall be acceptable to the Owner. The following data shall be recorded on each form:

Raceway number.

Raceway size.

Raceway material.

Estimated length of the raceway (from the Contractor).

Actual installed length of the raceway.

Origin and termination of the raceway.

Date of completion of raceway installation.

List of all cables installed in each raceway.

The coding system used to record all data shall be approved by the Owner.

Each form shall be submitted to the Owner within a reasonable time frame agreed to with the Contractor.

The Contractor shall maintain one set of cable tray and conduit drawings in his central office at the jobsite as an as-built set. This as-built set shall contain all marks necessary to locate and identify raceway which is not installed in accordance with the Contractor's drawings. These drawings shall be updated weekly to agree with the actual field installation of raceway. It shall be the responsibility of the Contractor to ensure that these drawings are accurate and up-to-date.

The Contractor's as-built drawing set shall be available to the Owner.

The Contractor's as-built record set shall be turned over to the Owner after installation of all raceway is completed.

16920.3.3 Conduit Components

An electrical conduit system shall be furnished and installed in accordance with the following specifications. Conduit components shall include conduit, fittings, supports, and hardware required for a complete system.

16920.3.3.1 Conduit Materials. Electrical conduit and associated component materials shall conform to the requirements of the articles that follow. Specific conduit component materials shall be as indicated on the drawings for their intended application.

16920.3.3.1.1 Rigid galvanized steel conduit. Steel conduit, couplings and elbows shall be a threaded hot-dipped galvanized rigid mild steel manufactured in accordance with ANSI/NEMA C80.1 and UL 6. The conduit interior and exterior surfaces shall have a continuous hot-dipped galvanized coating with a transparent overcoat of enamel, lacquer, or zinc chromate. Each length of conduit shall have a coupling on one end and a thread protector on the other. The thread protector shall have sufficient mechanical strength to protect the threads during normal handling and storage. Rigid galvanized steel conduit shall be similar to Type GRC, as manufactured by the suppliers listed on the Approved Suppliers List.

16920.3.3.1.2 PVC coated rigid galvanized steel conduit. The PVC coated galvanized rigid conduit must be UL Listed. A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit. The PVC coating on the outside of conduit couplings shall have a series of longitudinal ribs 40 mils in thickness to protect the coating from tool damage during installation. Condulets shall have a tongue-in-groove gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings. This internal coating shall be a nominal 2 mil thickness. Conduit or fittings having areas with thin or no coating shall be unacceptable. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30°F (-1°C). All male threads on conduit, elbows and nipples shall be protected by application of a urethane coating. All female threads on fittings or conduit couplings shall be protected by application of a urethane coating.

Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.

Installation of the PVC Coated Conduit System shall be performed in accordance with the Manufacturer's Installation Manual. To assure correct installation, the installer shall be certified by Manufacturer to install coated conduit.

The Contractor shall arrange for the manufacturer of the PVC coated RGS to provide training on proper installation to all personnel involved in the installation of the PVC conduit.

The Contractor shall repair or replace any PVC coated conduit where the outer PVC conduit has been scratched, chipped off, or otherwise damaged.

16920.3.3.1.3 Rigid plastic conduit. Plastic conduit and elbows shall be unthreaded Schedule 40 or Schedule 80 polyvinyl chloride manufactured in accordance with NEMA TC-2 and UL 651. Rigid plastic conduit shall be as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.4 Electrical Metallic Tubing (EMT). Electrical metallic tubing (EMT) shall not be used..

16920.3.3.1.5 Conduit subject to removal, vibration transmission, thermal expansion/contraction, or for ease of equipment removal - flexible metal conduit and fittings (liquidtight, Type EF). Liquidtight flexible metallic conduit shall be a plastic jacketed, heavy-duty, continuous interlocked, flexible, rust resistant, metal core manufactured in accordance with ANSI/UL 360. The plastic jacket shall be UV, oil, and acid resistant and shall be suitable for a temperature rating of 60° C. The metal core shall be a locking galvanized steel core for use with galvanized conduit systems. Liquidtight flexible metallic conduit used in high temperature areas shall have a thermoplastic PVC jacket suitable for a temperature rating of 105° C. Galvanized liquidtight flexible metallic conduit shall be similar to Sealtite Type UA as manufactured by Anamet Canada, Inc. or Owner-accepted equal. High temperature galvanized liquidtight flexible metallic conduit shall be similar to Sealtite Type HTUA, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.6 Flexible metallic conduit. Flexible metallic conduit shall be a heavy-duty, locking galvanized steel core manufactured in accordance with ANSI/UL 1. Flexible metallic conduit shall be similar to Type HWS, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.7 Flexible metallic couplings. Flexible metallic couplings shall be prefabricated lengths of flexible conduit comprised of a bronze braided brass core and insulating wire duct manufactured in accordance with UL 886. The metallic coupling shall have prefabricated male connectors on both ends. Flexible metallic couplings shall be used in Class I, Div. 1 locations where a liquidtight flexible conduit connection is required. Flexible metallic couplings shall be similar to Type ECGJH, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8 Rigid metal conduit bodies and fittings. Rigid metal conduit bodies and fittings shall conform to the requirements of ANSI/NEMA FB-1, UL 514B and UL 886 where these standards apply. Conduit bodies and fittings shall be appropriate for the area and equipment with which they are associated. Conduit bodies and fittings used in hazardous areas shall conform to NEC requirements for the area classification.

Threaded galvanized malleable iron or galvanized steel bodies and fittings shall be used with galvanized conduit. Unthreaded zinc coated steel fittings shall be used with electrical metallic tubing. Metallic tubing fittings shall be compression type and watertight.

Additional requirements for rigid metal conduit bodies and fittings are as follows.

16920.3.3.1.8.1 Conduit outlet bodies. Conduit outlet bodies shall be provided where required for pulling ease and changing conduit direction. Standard conduit outlet bodies shall be threaded to accept threaded cover screws. Standard conduit outlet bodies installed outdoors or in wet locations shall be gasketed to provide a watertight seal. Conduit outlet bodies used in hazardous areas shall be provided with internally threaded gasketed covers.

Standard conduit outlet bodies shall be similar to Types LB, X, LL, LR, T, TB, or C, as manufactured by the suppliers on the Approved Suppliers List.. Hazardous area conduit outlet bodies shall be similar to Type GUA, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.2 Grounding type insulated bushings. Grounding type insulated bushings with insulating inserts in metal housings shall be provided for the termination of all threaded conduits not terminated in hubs or couplings. Bushings shall be galvanized. Insulating inserts shall be phenolic or a similar thermoplastic material.

Grounding type insulated bushings shall be provided for all conduits containing power circuits and all conduits located in hazardous areas.

Insulated bushings shall be similar to Type IBC, as manufactured by the suppliers on the Approved Suppliers List. Grounding type insulated bushings shall be similar to Type IBC-L-BC, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.3 Locknuts. One interior locknut, one exterior locknut, and one bushing shall be provided at the termination of each rigid metal conduit not terminated in a hub or coupling. Exterior locknuts shall be gasketed. Locknuts shall be designed to securely bond the conduit to the box when tightened while also preventing loosening by vibration. Interior locknuts shall be similar to Type 1, as manufactured by the suppliers on the Approved Suppliers List. Exterior locknuts shall be similar to Type SLG, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.4 Unions. Conduit unions shall be provided for the connection of two threaded conduit ends when the conduit cannot be turned. Standard conduit unions shall be similar to three piece Type 4 Series, as manufactured by the suppliers on the Approved Suppliers List. Hazardous area conduit unions shall be similar to Type UNF, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.5 Raintight hubs. Raintight hubs shall be provided for the termination of threaded conduits on outdoor equipment where threaded hubs are not provided. Conduit fittings on outdoor equipment shall be gasketed. Raintight hubs shall be provided with an insulated throat. Standard raintight hubs shall be similar to Type CHM, as manufactured by the suppliers on the Approved Suppliers List. Hazardous area raintight hubs shall be similar to Type EYH-SG, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.6 Not used.

16920.3.3.1.8.7 Expansion fittings. Expansion fittings shall be provided in threaded conduit runs to allow for the expansion and contraction of conduit supported across expansion joints. Expansion fittings shall be watertight and shall be provided with bonding jumpers. Standard expansion fittings shall be similar to Type EX, as manufactured by the suppliers on the Approved Suppliers List.. Expansion fittings for hazardous areas shall be similar to Type UNFE, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.8 Drains. Drains shall be provided in the low spots of outdoor conduit runs, and in outdoor conduit runs prior to entering buildings, to remove condensation from the conduit. Conduit drains shall be similar to Type DB, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.9 Reducers. Reducers shall be provided to connect two different conduit sizes together. Reducers shall be external couplings similar to Type REC, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.8.10 Seal-off fittings. Seal-off fittings shall be provided to isolate conduit runs and prevent the passage of flammable gases, vapors, and dusts from hazardous areas. Seal-off fittings shall be suitable for vertical and horizontal conduit installations. Seal-off fittings shall have a removable plug for the placement of sealing fiber, and an additional removable plug for the placement of sealing compound. Seal-off fittings shall be similar to Type EYA, as manufactured by the suppliers on the Approved Suppliers List. Sealing fiber and sealing compounds shall be compatible with the seal-off fittings provided.

16920.3.3.1.9 Liquidtight flexible metallic conduit fittings. Liquidtight flexible metallic fittings shall be provided to connect liquidtight flexible metallic conduit to rigid metal conduit and devices. Liquidtight flexible metallic fittings shall have insulated throats and shall bear the UL label. Liquidtight flexible metallic fittings shall be similar to Type STB and Type STN, as manufactured by the suppliers on the Approved Suppliers List. Galvanized malleable iron fittings shall be used with galvanized core flexible conduit.

16920.3.3.1.10 Flexible metallic conduit fittings. Flexible metallic fittings shall be provided to connect flexible metallic conduit to light fixtures and wiring devices in finished areas. Flexible metallic fittings shall have "Squeeze" type or friction connectors for fastening the fitting to the flexible conduit. Flexible metallic fittings shall have insulated throats and bear the UL label. Flexible metallic combination fittings shall have a friction type connector on one end for fastening to flexible metallic conduit, and a compression type connector on the other end for fastening to electrical metallic tubing. Flexible metallic fittings shall be similar to Types C, 24 Series, and CB, as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.1.11 Rigid plastic conduit bodies and fittings. Rigid plastic conduit bodies and fittings shall be polyvinyl chloride and shall conform to the requirements of NEMA TC-3, NEMA TC-9, and UL 514B where these standards apply. Plastic conduit bodies and fittings shall be of the same schedule or type composition as the plastic conduit attaching to. Plastic conduit bodies and fittings shall use unthreaded solvent cement type joints. Plastic conduit couplings shall have center stops to ensure proper seating. Plastic conduit outlet bodies shall have gasketed screw type covers.

Spacers for underground rigid plastic conduit shall be plastic interlocking base and intermediate type spacers. The spacers shall have voids or openings to allow for the flow of concrete along the conduit, thus eliminating any hollow area within the concrete. The separation distance between the outer walls of all conduit interlocked together shall be as indicated on the drawings.

Plastic conduit bodies and fittings shall be as manufactured by the suppliers on the Approved Suppliers List.

16920.3.3.2 Conduit Supports. Conduit supports shall conform to the requirements of the articles that follow.

16920.3.3.2.1 Hanger rods. Hanger rods used for the support of formed channel shall be 1/2 inch diameter electrogalvanized continuous threaded steel rods. Hanger rods shall be similar those shown in Ameren Missouri Approved Suppliers

16920.3.3.2.2 Support channel. Support channel shall be hot-dipped galvanized formed channel made from 12 gauge steel in 1-5/8 inch series sizes. Support channel shall be similar to those shown in Ameren Missouri Approved Suppliers

16920.3.3.2.3 Support channel fittings. Support channel fittings shall be flat plate and angular fittings and brackets designed for use with the 1-5/8 inch series formed channel indicated previously. Support channel fittings shall be hot-dipped galvanized steel. Support channel fittings shall be as manufactured that shown in the Ameren Missouri Approved Suppliers.

16920.3.3.2.4 Conduit clamps. Conduits in single runs or groups of two shall be supported by one hole cast metal clamps with clamp backs, or with conduit clamps attached to beams. One hole clamps, clamp backs, and conduit clamps attached to beams shall be hot-dipped galvanized malleable iron. One hole conduit clamps and clamp backs shall be similar to that shown in the Refer to Ameren Missouri Approved Suppliers Conduit beam clamps shall be similar to that shown in Ameren Missouri Approved Suppliers.

Supports for banks of three or more conduits shall be constructed of formed channel with associated two piece galvanized conduit clamps. Two piece conduit clamps shall be designed for use with the 1-5/8 inch series formed channel indicated previously. Two piece conduit clamps shall be similar to that indicated in Ameren Missouri Approved Suppliers.

Conduits in single runs or groups of two terminated at cable tray shall be supported from the tray side rail using galvanized malleable iron cable tray conduit clamps similar to those shown in Ameren Missouri

Approved Suppliers. Banks of three or more conduits shall be terminated at cable tray with the use of two piece conduit clamps and formed channel attached to the tray side rail as indicated on the drawings.

16920.3.3.3 Conduit Installation. Conduit and associated components shall be installed as indicated on the drawings and as described in these specifications. The following installation requirements are in addition to the requirements indicated in Article 16920.3.1.

16920.3.3.3.1 Routing. Field routed conduit and associated supports shall not interfere with the installation or maintenance of any dimensioned equipment, building steel, cable tray, HVAC duct, fans, dampers, or prerouted piping.

Conduit shall not be routed under crane or trolley rails, or through areas designated for the maintenance or removal of equipment accessed by overhead removable panels and hatches. Any conduit which interferes with these areas or purpose shall be promptly removed so as not to delay installation or use of any equipment.

Except as otherwise specified, all conduit shall be installed in exposed runs parallel or perpendicular to dominant surfaces with right angle turns made of symmetrical bends or fittings. Except where prevented by the location of other work, a single conduit or a conduit group shall be centered on structural members.

16920.3.3.3.2 Conduit drains. Outdoor conduits shall not contain moisture pockets. Drains shall be installed in outdoor conduit to remove moisture at locations where conduits terminate on equipment or devices and at locations where conduits penetrate an exterior wall.

Conduits shall be installed so that water will not drain into any equipment containing electrical devices or connections. Drains shall be installed at lowest point in conduit above grade. Conduits terminating on equipment from above shall have a conduit seal fitting with drain installed in the conduit run near the conduit termination where practical. Conduit terminating on equipment from the side shall have a conduit "tee" body with drain installed in the conduit run near the conduit termination where practical. Conduit terminating on equipment from below shall have a conduit "tee" body with drain installed in the conduit run at the lowest vertical location directly below the equipment. Equipment serviced from below by underground or embedded conduits shall not require drains.

Conduits penetrating exterior walls shall have a conduit "tee" body with drain installed on the exterior side of the wall at the "low point" of the conduit as close as practical to the wall penetration.

16920.3.3.3.3 Couplings and unions. Rigid metal conduit shall be joined by threaded conduit couplings with the conduit ends butted. The use of running threads will not be permitted. Where rigid metal conduit cannot be turned and joined together by standard threaded couplings, conduit unions, or split couplings may be used. Conduit union coupling nuts shall be installed uppermost on vertical or inclined conduit runs to prevent the entrance of water into the union. Split couplings shall not be installed on outdoor conduit.

Plastic conduit shall be joined together in accordance with manufacturer recommendations using unthreaded couplings and a medium bodied solvent cement. Joining surfaces shall be wiped clean of dirt, moisture, or other contaminants prior to application of the solvent cement. If joining surfaces are extremely dirty or coated with oil, a cloth saturated with PVC cleaner shall be used to clean the surfaces. Joining surfaces shall be thoroughly dried before applying solvent cement.

Electrical metallic tubing shall be joined together by unthreaded compression couplings. The use of set-screw couplings will not be permitted.

16920.3.3.3.4 Bends and offsets. A run of conduit shall not contain more than the equivalent of four 90 degree bends, including those immediately at outlet bodies and fittings. Field bends shall be made without reducing the internal diameter of the conduit. The center line radius of field bends shall not be less than six times the nominal trade size diameter of the conduit.

The use of a pipe tee or vise for bending metal conduit will not be permitted.

Plastic conduit bends shall be factory fabricated wherever possible. Where field bending of plastic conduit is required, the conduit length shall be heated to approximately 275° F. Conduit heating may be by radiant heat, hot air, or hot liquid immersion. Open flame heating will not be permitted. Special mandrels or forms shall be used to provide a smooth bend without reduction of the conduit diameter. Conduit discolored by prolonged heating will not be acceptable.

16920.3.3.3.5 Fittings. Conduit outlet bodies installed in conduit runs shall be sized and installed in accordance with the NEC. Covers shall be installed on outlet bodies at the time of installation to prevent the entrance of moisture or contaminants into the conduit system prior to cable pulling operations.

Conduit outlet bodies shall not be installed in conduit runs containing 5 kV and higher voltage conductors, unless the type and location have been reviewed for excessive cable bending radius constraints as defined by the cable manufacturer.

Conduit fittings for metal conduit shall be installed wrenchtight.

Hazardous area conduit seal-off fittings shall be installed at locations required by the NEC for the classified area. Seal-off fitting compounds and fiber shall be installed as recommended by the fitting manufacturer. Completed conduit seal-off fitting installations shall not restrain equipment removal or access beyond that which would be encountered if there were no sealing fitting installed on the conduit run.

16920.3.3.3.6 Cutting and threading. The plane of all conduit ends shall be square and perpendicular with the center line. The ends of all conduit and tubing shall be reamed to remove all rough edges and burrs.

Where threads are required, they shall be cut and cleaned prior to conduit reaming. A cutting oil shall be used in threading operations. The dies shall be kept sharp and provisions shall be made for chip clearance.

All steel conduit ends, after cutting or threading, shall be regalvanized using a cold galvanizing zinc rich coating.

16920.3.3.3.7 Connections to boxes and cabinets. Conduit shall be securely fastened to all boxes and cabinets. Threads on metallic conduit not terminated in threaded hubs shall project through the wall of the box or cabinet to allow the bushing to butt against the end of the conduit. The locknuts both inside and outside shall then be tightened sufficiently to bond the conduit securely to the box or cabinet.

All conduit terminating on boxes or cabinets located outdoors, or terminating on indoor NEMA 12, NEMA 4, or NEMA 4X enclosures, shall terminate with raintight conduit hubs or threaded hubs provided with the enclosure. Gasketed sealing type locknuts may be used in lieu of threaded hubs for connections to indoor NEMA 12 enclosures.

If the conduit connected to the equipment exceeds the number or size of threaded hubs supplied with the equipment, additional material shall be furnished and installed as required to connect the conduit to the equipment.

16920.3.3.3.8 Cleaning. Precautions shall be taken to prevent the accumulation of water, dirt, or concrete in the conduit. Conduit in which water or other foreign materials have been permitted to accumulate shall be thoroughly cleaned.

16920.3.3.3.9 Liquidtight flexible conduit. Liquidtight flexible conduit inserts shall be installed at the locations indicated below. Liquidtight flexible conduit lengths shall not be greater than 24 inches in length for 2 inch and under nominal conduit diameter and 48 inches in length for nominal conduit diameter greater than 2 inches.

Liquidtight flexible metallic conduit shall be installed in all rigid metal conduit runs which are supported by both building steel and by structures subject to vibration or thermal expansion. This shall include locations where conduit supported by building steel enters or becomes supported by the turbine generator

foundation and where conduit supported by building steel or foundation becomes supported by steam generator framing.

Liquidtight flexible metallic conduit shall be installed in rigid metal conduit runs which cross expansion joints or which connect to building supported independent structures, such as heat exchangers, storage tanks, or ash hoppers.

Liquidtight flexible metallic conduit should be considered in all long rigid metal conduit runs where differential expansion problems may be expected.

Liquidtight flexible metallic conduit shall be installed adjacent to all equipment and devices which move in relation to the supply conduit due to vibration, normal operation of the mechanism, or thermal expansion.

The supply conduit shall be connected to pressure switches, thermocouples, solenoids, and similar devices with liquidtight flexible metallic conduit. Liquidtight flexible metallic conduit shall be installed adjacent to the motor terminal housing for motors requiring 4 inch and smaller conduit. Provisions for vibration and thermal expansion at motors requiring larger than 4 inch conduit shall be accomplished by use of pendent hangers or other acceptable means.

16920.3.3.3.10 Flexible metallic conduit. Flexible metallic conduit inserts not greater than 6 feet in length shall be installed for light fixture tap conductors above finished ceilings.

16920.3.3.3.11 Plastic conduit. Plastic conduit shall be installed in accordance with the installation requirements previously specified for rigid metal conduit. Expansion joints shall be provided as recommended by the manufacturer.

16920.3.3.3.12 Below grade conduit. Below grade conduit shall be PVC coated rigid galvanized steel or rigid plastic PVC Schedule 40 conduit as required by the Contractor's design . PVC coated galvanized steel shall be used under roadways and other similar high load areas. Aluminum conduit shall not be used for below grade conduit.

Below grade conduit shall be routed as closely as possible to the general routing and elevations indicated on the drawings.

As-built drawings shall be provided for all underground conduit installations accurately showing the location of the underground, embedded, or concrete encased conduits.

Where possible, critical conduits shall be installed in a duct bank. Conduits which cannot be installed in a conduit shall be red concrete encased.

Conduit riser elbows are shown in Ameren Missouri Approved Suppliers and shall be concrete encased.

Conduit riser extensions shall are shown in Ameren Missouri Approved Suppliers. Conduit riser extensions shall be concrete encased. Conduit riser extensions shall terminate 6 inches above finished building floors or finished grade elevations in yard areas. Conduit extensions shall be straight and plumb, plugged prior to pouring of concrete, and remain plugged until conduit is extended later or readied for cable pulling operations. Plugs shall be either threaded plastic or threaded metal inserts.

Concrete used for encasing below grade conduit shall conform to the requirements of Section 03311 - Cast-in-Place Concrete of these specifications. The concrete shall be vibrated to consolidate it around the conduit and shall be slow cured for several days to provide strength and prevent shrinkage.

Below grade conduit shall be accurately positioned and supported for encasement by plastic conduit spacers set in the conduit trench, or by steel wire hangers attached to temporary supports laid across the conduit trench. After the concrete encasement has hardened, the temporary supports and the exposed portions of the steel wire hangers not encased in concrete shall be removed.

Warning tape shall be placed in a trench directly over direct buried conduit.

The following requirements also apply to below grade conduit.

16920.3.3.3.12.1 Rigid galvanized steel conduit. Rigid galvanized steel conduit shall not be directly buried in the earth. Single runs of below grade rigid galvanized steel conduit shall be encased with a minimum of 3 inches of red concrete between the conduit outer walls and earth. Multiple runs of below grade rigid galvanized steel conduit shall maintain a minimum 2 inch separation between adjacent conduits to allow for concrete placement. Multiple runs of rigid galvanized steel conduit shall also be provided with 3 inches of concrete encasement between the conduit outer walls and earth.

16920.3.3.3.12.2 Rigid plastic conduit. Below grade rigid plastic conduit shall be concrete encased unless used exclusively for site lighting or other non-process circuits. Where indicated on the drawings, concrete encasement for plastic conduit shall have the same spatial and envelope requirements as rigid galvanized steel conduit.

Where rigid plastic conduit is directly buried in the earth, it shall be laid in a graded 3 inch deep bedding of sand or other finely divided job excavated material free from debris, organic material, and stones. After placement on the bedding, the conduit shall be covered with backfill to 6 inches above the conduit. The backfill shall be of the same material as the bedding. Backfill shall be compacted to meet density requirements of the surrounding earth.

16920.3.3.3.13 Conduit support spacing. All conduit runs shall be rigidly supported in accordance with the following requirements.

Vertical rigid metal conduit shall be supported in maximum 20 foot intervals. Vertical plastic conduit shall be supported at the maximum intervals indicated for their respective horizontal conduit support spacing shown below.

Rigid metal conduit and plastic conduit shall be supported within 3 feet of each junction box, pull box, cabinet, conduit body, or other conduit termination.

Horizontal rigid metal conduit and plastic conduit shall be supported at the indicated maximum intervals.

Table 16920-2 Maximum Support Intervals for Conduit

Maximum Support Intervals		
Nominal Conduit Size, inches	**Rigid Metal Spacing, feet**	**Rigid Plastic Spacing, feet**
1/2	10	3
3/4	10	3
1	12	3
1-1/2	14	5
2	16	5
2-1/2	16	6
3	20	6
4	20	7
5	20	7
6	20	8

16920.3.3.3.14 Conduit identification. All conduit shall be clearly identified with its raceway number and voltage level as indicated on the Contractor's detailed design drawings. Conduit identification shall be with Electromark Co. Type C-1003 markers or Owner-accepted equal, covered with clear wraparound bands.

Markers shall be positioned so that they are easily read by personnel standing on the floors and walkways. Markers shall be installed on each end of conduits which are in excess of 10 feet, and at only one end of conduits which are 10 feet or less in length.

16920.3.4 Wireway Components

An electrical wireway system shall be furnished and installed in accordance with the following specifications. Wireway components shall include wireway, connectors, fittings, covers, supports, and hardware required for a complete system.

16920.3.4.1 Wireway Materials. Wireway and associated component materials shall conform to the requirements of the articles that follow.

16920.3.4.1.1 Metallic wireway. Metallic wireway, fittings, and covers shall be constructed in accordance with UL 870 and NEMA for their intended service. Standard metallic wireway shall be constructed from manufacturer's standard gauge phosphatized sheet steel or galvanized steel. Metallic wireway for corrosive areas shall be constructed from stainless steel. Metallic wireway shall have "lay-in" features. Metallic wireway shall have removable covers and shall not have knockouts. Unless otherwise indicated on the drawings, wireway enclosure types shall be as indicated below:

Table 16920-3 Conduit Wireway Enclosure Types

Location	Enclosure Type
Indoor (nonhazardous)	
Conditioned rooms	NEMA 1
Process areas (dry)	NEMA 12
Process areas (wet)	NEMA 4
Corrosive areas	NEMA 4X
Outdoor (nonhazardous)	
Noncorrosive areas	NEMA 4
Corrosive areas	NEMA 4X
Hazardous areas	
Class I, Division 2	NEMA 12
Class II, Division 2	NEMA 12
Class III areas	NEMA 12

Metallic wireways shall not be installed in hazardous areas classified as Class I, Division 1 and Class II, Division 1.

16920.3.4.1.2 Nonmetallic wireway. Nonmetallic wireway, fittings, and covers shall be constructed in accordance with UL 94, UL 870, and NEMA for their intended service. Nonmetallic wireway shall be constructed from a flame retardant, fiberglass resin material that provides chemical resistance and physical strength. Nonmetallic wireway shall have "lay-in" features. Nonmetallic wireway shall have gasketed, removable covers and shall not have knockouts. Nonmetallic wireway may be used in indoor, corrosive area applications in lieu of stainless steel wireway.

16920.3.4.2 Wireway Supports. Wireway support components shall be comparable to support system components for cable tray as indicated in Article 16920.3.6.

16920.3.4.3 Wireway Installation. Wireway shall be installed in accordance with these specifications, the manufacturer's instructions, and as required by the Contractor's design. All field cuts shall be saw cut and square. Sharp edges shall be filed smooth and touchup painted or regalvanized. Wireway shall be

rigidly supported as required by the NEC. By design wireways shall be less than 50% filled to allow for additional conductors after construction.

16920.3.4.4 Wireway Identification. The identification number of each wireway shall be engraved on a phenolic nameplate and attached to the wireway. Nameplates attached to wireways in finished areas may be fastened using adhesive tape. For all other areas, nameplates shall be fastened using suitable hardware.

16920.3.5 Junction Boxes and Terminal Boxes

All boxes required throughout the electrical raceway system shall be furnished and installed in accordance with the drawings and the requirements which follow.

16920.3.5.1 Junction Box and Terminal Box Materials. Junction (pull) boxes and terminal boxes shall be constructed in accordance with UL 50 and NEMA for their intended service. Junction boxes and terminal boxes shall not have knockouts.

Enclosure type, material, and dimensions shall be as indicated on the drawings and as specified in these specifications. Where no type or size is indicated elsewhere for junction boxes and terminal boxes, they shall be in accordance with the requirements of the NEC, Article 314.

Unless indicated otherwise, enclosure types shall be as follows:

Table 16920-4 Junction Box and Terminal Box Enclosure Types

Location	Enclosure Type	
	Junction Boxes	**Pull Boxes**
Indoor (nonhazardous)		
Conditioned rooms	NEMA 1	NEMA 1
Process areas (dry)	NEMA 12	NEMA 12
Process areas (wet)	NEMA 4	NEMA 4
Corrosive areas	NEMA 4X	NEMA 4X
Outdoor (nonhazardous)		
Noncorrosive areas	NEMA 4	NEMA 4
Corrosive areas	NEMA 4X	NEMA 4X
Hazardous areas		
Class I, Division 1	NEMA 7*	NEMA 7*
Class I, Division 2	NEMA 7*	NEMA 12 (indoor) NEMA 3 (outdoor)
Class II, Division 1	NEMA 9*	NEMA 12 (indoor) NEMA 3 (outdoor)
Class II, Division 2	NEMA 12 (indoor) NEMA 3 (outdoor)	NEMA 12 (indoor) NEMA 3 (outdoor)
Class III	NEMA 12 (indoor) NEMA 4 (outdoor)	NEMA 12 (indoor) NEMA 3 (outdoor)

Note: * Indicates an alpha character identified by the group designation associated with the known suspended air hazard as identified in the National Electrical Code.

Junction boxes and terminal boxes 4 inch trade size or smaller in any dimension shall be galvanized malleable iron or acceptable equal cast ferrous metal for use with threaded, galvanized steel conduit.

Junction boxes and terminal boxes larger than 4 inch trade size, and having a depth of not over 24 inches, shall be constructed from manufacturer's standard gauge phosphatized sheet steel. The surfaces of the steel shall be finish coated inside and out after fabrication, in accordance with manufacturer's standard.

Junction boxes having a depth greater than 24 inches shall be constructed from steel plate reinforced as required to provide true surfaces and adequate strength to support a concentrated load of 200 pounds on the top after erection. The junction box surface shall be finish coated inside and out after fabrication, in accordance with the manufacturer's standard.

16920.3.5.2 Outlet Boxes and Switch Boxes. All outlet boxes, switch boxes, and associated fittings shall be constructed in accordance with UL 514.

All surface mounted outlet boxes, switch boxes, and associated fittings shall be galvanized malleable iron or Owner-accepted equal cast ferrous metal for use with threaded steel conduit.

16920.3.5.3 Installation. Cabinets and boxes shall be rigidly mounted. Mounting on concrete shall be by post-installed mechanical anchors. Mounting on steel shall be by drilled and tapped screw holes, or by special support channels welded to the steel, or by both. Cabinets shall be leveled and fastened to the mounting surface with not less than 1/4 inch air space between the enclosure and mounting surface. All mounting holes in the enclosure shall be used.

Except as prevented by the location of other work, all junction boxes, pull boxes, and outlet boxes shall be centered on structures.

Conduit openings in boxes shall be made with a hole saw or shall be punched. All unused threaded openings shall be sealed with threaded plugs.

16920.3.5.4 Terminal Box and Junction Box Identification. The identification number indicated on the drawings for each junction box and terminal box having a depth greater than 24 inches shall be engraved on a Phenolic tag and attached to the box.

The identification number of each junction box and terminal box having a depth of 24 inches and smaller shall be engraved on a phenolic nameplate and attached to the box.

Nameplates shall meet the requirements of Section 17302 – Phenolic Nameplates.

16920.3.6 Cable Tray Components

An electrical cable tray system shall be furnished and installed in accordance with the Contractor's design and the following specifications. Cable tray components shall include cable tray, fittings, supports, accessories, and hardware required for a complete system.

16920.3.6.1 Cable Tray Materials. Electrical cable tray and associated component materials shall conform to the requirements of NEMA VE-1 for metal cable trays, NEMA FG-1 for fiberglass cable trays, and these specifications. All cable trays shall have a class designation of 16C in accordance with NEMA VE-1 1998 unless otherwise indicated. In case of conflict between the NEMA standards publications and these specifications, the requirements of these specifications shall govern to the extent of such conflict. Cable tray components for similar cable tray materials shall be manufactured by one manufacturer.

16920.3.6.1.1 Steel cable tray. Steel cable tray shall be hot-dipped galvanized after fabrication in accordance with ASTM A123. The galvanizing coat shall cover all interior surfaces of hollow members, as well as exterior surfaces. The minimum metal thickness for tray bottoms or rungs shall be 18 gauge. Steel cable tray shall have concentric curved radius fittings.

Ladder type steel cable trays shall have rung spacings on 9 inch centers. The rung spacing shall be maintained at the center line of all horizontal and vertical elbows. Individual rungs shall provide a minimum of 1 inch of cable support surface.

Solid bottom steel cable tray shall be constructed with either a flat tray bottom within the cable loading area, or a corrugated tray bottom. Corrugated tray bottoms shall be constructed to provide cable support surface over a minimum of 50 percent of the cable length laid anywhere in the tray.

Hardware for steel cable tray shall be case hardened galvanized steel suitable for indoor and outdoor use.

16920.3.6.1.2 Aluminum cable tray. Aluminum cable tray shall be fabricated from copper free aluminum or aluminum alloy. The minimum metal thickness for tray bottoms or rungs shall be 0.063 inch. Aluminum cable tray shall have concentric curved radius fittings. Cable tray shall have a 4 inch loading depth with a minimum NEMA 16C classification.

Ladder type aluminum cable trays shall have rung spacings on 9 inch centers. The rung spacing shall be maintained at the center line of all horizontal and vertical elbows. Individual rungs shall provide a minimum of 1 inch of cable support surface.

Solid bottom aluminum cable tray shall not be used.

Hardware for aluminum cable tray shall be case hardened galvanized steel suitable for indoor and outdoor use. Hardware for aluminum cable tray in corrosive areas shall be Type 316 stainless steel.

16920.3.6.1.3 Fiberglass cable tray. Fiberglass cable tray shall be fabricated from a fiberglass composite resin that is flame retardant and resistant to ultraviolet light. Fiberglass cable trays shall have an outer surface coating that provides chemical protection. All fiberglass cable tray edges shall be sealed. Fiberglass cable tray shall have concentric curved radius fittings.

Ladder type fiberglass cable trays shall have rung spacings on 9 inch centers. The rung spacing shall be maintained at the center line of all horizontal and vertical elbows. Individual rungs shall provide a minimum of 1 inch of cable support surface.

Solid bottom fiberglass cable tray shall not be used.

Hardware for fiberglass cable tray shall be Type 316 stainless steel.

16920.3.6.1.4 Splice plates. Splice plates shall be fabricated from the same material as the cable tray systems they connect, and be engineered for the same. Splice plates shall be connected to the tray side rails using bolts designed to prevent rotation during tightening of the associated nuts. Nuts shall be flanged serrated locknuts, locknuts with serrated washers, or locknuts with captive washers. All bolts holes shall be used on the splice plates.

Splice plates shall include straight plates, step-down plates, vertical adjustable plates, horizontal adjustable plates, offset reducing plates, tray-to-box plates, and expansion plates. Expansion plates shall be constructed to allow a minimum of 1 inch of movement for metal cable trays, and a minimum of 0.625 inch of movement for fiberglass cable trays.

16920.3.6.1.5 Barrier strips. Barrier strips shall be hot-dipped galvanized steel for steel cable trays, copper free aluminum or aluminum alloy for aluminum cable trays, and flame retardant fiberglass composite resin for fiberglass cable trays. Plastic barrier strip splices shall be used to hold adjoining barrier strips in alignment.

16920.3.6.1.6 Cable tray covers. Cable tray covers shall be hot-dipped galvanized steel for steel cable trays, copper free aluminum or aluminum alloy for aluminum cable trays, and flame retardant fiberglass composite resin for fiberglass cable trays. Cable tray covers shall have flanged edges, turned down to provide rigidity. The minimum metal thickness for tray covers shall be 18 gauge for steel cable trays and

0.063 inch for aluminum cable trays. Plastic joint plates shall be used to hold adjoining cable tray covers in alignment.

Cable tray cover clamps shall be galvanized steel for steel cable trays, copper free aluminum or aluminum alloy for aluminum cable trays, and flame retardant fiberglass composite resin for fiberglass cable trays. Cable tray cover clamps used on outdoor cable trays shall be suitable for outdoor use as recommended by the manufacturer.

16920.3.6.1.7 Cable tray hold-down/expansion clamps. Cable tray hold-down clamps shall be galvanized steel for steel cable trays, copper free aluminum or aluminum alloy for aluminum cable trays, and flame retardant fiberglass composite resin for fiberglass cable trays. Cable tray hold-down clamps shall hold the bottom flange of the tray firmly in place on the supporting cross member without requiring drilling of the tray flange.

Cable tray expansion clamps shall be fabricated from the same material as the hold-down clamps. The expansion clamps shall allow the expansion and contraction of the cable tray along its longitudinal center line, while also maintaining the same location of the tray center line. The expansion clamps shall be designed to attach to the supporting cross member of the tray support.

16920.3.6.1.8 Structural requirements. Cable tray shall have a safety factor of 1.5 in regard to destructive load testing in accordance with the requirements of the specified standards for load span class designations, without failure or permanent distortion. In addition to the cable loads defined in the load span class designations, the cable tray shall be capable of supporting an additional 200 pound concentrated load. This concentrated load shall be applied at the midspan on the center line of the tray and at the midspan of either side rail, without causing failure or permanent distortion to the cable tray.

Cable tray shall have the following minimum load span class designations. The tray sizes indicated reflect the nominal loading area inside the tray, not the overall outside tray dimensions:

Table 16920-5 NEMA Class Designation for Different Tray Sizes

Tray Size, inches, nominal loading area	NEMA Class Designation
3 x 6	12A
3 x 12	12C
3 x 18	16B
3 x 24	16C
3 x 30	20B
3 x 36	20C
4 x 6	12A
4 x 12	12C
4 x 18	16A
4 x 24	16B
4 x 30	16C
4 x 36	16C
5 x 6	12A
5 x 12	12A
5 x 18	16A
5 x 24	16C
5 x 30	20B

Table 16920-5 NEMA Class Designation for Different Tray Sizes	
Tray Size, inches, nominal loading area	**NEMA Class Designation**
5 x 36	20C
6 x 6	12A
6 x 12	12A
6 x 18	12C
6 x 24	16A
6 x 30	16C
6 x 36	20C

16920.3.6.2 Cable Tray Supports. Cable tray supports shall conform to the requirements of the articles that follow. Cable tray support materials shall be as required by the Contractor's design. Cable tray supports shall have a minimum safety factor of 2.0 for any support element.

16920.3.6.2.1 Hanger rods. Hanger rods used for the support of formed channel shall be 1/2 inch diameter electrogalvanized continuous threaded steel rods for use with metal cable trays. Electrogalvanized hanger rods as shown in the Ameren Missouri Approved Suppliers.

Hanger rods used for the support of formed channel for fiberglass cable tray shall be 1/2 inch diameter continuous threaded Type 316 stainless steel. Stainless steel hanger rods as shown in the Ameren Missouri Approved Suppliers

16920.3.6.2.2 Support channel. Support channel shall be hot-dipped galvanized formed channel made from 12 gauge steel in 1-5/8 inch series sizes for metal cable trays. Support channel as shown in the Ameren Missouri Approved Suppliers

Support channel used for the support of fiberglass cable tray shall be flame retardant fiberglass composite resin formed channel made in 1-5/8 inch series sizes. Fiberglass support channel as shown in the Ameren Missouri Approved Suppliers.

16920.3.6.2.3 Support channel fittings. Support channel fittings shall be flat plate and angular fittings and brackets designed for use with the 1-5/8 inch series formed channel indicated previously. Support channel fittings shall be hot-dipped galvanized steel for metal cable trays and will be as shown in the Ameren Missouri Approved Suppliers Support channel fittings shall be as manufactured as indicated in Ameren Missouri Approved Suppliers

16920.3.6.2.4 Support loading. Cable tray supports shall be capable of supporting the uniform weight of the trays, plus their nominal uniform cable loads, plus a 200 pound concentrated load without exceeding the allowable load limit for any element of the support system when the safety factor is applied. The following cable loads shall be used for calculating the weight of cables in tray:

Table 16920-6 Cable Tray Nominal Cable Load per Linear Foot				
Tray Width, inches (nominal loading area)	**Nominal Cable Load per Linear Foot, pounds (nominal tray loading depth as indicated)**			
	3 inch	**4 inch**	**5 inch**	**6 inch**
6	15	20	25	30
12	30	40	50	60
18	45	60	75	90
24	60	80	100	120

30	75	100	125	150
36	90	120	150	180

16920.3.6.3 Cable Tray Installation. Cable trays and supports shall be installed in accordance with the cable tray manufacturer's instructions, the drawings, and these specifications.

16920.3.6.3.1 Tray surfaces. The Contractor shall cut the trays to length as required. The trays shall be cut with saws and all surfaces over which the conductors and cables will be laid shall be ground or filed to remove any sharp edges which could cause damage to the cable jacket or insulation either during installation or in normal service. The plane of all field cut tray ends shall be square and perpendicular with the center line. Areas on which galvanizing is removed or damaged shall be repaired using a cold galvanizing zinc rich coating. Field cut fiberglass tray edges shall be resealed using a manufacturer approved resin sealant.

16920.3.6.3.2 Application and location of supports. Cable trays shall be bracket supported from walls or columns and hanger supported from overhead structural members, at intervals not exceeding 12 feet when measured along tray center lines between supports. All fittings shall be supported in accordance with NEMA VE-2 for metal trays, and NEMA FG-1 for fiberglass trays.

Supports on or from concrete or masonry shall be secured with post-installed mechanical anchors. Beam clamps with safety anchor straps shall be used to secure supports to structural steel beams for horizontal tray hangers. Welding, beam clamps, or drilling and tapping shall be used to secure supports to column steel. Hanger rod support shall include two rods, one on either side of the tray. Nuts shall be fully threaded on the rods.

The exact location and dimensions of supports and hangers shall be the Contractor's responsibility. The support system shall be designed so that it does not interfere with the present or future installation or expansion of dimensioned equipment, prerouted pipe, pipe insulation, walls, building steel, or HVAC duct. Hanger rods shall not pass between the side rails or rungs of any tray.

Except where supported by brackets, cable tray shall be supported by hanger rods, cross members, and hold-down or expansion clamps.

Where feasible, supporting anchors, hangers, clamps, and hardware shall be installed as detailed on the drawings.

16920.3.6.3.2.1 Seismic supports. Seismic cable tray supports shall be located and installed as required to provide the necessary restraint against vertical, transverse, and longitudinal seismic forces which may be applied to the completed tray system. Seismic supports shall be appropriate for the published Seismic Zone Rating in accordance with project requirements and applicable building codes.

16920.3.6.3.3 Expansion joints. Cable tray expansion plates and expansion clamps shall be installed as required to allow for the thermal expansion and contraction of the completed tray system in accordance with manufacturer's recommendations. Bonding ground jumpers shall be installed across all expansion joints, attaching to the tray side rail beyond both ends of the expansion plate. Expansion joints shall allow for a maximum of 1 inch movement for metal cable trays and 5/8 inch movement for fiberglass cable trays.

16920.3.6.3.4 Tray covers. Where required, tray covers shall be installed after cable pulling through the tray is complete. Immediately before installing covers, all debris shall be removed from the tray. Joint plates shall be used at all cover joints and at locations where tray covers stop, to prevent the covers from buckling or bowing into the tray. Tray covers shall be secured to the tray using the manufacturer's recommended tray cover clamps or with self-tapping screws. In addition to the clamps, at least one bolted connection or screwed connection shall be installed on each cover section through each side rail on vertical tray to prevent the covers from sliding down the tray.

Where required, tray covers shall be cut or notched to provide clearance around clamps, conduits, and cables as required for proper fit. Covers shall be saw cut. The cut edges shall be filed smooth and

regalvanized or resealed. Cover edges which are in contact with cable shall be covered with protective material.

Cable tray covers shall be installed at the following locations. Unless otherwise indicated, the following guidelines apply to indoor and outdoor tray:

Accessible vertical ladder type trays shall be furnished with solid covers, starting 12 inches below the access floor or platform, and extending to a height of 8 feet above the access floor or platform.

Horizontal trays located under grating floors and platforms, or within 24 inches of insulated pipe, shall be furnished with covers which extend at least 2 feet beyond that part of the trays directly exposed beneath the grating floor, platform, or insulated pipe.

Horizontal covers for indoor power trays shall be tight-fitting raised solid covers. Horizontal covers for indoor control and instrument trays shall be tight-fitting or raised solid covers. Horizontal covers for outdoor power trays shall be tight-fitting ventilated covers. Horizontal covers for outdoor control and instrument trays shall be tight-fitting solid covers.

Covers may be omitted on lower stacked ladder type trays where a covered tray at a higher elevation in the stack provides complete vertical shielding to the lower trays.

Raised covers shall not be furnished on outdoor trays.

16920.3.6.3.5 Tray identification. Each tray shall be clearly identified with its raceway number and voltage level as indicated on the drawings. Identification labels shall be applied at all tray junctions and at intervals not to exceed 20 feet. Individual numbers shall be a minimum of 2 inches high by 3/4 inch wide. Trays shall be labeled using labels with a yellow background and black lettering/numbering.

16920.3.6.3.6 Temporary tray covers. Where horizontal tray is directly under grating, temporary covers shall be installed on top of the grating and securely fastened to the grating. Where horizontal tray is not under grating but the cable is still subject to damage from falling debris, temporary covers shall be connected to building steel or the tray support system. The temporary tray covers shall NOT create a tripping hazard. All temporary covers shall extend at least 6 inches horizontally beyond the tray being protected. Temporary covers shall not interfere with the installation of cable in the tray system. Temporary covers shall be constructed of 3/4 inch flame retardant plywood. The location, attachment, and support of temporary covers shall be acceptable to the Owner. Temporary covers shall be installed before any cable is pulled in the tray, and shall be removed after permanent covers are installed.

16920.3.6.4 Quality Control. All cable tray and associated components furnished shall be of uniformly high quality. In addition to conforming to the referenced codes and standards, the following shall also apply:

Finish shall be uniform. On the galvanized steel tray, a durable, high quality, relatively smooth coating is required. The Manufacturer's attention is directed to the requirements of ASTM A123, ASTM A384, and ASTM A385 in this regard. Grounds for rejection of members because of galvanizing defects shall be as listed in Table II of the "Inspection Manual for Hot-Dip Galvanized Products," published by the American Zinc Institute except that excessive general roughness, pimples, lumpiness, runs, black spots, dull gray coating, rust stains, and bulky white deposits shall be cause for rejection.

Straight members shall be free of bends, flat members shall be free from waves and bellies, and curved members shall curve uniformly.

Sharp corners and protrusions shall be avoided and dimensional transitions shall be gradual rather than abrupt.

Welding fillets shall be uniform in cross section, continuous where applicable, and free from voids, porosity, or inclusions. Metal adjacent to welds shall be free from burnouts or discoloration.

Interior of cable tray and cable tray components shall be free of sharp edges or roughness.

All cable tray and associated components furnished shall be such that the completed installation will provide a neat and symmetrical appearance. Their construction and assembly shall reflect careful workmanship and rigid quality control in their manufacture. All tray and fittings shall be uniform in appearance and shall be free of all markings except for piece designations, which shall be on the inside of the tray, and cable tray identification markers.

Components used in trays of different depths and widths shall be similar and uniform in material, shape, appearance, and method of fabrication. It is preferred that trays of different depths and widths shall differ only in dimensions. Differences in construction or appearance which are excessive in the opinion of the Owner shall be cause for rejection.

Method of joining tray sections, fittings, or tray sections and fittings shall provide a smooth, uniform junction of strength and rigidity equal to the tray side rail.

16920.3.7 Duct Bank and Electrical Manhole Components

An electrical duct bank and electrical manhole system shall be furnished and installed in accordance with the following specifications. Duct bank components shall include conduit, elbows, couplings, spacers, and termination accessories. Electrical manhole components shall include cable pulling eyes and cable racks.

Twenty-five percent spare duct bank tubes, or a minimum of four 4 inch and four 2 inch duct bank tubes, whichever is greater, shall be provided in each duct bank for use by the Owner. In addition, four (4) 4 inch and two (2) 2 inch ductbank tubes shall be installed in addition to the spare ductbank tubes specified above which will be dedicated to the future addition of future equipment. The number of spare duct bank tubes shall be in addition to the spare duct bank tubes that will be dedicated to the future addition of future equipment). The number of spare duct bank tubes shall be reviewed with and acceptable to the Owner. Cables in the duct bank tubes and trays shall be segregated by generating unit.

The duct bank system shall match the existing plant nomenclature and arrangement.

16920.3.7.1 Duct Bank and Electrical Manhole Materials. Duct bank, electrical manhole and associated component materials shall conform to the requirements of the articles that follow.

16920.3.7.1.1 Rigid galvanized steel conduit. Steel conduit, couplings and elbows shall be a threaded hot-dipped galvanized rigid mild steel manufactured in accordance with ANSI/NEMA C80.1 and UL 6. The conduit interior and exterior surfaces shall have a continuous hot-dipped galvanized coating with a transparent overcoat of enamel, lacquer, or zinc chromate. Each length of conduit shall have a coupling on one end and a thread protector on the other. The thread protector shall have sufficient mechanical strength to protect the threads during normal handling and storage. Rigid galvanized steel conduit shall be similar to Type GRC, as manufactured by suppliers listed on the Approved Suppliers List.

16920.3.7.1.2 Rigid plastic conduit. Plastic conduit and elbows for duct bank applications shall be unthreaded Schedule 40. Rigid plastic conduit shall be as manufactured by suppliers listed on the Approved Suppliers List.

16920.3.7.1.3 Duct bank elbows. Horizontal and vertical intermediate duct bank elbows for rigid galvanized steel conduit shall be of the same material as the rigid galvanized steel conduit. Horizontal and vertical intermediate duct bank elbows for rigid plastic conduit shall be of the same material as the rigid plastic conduit. Duct bank elbows shall have a minimum radius of 36 inches.

16920.3.7.1.4 Duct bank riser elbows. Duct bank riser elbows shall be PVC coated rigid galvanized steel elbows, made of the same material as the rigid galvanized steel conduit. Duct bank riser elbows shall have a minimum radius of 36 inches.

16920.3.7.1.5 Duct bank end bells. Duct bank end bells shall be plastic for use with the rigid plastic conduit. End bells shall be as manufactured by suppliers listed on the Approved Suppliers List.

16920.3.7.1.6 Duct bank plugs. Duct bank plugs for rigid steel conduit shall be threaded, malleable iron, zinc plated plugs, Type PLG, as manufactured by suppliers listed on the Approved Suppliers List. Duct bank plugs for rigid plastic conduit shall be plastic, high impact plugs tapered to fit the end bells provided. Plastic duct bank plugs shall have pull tabs. Plastic duct bank plugs shall be as manufactured by suppliers listed on the Approved Suppliers List.

16920.3.7.1.7 Pulling line. Pulling line installed in duct bank tubes shall be continuous fiber polyline. The pulling line shall be mildew and rot resistant, and shall have a minimum tensile strength of 200 pounds. Pulling line shall be as shown in the Ameren Missouri Approved Suppliers

Pull strings shall be installed in each duct bank tube.

16920.3.7.1.8 Cable pulling eyes. Cable pulling eyes shall be fabricated from galvanized steel rod and constructed to allow embedment into the walls of electrical manholes. Cable pulling eyes shall be similar to Type DU2T3, as shown in the Ameren Missouri Approved Suppliers.

16920.3.7.1.9 Cable racks. Cable racks installed in electrical manholes shall be fabricated from hot-dipped galvanized formed channel. Formed channel embedded in the walls of electrical manholes shall be similar as shown in the Ameren Missouri Approved Suppliers. Formed channel surface mounted to the walls of electrical manholes, and also used as horizontal cable supports, shall be similar to that shown in the Ameren Missouri Approved Suppliers," or Owner-accepted equal. Cable tray is also acceptable to act as a manhole cable rack.

16920.3.7.1.10 Concrete. Concrete shall conform to Section 03311 - Cast-in-Place Concrete. Concrete used for electrical duct bank shall be red and have red dye mixed throughout. Red dye applied to the top of the concrete following the final placement of concrete is not acceptable.

16920.3.7.1.11 Electrical manholes. Electrical manholes shall be as indicated on the drawings. Electrical manholes may be cast-in-place or prefabricated structures.

16920.3.7.2 Duct Bank Supports. Duct bank conduit supports shall be plastic, high impact, interlocking base and intermediate spacers designed to allow the flow of concrete through and around the spacers. Duct bank spacers shall be as shown in Ameren Missouri Approved Suppliers

16920.3.7.3 Duct Bank Installation. Each duct bank shall be laid to exact grade in the trench and the ends shall enter manholes or buildings as indicated on the drawings. No dips or low points which retain water in any duct will be permitted in ducts between manholes or between buildings and manholes. End bells shall be used on individual plastic ducts, and threaded couplings on individual rigid steel ducts, at the end of duct banks entering manholes or buildings except where another type of termination is specified or detailed on the drawings. All field bends and sweeps shall be a minimum 36 inch radius.

The ends of the individual plastic ducts shall be cleaned and swabbed with joint sealing compound, and the duct shall then be forced tightly into the coupling to make a watertight connection. The ends of threaded rigid steel conduit shall be installed in couplings with the conduit ends butted. The individual ducts shall be laid in place, held by standard spacers placed at 5 foot intervals, and secured in place with hemp or sisal twine, or tie wire. The concrete envelope shall be placed after the individual ducts are securely tied in place and adequately anchored and/or weighted to completely counteract the buoyancy of the ducts in the fluid concrete. Care shall be taken in pouring the concrete to prevent the empty ducts from being damaged or displaced, either in grade or alignment.

Defective ducts shall not be installed and shall be removed immediately from the site of the work. Particular care shall be taken to keep concrete or other substances from the inside of the individual ducts during construction. All magnetic materials installed in a duct bank shall be parallel to the lengths of the individual ducts.

16920.3.7.4 Testing and Cleaning. After completion of the duct bank and before cable is pulled into duct banks, each duct shall be thoroughly cleaned. All foreign material, earth, sand, and gravel shall be removed from the ducts by an acceptable cleaning method. Ducts which will not be used immediately shall be plugged at each end. A pulling line shall be installed in all unused ducts.

16920.3.7.5 Electrical Manhole Installation. Manholes shall be erected and installed at the locations and elevations indicated on the drawings. Manhole sides and tops shall be installed in accordance with the manufacturer's instructions. Joints shall be watertight. Manhole and duct bank interfaces shall be watertight.

16920.3.8 Underground Concrete Cable Trench System

If an underground concrete cable trench system is required by the Contractor's design, the Contractor may furnish either a cast-in-place or precast concrete cable trench system. If a cast-in-place concrete cable system is furnished, it shall meet the requirements of Section 03311-Cast-in-Place Concrete. If a precast underground concrete cable trench system is required by the Contractor's design, it shall be furnished and installed in accordance with the Contractor's drawings and the following specifications.

16920.3.8.1 General. A precast underground concrete trench system with covers extending above the surrounding crushed rock surfacing, or level with the road surface where crossing roads, shall be constructed at the locations indicated on the Contractor's drawings.

The trench system shall consist of precast concrete framing members, side sections and removable cover sections assembled to form a completely enclosed trench, except the bottom shall have a bedding of sand.

Construction shall be to grades as indicated on the Contractor's drawings.

16920.3.8.2 Material. A One-Piece concrete underground trench system as shown in Ameren Missouri Approved Suppliers shall be furnished.

The dimensions of the trench shall be as indicated on the Contractor's drawings.

The precast sections of the trench system shall be furnished in standard 10 foot lengths, except that special lengths shall be furnished where required by the Contractor's drawings.

The precast trench covers shall be provided with a Swing Lift lifting system. The special lifting took required for the lifting system shall be provided.

The trench system shall be designed for a HS-20 load.

Precast trench members shall be cast in steel forms using 4,000 pound or greater high early strength concrete. Members shall be cured for a period of at least 14 days.

The Contractor shall furnish all necessary special fittings, offsets, terminations, or other designated fittings as required.

16920.3.8.3 Excavation. All excavation and backfill shall conform to Section 02315.

16920.3.8.4 Installation. Installation shall be as indicated on the plans and Trenwa erection drawings.

If the bottom of the cable trench is enclosed, it shall have provisions to be self-draining such that water does not accumulate in the bottom of the cable trench.

Framing members shall be set only on firm, compacted earth, sand or gravel mix, at an elevation such that the top of bracket (and sidewall) will be at the final grade (top of crushed rock).

After setting frames and sides in place, backfill shall be placed along the sides and a minimum 4 inch bedding of sand shall be placed in trench to form a level bottom, just covering the framing members.

Backfill along the outside walls of the trench shall be mechanically tamped.

A ground cable shall be installed in the trench system on both sides over its entire length using manufacturer's noncorrosive metal cable clip supported on each framing member. The ground cable shall be sized as indicated on the Contractor's drawings.

Conduits entering the trench system shall be laid beneath the sides of the trench and terminated with an elbow.

Covers shall be placed on trenches after installation of cables is completed.

The cable trench system shall be protected against entrance of construction debris, rock, and earth during the construction and after placing of the sand bedding. The Contractor shall clean out trenches of any such foreign material prior to placing cables and just before final placing of covers.

The Owner shall be provided with a new set of manufacturer's cover removal tools as well as the tools used during the installation.

16920.3.9 Grout

Grout shall be as specified in Section 03611 - Grouting, and modified as follows:

> Nonshrinking grout shall be used whenever the space to be grouted has a thickness of 2 inches or more and free placement of grout will not be hampered. Fifty pounds of pea gravel may be added to each 100 pounds of grout materials.
>
> Grout shall be placed in strict accordance with the directions of the manufacturer to completely fill the openings without voids.

SECTION 16925
CONDUCTOR INSTALLATION

16925.1 General

This section covers the installation of cable, conductors, and accessories. Insulated cable, conductors, and conductor accessory installation shall be in accordance with the cable manufacturer's recommendations, circuit lists, raceway lists, the drawings provided by the Contractor, and these specifications.

Installation shall be defined to include receiving; unloading; storage; placement; splicing; terminating conductors; coiling and taping of spare conductors; and identification, testing, and verification of each circuit, cable, and conductor. Installation of cable in existing trays shall also include removal and replacement of existing cable tray covers.

Terminating a conductor shall include installing cable termination kits for shielded cable, attaching the conductor at its designated location, and insulating the entire connection where specified or required by the application.

Phase tape shall be applied to each conductor at the terminations of all power and lighting circuits that are not already properly color coded.

16925.1.1 Scope of Supply

Unless otherwise specified as being furnished by others, the Contractor, shall furnish all insulated power, control, instrumentation, communication, fiber-optic, lighting and grounding cable; terminations; fittings; splices; lubricants; equipment; and miscellaneous materials as required for a complete conductor installation.

16925.1.2 Not Used

16925.1.3 Performance and Design Requirements

Performance and design requirements for the equipment to be furnished under this article of these specifications are indicated herein.

16925.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16925-1 Codes and Standards

Work	In Accordance With
Cable Installation	IEEE 1185, ANSI/NECA/BICSI 568
Splicing/Terminating	IEEE 404, UL 486A, UL 486C, ASTM F1836, ANSI/NECA/BICSI 568 and manufacturer’s instructions for termination kits)
Field Testing	IEEE 400, ANSI/TIA/EIA-568B

All circuits and cable components shall be installed in accordance with the applicable requirements of NFPA 70 - National Electrical Code. All materials and devices shall be in accordance with the applicable requirements of the Federal "Occupational Safety and Health Standards."

16925.1.5 Materials
The following materials shall be used:

Table 16925-2 Materials	
Component	**Material**
Cables	Materials as indicated herein or in the technical attachments
Cable Accessories	As indicated in Article 16510.2.3
Cable Pulling Lubricant	As recommended by cable manufacturer

16925.1.6 Approved Manufacturers of Components
Cables shall be provided as indicated Table 1.6.1 in Section 16510 and the Suppliers in Ameren Missouri Approved Suppliers. Only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications.

16925.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16925-3 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Tests after placement	Articles 16925.3.5 and 16925.3.7	Contractor

16925.1.8 Not Used

16925.1.9 Not Used

16925.1.10 Certification Requirements
Certified test reports for each type of power cable furnished under this Contract shall be provided in accordance with the requirements of AEIC CS8 and ICEA S-97-682 (ICEA/AECI MV power cable), and in accordance with the requirements of ICEA S-95-658 (ICEA/UL LV power cable).

16925.2 Products
Conductors and accessories shall be furnished in accordance with the requirements of Section 16510 - Conductors and Accessories.

16925.3 Execution

16925.3.1 Handling of Cable
Cable reels shall be stored and handled in a manner which will prevent physical damage to the cable. Cable reels shall be stored resting on the edges of the reel flanges on a hard surface to prevent contact between cable insulation and earth due to sinking of the reel. Impact damage between reels shall be prevented by aligning reels flange-to-flange or by using guards across flanges. During storage, the ends of all cable rated 5 kV and above shall be protected with end caps.

16925.3.2 Cable Placement
All cable provided by the Contractor shall be routed as indicated therein.

Cable shall not be handled when the cable temperature is below the minimum temperature recommended by the manufacturer. If cable heating is required prior to placement, the cable shall be stored in a heated

building in accordance with the manufacturer's recommendations for at least 24 hours. Cable shall be placed the same day it is removed from heated storage.

If at any time during the progress of the work the Contractor finds raceways which appear inadequate to accommodate the assigned cable, he shall take steps to stop work and determine a solution.

All cable shall be carefully checked both as to size and length before being pulled into conduits or ducts. Cable pulled into the wrong conduit or duct or cut too short to rack, train, and splice as specified herein shall be removed and replaced. Cable removed from one conduit or duct shall not be pulled into another conduit or duct without prior approval from the Owner.

16925.3.2.1 Cable in Trays. All cable shall be carefully laid in or pulled through the tray system so that neither the cable nor the trays are damaged. Cable may be laid along the side of the tray system during placement provided it is protected from dirt, water, oil, or other detrimental materials and from mechanical injury. Cable shall be cut sufficiently long to conform to the contour of the trays, with particular attention paid to vertical inside bends. All excessive slack shall be removed from the cable so that it lies parallel to the sides of the trays. Multiple single conductor cable which constitutes a single power circuit shall be grouped together as defined by the NEC to minimize magnetic influence on other cable in the area.

Power cables shall be installed in tray in accordance with the NEC and the following additional requirements:

Medium Voltage Power Cables (2001 volts or over)
Medium voltage power cables (both single conductor and multi-conductor) shall be installed in cable tray in a single layer. If single conductor cables are triplexed or bound together in circuit groups, the sum of the diameters of all single conductors shall not exceed the cable tray width.

Medium voltage multi-conductor power cables shall be installed in cable tray in a single layer with a maintained spacing of not less than one cable diameter between cables.

Low Voltage Power Cables (2000 volts or less)
Low voltage power cables (all single conductor and multi-conductor greater than or equal to 4/0 AWG) shall be installed in cable tray in a single layer. If single-conductor cables are triplexed or bound together in circuit groups, the sum of the diameters of all single conductors shall not exceed the cable tray width. Multiconductor power cables less than 4/0 AWG may be installed in a random manner in accordance with NEC Article 392.9 (A)(2) and (3).

Low voltage multi-conductor power cables shall be installed in cable tray in a single layer with a maintained spacing of not less than one cable diameter between cables.

The cable shall be tied to the trays with nylon ties as necessary (but at not greater than 10 foot intervals) to hold it in place.

16925.3.2.2 Cable in Manholes and Trenches. Cable shall be supported at all times without short bends or excessive sags and shall not be permitted to lie on the manhole floor. Cable ends must not be submerged. Cable racks or trays shall be provided for permanent support. Temporary support required during placement shall be with rope slings, timbers, or alternate methods acceptable to the Owner.

16925.3.2.3 Cable Pulling. Fishing and pulling shall be done with flexible metal tape, CO_2 propelled polyethylene cord, nylon rope, or manila rope.

Unless specified otherwise or acceptable to the Owner, cable shall not be pulled in a single pull through two sections of raceway connected by a manhole or pull box. Cable shall be pulled out at each manhole and pull box to the length required for termination. Prior to repulling of the pulled out cable, the cable shall be thoroughly inspected, cleaned, and relubricated. Damaged cable shall be removed and replaced.

Cable may be pulled in a single pull through two sections of raceway connected by a manhole or pull box only if it can be determined by calculation to the satisfaction of the Owner that the pulling tension will not exceed the maximum tension allowed by the cable manufacturer.

Cable shall not be pulled using trucks, forklifts, cranes, or other devices where the tension of the cable pull cannot be easily controlled.

16925.3.2.4 Cable Grips. Factory installed pulling eyes shall be used for pulling cable where they are available. Woven wire cable grips shall be used to pull all single conductor cable 2/0 AWG and larger, where pulling eyes are not available, and all multiconductor cable. Pulling loops shall be used to pull single conductor cable smaller than 2/0 AWG. All sharp points and edges on the hardware attaching the pulling rope to the cable shall be taped to prevent snagging or damaging the raceway.

When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal plus 6 inches shall be cut off and discarded when the pull is completed. When pulling loops are used, the entire loop shall be cut off and discarded when the pull is completed.

As soon as the cable is pulled into place, the pulling eyes, cable grips, or pulling loops shall be removed and any cable which was sealed shall be resealed.

16925.3.2.5 Swivels. A reliable nonfreezing type of swivel, or swivel connection, shall be inserted between the pulling rope and the cable pulling eye, grip, or loop to prevent twisting under strain.

16925.3.2.6 Pulling Lubricants. Only lubricants recommended by the cable manufacturer and acceptable to the Owner shall be used. Lubricants shall be applied liberally and continuously during the pull.

16925.3.2.7 Inspection. The outside of each cable reel shall be carefully inspected and protruding nails, fastenings, or other objects which might damage the cable shall be removed. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be completely removed and replaced.

16925.3.2.8 Pulling Tension. The pulling tension of any cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both the manual and power types used by the Contractor shall have the rated capacity in tons clearly marked on the mechanism. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected.

16925.3.2.9 Sidewall Pressure. To avoid insulation damage from excessive sidewall pressure at bends, the pulling tension in pounds shall not exceed the cable manufactures recommendation.

16925.3.2.10 Cable Bends. Tape shielded, flat tape armored, and wire armored cable shall not be bent to a radius of less than 12 times the overall cable diameter. All other cables shall not be bent to a radius of less than 8 times the cable diameter.

16925.3.2.11 Supports. All cable supports and securing devices shall have bearing surfaces located parallel to the surfaces of the cable sheath and shall be installed to provide adequate support without deformation of the cable jackets or insulation.

Adequate cable end lengths shall be provided and properly placed in junction boxes and manholes to avoid longitudinal strains and distorting pressures on the cable at conduit bushings and duct end bells.

Final inspection shall be made after all cable is in place and, where supports or raceway fittings deform the cable jacket, additional supports shall be provided. Additional cable protection such as a wrapping of light rubber belting, friction tape, or similar material shall be provided where required.

Cable in vertical runs shall be supported by woven wire grips in accordance with the NEC requirements, except that the distance between supports shall conform to the following:

Table 16925-4 Conductor Vertical Cable Support Spacing		
Vertical Cable Support Spacing		
Conductor Size	**Aluminum Conductor**	**Copper Conductor**
1/0 AWG and smaller	150 feet	100 feet
2/0 AWG through 500 kcmil	100 feet	50 feet
Larger than 500 kcmil	70 feet	30 feet

16925.3.2.12 Cable Racks. Where cable trays are not specified in manholes, cable racks shall be furnished and installed according to the drawings and as required to provide the proper cable support. Cable racks shall be installed on spacings of not greater than 36 inches and shall be bolt secured to permanent wall surfaces with self-drilling anchors or continuous slot concrete inserts.

16925.3.2.13 Spare Conductors. All spare conductors of a multiconductor cable shall be left at their maximum lengths for possible replacement of any other conductors in the cable. Each spare conductor shall be neatly dressed and labeled for future use. A minimum of 15% spare conductors per cable will be required for installation. If percentage is less than 1, round to the next whole number.

16925.3.2.14 Lacing. Nylon ties shall be used to neatly lace together conductors entering panels, switchgear, and similar locations after the conductors have emerged from their supporting raceway and before they are attached to terminals.

16925.3.2.15 Cable Identification. The ends of all circuits shall be identified with a circuit tag. Each marker shall bear the number of the circuit according to the Contractor's cable list and drawings.

Cables run in cable trenches shall be labeled every 25 feet for easy identification.

At terminations, the Contractor shall identify each circuit. Each phase of multiphase power circuits shall be individually identified.

The circuit tag shall be so attached that it is readily visible for circuit identification.

16925.3.2.15 Additional Cable Identification Requirements. A label shall be applied on each end of every cable which includes the applicable schematic number and the "to/from" location. The information shall be on a separate label from the cable number label but placed near the cable number label. This additional labeling requirement only applies to Rush Island.

Phase tape shall be applied to each conductor at the terminations of all power and lighting circuits. The phase taping for power conductors shall be as follows:

Table 16925-5 Phase Tape Color Requirements for Single Conductor Power Cables	
208/120 V Circuits	Black - Phase A; Red - Phase B; Blue - Phase C; White - Neutral
480/277 V Circuits	Brown - Phase A; Orange - Phase B; Yellow - Phase C; Grey - Neutral
4160, 6900, 13800, 38000 V Circuits	Brown - Phase A; Orange - Phase B; Yellow - Phase C

Green shall be used for ground at every voltage level. Phase taping circuits shall not be required if cable with colored insulation is installed.

16925.3.2.16 Moisture Seals. Each cable rated 5000 volts and above shall be kept sealed except when termination and splicing work is being performed.

The ends of all power cables shall be sealed with heat shrinkable caps for circuits larger than #10 AWG. Circuits #10 AWG and smaller can be sealed with heat shrinkable caps or electrical tape. Cap sizes shall be as recommended by the cap manufacturer for the cable OD and insulation. Caps shall contain sufficient adhesive that shrinkage of the cap during application results in formation of a positive watertight seal capable of withstanding complete immersion or total exposure without permitting the entrance of moisture. Heat shrinkable caps shall be "Thermofit" as manufactured by Raychem Corporation or Owner acceptable equal. Lead covered cable shall be sealed by a lead cap wiped to the cable sheath.

Before and after pulling, the leading end seal of each length of cable shall be examined and repaired if necessary. All cut cable ends shall be promptly sealed after cutting except those to be spliced or terminated immediately.

16925.3.2.17 Direct Buried Cable. Direct burial of cable shall be accomplished in the following manner. Cable shall be direct buried only with the approval of the Owner. All below grade cables shall be installed in concrete encased conduit, concrete lined trenches, or duct banks.

16925.3.2.18 Cable in Cable Trenches. Direct buried cable trenches shall allow for 4 inches of bedding material on the sides of the buried cable. In addition, the cable trenches shall allow for 4 inches of bedding material below the buried cable and 8 inches of bedding material above the buried cable.

Bedding material shall be sand or a rock-free screened fill of earth free of rotting wood or organic matter that may attract insects.

Multiple direct buried cables shall not cross or rest upon one another. Buried cables shall be spaced a minimum of 6 inches between centers when laid horizontally in a trench to accommodate the installation of bedding material between them. Multiple layers of direct buried cable installed in the same trench shall maintain a minimum separation of 6 inches between centers, with bedding material installed between them.

Direct buried cable trenches shall not be routed under building foundations. Cable routed under building foundations shall be installed in conduit or duct bank that extends 2 feet beyond the edge of the building foundation at both ends.

If precast covers are not provided for the cable trenches, underground cable warning tape shall be installed in the trench for the direct buried cables, located 12 inches above the highest underground cable in the installation. Multiple runs of warning tape shall be installed in the cable trench to cover a minimum of 75 percent of the surface area of the cable trench for the entire length of the direct buried cable run.

16925.3.2.19 Internal Panel Wiring and Jumpers. Internal panel wiring and jumpers shall be installed in accordance with the Contractor's drawings, schematic and wiring diagrams, three-line diagrams, one-line diagrams, and as required for a complete functional operation of the system or equipment.

Wire markers shall be installed at each end of each jumper, not within the same or immediate adjacent terminal blocks, using slip-on wire markers. Brady self-laminating vinyl labels with 1/4 inch text shall be used for wire and jumper markers. The wire markers shall contain the opposite end designation of the jumper. Jumpers shall be Gray in color. Jumper wire notations shall be acceptable to the Owner.

Jumpers shall be identified on the drawings.

16925.3.3 Splices

Splices are not allowed. Accessory devices equipped with factory installed pigtails or where high temperature wire is necessary shall be terminated in a local junction box with terminal strips locally to connect to a particular device. Shields may be spliced where necessary to permit connection to the station ground.

Power cable circuits may not be spliced-absolutely no exceptions.

Splices shall not be made to utilize short lengths of cable nor shall they be made to provide correct lengths on cable initially cut too short for a particular circuit.

16925.3.4 Terminations

Cable shall be terminated in accordance with the following requirements:

Train cable in place and cut squarely to required length. Avoid sharp bends.

Remove necessary amount of cable jacket and insulation without damage to the conductor.

Install terminals or terminal connectors as required, ensuring a firm metal-to-metal contact.

Reducing pin terminals (if required and approved for use by Owner) shall be installed where 1000V power cables have been oversized and will not fit into mechanical connections such as on molded case breakers.

Install high voltage cable termination kits for shielded cable rated 5 kV and above using the procedures recommended by the manufacturer of the kit being used.

Insulate each connection of cable to an insulated conductor (whether cable, bus, or equipment bushing). The insulation shall cover all exposed surfaces of the conductors; the insulation voltage level of the completed termination shall be not less than the insulation voltage level of the connected conductors.

Instrument cable shields and drain wires shall remain on the pair as close to the termination point as practical. Shields shall be permanently taped to prevent unraveling and the drain wires shall have insulating sleeves installed up to the point of termination.

16925.3.4.1 Insulation of 600 Volt Cable Connections. Where connections of cable rated 600 volts or less require insulation, all exposed conductor and connector surfaces shall be covered with tape in accordance with the following:

A minimum of four half-lapped layers of rubber tape, elongated not more than 20 percent, applied over the silicone rubber tape.

A minimum of three half-lapped layers of vinyl tape applied over the rubber tape. The vinyl tape shall extend a minimum of two cable diameters over the cable jacket and a similar distance over the insulation of the conductor to which the cable is connected.

16925.3.4.2 Insulation of Connections on Indoor Shielded Cable Rated 5 kV and Above. Where indoor connections of shielded cable rated 5 kV and above require insulation, the connections shall be insulated using removable boots or connection kits.

16925.3.5 Tests After Placement

All insulated conductors shall be electrically tested after placement.

All circuits, including lighting circuits, shall be tested with the circuit complete except for connections to equipment. All splices, stress cones on shielded cable, and terminal connector attachments shall be complete prior to testing.

In addition to the tests performed after cable placement is complete, continuity tests shall be performed on all supervisory and communication cable before and after each splice is made.

Any circuit failing to test satisfactorily shall be replaced or repaired and then retested.

All equipment and labor required for testing shall be furnished by the Contractor.

The Contractor shall provide documentation of the tests on forms acceptable to the Owner for each test performed.

16925.3.5.1 Continuity and Identification Tests. All insulated conductors shall be tested for continuity and conductor identification.

16925.3.5.1.1 Continuity tests. Continuity tests shall include all tests necessary to confirm that each conductor is continuous throughout its entire length. Continuity checks shall be performed prior to termination to ensure proper routing and identification of the cables.

16925.3.5.1.2 Identification tests. Identification tests shall include all tests necessary to confirm that the conductor being investigated originates and terminates at the locations designated in the Circuit List or as indicated on the Contractor's drawings.

16925.3.5.2 Insulation Tests. Resistance from ground provided by the insulation on all field-installed insulated power conductors shall be measured, excluding 120 VAC non-essential power circuits.

16925.3.5.2.1 Cable rated 5000 volts and above. All conductors with insulation rated 5000 volts and above shall be given a field dc high potential test.

Application of test voltage shall be as specified on the Cable Test Data forms. Unless otherwise specified, the final test voltage shall be 35 kV for 5000/8000 volt cable (5 kV - 133 percent or 8 kV - 100 percent insulation level) and 55 kV for 15000 volt (100 percent insulated) cable. The duration of the test shall be 15 minutes after reaching the final test voltage.

The tests shall be performed by competent personnel specializing in electrical cable testing. Cable test data on each cable tested shall be reported to the Owner on Cable Test Data forms acceptable to the Owner.

Preparation for Testing. All equipment that is not to be included in the test should be disconnected, including surge arrestors, transformers, motors, circuit breakers, switch taps, and potential transformers. Where cable ends are not terminated on equipment, the ends should be fanned out and supported so that they are separated from each other and from ground by at least 1 inch for each 10 kV of test voltage. Cable termination kits shall be installed at each cable end. Ground all circuit conductors not under test with all cable shields including nearby equipment. Cable terminations and insulator surfaces should be cleaned to minimize leakage and to reduce the possibility of flashovers. To minimize corona at exposed conductor surfaces, the surfaces should be covered with a suitable insulating material. Before applying test voltage, the cable should be allowed to cool to ambient temperature as much as possible. Record ambient temperature, humidity, and cable data on the test form. The test equipment should be supplied from a stable constant-voltage power source. Do not use the same source which is supplying arc welders or other equipment causing line voltage fluctuations.

Test Method. The initially-applied voltage shall not exceed 1.8 times the rated alternating current phase-to-phase voltage of the cable. The voltage shall be increased continuously to the maximum test voltage value. The rate of increase shall be approximately uniform and shall not be more than 100 percent in 10 seconds and not less than 100 percent in 60 seconds. Maximum test voltage shall be maintained for 15 minutes. Current magnitudes shall be recorded at 1 minute intervals. At the end of the test period, set the test set voltage control to zero. Allow the residual voltage on the circuit to decay, then ground the conductor just tested. The cable should remain grounded for at least four times the duration of the test whenever possible.

Evaluation of Results. If the test report indicates a rising leakage current at steady voltage, the cable may be rejected by the Owner. Additional tests, as required, shall be performed by the Contractor at the Owner's request, for test results which are unclear, inconsistent, or inconclusive.

16925.3.5.2.2 Cable rated below 5000 volts. All insulated conductors, except supervisory and communication cable, rated less than 5000 volts shall be tested with a 1000 volt megger or an equivalent testing device. Insulation resistance measurements shall be made between each conductor and ground and between each conductor and all other conductors of the same circuit. Minimum acceptable resistance values shall be approximately 500 megohms.

16925.3.5.2.3 Supervisory and communication cable. All insulated conductors of supervisory and communication cable shall be tested for continuity.

16925.3.5.2.4 CAT5e and CAT6 communications cable. High performance cable certification shall be performed for the permanent link configuration and documented for all CAT5e and CAT6 cables. Testing shall be accomplished with a Level II (CAT5e) or Level III (CAT6) compliant test set with a minimum spectral frequency range of 1 to 100 MHz (CAT5e) or 1 to 250MHz (CAT6). The test specifications for all installed cables must meet or exceed the specifications for CAT5e or CAT 6 cabling, respectively, that are documented within the TIA/EIA-568-B.2.

Cables not achieving a PASS rating shall be corrected and recertified. Cables that cannot achieve a PASS rating shall be replaced and recertified. A rating of *PASS (marginally pass) or *FAIL (marginally fail) is not acceptable.

16925.3.6 Fiber-Optic Conductor Installation and Termination

The Contractor shall install fiber-optic cable and terminations as specified and in accordance with the cable and equipment manufacturer's recommendations. All fiber-optic accessories required for a complete installation shall be supplied and installed by the Contractor. Examples of fiber-optic accessories include fan-out kits, end connections, dust caps, cleaving tools, polishing equipment, etc.

Fiber-optic cable furnished may be either 62.5 micron multimode, 50 micron multimode, or 9 micron single mode type as determined by the Contractor's design and as approved by the Owner.

16925.3.6.1 Experience. Contractor personnel performing fiber-optic work shall be trained by the fiber-optic cable manufacturer, and shall use the connectors, tools, or other special equipment by the same supplier as the equipment being installed. The Contractor shall furnish all required special tools.

16925.3.6.2 Fiber-Optic Cable Preparation. Individual fibers of multi-fiber bundles shall be separated and connected to fan-out kits manufactured by the same supplier as the cable. Fan-out kit shall be furnished by the Contractor, and compatible with the fiber-optic cable being installed. Fan-out leads shall each be at least 1 meter in length and of sufficient length as required for connection to the patch panels. Individual fibers shall be labeled with the number of the cable and number of the individual fiber.

16925.3.6.3 End Connector Installation. All individual fibers of multi-fiber bundles shall have connectors installed. Individual fibers which are not used shall have at least 1 meter long of fiber free from the bundle to allow future connector installation. Unused fibers shall be installed so as to be protected from damage. Connectors shall be installed using the appropriate tool kit manufactured by the same supplier as the fittings, and in accordance with manufacturer's instructions. Fibers shall be terminated directly at the transmitting equipment or patch panels as indicated on the drawings. End connections shall be tested as specified below. The maximum allowable attenuation for any installed end connector is 0.30 dB. Installed connectors which exceed this amount shall be cut off and re-terminated with new fittings until the measured attenuation meets the above requirement.

Dust caps shall be installed on any un-terminated connectors.

16925.3.6.4 Redundancy. In general, all fibers shall be terminated. If a cable problem is detected during startup, the spare terminated fibers will be available for use without additional fiber-optic terminations.

16925.3.6.5 Splicing. Splicing of fiber-optic cable shall be avoided unless approved by the Owner. Splicing shall be made using fusion techniques compatible with the fiber. Splices shall have a maximum attenuation of 0.15 dB, as determined by an optical time domain reflectometer (OTDR) trace or end-to-end

attenuation test. Splices which exceed this attenuation shall be cut and redone until their attenuation is within compliance.

16925.3.6.6 Patch Panels. Patch panels, if required by the Contractor's design, shall be installed by the Contractor as specified by the manufacturer. Insert panels shall be installed in the field, where required. After installation, wall mounted panels shall be labeled with plastic nameplates consistent with other name-plates used around the plant. The nameplate shall include the panel number and a description in block letters. Dust caps shall be installed on any unused terminals after cables are connected.

16925.3.6.7 Inner duct. Inner ducts for fiber-optic cable shall be no smaller than 1 inch, flame-resistant, corrugated, orange colored, with measuring/pull tape, and shall be Carlon Plenum-Gard or acceptable equal for plenum, riser, and general purpose applications in accordance with NEC Articles 770 and 800. The actual size of the inner duct shall be indicated on the drawings and/or in the Raceway List, and coordinated with the fiber-optic manufacturer's requirements by the Contractor. The pulling tape shall have a recommended maximum working load of at least 1,200 pounds.

16925.3.6.8 Pulling Equipment. Pulling equipment for fiber-optic cable shall include a recording running line dynamometer graph to measure and record the pulling tension, as manufactured by A.B. Chance Co., Evergreen Co., T.A. Pelsue Co., or acceptable equal. The pulling equipment shall have "slip load" capability to allow the winch to maintain a constant pulling force without taking up the winch line. The pulling equipment shall also be equipped with a hydraulic bypass which shall be set so that a maximum tension of 150 pounds is not exceeded. A reliable, nonfreezing swivel shall be provided for insertion between the pulling line and the cable pulling grip to prevent twisting under strain. The swivel shall be equipped with shear or tension pins with a breaking strength of 150 pounds. Swivels shall be manufactured by Condux International or approved equal. Woven wire grips shall be provided to pull the cable unless not allowed by the manufacturer of the fiber-optic cable. Woven wire grips shall be Kellums grip or acceptable equal, with a minimum length of 18 inches. The grips shall have provisions for tying the Kevlar jacket to the grip.

16925.3.6.9 Pulling lubricants. Pulling lubricants shall be provided for pulling both the inner duct and the fiber-optic cable. Pulling lubricants for installation of the inner duct shall be as shown in the Ameren Missouri Approved Suppliers. Pulling lubricants for installing the cable shall be as listed in Ameren Missouri Approved Suppliers.

16925.3.7 Fiber-Optic Test Requirements

The following special fiber-optic cable test requirements are applicable for all fiber-optic cable installed and/or terminated by the Contractor.

16925.3.7.1 Fiber-Optic Testing. As a minimum, all testing shall conform to the requirements of ANSI/TIA/EIA-568B, optical fiber link performance testing, and TIA/EIA-526-14A, end-to-end attenuation testing.

Before termination, each fiber in a multi-pair bundle shall be tested with an OTDR in one direction for length transmission anomalies and end-to-end attenuation. Results shall be recorded and submitted to the Owner in the form of hard-copy printouts of the OTDR traces. After termination, each fiber-optic circuit which exceeds 200 feet (whether the fiber is used or not) shall have an OTDR test performed on it at the appropriate wavelength. For circuits which are less than 200 feet, an end-to-end attenuation test shall be performed. Results shall be recorded and submitted to the Owner in the form of hard-copy printouts of the OTDR signal traces (if OTDR is used) or as tables noting the results of the attenuation tests.

16925.3.7.2 Test Guidelines. Test jumpers and other equipment shall have the same connection type and fiber core size as the fiber being tested.

Optical sources shall be stabilized with center wavelengths within +/- 20 nm of the nominal wavelength and transmission mode of the cable being tested.

Multimode LED sources shall have spectral width of 30 to 60 nm at the transmission mode of the cable being tested.

Equipment used for testing shall be calibrated and tested and shall be traceable to the applicable National Institute of Standards and Technology calibration standard.

End connectors shall be cleaned prior to testing.

16925.3.7.3 Testing Results. The post-termination tests must ensure that the measured link loss for each complete circuit (including any intermediate patch panels and jumpers) does not exceed the minimum of the following:

The sum of the connector loss with the intermediate jumpers installed (based on the number of mated connector pairs at a maximum allowable loss of 1 dB per pair) and the normal optical attenuation of the cable (5.6 dB/mile).

The optical power budget for the individual circuit (if available - Contractor to notify Owner when this data is required).

If the OTDR (or end-to-end attenuation) test results do not conform with the above requirements, then the Contractor shall take the necessary actions (install new fittings, check for breaks in cable, perform splices, etc.) as required to bring the test results within compliance. Contractor shall advise the Owner for approval of any proposed remedies prior to implementation.

16925.3.7.4 Documentation for Fiber Optics. Contractor shall submit test documentation to the Owner as required above. Other documentation shall include cable specification sheets from the cable manufacturer and equipment specification sheets for other installation accessories such as fittings or fan-out kits. Documents shall also include as-built information showing the following:

Modifications to the fiber-optic routing.

Any splice points.

Final circuit lengths.

16925.3.8 Circuit Installation Records

The Contractor shall complete a Circuit Installation Record form for each circuit installed and a Circuit Termination Record form for each circuit terminated. Forms used shall be provided by the Contractor or an acceptable equal.

The following data shall be recorded on each Circuit Installation Record form:

Circuit number.

Origin and destination of the circuit (From-To).

Circuit routing by raceway number of actual installed route.

Cable type, size, and quantity.

Cable reel identification number.

Cable sequential foot markings at each end of the cable.

Date circuit installation was completed.

Foreman of pulling crew.

Maximum pulling tension if not pulled by hand.

The following data shall be recorded on each Circuit Termination Record form:

Circuit number.

Equipment where circuit was terminated.

Date termination was completed.

Voltage at which circuit insulation was tested and date of test.

Name of electrician who terminated the circuit.

Each form shall be submitted to the Owner within a reasonable time, agreed to with the Contractor, after the circuit was pulled or terminated.

Forms that contain erroneous, deficient, or inconsistent data will be returned to the Contractor for correction. The Contractor shall correct the forms and resubmit them to the Owner. A circuit will not be considered complete until a properly completed form has been received by the Owner.

The Contractor's field records shall be available to the Owner for inspection. If, in the opinion of the Owner, the Contractor is not maintaining an accurate and timely record of the actual routing of circuits, the Owner will serve written notice of the deficiency to the Contractor.

The Contractor shall update the Circuit List and drawings with the field records and shall submit these documents to the Owner after all circuit pulling and circuit terminating activities have been completed.

SECTION 16930
GROUNDING COMPOENTS AND INSTALLATION

16930.1 General

This section covers the furnishing and field installation of a grounding system and all components. The grounding system and installation shall be in accordance with the drawings provided by the Contractor and these specifications. All grounding conductors shall be copper clad wire.

16930.1.1 Scope of Supply

Any materials not specified as being furnished by others, but which are required for a complete grounding installation, shall be furnished.

16930.1.2 Items Furnished by Others and Interfaces

Items furnished by others and not in this scope of supply include the following:

Existing station ground grids.

16930.1.3 Performance and Design Requirements

Performance and design requirements for the equipment to be furnished under this section of these specifications are indicated herein.

16930.1.4 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.

Grounding systems and components furnished with these specifications shall be manufactured in accordance with applicable standards of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), the National Electrical Manufacturers Association (NEMA), the American Society for Testing and Materials (ASTM), and Underwriters' Laboratories, Inc. (UL). Grounding systems and components shall be installed in accordance with the applicable requirements of the National Electrical Code (NEC) and the Occupational Safety and Health Administration (OSHA) standards.

16930.1.5 Materials

Grounding component materials shall be furnished new and undamaged.

16930.1.6 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 Contractor wants to propose a nonlisted manufacturer that is considered to provide an equivalent level of quality, this manufacturer must be pre-approved by Owner 30 days prior to submitting bids. Acceptance of the manufacturer as a substitute is at the discretion of the Owner:

Table 16930-1 Approved Manufacturers

Component	**Manufacturer**
Ground rods	Ameren Missouri Approved Suppliers
Conductor	Ameren Missouri Approved Suppliers
Bus and Bars	Ameren Missouri Approved Suppliers
Exothermal Welds	Ameren Missouri Approved Suppliers
Compression Connectors	Ameren Missouri Approved Suppliers
Lugs - Exothermal/Mechanical	Ameren Missouri Approved Suppliers

Table 16930-1 Approved Manufacturers	
Component	**Manufacturer**
Lugs - Compression/Mechanical	Ameren Missouri Approved Suppliers
Ground Plates	Ameren Missouri Approved Suppliers

16930.1.7 Not Used

16930.1.8 Not Used

16930.1.9 Not used

16930.2 Not Used

16930.3 Execution

16930.3.1 Grounding Components

An electrical grounding system shall be furnished and installed in accordance with the drawings provided by the Contractor and the following specifications. Grounding components shall include ground rods, ground conductor, ground bus, above and below grade grounding connections, grounding lugs, and hardware required for a complete system.

The Contractor shall perform ground grid calculations and design the system in accordance with NEC 250 and IEEE 80 and IEEE 142.

16930.3.1.1 Grounding Materials. Grounding component materials shall be furnished new and undamaged, and shall conform to the requirements of the articles that follow.

16930.3.1.1.1 Ground rods. Ground rods shall be copper clad, cold drawn carbon steel manufactured in accordance with UL 467. The copper cladding shall be electrolytically bonded to the steel rod or bonded by a molten welding process. Cold rolled copper cladding will not be acceptable. Ground rods shall have a conical taper on one end to facilitate soil penetration. Individual ground rods shall be a minimum of 3/4 inch diameter and 10 feet long. Ground rods shall be similar to that shown in the Ameren Missouri Approved Suppliers.

16930.3.1.1.2 Conductors. Bare ground conductor shall be soft drawn, stranded copper conforming to the requirements of ASTM B-8. Minimum ground conductor size shall be #4/0 for ground grid and #2/0 for stub-ups and cable tray. Insulated ground conductor shall be soft drawn, stranded copper conforming to the requirements of UL 83. Insulated ground conductor shall have green insulation and shall meet the insulation requirements from the cable specification sheets. Ground conductors shall be as manufactured by the suppliers on the Approved Suppliers List.

16930.3.1.1.3 Busbar. Ground busbar shall be soft drawn, uncoated copper conforming to the requirements of ASTM B-187. Busbar shall be a minimum 1/8 inch thick and 1 inch wide. Where required, bus bar shall be provided with predrilled holes measuring 9/16 inch in diameter with NEMA center line hole spacings. Busbar shall be as manufactured as shown on the Ameren Missouri Approved Suppliers list.

16930.3.1.1.4 Exothermal connections. Exothermal connections shall be a standard duty copper molten weld conforming to the requirements of IEEE 837, IEEE 80 Section 11, and UL 467. Molds and powder cartridges used for making exothermal connections shall be furnished by the same manufacturer. Exothermal connections shall be similar to that shown in Ameren Missouri Approved Suppliers.

16930.3.1.1.5 Not used.

16930.3.1.1.6 Ground lugs. Ground lugs shall be single hole or two hole, heavy-duty, copper bars conforming to the requirements of IEEE 837 and UL 467. Two hole ground lugs shall have NEMA center line hole spacings. Ground lugs used with the exothermal weld process shall be similar to that shown in

the Ameren Missouri Approved Suppliers. Ground lugs used with the compression process shall be as shown in Ameren Missouri Approved Suppliers.

16930.3.1.1.7 Ground plates. Ground plates shall be high strength, four hole copper bodies conforming to the requirements of IEEE 837 and UL 467. Ground plates shall have NEMA center line hole spacings and shall be provided with hole plugs on the mating side of the plate. Ground plates used with the exothermal weld process shall be as shown in the Ameren Missouri Approved Suppliers. Ground plates used with the compression process shall be as indicated in Ameren Missouri Approved Suppliers."

16930.3.1.1.8 Hardware. Clamps, connectors, bolts, washers, nuts, and other hardware used with the grounding system shall be of copper, copper alloy, or stainless steel.

16930.3.2 Grounding Installation

Grounding system components shall be installed as indicated the drawings and as described in these specifications.

16930.3.2.1 Conductors. Exposed conductors shall be installed inconspicuously in vertical or horizontal positions on supporting structures. When located on irregular supporting surfaces or equipment, the conductors shall run parallel to or normal to dominant surfaces.

All below grade ground conductors shall be buried a minimum of 18 inches and a maximum of 30 inches below finished grade unless installed under a concrete foundation. Ground grid conductors under foundations shall have 6 inches of earth cover between conductor and bottom of foundation.

Conductors routed over concrete, steel, or equipment surfaces shall be kept in close contact with those surfaces by using fasteners located at intervals not to exceed 3 feet. Conductors routed around 90 degree corners shall be kept in close contact with the perpendicular surfaces and shall not be physically damaged due to an insufficient bending radius.

Ground conductors shall be routed as to not create a tripping hazard.

Damaged ground system conductors shall be repaired or replaced.

16930.3.2.2 Ground Rods. All ground rods shall be located as required by the Contractor's design and installed to the depth indicated. Where the required ground rod length exceeds 10 feet, ground rod standard sections shall be welded together to provide an extended rod with one true centerline a minimum of joint resistance. During welding, the ground rod sections being welded shall be supported by a guide to ensure proper alignment.

16930.3.2.3 Connections. All connections shall be made by the exothermal welding process. All surfaces to be joined by the welds shall be thoroughly cleaned. Powder cartridges and molds shall be kept dry and warm. Worn or damaged molds shall not be used.

The manufacturer's instructions on the use of exothermal welding materials shall be followed in all details.

All exothermally welded connections shall successfully resist moderate hammer blows. Any connection which fails such test, or which upon inspection indicates a porous or deformed weld, shall be remade.

All exothermal welds shall encompass 100 percent of the ends of the materials being welded. Welds that do not meet this requirement shall be remade.

All bolted and screwed connections shall be securely tightened.

Dies used in the compression tools shall be of the same manufacturer as the compression fittings. The manufacturer's instructions on the use of the compression tools and dies shall be followed in all details.

All bolted and screwed connections shall be securely tightened.

16930.3.2.4 Ground Plates. Ground plates embedded in concrete shall be carefully located and firmly secured to the concrete forms. The threaded holes in the mating surface of round plates shall be plugged prior to pouring concrete. The grounding conductor attached to the ground plates shall be inspected prior to the pouring of concrete to ensure a good solid connection in accordance with industry standards.

16930.3.2.5 Column Grounding. Structural steel columns shall be grounded by use of a servit post installed in a pre-drilled hole in the web of the column near the base as indicate on the drawings. The Contractor shall provide a hole in the web of structural steel columns not so equipped for grounding provisions. The hole shall be 9/16 inch in diameter and located approximately 8 inches up from the base. Prior to the installation of the servit post, paint, scale, and other nonconductive substances shall be removed from surfaces of ungalvanized structural steel members by grinding. Galvanized steel surfaces shall be leaned with emery paper.

16930.3.2.6 Conduit Grounding. All conduit grounding bushings within all enclosures, including equipment enclosures, shall be wired together and connected internally to the enclosure grounding lug grounding bus with a bare copper conductor. Grounding bushings shall be grounded with conductor sized in accordance with the NEC, but not smaller than 8 AWG.

All grounding bushings on conduit runs which are terminated at tray shall be connected to the tray grounding cable or tray side rail with bare copper conductor as indicated on the drawings.

Where a conduit run is terminated at tray and the conduit carries a separate insulated grounding conductor, this grounding conductor shall be terminated on the tray grounding cable. If the conduit run is terminated with a grounding bushing and the separate ground conductor it carries is sized in accordance with the requirements of the preceding paragraphs for conduit bushing grounding, the ground conductor in the conduit run may be continued through the conduit bushing ground connection and terminated on the tray grounding cable making unnecessary the installation of a separate conduit bushing grounding cable.

Conduit bushing ground conductors shall be connected to the tray ground cable using split bolt connectors or an Owner-acceptable equal mechanical connector.

Conduit terminated at equipment and device in threaded hubs shall not require additional grounding provisions.

16930.3.2.7 Tray Grounding. A bare copper grounding conductor shall be installed on all power level cable trays containing single conductor power cables. The tray grounding conductor shall be installed on the outside of the tray side rails, along the entire length of the trays, attaching to each tray fitting and to each straight section of tray at 6 foot maximum intervals. The tray grounding conductor shall be attached to the trays using bolted ground clamps, and shall be connected to the ground grid at locations as required by the Contractor's design. Splices for the tray grounding conductor shall be made using compression connectors.

Cable trays containing multi-conductor power cables, control, or instrument circuits shall not require a continuous ground conductor installed along the tray. Instead, these tray levels shall be grounded by means of a ground jumper extended from the tray side rail to the continuous ground conductor installed along a power level cable tray, to building steel, or to the ground grid. Grounding intervals shall not exceed 100 feet.

Grounding jumpers shall be required across all expansion splice plates, dropouts and adjustable splice plates where a continuous ground conductor is not installed along the tray level.

16930.3.2.8 Equipment Grounding. Electrical equipment that requires a ground grid extension stinger shall be connected to the ground grid with copper grounding conductor. An embedded Panduit ground pad shall be used for the equipment grounding connections. The location and configuration of the Panduit grounding pads shall be acceptable to the Owner. The term "electrical equipment," as used in this article, shall include all enclosures containing electrical connections or bare conductors except that individual devices such as solenoids, pressure switches, and limit switches shall be exempt from this requirement unless the device requires grounding for proper operation. Large electrical power distribution equipment

such as medium or low voltage switchgear or MCCs will be furnished with a ground bus which the Contractor shall connect to the ground grid at each end of the ground bus. Other equipment will be furnished with grounding pads and/or ground lugs which the Contractor shall connect to the ground grid. All ground connection surfaces shall be cleaned immediately prior to connection. Transformers, large motor bases, skids, etc. shall be connected to the ground grid twice at opposite corners of the transformer.

Where ground grid extension stingers are to be provided for connection to electrical equipment, the Contractor shall connect the grounding conductor to the equipment ground bus, pad, or lug. In addition to the ground grid extension stingers, a ground conductor shall be provided from the tray ground cable to the incoming line end of the ground bus in each assembly of medium or low voltage switchgear and MCCs indicated on the drawings.

Where a ground conductor is included with the phase conductors of power circuits, the ground conductor shall be connected to the equipment grounding facilities and to the source ground bus. Where a ground conductor is not included with the phase conductors, the equipment shall be grounded by connecting a separate ground cable to the equipment grounding facilities and to the tray ground cable or source ground bus. All equipment ground conductors which are not an integral part of a cable assembly shall be sized in accordance with the requirements of NEC. All ground conductors installed in conduit shall be insulated.

Power circuits shall include an insulated ground conductor to all 6,900 volt, 4,160 volt, 480 volt, and 208 volt loads to satisfy the requirements of the preceding paragraph. This ground conductor is either a separate cable, Type GI, or is contained within the multiconductor power cable. Power circuits from 120/208 volt power panels contain one additional conductor which is used for grounding smaller devices which require 120 volt power. Additional grounding cables which would duplicate the ground conductors already in the Circuit List are not required.

The Contractor shall design, furnish, and install all equipment and all required grounding cables. This shall include, but not be limited to, devices which have electrical connections but do not require a power circuit such as junction boxes and control equipment enclosures, any equipment to which the routed ground conductor is not of sufficient size to properly ground the equipment, and any other electrical equipment which is not grounded by means of a conductor.

Suitable grounding facilities shall be furnished on electrical equipment not so equipped. The grounding facilities shall consist of compression type terminal connectors bolted to the equipment frame or enclosure and providing a minimum of joint resistance.

Suitable grounding facilities for electrical equipment not so equipped, but requiring multiple grounding connections, shall include the installation of a bare copper ground bus for the connection of several grounding conductors. This ground bus shall be connected to the equipment frame or enclosure, providing a minimum of joint resistance.

The conduit system is not considered to be a grounding conductor except for itself. No equipment grounding conductor shall be smaller in size than 12 AWG unless it is a part of an acceptable cable assembly.

16930.3.2.9 Duct Bank, Trench, and Electrical Manhole Grounding. Two 4/0 bare copper ground conductors shall be routed with each duct bank routed outside the plant grid or outlying grids as indicated on the drawings. The duct bank ground conductors shall be located at the top of the duct bank and physically separated on each side. The duct bank ground conductors shall be connected to the plant ground grid and outlying grids at locations where the duct bank meets the perimeter of the grids.

Two 4/0 bare copper ground conductors shall also be run in each cable trench, one on each side of the trench, and connected to the ground grid in the same fashion as described in this section.

A ground conductor, equal in size to the ground grid conductors, shall be installed around the upper interior of each electrical manhole. This ground conductor shall be connected to the duct bank ground conductors or ground. The manhole ground conductor shall also be connected to any manhole rebar ground plates, conduit ground bushings, cable racks, and cable tray located in the electrical manhole.

16930.3.3 Ground System Resistance

All ground resistance measurements shall be made with the Fall of Potential or slope methods as defined in IEEE 81. Some of the acceptable instruments are as follows:

Advanced Geosciences, Inc., Sting R1, Mini Sting, Super Sting R1, or Super Sting R8.

Iris Instruments, SYSCAL R1 Plus, SYSCAL R2, or SYSCAL Pro.

After connection of ground rods to the ground system, the Contractor shall obtain a ground resistance measurement from a selected location on the ground grid using methods approved by the Owner. This data shall be obtained, identified, and recorded.

The ground resistance measurement data may indicate that additional ground rods are required. The Contractor shall furnish, install, and connect additional ground rods as necessary.

SECTION 16935
LIGHTNING PROTECTION

16935.1 General

16935.1.1 Scope of Supply

Scope of supply shall include designing, furnishing, and installing lightning protection equipment as specified herein and on the Lightning Protection Specification Sheet. Lightning protection shall be provided for the new structures and equipment being erected as part of this specification.

16935.1.1.1 Not Used.

16935.1.1.2 Plan and Section Drawings. Plan and section drawings provided by the Contractor shall indicate the locations for the components furnished under this Contract. The Contractor shall use the plan and section drawings to determine the quantities of materials and components as required for a complete lightning protection system.

16935.1.2 Not Used

16935.1.3 Performance and Design Requirements

Performance and design requirements for the lightning protection system are indicated on the Lightning Protection Specification Sheet included at the end of this section.

16935.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 16935-1 Lightning Protection Applicable Codes and Standards

Work	In Accordance With
Lightning protection (US)	NFPA 780 - 2008, "Standard for the Installation of Lightning Protection Systems" UL 96 - 1994, "Standard for Lightning Protection Components" UL 96A - 1994, "Standard for Installation Requirements for Lightning Protection Systems" LPI-175, "Standard of Practice" LPI-175, "Material Standard" Any other applicable state and local codes

16935.1.5 Materials

The following materials shall be used:

Table 16935-2 Materials	
Component	**Material**
As required by Contractor's design	As required by Contractor's design

16935.1.6 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 Contractor 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 Owner:

Table 16935-3 Approved Manufacturers	
Component	**Manufacturer**
Lightning Protection Equipment	Ameren Missouri Approved Suppliers

16935.1.7 Not Used

16935.1.8 Not Used

16935.1.9 Supplemental Specifications

Not Used

16935.1.10 Certification Requirements

The following certificates shall be provided prior to Owner's acceptance:

Table 16935-4 Lightning Protection Certification Requirements	
Certificate	**In Accordance With**
Master Label	UL and NFPA

16935.2 Products

16935.2.1 Lightning Protection - Design Requirements

The lightning protection system design shall be in accordance with the following requirements.

16935.2.1.1 Description. The system shall consist of air terminals, air terminal bases, interconnecting conductors, down-conductors, through-roof and through-wall assemblies, conductor holders, splicers, exothermal welds, fasteners, mounting accessories, heavy-duty stack materials, grounded metal objects on or within the structure as necessary, ground rods at each down-conductor, and connection of down-conductors to a grounding system. The system shall be designed to appear as part of the structure. Exposed roof conductors shall be placed so as to require a minimum displacement for future repair and maintenance of roofing.

Lightning protection system materials shall be in accordance with Article 16935.2.2. Lightning protection system installation shall be in accordance with Article 16935.3.

A complete lightning protection system shall be designed for the structures being furnished as part of this specification or for the existing structures if required when the existing stack is removed or lowered. The system components shall comply with the specifications of the current edition of the codes and standards listed in Article 16935.1.4.

Air terminals and associated interconnecting conductor shall not be required for those parts of a structure located within a zone of protection.

When specified in Article 16935.1.10, the Contractor's design and equipment shall meet all requirements to receive any lightning protection installation certifications attainable under the applicable codes and standards for each structure specified to be protected. The Contractor's lightning protection system design and equipment furnished will not be considered acceptable prior to certification of each structure.

16935.2.1.2 Engineering Data. This article stipulates the requirements for engineering data that the Contractor shall submit for design information and review.

All engineering data shall be identified with the structure it represents by use of the nomenclature established by the Contract Documents.

Drawings shall be in sufficient detail to indicate the kind, size, arrangement, and operation of component materials and devices; the external connections, anchorages, and supports required; and the dimensions needed for installation and correlation with other materials and equipment.

16935.2.2 Lightning Protection System Materials

16935.2.2.1 General. System components shall generally be of copper or copper alloy except where installations will be on or adjacent to aluminum surfaces. Copper materials shall not be used for installation on aluminum surfaces or in locations near aluminum where moisture can run off copper components onto aluminum surfaces. In these locations, system components shall be of aluminum with suitable bimetallic transitions used at connection points to copper components.

All lightning protection components and materials shall be manufactured from corrosion-resistant materials. No combination of materials shall be used that forms an electrolytic couple of such nature that corrosion is accelerated in the presence of moisture.

Components shall comply with the requirements of the referenced codes and standards for the type and height of the building being protected.

Unless specified otherwise on the Lightning Protection Specification Sheet or required by a specific installation requirement, the materials shall be as follows.

16935.2.2.2 Air Terminals. Air terminals shall be solid, bare, round copper bar a minimum of 10 inches in length and diameter of 3/8 inch for Class I applications and 1/2 inch for Class II applications minimum, or as required by the referenced codes and standards. Safety balls shall be provided on the air terminals to eliminate impalement hazards.

16935.2.2.3 Copper Main Conductor (Cable) for Class I Applications. Main conductor for Class I applications shall be stranded copper constructed with a smooth weave or twisted configuration. The conductor for Class I applications shall have a minimum of 17 AWG stranding, a minimum weight of 187 pounds per 1,000 feet, and a minimum cross-sectional area of 57,400 circ mils, or as required by the specified codes and standards.

16935.2.2.4 Copper Main Conductor (Cable) for Class II Applications. Main conductor for Class II applications shall be stranded copper constructed with a rope lay configuration. The conductor for Class II applications shall have a minimum of 15 AWG stranding, a minimum weight of 375 pounds per 1,000 feet, and a minimum cross-sectional area of 115,000 circ mils, or as required by the specified codes and standards.

16935.2.2.5 Copper Secondary Conductor (Cable) for Class I or II Applications. Secondary conductor for Class I or Class II applications shall be stranded copper constructed with a smooth weave or twisted configuration. The conductor shall have a minimum of 17 AWG stranding and a minimum cross-sectional area of 26,240 circ mils, or as required by the specified codes and standards.

16935.2.2.6 Aluminum Main Conductor (Cable) for Class I Applications. Main conductor for Class I applications shall be stranded aluminum constructed with a smooth weave configuration. The conductor

for Class I applications shall have a minimum of 14 AWG stranding, a minimum weight of 95 pounds per 1,000 feet, and a minimum cross-sectional area of 98,600 circ mils, or as required by the specified codes and standards.

16935.2.2.7 Aluminum Main Conductor (Cable) for Class II Applications. Main conductor for Class II applications shall be stranded aluminum constructed with a concentric configuration. The conductor for Class II applications shall have a minimum of 13 AWG stranding, a minimum weight of 190 pounds per 1,000 feet, and a minimum cross-sectional area of 192,000 circ mils, or as required by the specified codes and standards.

16935.2.2.8 Aluminum Secondary Conductor (Cable) for Class I or II Applications. Secondary conductor for Class I or Class II applications shall be stranded aluminum constructed with a smooth weave configuration. The conductor shall have a minimum of 14 AWG stranding and a minimum cross-sectional area of 41,100 circ mils, or as required by the specified codes and standards.

16935.2.2.9 Air Terminal Bases. Air terminal bases shall be as specified herein and as shown on the drawings for the roofing materials they will be mounted on.

16935.2.2.9.1 Adjustable point air terminal bases. Adjustable point air terminal bases shall be cast bronze or aluminum with an adjustable swivel point for connection of the air terminals specified herein. The adjustable point air terminal bases shall be constructed so they can be installed on a ridged roof, with a sloping, flat, or vertical surface. The air terminal bases shall have four holes for mounting. The air terminal bases shall provide positive single bolt tension cable clamping. Crimp type connectors at bases are not acceptable.

16935.2.2.9.2 Adhesive mounted air terminal bases. Adhesive mounted air terminal bases shall be cast bronze or aluminum. The adhesive mounting bases shall provide positive bolt tension cable clamping.

16935.2.2.9.3 Standing seam air terminal bases. Standing seam air terminal bases shall be cast bronze or aluminum, complete with a connection location for the air terminals specified herein. The standing seam air terminal bases shall be constructed with a bottom groove a minimum of 1/2 inch wide by 3/4 inch deep, and complete with two setscrews for securing to the standing seam. Each base shall have positive single bolt tension cable connectors for conductors that run parallel or perpendicular to the standing seam. Crimp type connectors at bases are not acceptable.

16935.2.2.9.4 Handrail mounting bases. Handrail mounting bases shall be cast bronze or aluminum and shall have provisions for connecting the air terminals and conductors specified herein. Handrail mounting bases shall be sized to fit securely into handrails.

16935.2.2.9.5 Tee mounted air terminal bases. Tee mounted air terminal bases shall be cast bronze or aluminum. The tee mounting bases shall provide positive bolt tension cable clamping for one cable run and one cable tap.

16935.2.2.9.6 Adjustable point adapters. Adjustable point adapters shall be provided for all air terminal mounting bases that would not otherwise allow the air terminal to be installed perpendicular to the ground. Adjustable point adapters shall be cast bronze or aluminum and shall include a means for tightening with a locking washer and/or nut.

16935.2.2.10 Through-Roof and Through-Wall Assemblies and Accessories. Through-roof and through-wall assemblies and accessories shall be furnished as specified herein and as shown on the drawings.

16935.2.2.10.1 Through-roof air terminal adapter assemblies. Through-roof air terminal adapter assemblies shall consist of a 1/2 inch diameter threaded rod, minimum 12 inches in length. Each assembly shall be furnished complete with two washers, two nuts, and a neoprene washer for weatherproofing a roof penetration. The lower end of the assembly shall be furnished with a universal parallel conductor connection, which will accept up to two conductors as specified herein. The top end of the assembly shall be furnished with an adjustable swivel point adapter for connection of the air terminals specified herein.

The assembly shall be furnished complete with all the mounting provisions required to protect the roof against leaks. All components of the assembly shall be manufactured from materials that are compatible with the system being installed.

16935.2.2.10.2 Through-roof conductor-to-conductor assemblies. Through-roof conductor-to-conductor assemblies shall consist of a 1/2 inch diameter rod, a minimum 12 inches in length. Each assembly shall be furnished complete with two washers, two nuts, and a neoprene washer for weatherproofing a roof penetration. Each end of the assembly shall be furnished with a universal parallel conductor connection, which will accept up to two conductors as specified herein. All components of the assembly shall be manufactured from materials that are compatible with the system being installed.

16935.2.2.11 Conductor Holder. Conductor holders for connecting lightning protection conductors to structural steel shall be cast bronze or aluminum, and shall provide a minimum of 1.5 square inches of positive bolt tension pressure. Each conductor holder shall be capable of holding the conductors specified herein. If copper conductor holders are specified in Article 16935.1.1, they shall be a 1 inch wide solid copper cable strap that forms around the conductors specified herein when installed, and shall be capable of being installed on a horizontal or vertical surface.

16935.2.2.11.1 Standing seam conductor holder. Standing seam conductor holders shall be brass or aluminum, constructed with a bottom groove a minimum of 1/2 inch wide by 3/4 inch deep and complete with a set screw for securing to the standing seam. Each standing seam conductor holder shall be capable of attaching the conductors specified herein when routed either parallel or perpendicular to the standing seam with a cable fastener as specified herein.

16935.2.2.11.2 Adhesive conductor holder. Adhesive conductor holders shall be capable of being installed on a horizontal or vertical surface and shall form around the conductors specified herein when installed. Adhesive conductor holders shall be cast bronze or aluminum. Each conductor holder shall be capable of holding the conductors specified herein.

16935.2.2.12 Splicers. Splicers for various applications shall be as specified herein.

16935.2.2.12.1 Parallel splicers. Parallel splicers shall be cast bronze or aluminum with positive bolt tension grip on conductors. Parallel splicers shall have provisions for connecting up to two conductors of the type specified herein and shall have a minimum total contact length of 1.5 inches parallel to the conductor.

16935.2.2.12.2 Butt end straight splicers. Butt end straight splicers shall be brass or aluminum and shall accept the conductors as specified herein. Butt end straight splicers shall be furnished with a minimum of two setscrews on each end of the splicer for connecting the conductor.

16935.2.2.12.3 Tee splicers. Tee splicers shall be cast bronze or aluminum and shall accept the conductors as specified herein. Tee splicers shall provide positive bolt tension grip on conductors.

16935.2.2.12.4 Four-way or cross-run splicers/connectors. Four-way or cross-run splicers or connectors shall be cast bronze or aluminum and shall be furnished complete with four bolts for positive bolt tension grip on conductors. The connectors shall be sized to accept two conductors as specified herein.

16935.2.2.13 Exothermal Welds. Welding charge formulation, equipment selection, and welding procedures shall be as recommended by the manufacturer of the exothermal weld materials for the size, shape, and composition of the materials being welded.

16935.2.2.14 Fasteners. Fasteners for various applications shall be as specified herein.

16935.2.2.14.1 Flat metal bonding plate. Flat metal bonding plates shall be cast bronze or aluminum with a minimum surface contact area of 3 square inches. Each bonding plate shall be furnished complete with bronze or aluminum screws for mounting.

16935.2.2.14.2 Cable fasteners. Cable fasteners shall be 5/8 inch wide solid copper or aluminum cable straps that form around the conductors specified herein when installed. The fasteners shall be capable of being installed on a horizontal or vertical surface.

16935.2.2.14.3 Pipe bonding clamps. Pipe bonding clamps shall be lead coated copper or aluminum and shall have provisions for connecting the conductors as specified herein. Pipe bonding clamps shall be sized according to the piping that requires bonding.

16935.2.2.15 Mounting Accessories. Mounting accessories used in the lightning protection systems shall be in accordance with the articles that follow.

16935.2.2.15.1 Neoprene sealing washers. Lightning protection components supplied with holes for permanent mounting that require drilling holes through the roof material shall be sealed with neoprene sealing washers for weatherproofing the roof connection points. Neoprene sealing washers shall be sized for the type of mounting provisions required.

16935.2.2.15.2 Concrete anchors with stainless steel nail. Concrete anchors shall be one-piece drive in type furnished complete with a stainless steel nail, 1/4 inch by 1-1/4 inch.

16935.2.2.15.3 Sheet metal screws. Sheet metal screws shall be stainless steel hex head slotted, #10 by 1 inch.

16935.2.2.15.4 Silicon sealant. Silicon sealant shall form a long lasting, flexible, watertight, and weatherproof seal. Silicon sealant shall be odorless and shall be paintable when dry. Silicon sealant shall be clear and shall be furnished in 10.1 ounce tubes for use in a caulking gun.

16935.2.2.15.5 Protector piping. Protector piping shall be polyvinylchloride (PVC) 1 inch outside diameter pipe. Each protector pipe shall be furnished complete with all hardware for mounting the protector pipe to structural steel, sheet metal, or a concrete wall.

16935.2.2.15.6 Adhesive compound. Fast drying adhesive compound shall be used.

16935.2.3 Not Used

16935.2.3.1 Heavy-Duty Stack Conductor. Heavy-duty stack conductor shall be stranded copper constructed with a rope lay configuration. The conductor shall have a minimum of 15 AWG stranding, a minimum weight of 375 pounds per 1,000 feet, and a minimum cross-sectional area of 115,000 circ mils.

16935.2.3.2 Heavy-Duty Stack Air Terminals. Heavy-duty stack air terminals shall be stainless steel rod, 24 inches in length, and a minimum diameter of 5/8 inch. Each heavy-duty stack air terminal shall be provided with not less than five full threads for attachment to the mounting bases specified herein. Safety balls shall be provided on the air terminals to eliminate impalement hazards.

16935.2.3.3 Heavy-Duty Stack Point Bases. Heavy-duty stack point bases shall have provisions for connecting a horizontal run and a vertical run of conductor as specified herein as well as a 5/8 inch air terminal as specified herein. The point bases shall be brass or another material suitable as approved by the Owner for the conditions anticipated at the top of the stack, a minimum of 1/16 inch on all surfaces, and complete with a 1/2 inch diameter, "LONG" 1-1/2 inch stud for anchoring. Point bases shall be furnished complete with anchoring hardware for mounting.

16935.2.3.4 Air Terminal Fasteners. Air terminal fasteners shall be bronze or another material suitable as approved by the Owner for the conditions anticipated at the top of the stack, a minimum of 1/16 inch on all surfaces, two bolt cap type point fasteners for use with heavy-duty stack air terminals as specified herein. Air terminal fasteners shall have a "LONG" 1-1/2 inch stud length for anchoring. All fasteners shall be furnished complete with all necessary hardware for anchoring to a concrete wall.

16935.2.3.5 Cross-Run Splicers. Cross-run splicers shall be cast heavy-duty bare brass and shall have provisions for connecting a vertical and horizontal run of conductor as specified herein. Each cross-run

splicer shall be provided with four bolts for anchoring and shall be furnished complete with all necessary hardware anchoring to a concrete wall.

16935.2.3.6 Conductor Fasteners. Conductor fasteners for the bare conductor shall be bare bronze, two bolt cap type conductor fasteners for use with conductor as specified herein. Conductor fasteners shall have a 1/2 inch diameter, "LONG" 1-1/2 inch stud for anchoring. All fasteners shall be furnished complete with all necessary hardware for anchoring to a concrete wall.

16935.2.3.7 Conductor Fasteners (Corrosive Environment). Conductor fasteners for the conductors shall be suitable for the corrosive environment, a minimum of 1/16 inch on all surfaces, two bolt cap type point fasteners for use with conductor as specified herein. Conductor fasteners shall have a 1/2 inch diameter, "LONG" 1-1/2 inch stud for anchoring. All fasteners shall be furnished complete with all necessary hardware for anchoring to a concrete wall. Lead shall not be used in the assembly or material for the conductor fasteners.

16935.2.3.8 Conductor to Plate Fasteners. Conductor to plate fasteners shall be bare brass with provisions for connecting the conductor as specified herein. Each conductor to plate fastener shall have a mounting stud that will connect to the 1/2 inch tapped hole as specified in rebar connecting assembly, with a length as required.

16935.2.3.9 Conductor to Plate Fasteners (Corrosive Environment). Conductor to plate fasteners shall be suitable for use and installation in the corrosive environment, a minimum of 1/16 inch on all surfaces, with provisions for connecting the conductor as specified herein. Each conductor to plate fastener shall have a mounting stud that will connect to the 1/2 inch tapped hole as specified in rebar connecting assembly, with a length as required. Lead shall not be used in the assembly or material for the conductor to plate fasteners.

16935.2.3.10 Rebar Connecting Assembly. Rebar connecting assemblies shall be furnished complete with a flush mount brass plate, bare copper conductor, and rebar bonding clamps. The flush mount brass plate shall be 4 inches by 4 inches and shall have a 1/2 inch diameter tapped hole for connecting to conductor to plate fasteners as specified herein. Three feet of copper conductor shall be furnished between each rebar bonding clamp and the brass plate. Rebar bonding clamps shall be cast bronze universal conductor to rebar bonding clamps. Rebar bonding clamps shall be sized to accommodate conductor sizes through 4/0 AWG and reinforcing bars up through 1 inch diameter. Rebar connecting assembly shall have provisions for connecting five rebars.

16935.2.3.11 Terminal Lugs. Terminal lugs shall be bare brass, cast heavy-duty terminal bonding lug with eye connector. Each terminal lug shall be complete with two set screws for connecting to the conductor as specified herein. Terminal lugs shall be furnished complete with hardware for mounting to structural steel.

16935.2.3.12 Terminal Lugs (Corrosive Environment). Terminal lugs shall be suitable for use and installation in the corrosive environment, a minimum of 1/16 inch on all surfaces, terminal bonding lug with eye connector. Each terminal lug shall be complete with two set screws for connecting to the conductor as specified herein. Terminal lugs shall be furnished complete with hardware for mounting to structural steel. Lead shall not be used in the assembly or material for the terminal lugs.

16935.2.3.13 Parallel Splicers. Parallel splicers shall have provisions for connecting two conductors as specified herein in parallel. Parallel splicers shall be bare brass.

16935.2.3.14 Parallel Splicers (Corrosive Environments). Parallel splicers shall have provisions for connecting two conductors as specified herein in parallel. Parallel splicers shall be suitable for use and installation in the corrosive environment. Lead shall not be used in the assembly or material for the parallel splicers.

16935.2.3.15 Butt End Splicers (Setscrew Type). Butt end splicers shall be cast heavy-duty bare brass and shall accept the conductor as specified herein. Butt end splicers shall be furnished with a minimum of two set screws on each end for connecting the conductor. Butt end splicers shall withstand a pull test of

890 N when installed and shall make contact with the conductor for a minimum distance of 1-1/2 inches measured parallel to the conductor.

16935.2.3.16 Butt End Splicers (Compression Type). Butt end splicers shall be made from 14 gauge copper and shall accept the conductors as specified herein. Butt end splicers shall have compression type fingers to crimp over the conductor.

16935.2.3.17 Tee Splicers. Tee splicers shall be made from 14 gauge copper and shall accept the conductors as specified herein. Tee splicers shall have compression type fingers to crimp over the conductor.

16935.3 Execution

16935.3.1 General

This article covers the construction specifications to install a complete lightning protection system for the structures indicated in Article 16935.1.1. The systems shall comply with the specifications of the current edition of the codes and standards listed in Article 16935.1.4. The installation shall be accomplished by an experienced installer, who is certified under the applicable codes and standards.

16935.3.2 Description

The system shall consist of air terminals, interconnecting conductors, down-conductors, connections to a grounding system, and bonding of grounded metal objects on or within the structure as necessary. The system shall be designed to appear as part of the structure. Conductor runs for the structure shall be concealed where possible and practical. Exposed roof conductors shall be placed to require a minimum displacement for future repair and maintenance of roofing.

The Contractor shall evaluate the need for lightning protection on all structures furnished and/or erected as part of this Contract based on codes and standards listed in Article 16935.1.4. The Contractor shall furnish and install lightning protection for any structure requiring lightning protection furnished and/or erected as part of this Contract or required by the removal or lowering of the existing stack.

16935.3.3 Installation

The Contractor shall install a complete lightning protection system for the structures based on the codes and standards included herein and as indicated on the Owner approved design drawings. Installation shall comply with the codes and standards referenced herein and with the following articles.

Copper materials shall not be used for installation on aluminum surfaces or in locations near aluminum where moisture can run off copper components onto aluminum surfaces. Connectors and fittings shall be suitable for use with the conductor and surfaces on which they are installed.

16935.3.3.1 Air Terminals. Air terminals shall be mounted to extend a minimum of 10 inches above the object to be protected, or as required by the referenced codes and standards. Spacing of air terminals on ridges or edges of roofs shall not exceed 20 feet on centers nor be more than 24 inches from the ridge ends or roof edges, or as required by the referenced codes and standards. Air terminals that extend a minimum of 24 inches above the object to be protected shall not exceed 25 feet spacing on centers. On flat or gently sloping roofs, additional air terminals shall be located at intervals not exceeding 50 feet on centers. Safety balls shall be provided on the air terminals to eliminate impalement hazards.

16935.3.3.2 Conductors. A complete cable system with related air terminals, splices, and bonds shall be used on each structure not inherently self-protecting. Conductors of the size required by codes and standards referenced herein shall interconnect all air terminals and provide a two-way path to ground from each air terminal. Conductors shall maintain a horizontal and/or downward path from each air terminal to ground without forming "U" or "V" pockets. All center roof air terminals shall be interconnected with conductors to the outside perimeter cable. Conductors on the flat roof areas may be run exposed. Down-conductors shall be installed around the perimeter of each roof in a minimum of two locations and at a maximum of 100 feet on centers.

Down-conductors routed to the structural steel from the roof system shall not be brought directly through the roof. Through-roof connectors shall be utilized for this purpose.

Dissimilar metal components shall not be connected together except by means of an approved bimetal transition fitting.

16935.3.3.3 Exothermal Welds. This article covers requirements for exothermal welding, including but not restricted to, cable-to-cable, cable-to-rod, and cable-to-steel structure connections.

Exothermal welds shall be made using new molds, sleeves, and cartridges sized in accordance with the welding equipment manufacturer's recommendations for the particular application.

Completed welds shall be capable of withstanding moderate hammer blows. Porous or deformed welds will not be acceptable.

The Owner may reject any connection if it fails when the cable is pulled; breaks loose from the structural steel when struck at an angle with a hammer; or does not appear to be a complete, properly shaped, and made connection.

16935.3.3.4 Bonding Metal Bodies. All metal bodies within 6 feet of a lightning protection conductor, or as required by the referenced codes and standards, shall be bonded to the system with approved fittings and conductor. Connections between dissimilar metals shall be made with approved bimetallic connections.

16935.3.3.4.1 Metal bodies of conductance. Bonding of all metallic objects and systems at roof levels and elsewhere on the structure shall be complete. Primary bonds for metal bodies of conductance shall be bonded with appropriate fittings and full size conductor. Metal bodies of conductance shall consist of, but not be limited to, the following:

Roof exhaust fans and vents.

HVAC units with related piping and ductwork.

Other roof piping systems.

Roof handrails and ladders.

Antenna masts.

Exterior architectural metal fascia and/or curtain walls or mullions, which extend the full height of the structure, if not inherently bonded through the structure frame.

16935.3.3.4.2 Metal bodies of inductance. Metal bodies of inductance located within 6 feet of a conductor or object with secondary bonds, or as required by the referenced codes and standards, shall be bonded with secondary cable and fittings. Metal bodies of inductance shall consist of, but not be limited to, the following:

Roof flashing.

Parapet coping caps.

Isolated metal building panels or siding.

Roof drains and downspouts.

16935.3.3.5 Fasteners. Fasteners shall be placed on each run of exposed conductor not more than 3 feet apart to the medium on which it is routed, or as required by the referenced codes and standards.

Concealed runs of conductor shall be anchored as necessary to maintain position and hold permanently in place.

16935.3.3.6 Connections. Splices in main conductor runs and connections to branches shall be made with pressure type bolted or compression type connectors. Underground connections shall be by exothermal welding or as shown in the Ameren Missouri Approved Suppliers.

16935.3.3.7 Grounding. Each ground shall terminate in a properly made ground connection to a Contractor-furnished ground rod and to the existing below grade grounding system. Down-conductors shall be routed a minimum of 18 inches below grade.

16935.3.3.8 System Certification. The installing Contractor and a representative of the Owner shall complete any applicable application for inspection. The Owner will witness and sign for the concealed grounding portion of the system. The Contractor and Owner will sign the form to signify the information being submitted as correct and their authorization of a completed project inspection by a local authority representative.

The Contractor shall correct all areas noted by the field inspector as not being in compliance with current code requirements, such as products, components of the design, or misapplication in the installation. The project shall not be considered complete until applicable certificates according to the codes and standards are issued for each structure being protected.

Lightning Protection Specification Sheet

Scope Summary	
Article 16935.2.1 - General specification for a lightning protection system to design, furnish the materials, and install a complete lightning protection system	
Certification Requirements	
UL master label	Yes
Structures Requiring Lightning Protection	
Application	Class I or Class II
Main conductor material	Copper
Secondary conductor material	Copper
Air terminal bases	
Type	Adjustable point or Adhesive mounted or Standing seam or Handrail or Tee-mounted
Material	Cast bronze or Aluminum
Conductor holders	
Type	Standing seam or Adhesive
Material	Brass or aluminum for standing seam type. Cast bronze or aluminum for adhesive type.
Splicers	
Type	Parallel or Butt end straight or Tee or Cross-run
Material	Brass or aluminum for butt end straight type. Cast bronze or aluminum for other types.

SECTION 16941
LIGHTING SYSTEM INSTALLATION

16941.1 General

16941.1.1 Scope of Supply

Scope of supply shall include designing, furnishing, and installing the lighting system as specified herein. New and relocated materials shall be installed in accordance with the drawings, or as directed by the Owner.

16941.1.2 Items Furnished by Others and Interfaces

Items furnished by others and not in this scope of supply include the following:

The building power supply will be provided by the Contractor.

16941.1.3 Performance and Design Requirements

Performance and design requirements for the equipment to be installed under this section of these specifications are indicated herein.

In addition to the requirements of this section, the following requirements shall also apply:

Section 16502 - Lighting.

Section 16920 - Raceway Components and Installation.

Section 16925 - Conductors Installation.

16941.1.4 Codes and Standards

Work performed under these specifications shall be done in accordance with the local 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:

Table 16941-1 Codes and Standards	
Work	**In Accordance With**
Lighting installation	NFPA 70 - National Electrical Code
Emergency lighting installation	NFPA 101 - Life Safety Code and NEC

16941.1.5 Materials

The following materials shall be used:

Table 16941-2 Materials	
Component	**Material**
Contractor to specify	

16941.1.6 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:

Table 16941-3 Approved Manufacturers	
Component	**Manufacturer**
Contractor to specify	

16941.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 16941-4 Test Requirements

Tests	In Accordance With	Conducted By
Operational test	NFPA 70 and NFPA 101	Contractor

16941.1.8 Technical Attachments

None.

16941.2 Not Used

16941.3 Execution

16941.3.1 Fixtures

All office area lighting shall be from recessed fluorescent static troffers supported from the ceiling system grid and support structure above the ceiling. Supports shall be designed for the project seismic criteria. Industrial enclosed and gasketed fluorescent fixtures shall be used for wet or damp indoor process areas. Industrial fluorescent fixtures shall be used for dry indoor process areas and electrical rooms. Surface mounted fluorescent fixtures may be used for gypsum board ceilings.

Emergency and exit lighting shall be furnished and installed in accordance with NFPA 101. Emergency lighting in the plant areas shall be powered from a centrally located lighting UPS system. Emergency lighting in small remote yard structures where the central UPS system is not practical shall be powered from integral battery/inverter packs as approved by the Owner. Exit lights shall have LED lamps.

Each complete light fixture shall be secured to its support assembly. This work includes, but is not limited to, all special drilling, assembling, disassembling, reassembling, and wiring. Except for light fixtures with swivel support power hook hanger assemblies, light fixtures shall be rigidly supported. Chain supports are not acceptable.

Light fixtures shall be controlled from light switches installed inside the room on the latch side of each door entrance. Rooms with multiple entrances shall utilize appropriate three- and four-way switching schemes. Light fixtures in the large open process equipment areas shall be controlled from panelboard circuit breakers. The panelboard shall be located in a readily accessible location to the space. Fixtures not controlled by local switches shall be circuited so adjacent fixtures are connected to alternate phases of the panelboard.

Conduits in finished areas connecting recessed light fixtures and their adjacent junction boxes shall be flexible metallic conduit 1/2 inch minimum size.

Immediate lamp replacement, whenever burnouts occur, shall be continuous until the date of commercial operation.

Luminaires in wash down areas shall be NEMA 4 enclosures minimum.

Roadway luminaires shall be mounted on aluminum or galvanized steel poles with helix or concrete anchor foundations.

All fixtures shall be labeled with the panel and circuit breaker it is being supplied from.

16941.3.1.1 Location. Fixture locations shall be coordinated with other work in the same area to prevent interference between lighting fixtures, tray, ductwork, piping, HVAC, hoists, monoriails, or other equipment. Light fixtures shall be symmetrically and uniformly spaced, as much as practical, and shall not be located over the top of piping, tray and equipment. Any fixture shall be relocated if, after installation, it is found to interfere with other equipment or is so located to prevent its practical and intended use. No fixture shall be located to prevent the full use of any accessway beneath a removable grating or slab. All light fixtures shall be easy to maintain on all platforms including stairways and process platforms. Unless otherwise noted, light fixture mounting elevations shall be to the bottom of the fixture enclosure.

Outdoor lighting of process equipment located outdoors and on outdoor platforms shall be easy to maintain.

16941.3.1.2 Alignment. Fixtures installed in rows shall be carefully aligned vertically and horizontally. Lighting fixtures and outlet boxes, mounted on building steel, shall be centered on the beam flanges or webs, except where deviations are required to avoid interference with ductwork, piping, HVAC, hoists, monorails, tray, or miscellaneous steel. Fixtures and stanchion mounting poles shall be carefully aligned vertically and horizontally.

16941.3.2 Wiring Devices

Wiring devices, such as switches and receptacle socket outlets, shall be installed in boxes approved for the purpose, and the polarity of receptacles shall be verified and tested.

Convenience outlet and switch boxes shall be clamped to structural steel where required, and the steel shall not be drilled and tapped. Receptacles shall be installed to provide access to the industrial process areas with a 100 foot extension cord. Weatherproof snap action covers shall be installed on all receptacles located outdoors and in wet locations. GFCI receptacles shall be installed in accordance with the NEC, such as wet/damp areas.

A convenience outlet must be installed within 12 feet of any control/DCS panel.

16941.3.2.1 Wiring Device Mounting Heights. The bottom of the wiring devices shall be mounted at the following distances above the finished floor. Note that "finished areas" are defined as rooms with a suspended ceiling system and "unfinished areas" are all other indoor locations:

Table 16941-5 Mounting Heights

Wiring Device	Location	Distance Above Floor
Receptacles	Offices and finished areas All other locations	15 inches 35 inches
Switches	All locations	46 inches

16941.3.3 Lighting Conductors

The following requirements shall apply to the installation of lighting conductors, in addition to applicable installation procedures specified in these specifications:

At least 6 inches of free conductor shall be left at each junction box.

Cables shall be installed in continuous lengths. Splices shall not be permitted.

All cables shall be identified with a unique identifier and shall be listed on the master cable schedule.

Circuits of different voltage levels shall not be mixed in the same cable or conduit.

Lighting conductors of 10 AWG and smaller may be stranded if used with devices, lugs, and connectors specifically applicable for stranded conductors. Stranded conductors are not to be used with screw head binding, such as with side wired devices. Proper backed-

wired or pressure devices UL listed for stranded conductor termination must be used where stranded conductors are selected.

Lighting and receptacle branch circuit voltage drop shall not exceed 3 percent. This shall include the voltage drop from the last outlet in the branch circuit to the lighting panelboard. Voltage drop calculations shall be provided to the Owner as requested. In addition, 120 volt branch circuits longer than 75 feet shall use 10 AWG and 277 volt branch circuits longer than 200 feet shall use 10 AWG conductors.

16941.3.4 Lighting Raceway

The following requirements shall apply to the installation of lighting raceway, in addition to applicable installation procedures specified in these specifications:

Raceway installed in finished areas, such as offices, locker rooms, toilets, control room, etc., shall be concealed in the walls, above the ceiling, or below the floor.

Conduit shall not be routed on the exterior surface of building walls.

Raceway shall be 3/4 inch minimum size.

16941.3.5 Not Used

16941.3.6 Grounding

All lighting fixtures and wiring devices shall be grounded back to the power source via a separate equipment ground conductor. The conduit system is not considered to be a grounding conductor, except for itself.

SECTION 17051
CONTROL DESIGN AND EQUIPMENET

17051.1 General

17051.1.1 Scope of Supply

Scope of supply shall include furnishing control system design and equipment as specified herein and in the referenced specification sections.

17051.1.2 Not Used

17051.1.3 Performance and Design Requirements

Performance and design requirements for the control system equipment are indicated herein and in the referenced specification sections.

17051.1.3.1 General Separation Requirements.

Single Train Systems.

All associated I/O required to control a single piece of equipment shall be in a single controller.

Any deviation shall be approved by Owner.

Dual Train Systems.

No single point of failure shall take down both trains.

If any single point of failure does exist, it shall be identified and approved by the Owner.

Separate process nodes/control cabinets if available.

At a minimum and Owner approved, separate controller modules and I/O.

Balance of plant or common controls shall not be embedded in any unit controllers.

One train will be able to be taken completely out of service without affecting the other train.

Separate power feeds from different buses.

'A' train equipment to be fed from 'A' train buses, etc.

Maintain separation on power supplies to ALL related supporting equipment.

Separate raceways.

Three (or Odd) Element Equipment Trains.

Maintain separation between A and B as mentioned above.

Load balancing for equipment normally in service should be considered when assigning trains.

The third (or odd) should be on a separate controller.

Common Systems.

Shall be designed so loss of common train will not immediately affect either unit.

Ideally, A and B trains are required for common systems, buses, etc.

If a third or C common train exists, it should be fed from a third or emergency bus/train.

The loss of a given unit bus shall not affect both common trains.

If redundant power supplies exist on common control systems, power feeds should be one from each unit.

Separation requirements should follow dual train systems above.

17051.1.4 Codes and Standards

Work performed under these specifications shall be done in accordance with the codes and standards referenced in the individual technical sections. Unless otherwise specified, the applicable governing edition and addenda to be used for all references to codes or standards 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference.

17051.1.5 Not Used

17051.1.6 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.

Table 17051-1 Approved Manufacturers

Component	Manufacturer
Control System and Simulator Configuration	Ameren Missouri Approved Suppliers

17051.1.7 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.

The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure.

17051.1.8 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:

Table 17051-3 Technical Attachments

Document Number/Description	Title	Revision
	I/O Point Identification Scheme	
	I/O Database – Minimum Requirements	
	Instrument Database – Minimum Requirements	
	Equipment Control Logic Templates	
	Standard Schematics – Medium Voltage Switchgear, Low Voltage Switchgear	

17051.1.9 Supplemental Specifications
Not Used

17051.2 Products

17051.2.1 Control Design and Equipment Specifications
This article defines the scope and design requirements for control of the equipment furnished under this specification.

17051.2.1.1 Definitions. The following definitions apply to the control requirements included in these specifications:

Table 17051-4 Definitions

Automatic Control	Properly timed and interlocked sequence of events that occur as a result of one or more initial conditions. The initiating condition may be an operator action or the existence of a process or equipment condition. Automatic control modes shall be designed to minimize the frequency of operator response.
Manual Control	Individual operation of motors, valves, gates, etc., by separate operator actions. Proper safety interlocks shall be in effect in the manual control mode to prevent equipment damage caused by operator action and for personnel safety.
Normal Shutdown	An orderly shutdown of the process system or equipment that includes a final purge, if required. After a normal shutdown, the system shall be ready for subsequent operation.
Emergency Shutdown	An operator or safety device (for example, emergency pull cord switch) initiated trip of the system which causes an immediate and simultaneous stopping of all equipment. An emergency shutdown does not include any purges of the system except for those described in the AQCS section for flushing and draining of slurry lines.
Trip Checks	Discrete logic used to facilitate the check-out of critical trips and interlocks.
Maintenance/Testing Mode	A supervised local mode of operation where only the circuit protective and personnel safety interlocks are enabled. This mode of operation is intended to be used for momentary or jogging operation during maintenance or testing periods.

Table 17051-4 Definitions	
Pull- to-Lock	"Pull to Lock" logic shall be incorporated into the control for equipment that is subject to automatic starting. Once "Pull to Lock" is engaged by the operator on a given piece of equipment, auto-starting shall be prevented by the logic. Local operation of the equipment shall not be impeded.
WPA	Refer to Article 17051.2.1.2.

17051.2.1.2 WPA Function. The system shall allow the operator to place any plant motor, electrically operated breaker, or solenoid operated device in a "WPA" (Worker's Protection Assurance) condition from the control station dedicated to that device. The WPA function shall simulate placing an "Out of Service" or "Local Control" tag on a physical control station, but will not replace the requirement for electrical and/or mechanical disabling of the equipment prior to maintenance. WPA is for indication only and shall not become part of the master WPA configuration. The on motor driven equipment, "Out-of-Service" shall prevent a DCS start. If the equipment is running, an "Out-of-Service" shall not be able to be selected.

The operator will be required to place the device's mode and output in the desired state prior to initiation of the WPA function. The system shall not prevent the changing of the output or the mode of the associated logic either by the operator or by the control logic while in the WPA state. WPA status shall be stored in nonvolatile memory so that the WPA state is retained on control processor failure and subsequent restart.

The Contractor shall provide device WPA logic and operator interface configuration for all power operated valves, motors, and electrically operated breakers included in the scope of the Contractor's programming services.

17051.2.2 Scope of Control Design and Equipment

The Contractor shall furnish a complete control system for photovoltaic array system and equipment and the engineering services to support the integration of this control system into the Owner's plant control system.

The Contractor shall furnish all instrumentation and control devices required to provide protection for all equipment and personnel. The Contractor shall provide the control and alarm functions required by the Contractor's design and as described in these specifications.

The control system shall include all required interlocks, monitoring, and alarms for proper operation and protection of equipment and personnel. Tripping of major equipment shall occur only to prevent equipment damage or personnel injury.

17051.2.2.1 Contractor's Control System. The Contractor shall furnish a complete control system for the specified equipment. The control system(s) shall include all required panels, instruments, local control stations, devices, and accessories and their configuration.

The Contractor shall furnish a control system that uses DCS equipment to implement the control requirements defined in these specifications. The Contractor's DCS shall use the hardware and software as that selected by the Owner for compatibility with the existing plant control system. The DCS equipment shall meet the requirements of 17101 - Distributed Control System.

17051.2.2.2 Contractor's Engineering Services. The Contractor shall furnish all engineering services required to integrate the control system into the Owner's existing plant control system and provide documentation for long term Owner maintenance.

The Contractor shall provide all control logic programming necessary for a complete operating system.

The control strategies to be implemented shall be subject to the Owner's approval.

The Owner will provide programming of the DCS workstation graphics using recommended graphic displays provided by the Contractor. Recommended graphics provided to the Owner are for reference only. The Owner reserves the right not to base their graphics on the Contractor's recommended graphics.

The engineering services shall include a complete control system input/output (I/O) database, functional description of the operation of the Contractor's equipment, detailed SAMA logic diagrams, detailed cabinet and panel layout drawings, instrument database, and detailed schematic and wiring diagrams.

The I/O database and instrument database shall include the content shown on the Owner's example databases in Article 17051.1.8. The I/O database and instrument database shall be provided on a CD ROM in Microsoft Excel (preferred) or Microsoft Access file format.

17051.2.3 Control System Logic Equipment

The Contractor shall furnish a control system that uses DCS equipment to implement the control logic requirements defined in these specifications. The DCS shall use the same hardware, software, and logic conventions as that selected by the Owner for compatibility with the existing plant controls. The DCS equipment shall meet the requirements of the Company.

All control system logic equipment shall be DCS unless approved by the Owner. Any PLC equipment shall meet the requirements of Section 17053 - Programmable Logic Controllers.

17051.2.4 Control System Operator Interface Equipment

The Contractor shall furnish the following local operator interface. The operator interface shall provide indication, control, and alarm annunciation as defined in section 1-D.

17051.2.5 Scope of Interface to Owner's Plant Control System

Interface to the Owner's Plant Control System shall be provided as defined herein:

> The system shall provide process data and equipment status to allow the operators in the existing plant main control rooms to assess the condition of the Contractor's process, equipment, and control system.
>
> Individual process, equipment, and control system alarms shall alert the operators in the plant main control room that a particular problem has occurred. The system shall provide the intelligence to allow the operator in the plant main control rooms to determine the nature of the problem and to take the necessary corrective action or to determine the type of personnel to send to the local area.

17051.2.5.1 Method of Interface to Owner's Plant Control System. The Contractor shall furnish the equipment required to implement the interface to the Owner's plant DCS as defined herein.

The interface shall be used to allow the DCS to generate interactive graphic displays for operator control of the Contractor's equipment. The DCS graphic displays serve the same function as a traditional Contractor-furnished subpanel with switches and indicating lights. All control logic for the Contractor's equipment shall reside in the Contractor-furnished control system.

The Contractor shall be responsible for furnishing all communications interface boards, ports, software drivers, protocol converters, and other required interface equipment and software required for the Contractor-furnished control system to communicate with the Owner's DCS by means of the specified interface method.

The Contractor shall provide foreign device gateways as required for data interface information that must be passed between any Contractor-furnished PLC system and the Contractor's DCS to meet the specified control and monitoring functions.

Data transmitted from the Contractor's control system to the Owner's DCS shall include all information necessary for the DCS graphic displays to monitor and control the Contractor's process, equipment, and

control system. Such data may include pertinent analog and digital status information, interlocks, alarms, and maintenance conditions.

Data transmitted from the Owner's DCS to the Contractor's control system shall include permissive signals, process data, and/or signals necessary to initiate an emergency stop of the Contractor's equipment from the DCS.

17051.2.6 Documentation

The Contractor shall furnish fully annotated and indexed hard copy printouts of the final control and monitoring application program.

The Contractor shall supply control system equipment operation and maintenance instruction manuals. The manuals shall include complete documentation on all programming and operator interface hardware and software.

The Contractor shall also provide drawings showing all power, communications, grounding, I/O, elementary (schematic) diagrams, wiring diagrams (internal, external connections, and interconnection diagrams). The drawings shall indicate the physical location of all equipment and show complete identification of all modules in all racks. Cabinet and panel outline drawings shall also be provided.

The Contractor shall furnish two electronic copies of the DCS software, PLC software, and any other programs required for the programming, troubleshooting, and maintenance of the control system and equipment provided by the Contractor. The electronic copies of the information shall be provided on DVDs. The Contractor shall also provide the engineering platforms and licenses for each workstation.

17051.3 Execution

The Contractor shall implement the Owner's logic strategies, electrical schematic standards, and instrument database and I/O database content and format for the PV systems. The Owner's logic templates, standard electrical schematics, and instrument and I/O database examples are identified in Article 17051.1.8. These are partially issued with the bid documents; the remaining will be issued after contract award.

Logic review meetings shall be conducted with the Owner and logic approved prior to implementation by the Contractor. The Owner and Contractor shall set a "freeze" date for the Contractor's implementation of the agreed control strategies.

The updated DCS configurations shall be provided to the Owner at the agreed milestone dates to allow the Owner to use the existing control simulator for operator training and for review of the control configurations provided by the Contractor.

17051.3.1 General Programming Guidelines

Control logic for each piece of equipment shall be on a single sheet or adjacent sheets.

Multiple sheets per document shall be limited to five.

Logic shall flow from left to right or top to bottom.

Inputs/outputs and communication I/O shall be on separate sheets from other logic.

Maintain neat and orderly logic flow, with space for additional future logic.

Place function codes and signals so all specifications are visible and not crossed by signal lines.

Avoid crossing signal lines if possible.

Digital signal flow lines shall be dashed. Analog signal lines shall be solid.

Comments shall be liberally added to provide clarity of programming.

Every physical input and output shall be available for trending.

Indirect modification of function code (adapt blocks) shall be on same page as the block being modified.

Each equipment permit shall be individually displayed.

No redundant lines of code. All logic shall be simple to follow.

Unused code shall be removed.

Final version of new code shall be loaded without errors or warnings.

Logic between trains shall be as identical as possible, down to the visual representation.

SECTION 17053
SUBSYSTEM – PROGRAMMABLE LOGIC CONTROL SYSTEM

17053.1 General

17053.1.1 Scope of Supply

Scope of supply shall include the programmable logic controller (PLC) equipment as specified in Section 17051 – Control Design and Equipment and as defined herein.

17053.1.2 Not Used

17053.1.3 Performance and Design Requirements

Performance and design requirements are indicated on the PLC System Specification Sheet included at the end of this section.

17053.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 17053-1 Codes and Standards

Work	In Accordance With
Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems	ANSI C37.90.1
Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange	EIA RS-232-D
Racks, Panels, and Associated Equipment	EIA RS-310-D
Electrical Characteristics of Balanced Voltage Digital Interface Circuits	EIA RS-422-A
Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems	EIA RS-485
Standard Digital Interface for Programmable Instrumentation	IEEE 488.1
Standard Codes, Formats, Protocols, and Common Commands	IEEE 488.2
Guide for Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Equipment	IEEE 518
Standards for Local and Metropolitan Area Networks	IEEE 802 (IEC 8802)
Standard Microcontroller Serial Control Bus	IEEE 1118

Table 17053-1 Codes and Standards	
Work	**In Accordance With**
Fieldbus	IEC/ISA SP50
Binary Logic Diagrams for Process Operations	ISA S5.2
Graphical Symbols for Process Displays	ISA S5.5
Environmental Conditions for Process Control Systems	ISA S71.02
Functional Diagramming of Instrument and Control Systems	ISA 5.1, SAMA/MCAA RC22-11
Information Technology - Open System Interconnection - Basic Reference Model	ISO OSI 7498-1
Enclosures for Electrical Equipment	NEMA 250
Enclosures for Industrial Controls and Systems	NEMA ICS6
National Electrical Code	NFPA 70
Cabinets and Boxes	UL 50
Industrial Control Equipment	UL 508

17053.1.5 Materials

Not Applicable

17053.1.6 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.

Table 17053-3 Approved Manufacturers	
Component	**Manufacturer**
Programmable logic controllers	Ameren Missouri Approved Suppliers

17053.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 17053-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Programmable logic controllers	Manufacturer's Standard	Contractor

17053.1.8 Not Used

17053.1.9 Supplemental Specifications

Not Used

17053.2 Products

The PLC shall receive status intelligence, perform logic functions, issue control commands, and provide alarms and status information for control and monitoring of the system equipment described in these specifications. The manufacturer and model of the PLC shall be as listed in Article 17053.1.6.

17053.2.1 PLC Requirements

The PLC equipment shall be a microprocessor based system with user programmable memory for storage of instructions to implement input/output (I/O) control, Boolean logic, timing, counting, arithmetic operations, data manipulation, and serial data communication with other control systems and equipment. The PLC shall be designed for industrial applications, suitable for operation in the environment specified in the technical supplementals.

The PLC shall be fully compatible with other Contractor-furnished equipment, and the Contractor shall be fully responsible for ensuring that the overall system operation meets the intent of these specifications. The Contractor shall be responsible for any changes in PLC equipment or software that are required because of defective equipment, incorrect internal connections, incorrect programming, or incorrect selection of equipment.

The PLC shall be furnished with sufficient memory to implement all specified control and monitoring functions plus the spare capacity listed on the PLC System Specification Sheet for future use by the Owner. All user memory shall be nonvolatile, either by use of battery-backed RAM, EEPROM, or similar technology. If batteries are used for memory retention, the batteries shall be capable of supporting the memory for a minimum of 2 months. Indication of low battery power shall be provided by the PLC. Means to protect against unauthorized changes to the application programs shall be provided.

In cases where the Contractor's process equipment includes multiple skids, panels, or cabinets with multiple signals at each location, remote I/O racks shall be used to reduce field wiring.

The Contractor shall select I/O modules that are compatible with the interrogation voltage used and the loads of the connected devices. I/O modules for contact inputs and outputs shall be furnished with status indicating lights for each point. Field powered I/O shall be electrically isolated from each other (no common hot, neutral, or return connections) and from all cabinet wiring.

Contact output modules shall be rated for the load capability defined on the PLC System Specification Sheet. Interposing relays with a minimum of two Form "C" contacts shall be provided for all digital outputs.

Each Form C relay output shall be able to switch a minimum of 10.0 amps at 120 volts ac or 3.0 amps at 125 volts dc with all outputs on a module active at the same time.

Each Form X relay output shall be able to switch a minimum of 10.0 amps at 120 volts ac or 10.0 amps at 125 volts dc with all outputs on a module active at the same time.

A mixture of Form C and Form X relays will be required on some relay output modules.

Relay outputs may be required to be energized indefinitely. Relays shall be rated for continuous duty.

Contact outputs shall close and open within 0.15 seconds.

Interposing relay coils shall be powered by the PLC digital output card. Interposing relay contacts shall be wired to terminal blocks in the PLC I/O equipment or termination cabinets. The interposing relays shall be labeled to identify the relay with its associated output. Digital outputs may be used to switch inductive loads. All required transient protection shall be internal to the output module. Triac style transistor outputs are generally not acceptable and shall only be provided if required for special applications with written Owner approval.

The Contractor shall furnish redundant power supplies required for powering analog transmitters that are not self-powered. Transmitter power supply circuits shall be individually current limited (preferred) or individually fused. One transmitter power or UPS power supply circuit is an acceptable alternative.

The system shall be supplied with spare I/O, rack space, and processing capacity as listed on the PLC System Specification Sheet. Spare I/O points shall be wired out to terminal blocks.

All input and output wiring to field equipment not located in the Contractor's cabinet shall be terminated on terminal blocks. Terminal blocks shall be sized to accommodate 12 AWG wire and shall be located in the Contractor's cabinet. Individual terminals shall be provided for each input and output.

The PLC equipment shall be powered from a UPS source through a separately fused bus within the Contractor's cabinet.

The system shall provide, for the Contractor's use, Form C contact outputs, which will alarm loss of any power supply or PLC equipment fault.

In the event of a PLC equipment malfunction or power supply failure, control signal outputs shall be commanded to a defined status to be defined by the Contractor through safeguard circuitry, thereby rejecting operating equipment to a predetermined safe status. Operator initiation shall be required to restart the system.

A limited amount of logging, trending, graphical interface, and historical data storage shall be available, since this shall be accomplished by the plant distributed control system (DCS).

17053.2.2 Software

Control and monitoring application programs for the PLC shall be developed by using the formats specified in IEC Standard 61131-3. The Contractor shall develop tested software for control and monitoring of the system in accordance with the requirements of these specifications. All programs shall be programmed in ladder logic; structured text is not an acceptable method of programming. Indirect and/or indexed addressing shall not be used without Owner’s approval. The programs shall be fully documented and cross-referenced. As a minimum, each contact, coil, and register shall be labeled with the functional description and address. Rung comments shall be used to describe all logic and document blocks of logic. Prior to final turn-over, rung comments shall be re-reviewed and modified as necessary to ensure consistency with the final logic.

The Contractor shall provide communication interface software for the control and monitoring application programs, including licenses and documentation. The software shall fully use a windows environment and shall be designed to run under the latest Microsoft Windows software. The software will be loaded onto the Owner’s PC. The programming software shall be licensed as directed by the Owner.

The Contractor shall provide a complete PLC I/O list as specified in Section 17051.2.2.2.

The Contractor shall furnish two final copies of the control and monitoring program clearly marked with program name, function, complete file name, revision number, and last revision date. Each program copy shall be provided on a CD or DVD that is compatible with the programming software furnished. The Contractor shall also furnish hard copy printouts of the final control and monitoring program as specified on the PLC System Specification Sheet.

17053.2.3 Interface to Plant Distributed Control System

A PLC to DCS data interface shall be provided. The interface will be used to allow the DCS to generate interactive graphic displays for operator control of the Contractor's equipment. The DCS graphic displays will serve the same function as a traditional Contractor-furnished subpanel with switches and indicating lights. All control logic for the Contractor's equipment shall reside in the Contractor-furnished PLC. The only logic in the DCS will be that required to emulate the control switch functions required to interface with the Contractor's control logic.

To enable efficient information exchange, the PLC data to be communicated to/from the DCS shall be organized into two continuous blocks of memory within the PLC; one for transmitted data and one for received data. Each memory block shall have 25 percent spare capacity for addition of future data exchange points.

The communication system used shall be based on the ISO Open Systems Interface (OSI) model to assure connectivity between different systems. The communications system shall be implemented by using Ethernet standards for the hardware layer. The communications interface shall be bidirectional, capable of receiving and originating messages over the communication network. All data conversions that are required for accessing the communications network shall be performed by the network interface (data link layer) and shall not require the data to be routed to a separate processor for this conversion.

Communication networks using RS-485 standards for implementation shall be based on Modbus Plus, Modbus TCP/IP or OPC communications protocols. The communications medium shall be twisted shielded copper conductors for indoor locations and those areas not subjected to induced signal noise. For communication networks routed outdoors, lengths over 200 feet, or in areas where induced signal noise is probable, fiber-optic cable shall be used. These communication networks shall communicate at a minimum of 19,200 bits per second without errors and, where required, modems or line drivers shall be furnished as a part of this system.

Ethernet based communication systems shall be implemented by using a bus topology employing Carrier Sense Multiple Access with Collision Detection (CSMA/CD). All Ethernet based communication networks shall conform to IEEE 802.2 (ISO 8802.2). In addition, CSMA/CD media access control shall conform to IEEE 802.3 (ISO 8802.3) and token passing media access control shall conform to IEEE 802.4 (ISO 8802.4). The Ethernet communications network shall communicate at a minimum of 10 megabits per second and shall use coaxial cable, unshielded twisted pair (UTP), or fiber-optic cable. The coaxial cable bus shall conform to ISO 8802.3 10BASE-5 requirements. The fiber-optic cable bus shall conform to ISO 10BASE-F requirements. UTP cable shall conform to Category 5e or better and shall be suitable for outdoor installation if required. Outdoor Category 5 or better cable shall include an overall shield. Ethernet communication networks shall include all necessary connectors, taps, switches, repeaters, cables, and terminators required for a complete communications system. The PLC network cables shall have an orange jacket. The network driver shall be selected to match the hardware configuration of the network. As a minimum, the network operating system shall support the Transmission Control Protocol/Internet Protocol (TCP/IP) communication protocol suite.

All necessary communication support hardware and software shall be provided. The software shall be designed so that the Owner can easily configure the communication between the DCS and the foreign device from the engineer/operator workstation.

The interface shall permit the data generated in the foreign device to be used in any process controller, displayed on any operator workstation, or used in any report. The interface shall also allow the configuration of push buttons and control stations on the DCS operator workstation displays that can be used to start and stop motors, open or close valves, other equipment, etc., that are controlled by the PLCs. The command and address attributes required for this configuration shall be straightforward and shall not require extensive mathematical calculations or programming.

The Contractor shall be responsible for furnishing all communication interface boards, ports, software drivers, protocol converters, and other required interface equipment and software required for the PLC to communicate with the DCS by means of the specified serial interface method. The Contractor shall also be responsible for identifying and configuring any special PLC data file register/array configurations and unique PLC hardware arrangements required to support the PLC/DCS communications. Failure to correctly configure the PLC points to communicate with the DCS shall be corrected.

The Contractor shall provide a data interface I/O list that indicates all information that must be passed between the PLC and DCS to meet the specified control and monitoring functions. The list shall indicate the signal name, address, on/off status for digital points, engineering units and engineering unit range for analog points, and digital data word format and range for each point. The list shall provide all information

necessary for decoding and engineering unit conversion of each point in the receiving system. The list shall be provided on CD or DVD in Microsoft Access (preferred) or Excel file format..

Data transmitted from the PLC to the DCS shall include all information necessary for the DCS graphic displays to monitor and control the Contractor's process, equipment, and PLC. Such data may include pertinent analog and digital status information, interlocks, alarms, WPA status and control, and maintenance conditions.

Data transmitted from the DCS to the PLC shall include signals necessary to provide an operator's control interface for the Contractor's equipment from the DCS and to initiate an emergency stop of the PLC logic from the DCS. PLC memory maps illustrating transmitted and received data block address locations, arrangement, and length shall be provided.

The Contractor shall provide drawings or printouts showing recommended graphic displays indicating the required control and monitoring functions for its equipment. The graphic displays will be programmed into the DCS by the Owner.

The Contractor shall provide written operating instructions and logic diagrams for its equipment designed to allow the Owner to verify the operation of the graphic displays.

17053.2.4 Optional VDU Based Graphical Operator Interface

Not Applicable.

17053.2.5 PLC Functionality Test

The complete programmable controller system shall be assembled by the Contractor's factory and functionally tested for circuit continuity, correct program function, and correct system response to power supply failure and equipment malfunctions. This test shall include the following:

A demonstration of the proper functioning of all hardware.

A demonstration of the proper functioning of all Contractor-supplied software.

A point-by-point exercise of each input and output.

A demonstration of auto-starts, auto-stops/trips, safety interlocks, or other functional checks required for proper operation.

A demonstration of all man/machine functions.

All input simulation equipment and output monitoring equipment required for testing shall be furnished by the Contractor. The Owner shall be given an opportunity to witness this test.

The Contractor shall furnish all programming hardware and software if it is separate from the PLC provided. Hard copies of the final programming shall be submitted as engineering information through the drawing review process.

17053.2.6 Personnel Training

The Contractor shall provide training for the Owner's personnel as specified on the Programmable Logic Control System Specification Sheet.

17053.2.7 Field Service

The Contractor shall provide the service of one or more field service engineers for commissioning, startup, and testing of the PLC equipment as specified on the PLC System Specification Sheet. The amount of field service is to be determined by the Contractor and shall be as required to provide complete startup, commissioning, and checkout of the PLC control systems.

17053.2.8 Documentation

The Contractor shall furnish soft copies and hard copy printouts of the final PLC control and monitoring application program.

The Contractor shall supply PLC equipment operation and maintenance instruction manuals and installation and commissioning manuals. The manuals shall include complete documentation on all programming and operator interface hardware and software.

The Contractor shall also provide drawings showing system configuration and all PLC power, system architecture, communications, grounding, I/O, and other internal wiring and external connection diagrams. The drawings shall indicate the physical location of all PLC equipment and show complete identification of all modules in all racks.

The Contractor shall furnish two electronic copies of the PLC programs, licenses, and any other programs required for the programming, troubleshooting, and maintenance of the control system and equipment provided by the Contractor. The electronic copies of the information shall be provided on DVDs.

Contractor shall also furnish a written description of logic and operations. This shall be provided to Owner as part of the design phase for review and comment prior to implementation. This shall also be provided in "as-built" form as part of final turn-over.

PLC System Specification Sheet

System Equipment		
The PLC equipment shall be selected from the following approved manufacturers and models:		
PLC Equipment Manufacturer	**Processor Model, Series or Family**	**I/O Family**
Modicon	Quantum or M340	
Structured text is not to be used unless the Owner gives prior approval. All programs are to be programmed in ladder logic. Indirect or indexed addressing shall NOT be used without Owner approval. In instances where it must be used, there shall be stringent documentation requirements that must be met and all arrays must be clearly documented.		
Programming software shall be: Unity		
Special Requirements (Enter any special needs, restrictions, preferences, etc.)		
Use of PLC equipment shall be minimized to the greatest extent possible. Use of local PLC control systems in lieu of DCS integration shall be reviewed and approved by the Owner.		

Contact Output Module Ratings			
	Voltage	**Switching**	**Continuous**
Control	120 VAC	1200 VA	180 VA
Low Power (control and alarm)	125 VAC	200 watts	40 watts
High Power (switchgear/SUS control)	125 VAC	1000 watts	500 watts
Special Requirements (Enter any special needs, restrictions, preferences, etc.)			
An interposing relay shall be provided for each contact output.			

Interface to Distributed Control System				
Yes		A serial data interface to the DCS shall be supplied by the Contractor as defined in the specification.		

System Spare Capacity (after FAT)	
Spare installed I/O points of each category	20%
Spare available I/O card slots in I/O cabinets	20%
Spare I/O terminal blocks in I/O cabinets	20%
Spare component space (processors, communication) controllers, memory modules, etc) in system cabinets	20%
Spare Boolean logic (application program) capacity (available for future use without exceeding manufacturer's recommended maximum loading) in the most heavily used processor	20%
Spare display processing and storage capacity (available for future use without exceeding manufacturer's recommended maximum loading) in the most heavily used display processor	20%
Special Requirements (Enter any special needs, restrictions, preferences, etc.)	
Spare Parts Requirements	
Spare parts required for startup and commissioning shall be provided by the Contractor as defined in the specification	
Spare parts required for operation shall be provided by the Contractor as defined in the specification.	1 year
Special Requirements (Enter any special needs, restrictions, preferences, etc.)	

Personnel Training	
Special Requirements	
Field Service	
Support services to be determined by Contractor	

SECTION 17101
DISTRIBUTED CONTROL SYSTEM

17101.1 General

17101.1.1 Scope of Supply

Scope of supply shall include furnishing a distributed control system (DCS) to control and monitor the flue gas desulfurization (FGD) system and associated equipment furnished under this contract as specified in Section 17051 – Control Design and Equipment and as indicated herein.

17101.1.2 Items furnished by Others and Interfaces

Items furnished by others and not in this scope of supply include the following:

Existing operator workstations located in the existing main control rooms.

Existing engineering workstation.

DCS processors, input/output (I/O) modules, and termination cabinets for existing plant equipment and interfaces (if required for interface of new ID fans).

Long-term historian.

Programming of DCS graphics.

Existing main control room printers.

17101.1.3 Performance and Design Requirements

Performance and design requirements for DCS equipment are indicated herein.

17101.1.4 Codes and Standards

Work performed under these specifications shall be done in accordance with the codes and standards referenced herein. 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference.

Table 17101-1 Codes and Standards

Work	In Accordance With
Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems	ANSI C37.90.1
Power Test Code - Fan Performance	ASME PTC 11
Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange	EIA 232-D
Racks, Panels, and Associated Equipment	EIA RS-310-D
Electrical Characteristics of Balanced Voltage Digital Interface Circuits	EIA RS-422-A
Standard Digital Interface for Programmable Instrumentation	IEEE 488.1
Standard Codes, Formats, Protocols and Common Commands	IEEE 488.2

Table 17101-1 Codes and Standards	
Work	**In Accordance With**
Guide for Protection, Interlocking, and Control of Fossil-Fueled Unit-Connected Steam Stations	IEEE 502
Guide for Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Equipment	IEEE 518
Standards for Local and Metropolitan Area Networks	IEC 8802 (IEEE 802)
Classification of Degrees of Protection Provided by Enclosures	IEC 529
Binary Logic Diagrams for Process Operations	ISA S5.2
Graphic Symbols for Process Displays	ISA S5.5
Environmental Conditions for Process Control Systems	ISA S71.02
Functional Diagramming of Instrument and Control Systems	ISA 5.1 SAMA/MCAA RC22.11
Information Technology-Open System Interconnection-Basic Reference Model	ISO OSI 7498-1
Enclosures for Electrical Equipment	NEMA 250
Enclosures for Industrial Controls and Systems	NEMA ICS6
National Electrical Code	NFPA 70
Cabinets and Boxes	UL 50
Industrial Control Equipment	UL 508

17101.1.5 Materials

The following materials shall be furnished and shall be new and unused:

Table 17101-2 Materials	
Component	**Manufacturer/Model**
DCS Control Processors (Redundant)	ABB/INFI-90
DCS I/O Modules	ABB/S800
DCS Communication Gateways	ABB
DCS Cluster Modems	ABB
DCS Connectivity Servers	ABB
DCS Engineer/Operator Workstations with KVM Extenders	ABB (match existing)
DCS Bridge Controllers (Redundant)	ABB
DCS Loop Termination Units	ABB
DCS Module Mounting Units	ABB
DCS Engineer/Operator Interface Stations and Consoles	Contractor Selected

17101.1.6 Approved Manufacturers of Components
The DCS components shall be supplied by ABB and shall be compatible with the existing plant control system.

17101.1.7 Test Requirements
Testing is to be considered part of the defined Scope of Work, and all associated costs are the responsibility of the Contractor. The requirements for testing of the DCS are listed in Article 17101.2.15, System Testing.

17101.1.8 Technical Attachments
Not Applicable

17101.1.9 Supplemental Specifications
Not Applicable

17101.2 Products

17101.2.1 System Requirements
The DCS shall provide the following functions as defined herein:

Data acquisition.

Modulating (continuous) control.

Discrete (sequential) control.

Alarm monitoring.

Information display.

System data reporting.

Short-term data storage.

The DCS shall be a fully integrated, flexible, and expandable microprocessor based control and information system. The system shall have a distributed architecture comprised of a family of independent functional processors. Each functional processor shall be a configurable unit programmed to execute a specific dedicated task using the most advanced application software available. Each functional processor shall utilize a dedicated set of hardware and communication channels to do its assigned task. Intelligent I/O hardware, terminations, and signal conditioning shall also be provided.

I/O modules shall be used for interfacing with sensors and receivers in the plant.

Terminology in these specifications conforms to the definitions given in the applicable standards specified. In addition, the following definitions shall apply:

Table 17101-3 Definitions	
Analog Point	Any analog input, analog output, or analog calculated variable.
Digital Point	Any digital input (low or high sequence-of-events [SOE] resolution), digital output, relay output, or digital calculated variable.
Process Control Unit (PCU)	An integral group of components used to execute control and data acquisition functions, consisting of power supplies, computer processors, memory, connection to the data highway communications network, and connection to the I/O communications network.
Operator Interface Processor	An integral group of components used to execute operator interface functions, consisting of power supplies, computer processors, memory, and connection to the data highway communications network.
Operator Interface Function	An interaction between the operator and the DCS wherein the operator issues a command, and the DCS executes the command and provides the feedback information on the monitor or the printer.
Operator Workstations	A video monitor or set of monitors driven by a single operator interface processor (server or client) and controlled by a single operator interface device (keyboard, mouse, etc.) where the operator interacts with the control system and the plant processes, and performs the operator interface functions.
Engineer/Operator Workstation (EWS/OWS)	Similar to the operator workstation in composition, except this station provides additional features for the Engineer/ Programmer to perform programming and configuration functions depending on log-in permissions.
Computer Interface Unit (CIU)	Communications hardware that allows a PC to communicate with other nodes on the INFI-NET data highway.
Function Block	Software control algorithms that are used to perform specific process control tasks. Function blocks reside in the user-defined memory of Process/Controller modules.

Table 17101-3 Definitions	
Modulating (Continuous) Control	Analog control loops that produce an analog output that continuously positions the final control element (control valve, damper drive, etc.) between the full close and the full open position, and the associated digital control logic for the control element interlocks, permissives, runbacks, etc.
Discrete (Sequential) Control	Digital control logic that produces a digital output that operates the controlled equipment (motor, dampers, valves, igniters, etc.) in discrete steps (on, off, open, close, etc.).
Data Acquisition Functions	Those functions involved with scanning, scaling and linearizing process data, calculating, and displaying plant measurement data used for information, not control, in the form of control and information displays and reports.
SOE Functions	Those functions associated with scanning, time tagging, and reporting the time of occurrence and sequence of digital input state change.
Foreign Device Interface (FDI)	The hardware and software necessary to provide bi-directional communication between the DCS and third party devices by means of a data communications interface protocol. This includes all necessary device drivers and application software to transfer analog points and digital points, including parameters such as value or status, point description, alarm state, and time tag.
Remote I/O	I/O equipment, including I/O modules, racks (branches), power supplies, interrogation power supplies, and connection to the remote I/O communications network, located in areas physically remote from the associated control processor.
Loop Oriented I/O Cards	Cards containing analog inputs, analog outputs, digital inputs, and digital outputs on a single card that is intended to be related to a single control loop.
Technicians	Personnel that have knowledge and specific training to perform DCS hardware troubleshooting and maintenance, and to use the system tools to troubleshoot plant equipment or control logic malfunctions. Technicians may also have knowledge and training to perform system configuration at the engineer/operator workstation.

Table 17101-3 Definitions	
Engineers/Programmers	Personnel that have knowledge and specific training to perform DCS configuration at the engineer/operator workstation, and to use the system tools to troubleshoot plant equipment or control logic malfunctions.
User	Technicians and/or engineers/ programmers that perform DCS configuration at the engineer/operator workstation.
Operator	Personnel that have knowledge and specific training to operate the plant and its equipment by using the features of the operator workstation.

17101.2.1.1 System Acceptability.

The system shall be designed and equipped to withstand, to the maximum extent possible, lightning surge by atmospheric electrical disturbance without damage or disruption.

All equipment shall be new, unused, and of the highest quality and good workmanship available from the manufacturer. Modern solid-state integrated circuits shall be utilized in electronic instruments and control components with digital technology emphasized whenever applicable.

The Contractor shall not propose nor provide equipment from any manufacturer for the duration of this Contract, to be superseded or outdated by a later generation of equipment. The Contractor shall not propose nor provide any control system (hardware or software) that is not in regular commercial use and service in installations of scope and magnitude similar to that for which the equipment is proposed or provided as a part of this Contract.

Prior to turn-over and acceptance of the system, all installed systems shall be at the same and latest version of software and firmware.

The DCS shall be capable of being expanded beyond the base system. The addition of hardware and new functions shall not affect the functions operating in existing hardware nor shall it degrade the performance of the existing system. Expansion shall be possible in the following areas:

Addition of I/O points.

Addition of I/O modules.

Addition of PCUs.

Addition of FDIs.

Addition of sequential control logic and control loops.

Addition of optimal or supervisory control.

17101.2.1.2 System Integrity. The DCS design shall incorporate functional and component redundancy to ensure maximum reliability during system operation, so that no single component failure, with the exception of individual I/O modules, shall affect the control and data acquisition functions of the system.

The control loops shall be functionally distributed. The system shall include redundant controllers with automatic fail over.

The system shall include redundant power supplies with automatic fail over.

The data highway shall be a redundant, high-speed, communication network. All process data shall be available on an open information management network.

Each system drop or communication node shall be designed such that the failure of any part of the system shall not affect the operation of any other part of the system, except for loss of data to the failed drop or node.

Process network communications shall be transparent to all application-level users. All data shall be available for all displays, calculations, and control programs, regardless of network origin and without requiring additional calling procedures.

Redundant controllers, transmitters, receivers, internal wiring and data busses, and cabling shall be provided on all data highway communications networks directly related to control and data acquisition functions. This includes the I/O communications networks from I/O to control processor and control processor to control processor data highway communications networks.

All processors performing control and/or data acquisition functions shall consist of a redundant pair of control processors. One member of the control processor pair shall be active; the other member of the pair shall be operating in a continuously updated, hot standby mode.

Internal power supplies shall be provided by the Contractor in a configuration so that the loss of one power supply shall not affect any control functions in the DCS.

The Contractor shall confirm that the proposed control equipment will be supported by the Contractor with the supply of spares and replacement parts for the expected useful life of the system. Support time period shall be at least ten years.

The control system shall have an availability requirement of at least 99.99 percent or better where availability is defined as:

$$\text{Availability \%} = \frac{\text{MTBF} \times (100)}{\text{MTBF} + \text{MTTR}}$$

MTBF = Mean Time Between Failure

MTTR = Mean Time To Repair

The system shall be used in areas with plant radios. The DCS shall operate normally, with no degradation in I/O or network performance when subjected to the effects of a 5 watt transceiver at a minimum distance of 6 feet from a DCS cabinet, regardless of antenna orientation or transceiver frequency.

17101.2.1.3 Failure Modes. The proposed process control and information management system shall be designed to operate in a coal-fired power plant environment with a high degree of reliability. To this end, the Contractor's system must meet these goals:

Minimize the Frequency of Failure: The Contractor must be certified as being compliant with ISO 9001 and have an extensive quality assurance program designed to ensure a rigorously tested system. The Contractor shall include details regarding the certification and quality program in the Proposal.

Minimize the Consequences of a Failure: The distributed architecture of the proposed system should inherently minimize the consequence of failure. The system shall be designed so that the failure of one "PCU" will not affect another "PCU" in the system. On-line diagnostics shall be provided to troubleshoot a "PCU" or module failure.

Minimize the Duration of Failure: The duration of a failure shall be minimized by the capability to diagnose all problems quickly and to replace any failed part easily. The system shall provide graphical representation for card-level diagnostics.

Diagnostic alarms shall be configurable for all controllers, all power supply voltage levels, and all modules. The diagnostic alarms shall identify the specific module causing the alarm; general alarms are unacceptable.

Redundancies: Redundancies shall be included in the communication system, controllers, power supplies, and power sources. All redundant systems shall be configured to switch automatically, with no process excursions, upon a failure.

The Contractor's design shall carefully consider the effects of potential hardware and software failures on the functions being performed by the system. The system shall be designed to do the following:

Detect failures by the use of continuously running diagnostic routines and bring them to the operator's attention.

Provide hardware and software designs that react to failures in a predictable and repeatable manner.

Mitigate the effects of failures by the use of equipment redundancy, software error correction, or other available means. Redundant equipment shall follow a “train” methodology where each tier of redundancy has proper separation throughout the system to the greatest extent possible.

General cases of failure modes and the required system responses are as follows:

System Power Loss. System control outputs shall fail to a predefined safe status. Control processors shall automatically restart upon restoration of power.

Control Processor Failure. Control shall transfer to the backup control processor in a bumpless manner. If the backup control processor is not available, the outputs shall fail to a predefined status. Output failure status shall be user selectable for fail-in-place, fail high, fail low, fail on, or fail off.

Control Processor to Data Highway Communications Network Failure. Failure of a single communication channel shall result in the bumpless transfer of communication to the redundant channel. In the case of failure of all communication, the control processor shall continue to operate and control its outputs, and information received over the data highway communications network shall be treated as signals with bad quality.

I/O Subsystem Failure. Associated output points shall fail to a predefined safe status. Under failure conditions, inputs shall be treated as signals with bad quality within the processor.

I/O Subsystem to Control Processor Data Highway Communications Network Failure. Associated output points shall fail to a predefined and repeatable safe status. Output failure status shall be user selectable. Under failure conditions, inputs shall be treated as signals with bad quality within the control processor.

Foreign Device Interface (FDI) Processor or FDI Communications Network Failure. Signals being received from the foreign device shall fail to a predefined status. Failure status shall be user selectable. Under failure conditions, inputs shall be treated as signals with bad quality within the FDI processor.

17101.2.1.4 System Timing. The update rate, processing rate, and response time of all control processors and the data highway communications network, and of the overall system shall be sufficient to

maintain control over the plant processes and equipment under all system operating conditions, including extreme upset conditions with all points in alarm.

At a minimum, the system shall scan all inputs and outputs, process all control logic, and perform all other functions required to record the changes and the time of the changes as follows:

The scan rate for all I/O shall be user selectable (must allow I/O scan every 0.1 second as a minimum).

Analog inputs and analog outputs shall be scanned at least every 0.02 second with at least 20 percent of the inputs and outputs able to be scanned at a faster interval.

Digital inputs and digital outputs shall be scanned at least every 0.1 second.

Digital SOE inputs shall be scanned at least every 0.001 second. The time resolution of SOE points in different control processors shall be the same as SOE points residing in the same control processor.

All non-SOE alarms shall be time tagged to a resolution of 0.1 second (or as specified in the I/O database).

The processing rate for all control logic routines and calculations shall be individually selectable.

Modulating control logic and calculations shall be processed at least every 0.25 second with the capability to process at least 10 percent of the logic at a 0.1 second interval.

Discrete control logic shall be processed at least every 0.25 second.

At a minimum, the system shall respond to operator commands and control system changes as follows:

Time to completely generate a display shall not exceed 1 second.

The indication of any variable, on all displays including alarm displays, shall be updated within 0.5 second of its value or status change.

The time to respond to any operator command shall not exceed 0.5 second.

The time to respond for FDI functions shall not exceed 0.5 second (response time will not include the time required for the foreign device to respond to the DCS; only the actual bi-directional communication time shall be considered).

The response time is the total elapsed time for transmission of data through the system communications path including feedback. This time shall include all communication time from control processor to control processor, I/O scans, nodes, FDIs, monitors, keyboards, and associated equipment internal to the system.

17101.2.1.5 System Spare Capacity. The Contractor shall provide the spare capacity listed on the DCS Specification Sheet, after complete engineering and implementation of all specified functions. The spare capacity will be used to accommodate any control and data acquisition functions that may be added to the system during the startup phase of the project, for the future equipment as designated by the Owner, and thereafter.

Spare I/O shall include all required I/O modules, power supplies, cabling, and terminal blocks. Spare I/O points and spare terminal blocks shall be spaced evenly throughout each cabinet.

Spare card slots shall be fully equipped with hardware and wiring at the time of shipment so that all that is required to activate and use the slot is the addition of a new module. The system shall include all backplane wiring, card to terminal block wiring, and power supply wiring necessary to support the spare

capacity. Where terminal blocks or terminal cards are unique to the type of I/O module to be installed, the cabinet design shall be such that the new I/O module to termination device wiring and the termination device can be easily installed by the user.

For components of the system that have modular power supplies, the Contractor shall provide the spare space/slots listed on the DCS Specification Sheet. For components of the system that have non-modular power supplies, the Contractor shall include sufficient power supply capacity to fully utilize the available spare slots without the addition of power supply modules.

17101.2.1.6 Service Conditions.
All equipment shall be designed for operation in plant areas with the environments defined.

17101.2.2 Processing Functions

17101.2.2.1 Input/Output Processing. During each scan cycle, the system shall perform the following input processing functions:

Apply time tag (at remote equipment for all remote I/O; at I/O card for all digital SOE inputs).

Software filters shall be provided in addition to the hardware filters for certain analog inputs as determined during detailed design.

Thermocouple reference junction temperature compensation shall be provided.

All analog outputs shall be monitored by continuous system diagnostics. (An open loop in any analog output shall result in a control action to be defined during detailed design.)

The system shall provide the following additional processing capabilities for all I/O:

Provision to manually substitute (force) values.

Provision to configure a signal fail state to minimum, maximum, or the last output value.

Provision for each I/O to be removed from and returned to scan.

The actual points requiring manual substitution and scan control shall be as determined during detailed design.

17101.2.2.2 Input Calculation Processing. The system shall convert analog inputs into engineering units. This conversion shall be software based so that each point can have its own range

The system shall perform real-time calculations using all of the input data processed. Calculation routines shall include, as a minimum, the following:

Arithmetic, exponential, and trigonometric functions.

Time-based functions (integration, rate-of-change, moving average, and similar functions).

Boolean calculations.

The system shall further perform real-time calculations using the calculated variables.

Point quality shall be carried through all control algorithms and calculations where required for control and operator indication, and the data value shall be displayed as asterisks or with a quality tag if the quality is other than "good."

Digital inputs will have one or more of the following functional uses:

Alarms.

Logic functions.

Control functions.

Indication.

Digital SOE inputs shall have the same functional uses and shall also be used to determine the cause of trip of major items of plant equipment.

17101.2.3 Modulating (Continuous) Control Functions

The Contractor shall engineer and configure a complete set of programmed instructions to execute the modulating control functions as specified on the DCS Specification Sheet. The programmed instructions shall clearly indicate the tuning parameters (specifications) for each analog algorithm.

Logic associated with "Housekeeping" functions such as rejection to manual, signal tracking, bumpless transfer, generation of alarms, internal and external displays, and the like shall be developed and configured by the Contractor. The logic provided by the Contractor shall also include tracking, indexing, reset anti-windup, bumpless transfer, and all other functions required to prevent control system and process upsets when any system mode is changed automatically or by the operator. The Contractor's configuration shall include directional blocking of control outputs to prevent exceeding limits on critical operating variables where required by code compliance and good operating practice.

The logic macro configurations and basic functionality shall match that of the existing plant as provided by the Owner.

The entire logic configuration required for a fully integrated, safe, complete, operable startup, shutdown, and online control and monitoring system for the equipment being provided under this Contract and its interface with the new and/or existing plant equipment shall be supplied by the Contractor.

All modulating control loops shall have automatic and manual capabilities as required by system design. Protective interlock actions (priority increase, priority decrease, hold) shall be enforced by the system logic regardless of whether the control loops involved are in automatic or manual control. The control system shall enforce a predetermined order of initiating automatic control of related functions. If a lower level loop is commanded to manual control, the related upper loops shall automatically reject to manual control. System capability shall allow analog point quality, as determined during input processing, to be used to reject associated loops to manual control as determined during detailed design. A control loop that has been rejected to manual control shall not revert to automatic control without operator initiation.

In cases where the DCS modulates more than one similar auxiliary device (e.g. spray valves, etc.), the logic shall automatically compensate the tuning constants of all affected control loops so as to provide equally responsive control no matter which combination of auxiliary devices may be in service and on automatic. The DCS shall permit automatic operation of some similar auxiliary devices even though some of such devices that may be in service are being operated manually.

The control system software shall be programmed to include function generator compensation for each analog output in order to linearize the control response when modulating final devices that may not be linear, are required by system design. Characteristic curves for final control drives shall be used by the Contractor to generate and program the linearized function generator outputs prior to the Factory Acceptance Test.

Multiple input signals shall be provided for the variables including, but not necessarily limited to, those listed on the DCS Specification Sheet. The control system shall provide logic to allow the operator to select the multiple measurement mode. The modes shall include selection of any one of the measurement signals, the average or the median of the signals. The logic shall also automatically allow selection of only those inputs that are not in "bad" quality. Comparison logic shall be provided to determine and alarm

significant deviation of the signals. Deviation alarms shall be factory programmed by the Contractor at plus or minus 10 percent of measurement span.

The control system shall provide logic to accumulate pulses, and shall allow manual and automatic hold and reset of the pulse accumulation. The logic shall also convert the accumulated pulses to engineering units.

The logical connections between functional blocks within all logic shall be represented in engineering units. It shall not be acceptable to present these values as a 0 to 100 percent signal unless percentage is the engineering unit defined for the application and approved by the Owner.

17101.2.3.1 Operator Interface Functions. Operator interface functions shall include interface to analog control loops, multiple measurement loops, and pulse accumulator loops, by the operator, from faceplates on the operator workstation monitors.

The analog control loop control stations shall simulate conventional hand/auto stations, allowing the operator to select a mode and to provide manual interface commands, and shall provide a display of all relevant variables associated with the control loops including the set point, the feedback signal, the control signals, and the status of the loop.

The required modes of operation and operator controllable parameters shall be as follows:

> Automatic Mode. This mode shall permit full automatic operation of the system with no intervention on the part of the operator except for the functions designated as operator adjustable, such as set point adjustment and biasing of control signals.
>
> Manual Mode. This mode shall permit manual "Raise" and "Lower" of system demand signals.

The multiple measurement loop control stations shall allow the operator to select the multiple measurement mode, and shall provide a vertical bar and analog value display for each of the analog inputs and for the multiple measurement loop output. The station shall also display the multiple measurement mode and quality of each analog value.

The pulse accumulator loop control stations shall allow the operator to reset and hold pulse accumulation, and shall provide an analog value display of the accumulated total.

The system shall provide system displays for on-line monitoring of control logic signal flow on any operator workstation in the system. These displays shall use color and other unique symbology or nomenclature to indicate input and output values, block parameters, and signal flow path for all function blocks and associated connections.

17101.2.3.2 General System Performance. During transient conditions causing deviations of process variables, the control system shall not permit deviations that exceed those required to safely operate the plant. The DCS shall be capable of producing smooth load changes without overshoot, unless these changes are not achievable because of plant equipment limitations. In no event shall the performance of the control system become the limiting factor on plant responsiveness. The process and mechanical end elements shall be the limiting elements in the control of the process.

17101.2.4 Discrete (Sequential) Control Functions

The Contractor shall engineer and configure a complete set of programmed instructions to execute the discrete control functions as specified on the DCS Specification Sheet. The programmed instructions shall clearly show the point tag number and the English description of all digital inputs and outputs. In addition to the point tag number and the English description, all digital input points shall also display the Set and Reset descriptions provided in the I/O database. The tag number, English description, and Set/Reset description (for DIs) information shall be displayed on the hardcopy program documentation as well as the programming display. Every location in the program that uses the digital input tag number and description shall also show the Set and Reset description provided in the I/O database.

The Set/Reset description shall be reviewed and approved by the Owner.

The functional logic diagrams, and logic descriptions, provided by the Contractor for Owner review shall describe the minimum criteria for the control system including operation, function, and safeguards. The logic design shall incorporate the basic logic design template of similar, existing equipment as provided by the Owner where possible. The Contractor shall make any additional changes that will improve the operational procedures or method of control. The entire logic configuration required for a fully integrated, complete, operable startup, shutdown and online control and monitoring system for the equipment being provided under this Contract and its interface with the new and/or existing plant equipment shall be supplied.

All control strategies shall have automatic, standby, and manual capabilities as required by system design. Protective interlock actions shall be enforced by the system logic regardless of whether the control strategies involved are in automatic (standby) or manual control.

The control system shall provide logic to accumulate pulses, and shall allow manual and automatic hold and reset of the pulse accumulation. The logic shall also convert the accumulated pulses to engineering units. The control system shall also be capable of monitoring breaker closures for accumulation, and shall allow manual and automatic hold and reset of the accumulated values.

17101.2.4.1 Discrete Control Functions. As required on the DCS Specification Sheet, the Contractor shall engineer and configure a complete set of programmed instructions to execute the discrete control functions, which shall include, but not necessarily be limited to, the following:

Open/Close of electrically operated breakers.

Enable trip checks.

17101.2.4.2 Not Used.

17101.2.4.3 Operator Interface Functions. Operator interface functions shall include mode selection and initiation of manual commands, made by the operator from control stations on the operator workstations. The control stations shall provide control functions, including, but not necessarily limited to, the following:

Start, stop, open, close, auto, manual, reset, and trip commands.

Momentary push buttons (with adjustable pulse duration).

Status indication for motor running/stopped/tripped and valve and breakers open/closed.

Indication for equipment mode, permissive condition, failure condition, first-out indication, and operational sequence status.

Indication for WPA in place.

The system shall provide system displays for the on-line monitoring of control logic signal flow on any operator workstation in the system. These displays shall use color and other unique symbology or nomenclature to indicate on-state, off-state, and signal flow path for all logic blocks, contacts, coils, and associated connections.

17101.2.4.4 Not Used.

17101.2.5 Alarm Functions

17101.2.5.1 Analog Alarm Functions. The system shall perform comparison of limit functions on any or all analog points, as determined during detailed design. The system shall allow the user to selectively activate or deactivate these alarms. Each analog input variable, or calculation result, shall have an

individual set of alarm limits. These limits shall be either manually set, calculated as functions of other variables, or rates of change with time. Violations of these limits shall initiate alarms and/or initiate execution of special software programs. The analog alarm functions shall be on a per analog point basis, and shall include, but not be limited to, the following:

Provision to assign high and low transducer range limits for quality determination.

Provision for analog points to be deleted from and restored to alarm status by the user or automatically from internally generated variables.

Provision to assign high and low alarm limits, and at least one level of incremental alarm limits, either fixed or as a function of another system point.

Provision to assign an alarm deadband.

Provision to assign a moving average or a set/reset function for analog alarms.

Provision to assign rate of change alarm limits and deadband.

Provision to impose alarm cutout (masking) conditions as a function of another system point.

A copy of the comprehensive alarm list which includes all I/O generated and internally calculated alarms shall be submitted to the Owner for review.

17101.2.5.2 Digital Alarm Functions. The system shall compare the status of any or all digital points (digital points and/or SOE digital points) against the user selectable alarm state of these points, as determined during detailed design. The system shall allow the user to selectively activate or deactivate these alarms. Digital points entering the alarm state shall initiate alarms and/or initiate execution of special software programs. The digital alarm functions shall be on a per digital point basis, and shall include, but not be limited to, the following:

Provision for digital points to be deleted from and restored to alarm status by the user or automatically from internally generated variables.

Provision to alarm on a digital point status of "1" (on) or "0" (off).

Provision to alarm digital points on any change of state.

Provision to assign a time-delay to all digital alarms.

Provision to impose alarm cutout (masking) conditions as a function of another system point.

The DCS shall be designed to allow the alarm message text to be different than the digital input English Description. When the words "NOT", "NO" or other negative text are part of the digital input English Description for a point that is to be alarmed, the alarm message text displayed to the operator shall be similar to the input point description, with the words "NOT", "NO" or other negative text omitted. The Contractor shall be responsible for programming the alarm message text in a manner that does not use the words "Not", "No" or other negative text in the alarm message text.

The alarm nomenclature in use by the plant shall be implemented in the alarm descriptions as much as possible.

17101.2.5.3 System Alarms. The system shall provide alarms for system failure conditions including, but not limited to, the following:

Loss of any redundant power feed.

Cabinet temperature high, loss of power to cabinet cooling fans, or loss of cabinet air conditioner function (for all electronics cabinets).

Power distribution breaker trips and/or blown fuses.

Loss of any voltage level from any power supply including voltage out of spec (low/high).

Battery low (many hours before deterioration to the extent that it cannot maintain the functions of the equipment it supplies).

Failure of any PCU or control module.

Failure of any operator interface processor.

Failure of any system input or output module.

Failure of any FDI.

Failure of any communications controller.

Diagnostic programs shall have routines to generate component status alarms. These alarms shall include, but not be limited to, the following:

Control and operator interface processor failure.

Communications failure.

Disk read/write error.

Printer failure.

All failure alarms shall identify the failure to the cabinet, rack (branch), and card (module) level (as a minimum). All failures and malfunctions, when detected, shall immediately be alarmed.

A copy of the comprehensive system alarm list shall be submitted to the Owner for review.

17101.2.5.4 Alarm Annunciation. The system shall allow any operator and/or engineering workstation to display the DCS alarms.

The system shall record all alarm events to a storage file in chronological order in accordance with Article 17101.2.8.

17101.2.6 Calculations

17101.2.6.1 Real-Time Variable Calculations. The system shall perform real-time variable calculations using input data and other calculated variables. The Contractor shall be responsible for performing all calculations required to meet the control and information functions specified herein.

Calculated variables are defined as system database points that are derived from software calculations of a level higher than the initial input point conversion to engineering values. These calculated variables shall be available for use in other calculations, control logic, control and information displays, reports, trending, historical data storage, and FDI.

All calculation results shall be automatically quality coded according to the worst quality of any of the inputs to each calculation.

17101.2.7 Control and Information Display Functions

The display functions as described herein shall be assignable by the operator to any DCS workstation within the system.

Trending displays shall be done by the Owner.

Displays shall be provided as specified on the DCS Specification Sheet.

17101.2.7.1 Trend Displays. The system shall allow any system variable to be trended, and shall allow points from short-term and long-term storage to be trended. The trend display period between points on trends using data from short-term and long-term data storage shall be the same as the storage frequency selected for those points. Trending resolution shall not be coarser than ±1/2 percent full scale.

All inputs and outputs shall be able to be trended. Each point shall have a 24 hour historical trend available for reference. All long-term historical data will be collected in the Owner's PI.

17101.2.7.2 Not Used.

17101.2.7.3 Not Used.

17101.2.7.4 Not Used.

17101.2.7.5 Not Used.

17101.2.7.6 Not Used.

17101.2.7.7 Not Used.

17101.2.7.8 Not Used.

17101.2.7.9 Not Used.

17101.2.7.10 Summaries. The system shall be configured to allow the operator to display on any operator workstation monitor and print the following summaries:

Summary of all points in alarm.

Summary of all existing "bad" quality points.

Summary of all existing points with substituted (forced) values.

Summary of all existing points not being scanned or alarm limit checked.

Summary of all existing analog and digital inputs and outputs with point specifications such as ranges, limits, etc.

Summary of all points in tag-out.

17101.2.8 System Data Reporting Functions

The DCS shall provide data reporting functions as defined herein. All reports shall be made from stored data so that once a report is initiated, it can be completed without interruption. The system shall include major types of reports described below.

The system shall include a library of Owner-configured report formats as specified in the following articles. Owner-configured reports shall include all required headers, footers, subheadings, column headings, and descriptive text. The type and quantity of configured reports shall be as specified on the DCS Specification Sheet. All reports and summaries shall be configured and tested during the factory acceptance test.

The system tools shall allow the user to assign run time properties to any report format, such as specific point tag names, title, file name, and destination. For each report, the user shall be able to define whether that report is sent to a printer, viewed on screen, or saved as a file with complete formatting information. Supported file types shall include, as a minimum, comma-delimited ASCII, comma-separated variable (CSV), XML, Microsoft Excel spreadsheet, and HTML file.

17101.2.8.1 Periodic Reports. Periodic reports shall contain the current and averaged values of system variables collected during the period. The reports shall be printed out on demand by the operator. Each report shall be designed to collect data for a minimum of 100 points. The actual number of points contained in each report and the points to be collected shall be user selectable.

17101.2.8.2 Trend Reports. Trend reports shall contain current and averaged values of system variables at predetermined intervals. The reports shall be printed out on demand by the operator. Each report shall be designed to collect data for a minimum of 100 points. The actual number of points contained in each report, the points to be collected, and the length of the collection intervals shall be user selectable.

17101.2.8.3 Post-Trip Review Report. The post-trip review report shall contain current values of system variables at predetermined intervals before and after a plant or major equipment trip. The report shall be printed out on demand by the operator. The report shall be designed to collect data for a minimum of 100 points. The actual number of points contained in the report, the points to be collected, the length of the collection intervals, and the number of collections before and after the trip shall be user selectable.

17101.2.8.4 Maintenance Data Report. The maintenance data report shall calculate and display the number of starts and stops and the accumulated running time of all rotating equipment monitored by the system. The report shall be printed out on demand by the operator. The report shall be designed to collect data for a minimum of 100 pieces of equipment. The actual quantity of equipment contained in the report shall be user selectable.

17101.2.8.5 Housekeeping Report. The housekeeping report shall contain a listing of all changes made to the system by operating and engineering personnel. The reports shall be printed out on demand by the operator.

17101.2.8.6 Sequence-of-Events Report. The SOE report shall contain the status changes of all SOE points from all control processors after a status change of a trigger point. The system shall allow any or all SOE points to be a trigger point, and this designation shall be user selectable. The system shall store the reports of the five most recent events, in chronological order, for later retrieval on demand by the user.

17101.2.8.7 User Reports. The system shall also include a report writer package that allows the user to create, edit, and store new reports and new report formats in addition to the configured reports defined above. The reporting package shall allow reports to be built in a flexible free-format environment similar to commercial spreadsheet software and shall provide the following features:

Real-time data, historical data, and messages combined in flexible layouts to produce meaningful reports.

Information such as headers, footers, number of columns, column format, column headings, calculation equations, and descriptive text defined and entered by user for each report.

Reports enhanced through the use of various formatting styles, color to highlight information, and insertion of charts such as bar charts and pie charts.

User created templates and macros for frequently used formats.

17101.2.9 Historical Data Functions

The DCS shall provide historical data functions as specified herein. The data collection and storage system shall provide the following features:

Collection frequency, point collection delta value, or collection change of state shall be user selectable on a per point basis. At a minimum, collection frequencies of 0.5 second, 1 second, 10 seconds, 1 minute, 10 minutes, and 1 hour shall be provided.

Point data to be stored, at minimum, shall consist of tag name, value or status, and time tag.

17101.2.9.1 Short-Term (Trend) Data Storage. The system shall provide 1 hour short-term data storage to allow data retrieval for recent and active trend displays. Any system variable (I/O point, calculated variable, etc.) shall be available for storage. This stored data shall be available for display in any trend display, any process control display, or any report.

17101.2.9.2 Long-Term (Historian) Data Storage. Provided by the Owner's existing OSI PI system.

17101.2.10 System Equipment

The Contractor's system shall allow all cards or modules to be removed for maintenance while under power without causing damage to the card/module, to the system, or trip the unit; or shall allow for the powering down of one of a redundant pair of modules to allow its removal for maintenance.

All equipment shall be installed in cabinets, consoles, or panels furnished by the Contractor.

Nameplates shall be furnished and installed on the exterior of all major equipment, including all operator interface cabinets/consoles, control and electrical panels, and cabinets.

Nameplates shall meet the requirements of Section 17302 - Phenolic Nameplates. A list of the nameplates shall be provided to the Owner for approval.

Equipment designation nameplates shall be furnished and installed on the front and back interior of all cabinets and panels. This provides for equipment designation with doors removed. Internal nameplates shall also be furnished and installed for all cabinet and panel internal components including, but not limited to, internal devices, modules, and terminal blocks (identification scheme to be finalized during detailed design). The internal nameplates shall be designed as follows:

Nameplates shall be located in a manner that allows viewing after the internal panel and field wiring has been installed.

Nameplate inscriptions for internal panel equipment labels shall match the designations shown on the DCS manufacturer's documentation as approved by the Owner.

Any equipment tagging schemes used by the Contractor for designing and configuring the system (cabinet reference numbers on drawings, equipment references on database lists, etc.) shall functionally match the equipment tagging designated by the Owner.

17101.2.10.1 Communications Networks. The Contractor shall furnish all devices necessary to implement the communications networks design as specified herein and on the DCS Specification Sheet. These devices shall be installed in system cabinets and may include, but not be limited to, communications modules, hubs, routers, switches, line drivers, receivers and transmitters, protocol converters, fiber-optic patch panels, fan out kits, media converters, signal conditioners, prefabricated cables, and cable adapters/connectors.

17101.2.10.1.1 Data highway communications network. The system communications networks shall include a redundant control processor to control processor data highway communications network. The capability shall be provided for connection of future nodes to the data highway communications network, such as additional control and operator interface processors, monitors, programming devices, or FDIs to other systems. The data highway communications network shall be expandable to accept at least 100 future additional nodes. The system shall be designed so that new nodes can be added without shutting

down the system or causing a loss of control, information display, or alarm information. The data highway communications network shall not be dependent on any master controllers for its operation.

The system shall be designed so that new nodes can be added to the communication network without shutting down the system or causing a loss of control, information display, or alarm information.

Transfer of system communication from any primary to secondary network device shall be alarmed.

Each network node device shall be capable of communicating directly with other nodes.

The communication protocol shall include positive acknowledgement of all messages transmitted. Communications diagnostics are to be continuous such that a failure is alarmed in a maximum of 1 second.

17101.2.10.1.2 Operator interface communications network. The system communications networks shall also include an operator interface communications network for data transfer from the data highway communications network to the operator and operator/engineer interface processors, monitors, keyboards, and printers.

The operator interface network shall be designed such that a failure of any operator interface processor, or the failure of any part of the operation interface communications network, shall not cause the loss of more monitors than the total number of monitors specified per workstation. Each node of the operator interface communications network shall be able to communicate peer-to-peer with the others. The operator interface network shall be designed to allow for expansion.

If the operator interface communications network is an Ethernet network it must, at a minimum, conform to the following additional requirements:

Ethernet networks shall, at a minimum, conform to the requirements of IEEE 802.3, 100 base systems. The Contractor shall be fully responsible for the design and implementation of the network. The network design shall be done by a qualified network engineer, with the final design of the network acceptable to the Owner.

Ethernet networks shall provide connectivity to existing plant networks, and shall be compatible with slower equipment that may be connected to the network. The network must be designed so that these connections to external networks shall not degrade the performance of the DCS Ethernet networks.

All Ethernet based communication networks shall use Category 5e or better unshielded twisted pair (UTP) for cables run inside buildings and multi-mode fiber-optic cable for cables run outside or between buildings. Twisted pair cable networks shall conform to 100BASE-TX or 1000BASE-T or newer requirements. Fiber-optic cable networks shall conform to ISO 8802.3 100BASE-FX or 1000BASE-SX or newer requirements. The network shall be designed for maximum speed through the use of Gigabit (or faster) components where possible.

Switch ports shall be capable of both 100 Mbps and Gigabit operation, full and half duplex. Switch ports shall be auto sensing so that the correct network bandwidth is applied to the connected equipment.

Maximum network segment lengths shall conform to the IEEE 802.3 standard requirements.

Bit-shift delays and interframe gap shrinkages shall conform to IEEE 802.3 guidelines, particularly for complex multi-segment system designs.

Ethernet networks shall use a port switched configuration with redundant network hardware, and shall minimize the use of non-switching hubs.

Switches shall be auto-sensing with remote management capability. All cabling required to perform remote management (setup) of the switches shall be provided by the Contractor.

Switches shall include a rapid spanning tree protocol (algorithm) compatible with IEEE 802.1D or a multiple spanning tree protocol (algorithm) compatible with IEEE 802.1Q to protect against inappropriate network loops. These two protocols may be referred to as RSTP or MSTP.

Rack mounted equipment shall be supplied wherever possible.

17101.2.10.1.3 I/O communications network. Local and remote I/O communications networks for data transfer from the control processors to the I/O shall be included in the system communications networks.

17101.2.10.2 Process Control Units (PCU). All control and data acquisition functions shall be implemented by modularized distributed control processors without the use of any disk drives. All control processor modules shall be of the manufacturer's standard design and shall be identical in terms of their physical hardware, to the greatest extent possible, to minimize the number of types of control processor modules. All required surge suppression and power filtering equipment shall be provided by the Contractor to ensure that the processors are not damaged and processor function is not impaired by supply voltage transience or cycling power.

Control processors shall be self-booting and shall be designed to automatically receive configuration information from the system server via the data highway communications network when initially installed or after a power loss resulting in loss of configuration memory. Each control processor shall contain a complete library of control function algorithms stored in nonvolatile memory. Each control processor shall utilize these algorithms along with its unique configuration information to implement its process control functions. Control processors shall be designed for multi-segment operation, so that a minimum of five program segments can run independently at individual user selectable scan rates.

Control processors specified to have redundancy shall have a pair of completely duplicate control processors connected separately to the data highway communications network. One member of the control processor pair shall be active; the other member of the pair shall be operating in a continually updated, hot standby mode. In the event of a failure in the active member, all functions shall immediately be assumed and conducted by the standby member, which shall then function as the active control processor. Redundant control processors shall utilize a state replication model so that the standby control processor begins executing at exactly the same point in the program scan cycle as the primary control processor was when it failed. When the failed control processor is replaced or reactivated, it shall automatically assume the function of the hot standby control processor. The assignment of the active and hot standby mode for the pair shall be user selectable, with a method for switching operating modes between the pair without interrupting system control functions. The processors may be switched from active to hot standby (and reverse) via local action and via action taken at the DCS engineering workstation.

Each control processor shall be assigned a specific control and/or data acquisition function. Assignment of functions to the control processors shall be acceptable to the Owner.

17101.2.10.3 System I/O Equipment. I/O equipment shall be furnished as required by the DCS Specification Sheet.

Field powered I/O shall be electrically isolated from each other (no common hot, neutral, or return connections) and from all cabinet wiring. All I/O modules shall meet the requirements of IEEE C62.41, IEEE C62.45 and/or IEEE 518. All required peripheral equipment for signal conditioning, impedance matching, balancing, and other similar functions shall be furnished and installed by the Contractor.

The Contractor shall fully configure, prior to system shipment, all I/O modules to match the I/O type as specified in the I/O database. This hardware configuration shall include, but not be limited to, the installation of all dip shunts, dip switches, I/O wetting kits, and jumpers.

Loop cards, where multiple I/O types such as AI, AO, DI, DO are combined on a single I/O module, are not acceptable and shall not be used.

The system shall provide automatic detection of open-circuit conditions.
Minimum isolation between points and ground shall be 50 volts dc continuous and able to withstand voltage surge of 500 volts dc for up to 1 minute.

All I/O modules shall include user configurable fail-safe mode selection to allow individual selection of module response to control processor data highway communications network or I/O communication network failures.

I/O rack (branch) slots shall accept either input modules or output modules of any type as required. I/O modules shall be replaceable without removing any field wiring. Maximum I/O module point loading shall be as defined on the DCS Specification Sheet. If any of the Contractor's I/O modules exceed these maximums, the points in excess of the maximums shall be considered unusable.

I/O modules shall not contain more than 16 points per module.

I/O modules shall be replaceable with power on without removing any wiring.

Digital I/O interrogation power switching shall be as defined on the DCS Specification Sheet.

All I/O required by the Contractor to implement the specified scope of the system shall be provided. These I/O shall include, but not be limited to, the following:

Power supply voltage checks.

Power supply failure alarms.

Cabinet cooling fan failure alarms.

Cabinet temperatures.

Cabinet temperature alarms.

The DCS I/O system shall be compatible with the Owner's tray/conduit/duct bank segregation system for field circuits.

I/O modules shall have flexible mounting features in that modules can be mounted locally with the process controller. In addition, it shall be possible to locate I/O modules remotely from the controller without affecting performance, hardware, or software configuration.

The I/O modules shall have a keying arrangement protecting against personal danger and break-down of the module. The keying shall also prevent startup of a wrong module type in the specific position compared to the configuration in software.

The scope of the DCS I/O partitioning shall be as defined herein. The DCS I/O partitioning shall be completed so that the following rules are observed (unless noted otherwise):

Redundant analog inputs for a single process measurement shall be wired to separate analog input cards as well as separate racks (branches) within the DCS. The remaining channels on each of these cards can be used for other process measurement inputs. I/O cards containing redundant analog inputs for a common control loop shall be addressed to the same processor.

Redundant digital inputs shall be wired to separate digital input cards as well as separate racks (branches) within the DCS. The remaining channels on each of these cards can be

used for other process measurement inputs. I/O cards containing redundant digital inputs for a common control loop shall be addressed to the same processor.

Redundant digital (relay) outputs shall be wired to separate digital output cards as well as separate racks (branches) within the DCS. The remaining channels on each of these cards can be used for other process controls. I/O cards containing redundant digital (relay) outputs for a common control loop shall be addressed to the same processor.

Redundant I/O partitioned to separate cards on separate racks (branches) shall either be fed from separate power supplies or the power supplies feeding the I/O cards shall be redundant. The arrangement shall be such that no single source of failure (point, card, power supply, processor, etc.) can simultaneously fault the redundant points.

Redundant trains of equipment (pumps, valves, fans, etc.) shall have their respective I/O separated such that the I/O for the redundant equipment shall reside on separate I/O cards as well as separate racks (branches) within the DCS. I/O for redundant equipment shall be addressed to the same processor.

Non-redundant I/O common to a particular device or piece of equipment shall be wired to the same I/O card. If non-isolated I/O cards are used, the individual signals shall be wired to the same fused group of that I/O card (to the greatest extent possible).

Input and output cards associated with one particular device or piece of equipment shall be addressed to the same processor.

Non-redundant I/O common to a particular control loop shall be common to the same processor (to the greatest extent possible).

The inputs and outputs associated with a particular device or piece of equipment shall be located in the same cabinet (bay) side to avoid running conductors of one cable to different cabinets, bays, or sides (to the greatest extent practical).

17101.2.10.3.1 Digital inputs. Sensing circuitry for digital inputs shall have high input impedance. Individual status lights shall be provided for each input on all digital input modules. Status lights shall monitor the logic side of the input rather than the field side.

The system shall be capable of receiving 24 VDC, 48 VDC, 125 VDC, 120 VAC, as inputs.

The system shall support both normally open and normally closed contacts.

The system shall allow the user to individually select the input interrogation voltage source for each digital input on each card. The available interrogation voltage sources shall include the following as a minimum:

DCS internal system I/O interrogation power (contact sensing).

Contractor-supplied external contact voltage (voltage monitoring).

Contractor-supplied and routed power (contact sensing). Routed power is internally wired in the I/O cabinets.

The interrogation power source provided for each digital input card shall be monitored and alarmed. If an I/O card has two fuses that direct interrogation power, alarming shall be provided for each fuse. Alarming shall be accomplished by wiring a single input for each fuse into an I/O point on the associated card.

The field circuit cables used for digital inputs shall be unshielded control cable and shall be routed in control voltage cable trays with other 120 volt ac and 125 volt dc circuits. The digital input cards for use with ac interrogation voltage shall be designed so that they are impervious to the effects of capacitive coupling in the field cables to the point that they allow the input module circuitry to effectively differentiate

between the closed and open states of the field contact. The use of external pulldown resistors is not allowed.

Digital inputs shall be provided with contact bounce filtering. The filter shall delay digital inputs to protect against input device bounce and electrical noise on input lines.

17101.2.10.3.2 Digital outputs. Digital output equipment shall be used to provide control intelligence (mechanical or solid-state contact) to field devices requiring digital (on, off; "1," "0") commands.

Individual status lights shall be provided for each output on all digital output modules. Status lights shall monitor the field side of the output rather than the logic side. Where individually fused outputs are provided, each output shall be provided with a blown fuse indicator.

Digital output modules shall be rated for the loads shown on the DCS Specification Sheet. For all digital output modules, the Contractor shall furnish and install within the DCS cabinets interposing relays with a minimum of two form "C" contacts designed to provide the load capability.

Each Form C relay output shall be able to switch a minimum of 10.0 amps at 120 volts ac or 3.0 amps at 125 volts dc with all outputs on a module active at the same time.

Each Form X relay output shall be able to switch a minimum of 10.0 amps at 120 volts ac or 10.0 amps at 125 volts dc with all outputs on a module active at the same time.

A mixture of Form C and Form X relays will be required on some relay output modules.

Relay outputs may be required to be energized indefinitely. Relays shall be rated for continuous duty.

Contact outputs shall close and open within 0.15 seconds.

Interposing relay coils shall be 24 volts dc and powered by the DCS outputs. Interposing relay contacts shall be wired to terminal blocks in the DCS I/O equipment cabinets or termination cabinets.

Where fail-safe digital outputs are required to safely shut down equipment or to enable backup control of equipment on a DCS failure, the Contractor shall provide the necessary fail-safe logic relays in the I/O cabinets. The relays shall be provided with a minimum of two Form "C" contacts rated to switch the load of the driven equipment. Relay contacts shall be wired to terminal blocks in the DCS I/O equipment or termination cabinets.

Digital outputs may be used to switch inductive loads and these inductive loads may be interrupted by external contacts. All required transient protection shall be internal to the output module. Triac style transistor outputs are generally not acceptable and shall only be provided if required for special applications with written Owner approval.

The system shall allow the user to individually select the output power source for each digital output on each card. The available power sources shall include the following as a minimum:

DCS internal system I/O power (wetted contact).

External contact voltage (dry contact).

Supplied and routed power (wetted contact). Routed power is internally wired in the I/O cabinets by the Contractor as specified in Article 17101.2.11.2.

17101.2.10.3.3 Analog inputs. The input of all analog-to-digital converters shall have a minimum accuracy and resolution of ±0.1 percent of full scale.

Analog input modules shall accept all ranges of inputs from thermocouples, RTDs, analog transmitters, slide wires, vibration transducers, or any dc current or voltage signal from a process transducer. If the

Contractor's I/O modules cannot accept a signal type and range listed in the I/O list, the Contractor shall furnish, install, and wire in the I/O cabinet a signal conditioner with the proper I/O ranges to convert the field signal to a level acceptable to the Contractor's system. If the Contractor's I/O modules can not directly accept an analog signal from another control system's I/O module, then the Contractor shall furnish, install, and wire in the I/O cabinet the appropriate signal isolators and/or conditioners. Precision resistors shall be furnished by the Contractor as an integral part of the analog input system. All jumpers, resistors, and/or other devices required to resolve point alarms for spare I/O shall be provided by the Contractor and shall be factory installed.

An input filter shall be used to attenuate any high frequency noise components that may be coupled with the signal. Low pass filtering shall cut off at a maximum of 2 hertz. Common mode noise rejection shall be a minimum of 110 dB at 60 hertz. Normal mode noise rejection shall be not less than 60 dB at 60 hertz. Series mode signal-to-noise rejection ratio shall be not less than 1,000:1 for thermocouples and other low level signals.

The removal of analog input cards for service or maintenance shall not affect the continuity of current type input field circuits.

Thermocouple input cards shall be designed so that all thermocouple types can be mixed on each card and shall be designed to accept both field grounded and ungrounded thermocouple circuits. Thermocouple type shall be user selectable on a per channel basis.

The system shall be capable of receiving 100 ohm platinum, 10 ohm copper, and resistive potentiometer 3-wire RTD inputs directly.

The system shall be capable of supplying the 24 VDC loop power for 4 to 20 mA, 2-wire or 3-wire transmitters. The choice of field or system power shall be user selectable for each point.

The system shall also be capable of accepting 1 to 5 VDC, 0 to 5 VDC, 0 to 10 VDC, -20 to +20 mA, -5 to +5 VDC, and -10 to +10 VDC inputs.

The system shall allow the user to individually select the transmitter power source for each analog input channel on each analog input module. The available power sources shall include DCS internal system I/O power (system powered) and transmitter supplied power (field powered). The analog input modules shall provide electrical isolation between field powered and system powered inputs. The Contractor may furnish the specified quantity of analog input modules without isolation for use with system powered inputs only and designed for 4 to 20 mA signal range for use with large quantities of 2 wire transmitters. Transmitter circuits shall be individually fused or current limited. If fuses are used, they shall be located in the I/O cabinets. Bridge circuits and power supplies, if required for RTDs and slide wires, shall be provided in the I/O cabinets.

17101.2.10.3.4 Analog outputs. Analog output amplifiers shall have drift characteristics that meet the system accuracy requirements. The output of all digital-to-analog converters shall have an accuracy and resolution of ±0.1 percent of full scale of the signal. Analog outputs shall produce 4 to 20 mA current loops capable of driving 500-850 ohm loads.

The system shall be capable of supplying 24 VDC loop power. The choice of field or system power shall be user selectable for each point.

The system shall be capable of providing a user selectable default option for each individual point in the event of loss of communication with controller.

If the Contractor's I/O modules can not transmit an analog signal directly to another control system's I/O module, then the Contractor shall furnish, install, and wire in the I/O cabinet the appropriate signal isolators and/or conditioners. All jumpers, resistors, and/or other devices required to resolve point alarms for spare I/O shall be provided by the Contractor and shall be factory installed.

Analog outputs shall be used for control (to position valves, dampers, etc.) and for information (to drive indicators, recorders, etc.).

17101.2.10.3.5 Pulse inputs. Pulse input cards shall receive pulse inputs in the form of contact closures occurring at a rate that will not exceed 2,000 pulses per second. The pulses shall be those typically output by watt-hour measuring equipment.

17101.2.10.3.6 Foreign device interfaces. The Contractor shall provide all hardware and drivers to communicate with Contractor-furnished foreign devices, such as personal computers and PLC as defined on the DCS Specification Sheet.

The communications medium shall be twisted shielded copper conductors for indoor locations and those areas not subjected to induced signal noise. For communications networks routed outdoors or in areas where induced signal noise is probable, fiber-optic cable shall be provided. Regardless of location, any communication cable distances over the communication equipment or cable manufacturer's maximum length for copper shall be run via fiber optic; also, any Ethernet circuits of 200 feet shall be run via fiber optic.

The Contractor shall furnish all devices necessary to implement the FDIs specified herein. These devices shall be installed in system cabinets, and may include, but not be limited to, communications modules, modems, hubs, routers, switches, protocol converters, fiber-optic patch panels, media converters, signal conditioners, and prefabricated cables.

All Ethernet based communication networks shall use Category 5e (or better) unshielded twisted pair UTP for cables run inside buildings and multi-mode fiber optic cable for cables run outside, between buildings or any circuits over 200 feet in length. Twisted pair cable networks shall conform with ISO 8802.3 100BASE-TX or 1000BASE-T or newer requirements. Fiber-optic cable networks shall conform with ISO 8802.3 100BASE- FX or 1000BASE-SX or newer requirements. The network shall be designed for maximum speed through the use of Gigabit (or faster) components where possible. Ethernet communications networks shall include all necessary hubs, switches, connectors, patch panels, fan out kits, taps, repeaters, cables, terminators and any other components required for a complete communications system.

The interfaces shall permit the data generated in the foreign devices to be used in any process controller, displayed on any operator workstation, or used in any report. The interface shall also allow the configuration of push buttons and control stations on the DCS operator workstation displays that can be used to start and stop motors, open or close valves, etc., that are controlled by the PLCs.

Interface modules shall be capable of communicating using industry standard protocols. Acceptable protocols include: Modbus & OPC.

17101.2.10.4 Not Used.

17101.2.10.5 Engineer/Operator Workstations. Engineer/operator workstations shall be furnished as specified on the DCS Specification Sheet. The term engineer/operator workstation refers to the workstations that have typically been called Engineering Workstations (EWS), but have the dual functionality of a EWS and an operator workstation controlled by log-in permissions. Each engineer/operator workstation shall consist of monitor, standard keyboard, pointing device, and supporting electronics (operator interface processors, display generators, data highway communications network equipment, etc.).

The engineer/operator workstation shall be designed to include, at a minimum, the following physical characteristics:

Each workstation shall be able to monitor, view, create, modify, debug, and document any control or information display, program, database, or other function within the DCS.

Each workstation shall include the capability to provide both on-line and off-line development of control and data acquisition programs and control and information display development.

Each workstation shall include password protection to ensure that unauthorized program entry and alteration cannot occur.

Each workstation shall include the current state-of-the-art hardware platform (CD/DVD rewriteable drives, ports, processor/bus, RAM, etc.) available. Each workstation shall have a RAID 1 (minimum) data mirror hard drive configuration.

Each workstation shall have a two DVI monitor output capability.

Each workstation shall have a minimum of two monitors. The make and model of the monitors shall be approved by the Owner.

Graphic outputs shall utilize extension hardware when cable lengths are in excess of 10 feet.

All keyboard and pointing devices shall be of type USB and shall utilize USB extender hardware where necessary.

The engineer/operator workstation shall provide all the functions of a full-featured operator workstation.

The EWS/OWS PC shall be of the same make and model of the existing plant EWS/OWS.

17101.2.10.6 Not Used.

17101.2.10.7 Printers. The existing printers in the main control rooms shall be used for the DCS printer.

17101.2.10.8 Operator Control Console. If required by the DCS Specification Sheet, the Contractor shall furnish an operator control console. The console shall consist of a structure for mounting workstation monitors and keyboards. The console shall be designed as an open structure on the front to provide knee space (minimum of 19 inches deep and 28 inches high) for personnel seated in front of the workstation monitors.

The desktop section shall be of premium quality, steel-reinforced construction. Glued biscuit joints are not acceptable construction.

17101.2.10.9 System Cabinets. Cabinets shall consist of system electronics cabinets, I/O equipment cabinets, remote I/O equipment cabinets, and interposing termination cabinets as required on the DCS Specification Sheet.

When determined by the Contractor's detailed design, cabinets shall be factory assembled in bay sections to minimize field wiring across shipping splits. The Contractor shall provide all plug-in connectors, disconnects, and wiring pigtails required to cross shipping splits.

The Contractor shall provide a sufficient quantity of system cabinets to house the controller equipment specified, the I/O specified, and the space required for field-wiring termination.

The Contractor shall design and supply rigid, self-supporting, free-standing cabinet for incorporation within a suite of bolted cabinets. Cabinets shall be capable of being bolted together and panel sides shall be removable. Contractor may install a maximum 6 inch wire-way beneath and/or between cabinets for cable routing.

Cabinets shall be a minimum of 24 inches in width, 72 inches in height, and 32 inches in depth. Cabinets shall be a maximum of 90 inches in height and 40 inches in depth.

The system cabinets shall be fully-enclosed, 19-inch rack type, with front and rear access doors without locking mechanisms. DCS cabinet doors and panels shall be fitted with dust-tight seals and shall conform to NEMA 12 standards or better.

Access to the equipment mounted within the panel shall be from vertically hinged doors. Hinges shall be designed to allow the easy removal of the entire door. A metallic pocket shall be provided on the inside on the door to contain drawings and data. Access doors shall not exceed 30 inches in width. Where a larger door is required, double door with unobstructed opening shall be provided. Mullions shall be located so as not to interfere with access to wiring termination or devices.

All devices shall be mounted to the back panel of the cabinets. No devices shall be mounted on the side panels. Terminal blocks may be installed on the side wall only if space is not available on the back panel; side wall mounted terminal blocks shall be mounted on 45 degree angled stand-offs.

All devices shall be accessible without stepping into the cabinet. All devices must be a maximum of 15 inches from the open face of the cabinet. All termination shall be accessible for an average sized person to reach without a ladder or stepstool; No termination shall be higher than 72 inches from floor grade.

Interconnecting wiring shall be provided between all electrical devices mounted in the cabinets and enclosures and between the devices and terminal blocks if the devices are to be connected to equipment outside the cabinets or enclosures. Wiring shall be arranged so that devices may be removed and/or serviced without disturbing any wiring.

All of the circuits in the cabinets shall be isolated from the cabinet structure, including the cable shields. The cabinet structure shall be grounded to the building steel ground grid. The Contractor shall provide wiring to connect all terminals and equipment requiring ground connection to the isolated cabinet ground bus. The isolated ground bus shall be connected to the ground grid via insulated cable.

Terminal blocks for power, communication, and utility circuits shall be grouped in one section of the cabinet. Analog and digital I/O shall be grouped together by analog/digital function and shall be mounted in separate cabinets to the greatest extent possible.

17101.2.10.9.1 Cabinet Ventilation, Heating and Cooling. Cabinets should utilize natural ventilation wherever possible. Adequate natural ventilation should be provided to ensure the internal ambient temperature does not exceed the safe continuous operating temperature of the components located therein. Maximum internal ambient temperature rise is to include allowance for the full spare capacity (including installed, unused, and uninstalled) to be fully implemented.

Where necessary, the cabinet design may incorporate fans and blowers. All fans and blowers shall utilize an integral filter assembly on the air intake, located so that filter removal for cleaning is easily accomplished. Any DCS cooling fans or blowers shall operate with a noise level less than 45 dB at one meter.

Fans shall be powered from a utility power source separate from the DCS logic power. Fans that are necessary for proper operation of the equipment within the cabinet shall be provided as redundant pairs and shall be provided with fan failure alarms.

Any cabinet containing a control processor shall include internal cabinet temperature transmitters furnished and installed by the Contractor to allow system monitoring and alarming capability as an I/O point.

All cabinets shall be provided with a ventilation filter to prevent entry of dust. Filters are to be designed to be removed and services without the use of tools.

Where system cabinet heating or cooling is required based on the specified equipment service conditions and the Contractor's equipment environmental constraints, redundant electrical space heaters or air conditioners shall be provided. This equipment shall include thermostats, fuse blocks with fuses or circuit breakers, and terminal blocks for the Contractor's redundant power feeds (fed from different power panels via the “train” redundancy methodology).

Air conditioning equipment shall be suitable to maintain cabinet temperature conditions under full solar radiation exposure with no shading or other similar protections from sunlight. Space heater capacity shall be as required to maintain the enclosure internal temperature above the dew point under the specified service conditions. Normal use of space heaters shall not change or discolor any painted surface, and space heater sheaths shall be of a corrosion-resistant, nonoxidizing material. The heaters shall be located so that heat from the heater does not cause overheating of any internally mounted components. The heaters shall be rated double the applied voltage, however sized for the applied voltage. Protective guards shall be provided to prevent accidental contact with the heaters. The air conditioning equipment, space heaters, thermostat, and circuit disconnect device shall not interfere with normal cable entrance into the enclosure.

Alarms shall be generated for failure of HVAC equipment, transfer to backup/redundant equipment, and other similar events. Alarms shall be hard-wired inputs to the DCS modules at the respective cabinet locations. Alarm and display development I/O shall be provided by the Contractor and approved by the Owner.

17101.2.10.9.2 System electronics cabinets. System electronics cabinets shall house the system control processors, communications equipment, and power supplies.

In addition, local engineer/operator workstations and miscellaneous electronics equipment, as specified, shall be housed in the system electronics cabinets.

17101.2.10.9.3 I/O equipment cabinets. I/O equipment cabinets shall house the system I/O racks (branches), modules, and associated communication equipment and power supplies.

I/O modules shall be arranged vertically and numbered sequentially from top to bottom. If a second branch of I/O modules is located on the same side, it shall NOT be inverted.

Interposing terminations shall be located in the same cabinet, same side as its associated I/O module. High density termination I/O modules shall not be used.

17101.2.10.9.4 Remote I/O equipment cabinets. Remote I/O equipment cabinets shall house the system I/O racks (branches), modules, and associated communication equipment and power supplies.

17101.2.10.9.5 Interposing termination cabinets. Interposing termination cabinets shall serve as the interface between the DCS I/O card and the field I/O devices. The interposing termination cabinets shall be designed to allow optimum arrangement of the I/O cables and cable conductors and shall have an environmental rating equal to, and door access the same as, I/O equipment cabinets in the same area.

Interposing termination cabinets shall house terminal blocks for termination of the field I/O circuits. Cabinets supplied for termination of field I/O shall meet the following additional requirements:

Termination cabinets shall be designed to provide an individual terminal for each signal lead of each I/O point. Grouped and shared common and return signal terminations shall not be provided. Cable shield terminations shall be provided adjacent to the circuit terminals.

Terminal blocks shall have screw terminals

Use of High-Density terminal blocks shall not be permitted.

Termination cabinets that are separate from the I/O modules and contain thermocouple circuits shall be provided with means for cold junction compensation.

Interposing relays, as required, shall be installed in the interposing termination cabinets.

The Contractor shall furnish all prefabricated interconnecting cables between the interposing termination cabinets and the I/O equipment cabinets.

17101.2.10.9.6 Network equipment cabinets. Cabinets supplied for network equipment (switches, routers, etc.) shall meet the following additional requirements:

Cabinet shall be free-standing (floor mount) with lockable front and rear doors, if required in accordance with NERC CIP rules. When required by the specification sheets, the front door shall have a polycarbonate insert for equipment viewing.

The cabinet shall include 19 inch rack style mounting with all mounting hardware included (shelves, brackets, etc.).

The cabinet shall be provided with dual power strips hardwired to a terminal strip for connection to two separate UPS power feeds.

Integral wireway and/or wire management shall be included in the cabinet.

17101.2.10.9.7 Fiber-optic patch panels. Where fiber-optic cables are used for data highway, remote I/O, or miscellaneous network connections, the Contractor shall provide fiber-optic patch panels and patch cords to connect fiber-optic cables to the DCS equipment. Patch panels shall be furnished with connectors for all fibers in multi-fiber bundle cables, whether all individual fibers are used or not. Patch panel design and specification shall be the responsibility of the Contractor, and shall be approved by the Owner. Patch panels shall be mounted inside or outside DCS cabinets as specified on the DCS Specification Sheet. Panels within DCS cabinets shall have patch cords factory installed and connected to internal components. Panels outside DCS cabinets shall be suitably rated for the equipment environment specified, and shall be furnished with patch cords for connecting to the DCS cabinets. Combined patch panels may be furnished for bayed groups of DCS cabinets.

17101.2.10.10 Not Used.

17101.2.10.11 Time Synchronization Equipment. The existing plant DCS will synchronize the system clock of the FGD DCS to within 0.001 second of a time signal received from the existing GPS synchronized timing receiver.

17101.2.10.12 Interconnecting Cables. As required by the DCS Specification Sheet, the Contractor shall provide all interconnecting cables, such as data highway communications network, remote I/O communications network, and Ethernet (metallic or optical fiber), required for connections between the various physically separated items in the scope of supply. Metallic and fiber-optic cable using plug-in connectors shall be completely fabricated and tested by the Contractor and shall be used to interconnect the system during the factory tests.

17101.2.10.13 Installation and Maintenance Equipment. The Contractor shall furnish two sets per plant of all special tools and equipment used in installing, modifying, and maintaining the DCS equipment. All tools and equipment will be used during system checkout and startup, and will become the property of the Owner. Any missing, modified, or damaged tools shall be replaced.

Installation and modification tools shall include, at a minimum, all special tools necessary to duplicate the interconnection method used to fabricate assemblies, such as screwdrivers (if special in design); tools required to crimp, insert, or remove pins from any connector and/or terminal block supplied; and all tools required to insert or remove EEPROMs, dip shunts, or any other removable circuit board components.

In addition, maintenance tools shall be provided to supplement and monitor hardware diagnostic test programs. The maintenance equipment shall include all devices required to perform the hardware diagnostic testing in a manual or off-line mode. This shall include, if required by the system, each type of extender board needed to access circuit boards or cards.

17101.2.11 System Power and Grounding

17101.2.11.1 Power Sources for System Use. The Contractor shall provide a separately protected redundant pair of UPS derived power feeds to each system electronics cabinet, each I/O equipment cabinet, each remote I/O equipment cabinet, each network equipment cabinet, and each cabinet containing equipment utilizing redundant internal power supplies. Redundant power conversion equipment shall be supplied by the Contractor and the system shall be fully functional if either feed of the pair is energized.

The Contractor's power sources used for the primary and secondary power feeds shall be as described on the DCS Specification Sheet.

Power feeds shall also be supplied by the Contractor to the I/O equipment cabinets for field powered devices.

Peripheral devices furnished as part of the system shall be supplied from separately protected feeds from the Contractor's power system.

The Contractor's system shall be arranged so that no more than 16 amperes steady-state shall be required from any one of the Contractor's power feeds (80 percent loading on a standard 20 ampere breaker). This steady-state load calculation shall include the accommodation of 20 percent spare/future additions.

If the Contractor's equipment requires isolation from the power source(s), the Contractor shall furnish all required power supply isolation/conditioning transformers.

17101.2.11.2 Power Distribution. The Contractor's internal power distribution system shall be arranged as described herein.

Power shall be distributed from the top of the cabinet. All power distribution devices, including power supplies, fuse blocks, circuit breakers, etc., shall be mounted near the top of the cabinet.

Each cabinet or item of equipment furnished by the Contractor shall be provided with fuse blocks or circuit breakers, which shall be the point of interface to the power sources. All power and transmitter circuits from the Contractor's equipment to any remotely installed item shall be individually fused and powered from within the Contractor's cabinet. Fuses/breakers shall be provided by the Contractor and mounted in a central location providing convenient access for replacement. Fuse rating selection shall place more emphasis on continuity of service within ampacity rating of the power circuits than on minimization of overcurrent damage to the equipment served by the fuse. The proper coordination of branch circuit protective devices shall be the Contractor's responsibility. A fault on a single branch circuit shall disable only that circuit; it shall not cause the failure or tripping of any protecting devices in the Contractor's power sources feeding the DCS.

The Contractor's equipment shall not parallel any power feed with any other power feed. Make-before-break transfer switches between ac sources will not be permitted.

Digital inputs and digital outputs identified as routed shall have power internally wired in the I/O cabinets by the Contractor. This internally wired power shall provide 120 volts ac or 125 volts dc for digital input contact sensing and digital output contact wetting. The Contractor shall provide power feeds to each cabinet location identified as requiring routed power. The Contractor shall furnish and install terminal blocks in the cabinets to receive the incoming power source, and shall factory wire the branch circuits between the power feed terminal blocks and the digital input terminal blocks or digital output relay contacts. The Contractor's design may include combined fusing, using fused link terminal blocks, for the branch circuits to digital input terminal blocks. The combined fusing design shall be acceptable to the Owner. Each branch circuit to the digital output relay contacts shall be individually fused using fused link terminal blocks.

An auxiliary relay shall be furnished and installed by the Contractor for each routed power feed. The auxiliary relay shall be energized whenever the routed power feed is available and shall de-energize upon loss of power. A relay contact shall be wired by the Contractor to an I/O point for alarming.

The Contractor's equipment shall impose no grounds on any ac power source unless specifically permitted by the Owner. If ground connections are required by design of the Contractor's equipment, the Contractor shall provide isolation transformers to prevent transmitting these grounds to any ac power source. If the Contractor's system requires source ground isolation, the Contractor shall provide the required isolation transformers.

The Contractor's equipment shall impose no grounds on any dc power source. All dc I/O interrogation power sources supplied by the Contractor shall be ungrounded.

17101.2.11.3 System Power Supplies. The Contractor shall provide and install within the systems all equipment required to transform, regulate, condition, isolate, and rectify the Contractor's power sources for use by the system.

The Contractor shall include any filtering equipment necessary to ensure that any spikes or harmonic distortions produced by the equipment supplied shall not affect the operation of the Contractor's system. Any spikes or harmonic distortions produced by the Contractor's system shall not affect the operation of the power system or other equipment.

All power supplies shall be provided in a configuration so that the Contractor's system shall remain fully functional if any one power supply fails. The intent of this requirement is that no single failure of power supply equipment or the restoration of the failure shall degrade or interrupt the normal functioning of any part of the Contractor's system including control and data acquisition function processing, I/O network communication and data highway network communication, and I/O transmitter and interrogation power. Each power supply shall be provided with a trouble indicating light and a digital contact wired to a DCS input that indicates loss of power supply output.

The Contractor shall provide power supplies and/or cabinet internal wiring required to energize system powered digital inputs and outputs.

The Contractor shall provide power supplies to energize all system powered 2 wire transmitter inputs and all RTD inputs.

17101.2.11.4 Software Battery Backup. The use of batteries shall be minimized. Where battery backup of random access memory is required, the batteries shall be sized to retain this memory for a minimum of 48 hours. All batteries shall be replaceable without any interruption of the function for which the battery provides backup.

17101.2.11.5 System Effects on Power Sources. The Contractor's systems shall be specifically designed to strictly limit any effects fed back from systems into the power source wiring. The power supply inputs shall have a linear curve for consumed current versus voltage from 10 to 100 percent load. Power supplies that create reflected current harmonics shall have input filters to limit the total harmonic distortion to less than 2 percent, and a wave form crest factor ratio of peak to RMS current that does not exceed 3. Other system design requirements for harmonics shall meet or exceed IEEE 519.

17101.2.11.6 System Grounding. The Contractor's electrical system or logic ground shall be designed according to the manufacturer’s recommendations and for grounding to the station ground mat at a single connection point. The Contractor shall furnish an insulated ground cable from this point on the station ground mat to the system cabinets in each physical lineup. The insulated ground cables shall be connected to an insulated copper grounding busbar provided by the Contractor in each cabinet. The Contractor shall connect the grounding busbars for each cabinet in a lineup.

The system cabinets shall be equipped to accept the insulated ground cables, which at this point will be isolated from the building ground. Any internal component grounds or commons shall be connected to the system ground, which shall be kept isolated from the building ground.

Each cabinet structure will be safety grounded to building steel. The Contractor shall provide separate connection points within each cabinet for attachment of Contractor-furnished cables to the building ground.

When shielded terminations are required in cabinets furnished under these specifications, suitable terminals and supports shall be furnished adjacent to input terminals.

17101.2.12 Software

A complete set of software program packages shall be provided to implement the functions of the DCS. The Contractor shall be responsible for developing, debugging, and testing all software provided with the DCS.

The Contractor shall grant to the Owner and/or end user licenses to use all software provided with the DCS for monitoring and control of the plant systems and equipment that constitute the project. The license shall include the right to make backup copies of all software provided by the Contractor.

EWS/OWS software shall be Process Portal A (PPA).

Logic Configuration software shall be Composer.

17101.2.12.1 Not Used.

17101.2.12.2 Not Used.

17101.2.12.3 Applications Software.

17101.2.12.3.1 Not Used.

17101.2.12.3.2 Not Used.

17101.2.12.3.3 Databases. An I/O list database shall be developed to allow design information transmittal between the Contractor and the Owner. A system database shall be developed that will allow access of the I/O by the control system.

In the databases, a unique identifying code (tag name) shall be assigned to each analog, digital, calculated, data linked, or manually inserted point, by which the point may be referenced by both the operator and the system. The code format shall be in accordance with the Owner's standard.

17101.2.12.3.3.1 I/O list database. The Contractor shall provide initial information, including the tag name, functional point description, and electrical characteristics for the process I/O, using a commercially available database program in an agreed upon format. After the initial I/O list database submittal is approved by the Owner, the Contractor shall be responsible for maintenance of the database until the system is shipped to the project site.

The Contractor shall add I/O card and termination information to the database. In addition to providing information on active I/O, the Contractor shall populate the database with the hardware information for all available spare points on all cards. The database shall then be submitted to the Owner for review. The I/O termination locations shall be acceptable to the Owner, and shall be in an arrangement that will assure that functional and electrical characteristics are matched. The I/O termination locations shall not be selected in a particular order solely to satisfy Contractor's requirements.

Alarm priorities, data storage requirements, and similar information shall be submitted by the Contractor during detailed design. The Owner may, from time to time, provide other additions or revisions to the database that the Contractor shall incorporate into the master database. The additions or revisions may be in hard copy or electronic format.

At the time of shipment, the Contractor shall furnish an as-shipped I/O list database to the Owner. The as-shipped database shall be in the same format as the initial I/O list database.

The Contractor shall use the I/O list database to generate the system database.

17101.2.12.3.3.2 System database. The Contractor shall provide a system database covering all system points and their attributes. The database organization shall be a standard database format, so that a point shall be stored as a file record and the attributes of that point shall be stored in the file as fields.

Each point shall be supported by a set of parameters that represent the point properties. Typical point parameters shall include, but shall not be limited to, tag name functional point description, engineering units (analog points), state descriptions (digital points), scan rate, alarm limits, and value.

17101.2.12.4 Diagnostic Programs. Diagnostic programs shall be provided for the following diagnostic tests:

Initiation checks.

Online diagnostics.

The initiation checks shall be initiated each time power is applied to a control or operator interface processor. These checks shall monitor the startup sequences of the processor to ensure that the processor has been successfully powered up and in the proper working condition.

The on-line diagnostics shall be executed automatically during normal online operation of the control and operator interface processor, providing continuous monitoring of the processor functions, including, but not limited to, logic processing, I/O processing, memory functions, and communications functions. Data highway communications network, controller, card, and error status information shall be available and the system shall present this information in English terms. Cross-referencing of numeric values to a diagnostic manual for initial problem determination is not acceptable.

Hardware diagnostic test software shall be provided for the following computer equipment. These diagnostics shall include fault analysis to the circuit board level:

Distributed processing units.

Memories.

I/O equipment (communications, racks (branches), power supplies, and individual I/O modules).

Peripheral and display devices.

All communications networks.

Peripheral devices requiring diagnostic test software shall include the following:

Mass memories (disks, etc.).

Multiplexing system.

"Watchdog" diagnostics shall be provided that periodically check the operation of all communications network nodes and alarm detected problems. Time synchronization between all nodes shall be periodically checked and set by the DCS to prevent inaccurate timing of alarms or SOEs.

17101.2.13 DCS Specific Documentation

In addition to hard copies, all system drawings shall be provided in searchable PDF format and in the system's standard (machine output) documentation format on CDs or DVDs.

17101.2.13.1 Program Storage. All operating system and applications software shall be provided with the system on CDs or DVDs. The Contractor shall provide clean (no patches) source files of all programs. Two complete sets of system loadable files and application loadable and source files shall be furnished to the Owner. The CDs or DVDs shall be delivered to the jobsite separately from the system hardware.

17101.2.13.2 Hardware Maintenance. Sufficient documentation shall be provided to assure efficient maintenance of all Contractor-furnished hardware by Owner's personnel. This documentation shall include point-to-point wiring diagrams and schematic diagrams of all electronic assemblies, supplemented with concise descriptions of the theory of operation of individual subsystems, including third-party hardware.

The Contractor shall furnish documentation that will assist the Owner's personnel in assuring a short mean-time-to-repair in the event of a failure. This may be accomplished by documenting problem symptoms along with possible repair solutions.

Full procedures associated with on-line and off-line diagnostics shall be provided as part of the system. The procedures shall be complete enough to allow maintenance of the equipment to the card level.

17101.2.13.3 Programming Reference. Documentation shall be supplied to assist the Owner's personnel in software development and maintenance. This documentation shall include descriptions of all programming languages, editors, and utilities supported by the DCS.

Programming documentation shall be included on two levels. One level will be used for training personnel who have a programming background, but are unfamiliar with the particular language; the other level shall be used for reference by personnel who are familiar with the language, but need concise in-depth information for assistance.

17101.2.13.4 System Troubleshooting Guide. Documentation shall be supplied to assist the Owner's personnel in analyzing system failures. Documentation shall include, but not be limited to, procedures to follow after a system failure to isolate the error, locations of pertinent operating system parameters for automatic restarts, and a list of errors that cause system failure.

A troubleshooting guide for software as well as hardware will assist the Owner's personnel to locate problems on a malfunctioning system.

17101.2.13.5 Control Program Documentation. The Contractor shall provide hard copy printouts of all control programs in the system's standard (machine output) documentation format.

The Contractor shall document all modulating control programs with functional logic diagrams conforming to the format defined in former SAMA Standard PMC22.1 "Functional Diagramming of Instrument and Control Systems," and/or with written descriptions as specified on the DCS Specification Sheet. Composer logic documents shall be limited to five sheets (tabs) per document.

The Contractor shall document all sequential and digital control programs (motor control, valve control, etc.) with diagrams conforming to one of the formats defined in IEC Standard 61131-3, and/or with written descriptions as required by the DCS Specification Sheet.

17101.2.14 Meetings

The Contractor shall, at a minimum, arrange and attend kick off and design review meetings as defined on the DCS Specification Sheet. The Contractor shall coordinate these meetings with the Owner and Owner's representatives.

17101.2.15 System Testing

17101.2.15.1 Factory Testing. The minimum duration for the factory acceptance test shall be as defined on the DCS Specification Sheet. Factory testing shall include, but not be limited to, the following:

Point-by-point verification and exercising of all inputs and outputs. Owner may elect to witness these tests separately from and prior to the factory acceptance test.

Point-by-point continuity check of the terminal cabinets (if not checked as part of I/O verification).

Repeated powering up and powering down of all system components.

Demonstration of the proper functioning of all hardware.

Demonstration of single failure responses to detectable failures including proper operation during failover from primary to backup control processor and back again to primary, failure of one channel of each redundant communication system, and power supply failures.

Demonstration of the timing and accuracy of the SOE system both in the same control processor and between control processors.

Demonstration of required spare system capacity.

A closed loop checkout of all modulating control logic using a simulation of the process.

A closed loop checkout of all discrete control logic using simulation of the field devices.

Demonstration of all operator interface functions.

Demonstration of interlocks and auto-start/auto-stop features.

Functional review of all Owner-configured control and information displays.

Demonstration of the proper functioning of the Contractor-supplied software. Included in the software tests shall be procedures to verify the proper operation of the following system software functions: all on-line editing functions; all analog scan conversion and limit checking routines; all digital scan routines; all operator communication routines; all editors, configurators, compilers, and assemblers; all software debug programs; all software diagnostic routines; all display and printing routines; all alarm output routines; and all programming support routines. Included in the software tests shall be procedures to verify the proper operation of the applications programs using simulated I/O, all real-time variable calculations, and all performance calculations.

All prefabricated cables supplied under this Contract. The prefabricated cables shall be connected for the tests in exactly the same configuration as they will be installed at the plant site. The Contractor may use temporary test cables during the test for all cable being supplied without factory installed connectors.

Demonstration of the proper functioning of all FDIs using Contractor-furnished PLCs or PCs, or manufacturer-furnished emulators.

Three months prior to the start of the factory test, the Contractor shall submit to the Owner for approval the exact testing procedure that he intends to use. Following Owner review, the Contractor shall submit a final test procedure and schedule.

The Contractor shall furnish all power supplies, switch and light panels, meters, signal generators, test cables and jumpers, logic simulators, and emulators required to perform the specified tests.

Following the test if, in the opinion of the Owner, the system has not been adequately manufactured, tested, or debugged, the test shall be rerun. All of the Contractor's costs associated with retesting the system shall be the responsibility of the Contractor. The system shall not be shipped without the approval of the Owner.

Factory tests shall be witnessed by the Owner. The results of all factory tests shall be documented and submitted to the Owner.

17101.2.15.2 Performance Testing. If during plant commissioning, the Owner sees significant evidence indicating a problem with the DCS performance, the Contractor's technical representative shall participate

in testing the performance of the DCS. When the DCS is deemed by the Contractor to be in final and completed status and with concurrence of the Owner, performance tests shall be conducted to verify that the response times of the DCS are in accordance with the requirements of Article 17101.2.1.4 titled System Timing. The testing procedures shall be agreed upon by the Contractor and the Owner prior to the tests.

The generating plant shall be in normal operation, under automatic control, and with the DCS equipment fully functioning. Minor discrepancies to the above preconditions may be waived by joint agreement of the Contractor and the Owner.

17101.2.16 Packaging for Shipment

Prior to shipment, all shipping stops, bolts, ties, etc., shall be installed in cabinets and devices. The Contractor shall install additional protection as required to prevent damage during shipping. Any delicate modules or circuit boards shall be disconnected, packed, and shipped to the jobsite to be remounted. All accessories, mounting devices, and packing lists shall be packed and shipped with the equipment.

Each separately shipped group of equipment shall be prepared as an individual shipping unit and shall be braced adequately and rigidly so that no damage will occur in transit, lifting, or installation. Provisions shall be made for lifting and skidding. All lifting points shall be clearly marked. Disconnected wiring shall be properly supported. The equipment shall be adequately protected against the weather and mechanical damage during transit and storage.

17101.2.17 Not Used

17101.2.18 Field Technical Services

DCS Specification Sheet

System Spare Capacity (17101.2.1.5)	
Spare installed I/O points of each type (per train)	25%
Spare available I/O card slots in I/O cabinets	20%
Spare terminal blocks in I/O cabinets	25%
Spare component space (future control processors, communication controllers, memory modules, power supply modules, etc.) in system electronic cabinets	20%
Spare logic block, database, and execution capacity (available for future use without exceeding manufacturer's recommended maximum loading) in each control processor	20%
Spare display and database processing and storage capacity (available for future use without exceeding manufacturer's recommended maximum loading) in each operator interface processor	20%
Special Requirements (Enter any special needs, restrictions, preferences, etc.)	
Spare quantities required at time of DCS equipment shipment to the job site.	

Modulating Control Functions (17101.2.3) and Control Program Documentation (17101.2.13.5)	
Yes	Modulating control functions shall be programmed by Contractor as defined below and in the specification.
Logic Configuration Engineering Services Scope	Strategy by Contractor

This is a fully configured, assembled, staged, and tested logic system. The Contractor shall provide detailed functional descriptions and detailed functional logic diagrams defining the application requirements for Owner approval. The Owner will review the Contractor's logic descriptions/diagrams to ensure that it is consistent with the existing plant control strategies and complies with the specification requirements. The Contractor shall configure the logic system in accordance with the approved logic descriptions/diagrams. The Contractor shall also develop an I/O database in an agreed upon format for the Owner's review and for the Contractor's use in implementing the system database.

The Contractor shall provide engineering to define and produce the system configuration diagrams, I/O database, cabinet arrangement drawings, cabinet internal wiring diagrams, external connection diagrams for power, grounding, and communications, detailed job specific I/O termination drawings, logic configuration drawings, application logic files, and control system tuning parameters and timing settings. The Contractor shall furnish standard product literature and drawings including, but not limited to, hardware and software instruction manuals, and certified equipment outline and wiring drawings. After startup of the units, the Contractor shall update and reissue all hardware, wiring, and logic drawings to reflect the changes made during installation and commissioning of the DCS.

Owner-Provided Information		Contractor-Furnished Information	
No	Existing Configuration Diagrams	Yes	Detailed System Analog Configuration Printouts
No	Written Descriptions of Operation	Yes	Detailed Logic Diagrams
No	Simplified Logic Diagrams	Yes	Detailed Written Descriptions of Operation
Yes	Macro logics to be used.		

Special Requirements (Enter any special needs, restrictions, preferences, etc.)

1. Contractor shall document the modulating control logic using their standard methods. However, the

documentation shall provide content similar to SAMA RC 22-11 format. 2. Contractor shall submit programmed configuration drawings and detailed functional descriptions of operation for Owner review prior to the Factory Acceptance Test (FAT).
3. All Contractor-developed programming shall compile and execute without any errors and warnings.

The Contractor shall program modulating control loops for equipment including, but not limited to, the following.

Item	Quantity	Loop Name
1	As req'd	As defined by Contractor
2		
3		
4		
5		
Special Requirements (Enter any special needs, restrictions, preferences, etc.)		
None.		

Multiple Measurements (17101.2.3)			
Item	**Quantity**	**Control Signal Name**	**No. of Signals**
1	As req'd	All critical processes and equipment	3
2			
3			
4			
5			
Special Requirements (Enter any special needs, restrictions, preferences, etc.)			
None			

Discrete Control Functions (17101.2.4) and Control Program Documentation (17101.2.13.5)	
Yes	Discrete control functions shall be programmed by the Contractor as defined below and in the specification.
Logic Configuration Engineering Services Scope	Strategy by Contractor
This is a fully configured, assembled, staged, and tested logic system. The Owner will provide generic logic diagrams, or steering logic for approved logic macros, for the Contractor's use in implementing the system logic configuration. The Contractor shall prepare the detailed logic configuration drawings and written descriptions of the operation. The Contractor shall develop an I/O database in an agreed format for the Contractor's use in implementing the system database. The Owner will review the logic configuration and descriptions to ensure that it is consistent with the existing plant control strategies provided and complies with the specification requirements. The Contractor shall configure the logic system in accordance with the approved logic drawings.	
The Contractor shall provide engineering to define and produce system configuration diagram, cabinet arrangement drawings, cabinet internal wiring diagrams, external connection diagrams for power, grounding, communications, and detailed job specific I/O termination drawings, logic configuration drawings, and application logic configuration files. The Contractor shall furnish standard product	

literature including, but not limited to, hardware and software instruction manuals, and certified equipment outline and wiring drawings. After startup of the unit(s), the Contractor shall update and reissue all hardware, wiring, and logic drawings to reflect the changes made during installation and commissioning of the DCS.			
Owner Provided Information		**Contractor-Furnished Information**	
No	Example Descriptions of Operation	Yes	Detailed Written Descriptions of Operation
No	Simplified Logic Diagrams	Yes	Detailed Logic Diagrams
Yes	Steering Logic for Approved Macros/templates		
Yes	Discrete control logic shall be implemented by the Contractor in steering logic format with approved Owner standard logic macros.		
Special Requirements (Enter any special needs, restrictions, preferences, etc.)			
1. Contractor shall submit programmed configuration drawings for Owner review prior to the Factory Acceptance Test.			
2. All Contractor-developed programming shall compile and execute without any errors and warnings.			

The Contractor shall program control logics for equipment including, but not limited to, the following:		
Item	**Quantity**	**Equipment Description**
1	As req'd	As determined by the Contractor
2		
3		
4		
5		
Special Requirements (Enter any special needs, restrictions, preferences, etc.)		
None.		

Control and Information Display Functions (17101.2.7)	
Display Development Engineering Services Scope	Contractor and Owner
The Owner will configure all control and information displays including process control displays, faceplate displays, text displays, trend displays, and group displays. The Contractor shall submit one color hard copy print of each recommended display and a copy of the associated display configuration file for the Owner's review and possible use. The final display configuration file, as configured by the Owner in the system, will be provided to the Contractor for display data point linking and FAT demonstration.	
Special Requirements (Enter any special needs, restrictions, preferences, etc.)	
Graphic displays shall be generated using Owner's standard format, symbols, and colors.	

System Data Reporting Functions (17101.2.8)		
	Minimum System Capability	**Number of Reports Provided by Contractor**
Periodic Reports (17101.2.8.1)		
Trend Reports (17101.2.8.2)		

Post-Trip Review Report (17101.2.8.3)		
Maintenance Data Report (17101.2.8.4)		
Housekeeping Report (17101.2.8.5)		
Sequence-of-Events Report (17101.2.8.6)		
User Reports (17101.2.8.7)		
Total Programmed by Owner	As required	
Special Requirements (Enter any special needs, restrictions, preferences, etc.)		

I/O Requirements (17101.2.10.3)	
Logic Configuration Engineering Services Scope	
The Contractor shall be responsible for partitioning of the I/O and logic to meet the requirements for process and equipment separation and redundancy. At a minimum the following rules shall apply. Where multiple measurements of a single process parameter are input to the system for redundancy, none of the measurements shall be assigned to the same I/O card or rack. Where similar parameters from two or more redundant pieces of equipment are input to the system, those similar parameters shall not be assigned to the same I/O card or rack. The Contractor shall submit the I/O assignments to the Owner for review prior to the hardware cutoff. If in the opinion of the Owner, the partitioning does not provide adequate process security, the Contractor shall re-partition the affected I/O based on the Owner's comments.	
Special Requirements (Enter any special needs, restrictions, preferences, etc.)	
The interrogation power source provided by the DCS for each digital input card shall be monitored and alarmed. If an I/O card has two fuses that direct interrogation power, alarming shall be provided for each fuse. Alarming shall be accomplished by wiring a single input for each fuse into an I/O point on the associated card. The I/O required to do this is not included in the I/O counts provided in this datasheet.	

Digital Output Module Rating (17101.2.10.3.2)						
				Break		
	Voltage	**Make**	**Carry**	**Resistive**	**Inductive**	**Contacts**
Digital Output	120 VAC	10 A	10 A	10 A	3 A	1 Form C
Digital Output	125 VDC	10 A	10 A	3 A	1 A	1 Form C
Digital Output						
Contact rating reference temperature					75° F	
L/R					20 ms	
Special Requirements (Enter any special needs, restrictions, preferences, etc.)						
None.						

Foreign Device Interfaces (17101.2.10.3.6)	
	Foreign device interfaces shall be provided by Contractor as defined below and in the specification.
Unit of length	Feet

Item	Interface Quantity	Length	I/O per Interface				Redundant	Description
			AI	AO	DI	DO		
1	As req'd	As req'd	As req'd	As req'd	As req'd	As req'd		As determined by the Contractor
2								
3								
4								
5								
Special Requirements (Enter any special needs, restrictions, preferences, etc.)								
The Contractor shall provide an I/O database for each foreign device interface								

System Cabinet Requirements (17101.2.10.9)	
Yes	System electronics cabinets shall be provided by Contractor as defined in the specification.
Yes	I/O equipment cabinets shall be provided by the Contractor as defined in the specification.
Yes	I/O interposing termination cabinets shall be provided by the Contractor as defined in the specification.
Yes	Remote I/O equipment cabinets shall be provided by Contractor as defined in the specification.
Yes	Remote I/O interposing termination cabinets shall be provided by the Contractor as defined in the specification.
No	Polycarbonate insert for equipment viewing in Network cabinet door (Article 17101.2.10.9.5)
Fiber-optic patch panel location	Inside DCS Cabinets
Special Requirements (Enter any special needs, restrictions, preferences, etc.)	
1. Cabinets that are physically connected to each other (i.e. termination cabinet and I/O cabinet) or are on the same data highway drop shall be given a common tag number. Each individual cabinet shall have a 'bay' tag to differentiate it from the other cabinets.	
2. Control processor designations PCU 72 through 79 have been reserved for the FGD additions.	

System Cable Requirements (17101.2.10.12)			
Cable shall be provided by Contractor as defined below and in the specification:			
Unit of length			Feet
Item	**Application**	**Cable Type**	**Length**
1	As required	As required	As required
2			
3			
4			
5			

System Power Sources (17101.2.11.1)						
Primary and secondary voltage frequency (if AC)			60 Hz			
			Primary		Secondary	
Item	Location	Equipment Type	Voltage	Source	Voltage	Source
1	TBD by Contractor					
2						
3						
4						
5						
Special Requirements (Enter any special needs, restrictions, preferences, etc.)						
Primary and secondary sources shall not be used to feed routed power points. Power sources shall be UPS derived.						

SECTION 17205
LOCAL INSTRUMENT RACKS AND ENCLOSURE

17205.1 General

17205.1.1 Scope of Supply

Scope of supply shall include furnishing instrument racks and instrument enclosures as defined herein and on the Local Instrument Racks and Enclosures Specification Sheet.

17205.1.2 Not Used

17205.1.3 Performance and Design Requirements

Performance and design requirements for the local instruments racks and enclosures are indicated on the Local Instrument Racks and Enclosures Specification Sheet included at the end of this section.

17205.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 17205-1 Codes and Standards

Work	**In Accordance With**
Enclosures	ANSI/NEMA 250 Enclosures for Electrical Equipment (1000 volts maximum) NEMA ICS 6 Industrial Control & System Enclosures
Wiring	NFPA/NECH PT1 National Electric Code
Piping	ANSI/ASME B31.1 Power Piping

17205.1.5 Materials

The following materials shall be used:

Table 17205-2 Materials

Component	**Material**
Local Instrument Racks/Enclosures	Ameren Missouri Approved Suppliers

17205.1.6 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:

Table 17205-3 Approved Manufacturers

Component	**Manufacturer**
Enclosures	Ameren Missouri Approved Suppliers
Instrument Racks	Ameren Missouri Approved Suppliers

17205.1.7 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. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 17205-4 Test Requirements		
Tests	**In Accordance With**	**Conducted By**
Pressurized leak tests	ASME B31.1 Code for Pressure Piping	Contractor

17205.1.8 Technical Attachments

Not Applicable

17205.1.9 Supplemental Specifications

Not Applicable

17205.2 Products

17205.2.1 General

This article covers furnishing instrument racks and instrument enclosures complete with Contractor-furnished and installed components, tubing, and wiring.

17205.2.2 Structures

Local instrument racks and enclosures shall be freestanding or wall mount type, and designed according to the requirements herein.

17205.2.2.1 Free-Standing Instrument Enclosures. Each instrument enclosure structure shall consist of one or more modules and one electrical junction box end all bolted together. Modules and junction boxes shall have an enclosure rating as indicated on the Local Instrument Racks and Enclosures Specification Sheet. Bulkheads for process field connections shall be located as indicated on the Local Instrument Racks and Enclosures Specification Sheet.

For each instrument enclosure, doors shall be located as indicated on the Local Instrument Racks and Enclosures Specification Sheet. Each door shall have a three-point latching system and concealed quick removal type pinned hinges. Single door and double door openings shall each be free of structural members and allow unobstructed access. Each double door shall be interlocking.

Front access doors shall not exceed 30 inches in width. Hinges shall be located so as not to interfere with access to wiring termination or devices.

A 6 inch stamped louver is required on the top and bottom of each door for the insulated outdoor enclosures.

Vibration isolation mounting shall be provided as follows when indicated on the Local Instrument Racks and Enclosures Specification Sheet.

When each instrument enclosure is completely assembled (with all components and materials installed), the loading at each corner shall be determined by weighing. The loading at each corner shall be used to determine the correct size of each vibration isolation mounting pad specified on the drawing. Pad size shall be in accordance with the pad manufacturer's recommendations. The Contractor's drawings shall indicate the size of the pad installed at each corner.

17205.2.2.2 Wall Mounted Enclosures. Wall mounted enclosures shall have flush pan type doors with semiconcealed pin type liftoff hinges and a three-point latching handle.

17205.2.2.3 Instrument Racks. Instrument racks shall be open, non-enclosed type structures. Instrument racks shall be heavy duty metal construction and designed to support the instruments and devices mounted on the structure. Instrument racks may be factory modular construction or field constructed. Instrument racks shall be freestanding structures, installed on floors or slabs, or wall mounted structures installed on building support steel.

Instrument racks (stands) consisting of a single vertical pedestal and horizontal tree members can be provided for mounting up to three instruments. Instrument racks shall be mounted in locations which are easily/readily accessible by personnel on platforms or at ground level.

17205.2.3 Reports and Diagrams

The Contractor shall provide diagrams showing the construction of each instrument rack and enclosure and the mounting location of the junction box where applicable. The diagrams shall also show the mounting location, including listing, of all instruments to be installed on the structure. The diagrams shall show the planned routing of instrument piping to each instrument from the point of entry into the structure.

17205.2.4 Components and Materials

The components and materials described in the following articles shall be installed or furnished and installed in the instrument enclosures or racks as indicated.

17205.2.4.1 Not Used.

17205.2.4.2 Contractor-Furnished Components and Materials. The Contractor shall furnish the components and materials specified in the following articles.

17205.2.4.2.1 Not Used.

17205.2.4.2.2 Not Used.

17205.2.4.2.3 Not Used.

17205.2.4.2.4 Not Used.

17205.2.4.2.5 Terminal blocks. Terminal blocks shall be furnished and mounted in the junction boxes for the termination of field wiring. Terminal blocks for all instrument and device wiring shall be in accordance with Article17205.1.9.

Field wires shall terminate directly on transmitters.

17205.2.4.2.6 Fuses and fuse blocks. Fuses and fuse blocks shall be provided in accordance with the Local Instrument Racks and Enclosures Specification Sheet.

17205.2.4.2.7 Lighting and receptacles. Lighting fixtures, light switches, and duplex receptacles shall be furnished as indicated on the Local Instrument Racks and Enclosures Specification Sheet.

Outlet boxes, switch boxes, and device covers shall be UL listed galvanized stamped steel.

17205.2.4.2.8 Space heating. Space heaters shall be furnished as indicated on the Local Instrument Racks and Enclosures Specification Sheets. Heating thermostats shall be adjustable over the indicated range.

Space heaters shall be capable of maintaining the enclosure interior at a temperature of 70° F when the ambient temperature is 40° F or lower. For indoor enclosures, the primary intent of the space heater is control of condensation.

Outdoor enclosures will be provided with wall and door insulation. The insulation thickness and space heater capacity shall be coordinated to maintain the enclosure internal temperature above freezing under the specified site conditions.

17205.2.5 Installation

The Contractor shall submit component arrangement and instrument installation drawings for each instrument enclosure or rack. The drawings shall indicate the arrangement of all instruments, tubing, valves, and fittings to be installed within the enclosure or rack. During the review of the initial drawing submittal, the Owner may elect to reassign instruments within an enclosure or rack to different areas or to move instruments to a different enclosure or rack, up to a total quantity of 10 percent, without incurring additional charges. After the drawings are accepted by the Owner, the components and tubing shall be installed in the arrangement indicated by the drawings.

The Contractor shall provide instrument piping details for all enclosure or rack mounted equipment.

Schematic wiring diagrams, instrument loop diagrams, and connection and interconnection wiring diagrams shall be prepared and submitted by the Contractor. After the drawings are accepted by the Owner, wiring shall be installed in accordance with the drawings.

Additional installation requirements are specified in the following articles.

17205.2.5.1 Instruments. Instruments shall be installed using custom fabricated supports that are attached to vertical tee members provided for this purpose. Custom construction shall comply with the mounting recommendations of the instrument manufacturers. Brackets, clamps, and other supports furnished with the instruments may be employed in the construction of supports. Painting of custom fabrication shall conform to the requirements in Article 17205.1.9.

17205.2.5.2 Not Used.

17205.2.5.3 Not Used.

17205.2.5.4 Not Used.

17205.2.5.5 Terminal Blocks. Terminal blocks shall be installed and labeled in accordance with the requirements in Article 17205.1.9.

17205.2.5.6 Fuses and Fuse Blocks. Fuses and fuse blocks shall be installed as required by the Contractor's schematic wiring diagrams and as indicated in Article 17205.1.9.

17205.2.5.7 Lighting and Receptacle Components. As indicated on the Local Instrument Racks and Enclosures Specification Sheet, one lighting fixture and one duplex receptacle shall be installed in each instrument enclosure module. A light switch for control of each fixture shall be installed inside each module beside an access door.

17205.2.5.8 Space Heating. Where indicated on the Local Instrument Racks and Enclosures Specification Sheet, each instrument enclosure shall be furnished with enclosure heaters. One or more space heaters shall be installed in each module and in the electrical junction box end. All space heaters in the enclosure shall be fed by a single manual starter and controlled by a single thermostat. For outdoor enclosures, a single humidistat shall additionally be furnished for space heater control. Heating thermostats and humidistats shall be adjustable over the indicated range.

Space heaters shall be located near the bottom of the enclosure. The thermostat and humidistat shall be located in a module, 3 feet above the enclosure bottom, displaced horizontally as far as possible from the nearest heater. The starter shall be installed in the electrical junction box end.

Outdoor enclosures shall be provided with wall and door insulation. Insulation shall be installed on the inside of the doors and the inside of the exterior walls of instrument enclosures. Insulation shall be attached with specially designed studs and installed with the cladding or vapor barrier exposed.

The insulation thickness and space heater capacity shall be coordinated to maintain the enclosure internal temperature above freezing under the specified site conditions.

17205.2.5.9 Wiring. Except for thermocouple and other special circuits, the Contractor shall completely wire each instrument enclosure so that the only field wiring required shall be the connection of external circuits to terminal blocks within the electrical junction box end and, if the enclosure is shipped in more than one section, the interconnection of terminal blocks at shipping splits. Thermocouple and other special circuits shall be field wired directly to instrument terminals.

Instrument enclosures that are split for shipment shall be furnished with all wiring required to interconnect the shipping sections.

17205.2.6 Shop Coating

Shop coatings shall conform to Article 17205.1.9.

Paint films that show sags, checks, blisters, teardrops, or fat edges will not be acceptable, and if any such defects appear, they shall be repaired by and at the expense of the Contractor.

17205.2.7 Nameplates and Name Tags

Nameplates shall be provided in accordance with Section 17301 – Stainless Steel Tags and Section 17302 – Phenolic Nameplates.

An engraved oversize (2 inch by 6 inch) nameplate shall be attached to the front of each instrument enclosure or rack for identification. Additional nameplates shall be attached to the outside of each bulkhead to identify the tubing connections.

An engraved nameplate or name tag shall be attached to or near each component within each enclosure or rack.

Nameplates shall be engraved as approved by the Owner.

17205.2.8 Shipping and Handling

All enclosures and racks shall be crated or packed to prevent shipping or handling damage.

17205 Local Instruments Racks and Enclosures Specification Sheet

ID Number	
General criteria	
Structure type	Free-standing enclosure or Wall mounted enclosure or Open rack in accordance with application
Nominal size, ft	
Length	In accordance with application
Depth	3
Height	6
Location	In accordance with application
Front faces	In accordance with application
Enclosure mechanical criteria	
Rating	In accordance with Article 17205.1.9 for area.
Environment	Indoors or Outdoors
Bulkhead location	Top or Side (in accordance with application)
Door locations	Front
Vibration isolation required	Yes (free-standing enclosures)
Instrument blowdown header required	In accordance with application
Control air header required	In accordance with application
Enclosure electrical criteria	
Space heater required	Yes
Space heater heating units	W
Space heater voltage	120 VAC
Space heater thermostat range	55 to 90° F
Space heater humidistat range	0 to 80 percent RH (Cabinets located outdoors)
Fuses and fuse blocks	Yes
Interior light and switch	Yes
Duplex receptacle	No
Junction box wiring entry	Side or Bottom (In accordance with application)
Additional enclosure requirements	

SECTION 17220
PLASTIC INSTRUMENT ENCLOSURES

17220.1 General

17220.1.1 Scope of Supply

Scope of supply shall include furnishing fully-assembled, electrically heated, self-regulating instrument enclosures consisting of the enclosure, enclosure mounting bracket, instrument(s) to be protected, instrument(s) support, heater, thermostats, and signal and power terminations as defined herein and in accordance with referenced sections.

17220.1.2 Not Used

17220.1.3 Performance and Design Requirements

Performance and design requirements for the equipment to be furnished under this section of these specifications are indicated herein.

17220.1.4 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 17220-1 Codes and Standards

Work	In Accordance With
Enclosures	ANSI/NEMA 250 Enclosures for Electrical Equipment (1000 volts maximum)
Wiring	NFPA/NEC PT1 National Electrical Code

17220.1.5 Materials

Refer to Article 17220.2 for specific material requirements.

17220.1.6 Approved Manufacturers of Components

Only the following manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications:

Table 17220-2 Approved Manufacturers

Component	Manufacturer
Plastic Instrument Enclosure	Ameren Missouri Approved Suppliers

17220.1.7 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:

Table 17220-3 Test Requirements

Tests	In Accordance With	Conducted By
Pressurized leak tests	ASME B31.1 Code for Pressure Piping	Contractor

Pressure tests shall be performed by the Contractor as required in Article 17920.3.8. Tests shall be made with the piping system isolated from the respective instruments. Isolation shall be achieved by closing the instrument manifold valves or individual instrument shutoff valves at the instruments.

17220.1.8 Technical Attachments
Not Used

17220.1.9 Supplemental Specifications
Not Used

17220.2 Products

17220.2.1 Required Features
Furnish electrically heated, corrosion resistant, UV protected instrument enclosures to meet ASME B31.1 requirements in an outdoor installation. Manufacture each enclosure to completely cover each instrument mounted within. Each enclosure shall additionally include at least the features specified below:

Table 17220-4 Required Features

Component	Requirement
Style	Removable diagonally fitted lid with retaining chain, for one or multiple instruments; no lid support required
External and Internal Support Plates	Stainless steel, with number as required to support assembled enclosure weight with instrument(s) plus 10% safety factor
External and Internal Hardware	All stainless steel external, including fasteners and any hinges; galvanized carbon steel internal
Latches	Locking, all stainless steel
Instrument Tubing and Fittings	Reference Sections 17025 and 17920
Window Required	Yes
Window Material	Safety glass or Lexan
Instrument Mounting	By brackets furnished with transmitter and/or manifold; spacing a minimum of 12 inches between instrument center lines when two instruments are in an enclosure; liquidtight flexible conduit from conduit entry to each electronic instrument
Penetrations	Grommeted and insulated; with heat-shrink type waterproof insulated fittings; with sealant; blowdown through bulkhead fittings only; conduit bulkhead entry fitting
Heater, Thermostat, and Insulation	Sized for minimum maintenance temperature at ambient conditions, with wind effect; heater fused and installed with brackets as required; heater demand load not to exceed 150 watts
Insulation Material	Urethane or polyurethane foam-in-place type, with aluminum foil shell as required. Insulation shall be non-hydroscopic and chloride free
Wind Effect for Calculations	30 mph
Enclosure Material	UV stabilized polyurethane, glass reinforced epoxy vinyl ester resin, or fiberglass reinforced polyester; gaskets suitable for ambient conditions

Table 17220-4 Required Features	
Component	**Requirement**
Enclosure Rating	In accordance with Article 17220.1.9 for the area
Enclosure Mounting	Hub for floor-mounted 2 inch pipe stand or post
Drain	Manual wing nut type
Power Connection	Terminals internal to enclosure, installed and wired at factory to distribute power to instrument tubing bundle and enclosure heater, with one conduit entry to accommodate power for both enclosure and bundle
Power Supply	Nominal 120 VAC, 60 Hz
Ambient Conditions	In accordance with site weather data.
Enclosure Flame Rating	None required
Agency Listings	UL listed or FM approved for electrical area classification for enclosures and components

Contractor shall mount a manifold to each instrument requiring one, along with the required tubing and fittings for a complete assembly. Each instrument shall be mounted to permit easy access for calibration and maintenance without removing the heater and with the lid opened. Contractor shall install a tubing stub to the instrument assembly, protruding through the penetration grommet to 1 inch beyond the outside of the enclosure; the tubing stub will be removed and discarded during field installation.

17220.2.2 Not Applicable

17220.2.3 Penetrations

Design enclosure penetrations as indicated below for sizing of heat shrink fittings.

Table 17220-6 Enclosure Penetrations	
Component	**Requirement**
Differential Pressure Transmitters Differential Pressure Indicators Differential Pressure Switches	Twin insulated tubing bundles, for two process lines, with integral heat trace cable
Static Pressure Transmitters Static Pressure Indicators Static Pressure Switches	Single insulated tubing bundles, for one process line, with integral heat trace cable

17220.2.4 Warning Nameplate

Where blowdown valves are included in the arrangement, Contractor shall furnish and mount a phenolic warning nameplate inside each enclosure in a position clearly visible to one who will blow down the instrument. Construct each nameplate in accordance with Section 17302 – Phenolic Nameplates. Text shall be as indicated below:

BLOWDOWN NOT TO EXCEED 1 MINUTE DURATION.
ENCLOSURE LID TO REMAIN OPENED DURING BLOWDOWN AND UNTIL PROCESS TUBING TEMPERATURE HAS RETURNED TO AMBIENT.

17220.2.5 Accessories

Furnish other accessories and/or externally mounted devices, not mentioned herein, as specified or noted on the device list, such as mounting stands.

17220.3 Execution

17220.3.1 Not Used

17220.3.2 Engineering Data

Furnish a statement of the toxicity of enclosure materials when burned for environmental engineering consideration.

In addition to engineering data specified in another section, furnish heat loss calculations for review. Calculations shall include heat transfer for determining insulation thickness and heater sizing. Engineering data shall be in English units and shall be sufficient for Owner to verify insulation and heater selections.

17220.3.3 Shipping

Ship each enclosure as an assembled unit, including mounted instruments and tubing, to job site. Package each enclosure to protect all parts of the assembly against damage in transit.

SECTION 17300
INSTRUMENTATION

17300.1 General

Instruments shall be furnished in accordance with the requirements of the applicable subsections and as specified herein. All instruments and ancillary devices supplied under this specification shall meet the environmental conditions and hazardous area classification required by the process measurement application/area. Each instrument shall be furnished with a stainless steel tag in accordance with Section 17301 – Stainless Steel Tags. Instruments shall have the environmental conditions and/or hazardous area listing on the nameplate and supporting supplier documentation.

17300.2 Materials

Materials received or installed at the site having damaged or defective surfaces or surface coatings shall be repaired at the manufacturer's expense.

17300.3 Coatings

All metallic surfaces subject to corrosion, excluding stainless steel, shall be furnished with the manufacturer's standard paint or plating applied in the shop. Ferrous surfaces that should not be painted and are subject to corrosion should be coated with a rust-preventive compound. Surfaces that will be inaccessible after assembly shall be protected for the life of the equipment. Exposed surfaces shall be finished smooth, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting. The surfaces shall be cleaned and prepared in the shop.

17300.4 Lubricants

An anti-seize compound or a spray lubricant shall be applied to all enclosure threads to prevent thread galling.

17300.5 Shipping and Storage Protection

Instruments that are flanged or are to be mounted between flanges shall be furnished with wooden flange face protectors. Instruments that have process, instrument air, or electrical connections shall be furnished with plugs or caps to protect instrument internals and threads. If more than one electrical connection is provided, a permanent electrical connection plug shall be furnished for each spare connection. Each instrument shipment weighing more than 200 pounds shall be packed in a weatherproof wooden crate for protection.

17300.6 Service Conditions

Instruments shall be constructed to withstand the service conditions of the systems to which they are connected. The suitability of each instrument shall be confirmed for the listed service conditions and the Owner shall be immediately advised of any required installation constraints.

17300.7 Transmitter Calibration

Each transmitter, including primary measuring devices with transmitter outputs, shall be calibrated and certified in accordance with the following.

17300.7.1 Factory Calibration

Each transmitter shall be factory calibrated to the engineering range required by the application. Calibration shall include factory entry of the transmitter identification and any other data required to commission the transmitter for service. Data required for factory calibration are provided by the Contractor in MS Access or MS Excel format.

17300.7.2 Calibration Certification

Each transmitter shall be provided with a certificate of calibration that identifies it by model number, serial number, and tag number. The certificate shall include calibration data from at least five span points (0 percent, 25 percent, 50 percent, 75 percent, and 100 percent) to document both the expected and the measured transmitter current output for the specified measurement range. The certificate shall certify that all tests were performed with equipment whose calibration is directly traceable to the National Institute of Standards and Technology (NIST). Each instrument shall be calibrated with an MGTG to INST ratio of 2:1

(Calibration equipment should be at a higher classification than the instrument being calibrated). Copies of the certificate shall be provided to the Owner.

17300.8 Adjustable Switch Calibration

Each switch that has adjustable settings shall be calibrated and certified in accordance with the following.

17300.8.1 Factory Calibration

Each switch shall be factory calibrated to the setting required by the process measurement application. Data required for factory calibration are provided by the Contractor in MS Access or MS Excel format.

17300.8.2 Calibration Certification

Each calibrated switch shall be provided with a certificate of calibration that identifies it by model number, serial number where applicable, and tag number. The certificate shall include calibration data to document both the specified and the calibrated switch setting for the specified measurement range. The certificate shall certify that all tests were performed with equipment whose calibration is directly traceable to the NIST. Each instrument shall be calibrated with an MGTG to INST ratio of 2:1 (Calibration equipment should be a higher classification than the instrument being calibrated). Copies of the certificate shall be provided to the Owner.

17300.9 Handheld Communicators

Transmitters with HART outputs shall communicate digitally with a handheld programming device for input of configuration data and to perform diagnostic functions. Each handheld communicator shall be furnished with the largest amount of memory available from the manufacturer and a Data Pack to allow for the storage of up to 500 device configurations in removable, nonvolatile memory.

17300.10 Engineering Data

Drawings, data, and reports shall be submitted to the Owner for review or record as specified in the supplemental sections and as below. All submitted drawings shall contain the following:

End user name.

Applicable generating unit number.

Device described in the drawings.

Owner/Engineer's specification number.

Applicable device tag number.

17300.10.1 Panels

The following documentation shall be submitted to the Owner for review for each panel specified in the instrumentation sections. Panels shall meet the area classification indicated for their installed location. Exterior panels shall be NEMA 4 minimum, and in potentially corrosive atmospheres shall be NEMA 4X. If panel terminal designations, device interconnections, device features and options, or other features are modified as a result of the fabrication process or factory testing, revised drawings shall be submitted:

Fabrication drawings and details of wiring, piping, and painting. Panel and subpanel drawings shall include overall dimensions, metal thickness, door swing, mounting details, and front of panel arrangement to show general appearance, with spacing and mounting height of instruments and control devices.

System wiring and installation drawings for all interconnecting wiring between components of the systems furnished and related equipment. Wiring diagrams shall show complete circuits and indicate all connections.

Schematic diagrams.

Details, specifications, and data covering the materials used.

Descriptions and drawings as necessary to describe parts, devices, and accessories forming the equipment furnished.

17300.10.2 Not Applicable

17300.10.3 Not Applicable

17300.10.4 Transmitters, Analyzers, and Process Switches

The following shall be submitted to the Owner for review:

Drawings showing dimensional data.

Model number.

Weight.

Terminal block arrangement and designation.

Hazardous and/or environmental area classification.

Other information specified.

17300.10.5 Certified Drawings

Drawings shall be furnished factory certified correct as-built for dimensions, calculations, material originations, and postweld stress relieving. Final primary flow element details and calculation results shall be tabulated in data sheet format similar to the Instrument Society of America primary element specification forms. If bound herein, any copies of the Primary Element Data Sheets shall be revised to show final data and shall be submitted to the Owner.

17300.10.6 Instruction Manuals

Instruction manuals preparation and submittal of the preliminary and final instruction manuals.

Table of contents and index tabs.

Specifications.

Description of the equipment.

Operating instructions.

Instructions in the methods of receiving, inspection, storage, and handling.

Complete installation and maintenance instructions.

Assembly drawings.

Parts lists.

Nameplate information and shop numbers for each item of equipment and component part thereof.

List of recommended spare parts and prices.

List of maintenance tools furnished with the equipment.

MSDS if applicable or statement that MSDS is not applicable.

17300.11 Codes and Standards

Work performed under these specifications shall be 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference:

Table 17300-1 Codes and Standards

Work	**In Accordance With**
Instrumentation	ANSI (American National Standards Institute)
	AGA (American Gas Association)
	ASME (American Society of Mechanical Engineers)
	ASTM (American Society for Testing and Materials)
	FM (Factory Mutual)
	IEEE (Institute of Electrical and Electronics Engineers)
	ISA (Instrument Society of America)
	NEMA (National Electrical Manufacturers Association)
Flanges	ANSI B16.5
Piping	ANSI B31.1

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SECTION 17301
STAINLESS STEEL TAGS

17301.1 General

Stainless steel tags shall be furnished as specified herein. In general, a stainless steel tag shall be furnished for each instrument.

17301.2 Construction

Each stainless steel tag shall be attached to the instrument with 16 AWG stainless steel wire or rivets. The first two lines of each tag shall be legibly stamped, engraved, or electro/laser etched with the appropriate "ABBREVIATED DESCRIPTION" as shown on the Contractor's instrument list or data sheet; the same process shall be followed with the third line adding the appropriate "ID NUMBER." Each tag shall be constructed from stainless steel material at least 18 gauge in thickness. The Owner's ID number shall be engraved on the stainless steel tag.

17301.2.1 Size

Each tag shall be at least 3 inches by 5 inches in size. It shall hold at most three lines of text with not more than 20 characters per line.

17301.2.2 Text

Lettering shall be electro/laser etched, stamped, or engraved on a polished plate, with text at least 3/16 inch in height, 1/16 inch in depth. Text shall be sized as large as possible within the size constraints of the tag. Stamping shall be done in such a manner that the information will remain readable if the tag is painted over.

17301.3 Not Used

17301.4 Not Used

17301.5 Manufacturer's Nameplates

In addition to the nameplate described above, a manufacturer may also furnish its standard nameplate. This manufacturer's standard nameplate shall also be stamped, engraved, or electro/laser etched with the Owner's "ID NUMBER." This nameplate shall be permanently attached to each instrument and shall include the manufacturer's standard information such as the following:

Manufacturer's name or trademark.

Serial number.

Model number.

Pressure rating.

Body material.

ID number.

Adjustable range.

Input range.

Output range.

Power required.

Explosionproof with CL, Div. & Grp. and UL or FM marking or stamp.

Intrinsically safe equipment with CL, Div. & Grp. if limited where applicable.

NEMA enclosure rating.

SECTION 17302
PHENOLIC NAMEPLATES

17302.1 General

Furnish phenolic nameplates as specified herein. In general, furnish permanently mounted phenolic nameplates for control stations, certain instruments, and major equipment including all operator interfaces, control and electrical panels, cabinets and enclosures, and instrument racks.

17302.2 Construction

Construct each nameplate with a brief description of the equipment and the Owner equipment identification number legibly engraved on its face. Where applicable, equipment shall be labeled with the voltage level and the source of the normal power feed. If there is a backup power feed to the equipment, the backup power feed shall also be identified on the nameplate. Each nameplate, except nameplates for emergency devices or back-of-panel instruments, shall be beveled, laminated three layer white phenolic plastic engraving stock with black core unless specified otherwise in Section 17300. Nameplates shall be on the minimum height as shown on the Engraved Nameplate Standard for Electrical Equipment.

17302.2.1 Equipment Cabinet and Enclosure Nameplates

Each nameplate shall be 2 inches by 8 inches in size and shall hold at most three lines of text. The top two lines of text shall be a brief description of the equipment and shall be 3/8 inch high. The bottom line of text shall be the equipment "ID NUMBER" and shall be 3/16 inch high.

17302.2.2 Local Control or Indicating Station Nameplates

Provide each local control station or indicating station with one nameplate 3/4 inch by 3 inches in size. Each nameplate shall hold at most two lines of text 3/16 inch in height. Use both lines of text for the service description of the equipment, including an abbreviated equipment number.

17302.2.3 Panel Mounted Instrument Nameplates

Provide nameplates for panel mounted instruments on both the front face and rear face of the panel. Nameplates shall be affixed to the panel surface adjacent to the instrument. They shall be 1 inch by 3 inches in size and shall hold at most three lines of text. The top lines of text shall be the instrument "ABBREVIATED DESCRIPTION" and shall be 3/16 inch in height. The bottom line shall be the "ID NUMBER" and shall be 1/8 inch in height.

17302.2.4 Fasteners

Nameplates for instruments or equipment to be installed in non-air-conditioned areas shall be attached with stainless steel pan head screws, drive screws, or rivets, or epoxy glue. The method used to attach the nameplates shall not affect the enclosure NEMA rating of the enclosure or equipment on which the nameplates are being attached. Epoxy glue is allowed as a substitute should the screw methods compromise the NEMA rating of the instrument or equipment where the nameplate is to be installed. Embossed tape will not be permitted for any application.

17302.2.5 Installation

Surfaces shall be degreased and cleaned prior to the attachment of the nameplates. Nameplates shall be installed parallel to equipment lines.

SECTION 17501
TEMPERATURE TRANSMITTERS

17501.1 General

Furnish temperature transmitters as specified herein, and in accordance with Section 17300 - Instrumentation.

17501.2 Required Features

Furnish each unit constructed in "hockey-puck" style with "smart" microprocessor-based transmitter integrally mounted with its temperature sensor. Transmitter features shall include output damping and internal diagnostics. Each temperature transmitter shall include all features listed below:

Table 17501-1 Required Features	
Housing Construction	In accordance with the application
Supply Voltage	24 VDC
Indication	In accordance with the application
Memory	In accordance with the application
Recalibration	In accordance with the application
Burnout	In accordance with the application
Fault Reset	In accordance with the application
Overrange/Underrange	In accordance with the application
Inputs	In accordance with the application
Input Response Time	In accordance with the application
Outputs	4-20 mA analog, two-wire, linear with process engineering units
Output Action	In accordance with the application
Output Isolation	In accordance with the application
Surge Suppression	Compliant with IEEE C62.41 Cat. B and IEEE C37.90.1.
Ambient Conditions	Refer to site weather conditions.
Hazardous Area Classification	In accordance with the application

17501.3 Temperature Sensors

Each transmitter input shall be coordinated with the device type required by the application. The Contractor shall confirm the suitability of each temperature transmitter for its service conditions.

17501.4 Not Used

17501.5 Field Mounting

Where required by the environmental, the transmitter shall be furnished separate from its sensor assembly in an explosionproof junction box for mounting by the Contractor on a pipe stand flat surface.

17501.6 Integral Mounting

Where no special is necessary, furnish each transmitter mounted in and wired to a sensor assembly as specified below.

17501.7 Sensor Assemblies

Sensor assemblies shall include thermocouple or resistance temperature detector (RTD) thermal elements, thermowells, connection heads with terminal blocks, and extension nipples. Each sensor assembly shall have standard limits of error (ANSI MC96.1-1982). Each sensor assembly shall be factory tested for open circuits prior to shipment.

17501.7.1 Connection Heads

Thermocouple assemblies shall be furnished complete with weatherproof connection heads and nipple-union-nipple assembly. Heads shall be designed for positive connection to the thermowell and for a terminal temperature differential of not more than 0.1° F. Each head shall be internally threaded and fabricated from aluminum and shall allow for integral mounting of a "hockey-puck" style temperature transmitter. Each element shall be furnished with separate positive and negative terminals for extension wire connection and with a grounding screw for termination of each extension wire shield. Terminal blocks shall be dual style for two temperature elements. Terminal blocks shall be compression style with nickel-plated brass blocks on a ceramic baseplate. Slotted-post or other style blocks are not acceptable. Nipple-union-nipple assembly shall be stainless steel, 6 inches in length. Each connection head cover shall be attached to the connection head with a stainless steel chain. The chain shall be attached to the cover and the head with stainless steel screws or rivets. The electrical conduit connection shall be 3/4 inch NPT.

17501.7.2 Sensor Design

Each sensor shall have a compacted magnesium oxide insulated sheath with a spring to assure positive mechanical contact between the active portion and the bottom of the thermowell. Sensor sheaths shall be constructed of 304 stainless steel and have 1/4 inch outside diameters. For thermocouple type sensors, extension wire diameter shall be a minimum of 20 AWG. Sensor assembly design shall facilitate removal of the sensor from the thermowell during normal operating conditions.

17501.8 Approved Manufacturers

For the following components, only the listed manufacturers are recognized as maintaining the level of quality of workmanship required by these specifications:

Table 17501-2 Approved Manufacturers

Component	Manufacturer
Temperature Transmitters	Ameren Missouri Approved Suppliers

17501.9 Technical Attachments

17501.10 Supplemental Specifications

Not Used.

SECTION 18031
ELECTRICAL STARTUP, TESTING, AND CHECKOUT

18031.1 General

18031.1.1 Scope of Work

This section describes and defines general criteria which pertain to the startup, testing, and checkout work covered by these specifications. This work is in addition to testing activities required in other sections of this specification and the Owner's Commissioning procedures, forms, and processes as reference in Section 1D, 4.0 Testing. The Contractor shall be responsible, as part of the base scope, for all labor and materials required to demonstrate that the electrical equipment has been installed correctly and functions properly. Functional testing shall include a demonstration that all major equipment installed can be operated in accordance with the design from local and remote stations, control loops and protective devices perform as designed, and other equipment operates in accordance with their specification. After such demonstration, the systems and components shall be turned over to the Owner.

Upon acceptance of mechanical completion, the Contractor shall provide standby craft labor to correct discrepancies found during initial operation. Such standby craft labor shall not be utilized for completion of Contractor punch list items for work identified as resulting from Contractor's lack of construction completion or Contractor's warranty work. Construction checkout of all electrical systems shall be provided by the Contractor subject to approval by the Owner. The scope of work extends to all equipment connected and/or installed under these specifications.

The Contractor test procedures and plans shall meet NETA and IEEE standards for testing of switchgear, load centers, MCCs, wet and dry transformers, relay protection, and circuit breaker testing, as well as circuit loop checks and control loop checks. The Contractor shall document all testing and inspections on Owner's commissioning checkout forms or Contractor's forms approved by the Owner. The Contractor shall supply to the Owner's Startup group their proposed Electrical and Instrumentation Testing procedures for review.

All checkout and testing leading up to operation testing of equipment shall be performed by a Contractor specializing in this type of work: NETA certification shall be required for electrical testers engaged in live testing of power equipment such as transformers, protective relays, switchgear, switches, buswork, motors, cable, breakers, contactors, breaker and motor control circuits, DC systems, emergency generators, and other applicable power devices.

The following activities shall be performed as part of the equipment installation. The Contractor shall perform all mechanical and electrical work required to calibrate, check out, and make the equipment ready for service as required by these specifications.

The following activities shall be completed under these specifications:

Visual and mechanical inspection of equipment.

Mechanical adjustment and testing of all electrical equipment, as required, to ensure proper mechanical functioning and operation.

All testing and reconnection necessary to obtain correct operation of the electrical equipment.

Loop verification of all control and instrumentation circuits to confirm continuity of conductors and that conductors originate and terminate at the locations designated on the drawings.

All mechanical adjustment necessary or recommended by the manufacturer of all Contractor-supplied electrical equipment being connected or installed. Stainless steel shims cut to the same size as the motor foot shall be installed beneath each motor

wherever practical when aligning shafts so that future realignment may be performed without grinding the motor baseplate.

All motors shall be checked for proper rotation before connection to the driven equipment. A record shall be kept of all motor rotation checks.

Complete testing of the lighting and receptacle system (including welding receptacles added to the system).

All cable and wiring tests (in accordance with Section 16510) are complete.

All circuit installation records (in accordance with Section 16925) are complete.

All instruments are wired and calibrated.

Protective relaying and settings, including current and potential transformers.

After all equipment testing has been completed, the electrical equipment such as switchgear, MCCs, control panels and cabinets, etc. shall be cleaned of dust, dirt, debris, and other foreign matter prior to turn-over to the Owner. The Contractor shall verify that any air filters on the panels have been properly installed and are in good condition.

Assistance shall be provided by the Contractor as required during trial operation and functional testing to correct installation deficiencies.

18031.1.2 Not Used

18031.1.3 Not Used

18031.1.4 Codes and Standards

Work performed under these specifications shall be done in accordance with applicable 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 Owner's specifications. In case of conflict, the latter shall govern to the extent of such difference.

18031.1.5 Not Used

18031.1.6 Not Used

18031.1.7 Test Requirements

The following testing shall be conducted in accordance with the requirements stated throughout the specifications and with the specified reference standards below. This testing is to be considered part of the defined Scope of Work. The Contractor is responsible for all costs associated with correcting deficiencies and retesting in the event of a test failure:

Table 18031-1 Test Requirements

Tests	In Accordance With	Conducted By
Acceptance Testing	IEEE, NETA	Contractor

18031.1.8 Not Used

18031.1.9 Not Used

18031.2 Not Used

18031.3 Execution

18031.3.1 Calibration, Testing, and Checkout Procedures

The following procedures shall be performed and followed by the Contractor. The Contractor shall inform the Owner that specific items, devices, or systems are installed and available for checkout. Documentation of the inspections and testing shall be recorded on Owner-approved checkout forms.

18031.3.1.1 Inspection. The Contractor shall inspect the installed instrument systems and the installed equipment specified herein prior to starting calibration and checkout and shall report in writing to the Owner all deficiencies that could prevent proper checkout of such equipment and systems. Such deficiencies, if caused by or during installation by the Contractor, shall immediately be corrected.

18031.3.1.2 Discrepancy Procedure. The Contractor shall endeavor to promptly discover major discrepancies in equipment, materials, and installation so that corrective procedures can be initiated without delay. When the Contractor discovers equipment with an incorrect rating, damage, not being as specified, or is otherwise unsatisfactory, arrangements shall be made for replacement of the equipment. The Contractor shall promptly report to the Owner any improper field installations or material usage which the Contractor believes should be corrected. The Owner shall be kept informed of the status of the corrective action by the Contractor.

18031.3.1.3 Calibration in-Place. All equipment furnished and installed by the Contractor shall be calibrated at the site after installation and calibration may be witnessed by Owner. The Contractor's technicians performing the calibration shall be experienced in the calibration and adjustment of mechanical equipment and final drive devices of that type. Technicians shall be experienced in working with the necessary diagrams and documents in accordance with the calibration and checkout work assigned to each technician.

Devices and equipment shall be adjusted and calibrated with the equipment normally installed in place. Exceptions to this procedure will be permitted with the concurrence of the Owner for the specific device categories for which in-place calibration is not practical.

18031.3.1.4 Calibration Range. Analog devices shall be calibrated to be accurate within the manufacturers' specified tolerances over a range of 0 to 100 percent full range, with check readings for accuracy and hysteresis at 0, 25, 50, 75, and 100 percent of full range. Digital or switch contact devices shall be set to actuate or change state at the required process condition and shall be checked for accuracy and hysteresis (deadband) at this condition. Both accuracy and hysteresis for both analog and digital devices shall be certified to be within the manufacturers' stated tolerances. For instrumentation that interfaces with the DCS, all ranges will be confirmed through the DCS for accuracy. Discrepancies between the Contractor calibration range and DCS calibration range will be resolved by the Contractor.

18031.3.1.5 Not Used.

18031.3.1.6 Contractor-Caused Defects. The Contractor shall promptly repair at no additional cost to the Owner any of the Owner's equipment or devices or the Contractor-supplied equipment which is damaged by the Contractor's personnel in the course of performing the work. Such damage shall be promptly reported to the Owner.

18031.3.1.7 Manufacturers' Procedures. The Contractor shall follow the manufacturers' instructions in the performance of his work and perform all required and recommended tests, calibrations, and adjustments to settings identified in the drawings and installation and operating instructions from the manufacturers of the equipment appropriate to the work. This shall include any testing or verification required to uphold the manufacturer’s warranty. This shall also include any testing and maintenance required by the manufacturer while equipment is in storage or stasis.

18031.3.2 Personnel

The Contractor shall provide all personnel required to complete the work in accordance with the project schedule. The Contractor shall provide sufficient qualified staff so that the project schedule is met.

The Owner will have the authority to approve and require changes in the Contractor's actual manpower level, including the number of technicians and craft personnel assigned. The number authorized and required may be above or below the Contractor's planned number.

Personnel not performing safely and efficiently, in the opinion of the Owner, shall, upon notification to the Contractor, be immediately removed from the project.

Personnel provided by the Contractor shall include the following classifications.

18031.3.2.1 Startup Coordinator. The Contractor's Startup Coordinator shall be experienced in the supervision of power plant calibration and checkout operations and in the required coordination with the Owner.

18031.3.2.2 Electrical and Instrumentation Technicians. The Contractor's technicians shall be experienced in the calibration and adjustment of electrical apparatus, instrumentation, control equipment, and final drive devices. Technicians shall be experienced in working with control electrical schematic and wiring diagrams, electrical one-line diagrams, and electrical three-line diagrams in accordance with the calibration and checkout assignment.

18031.3.2.3 Craft. Sufficient numbers of craft personnel shall be provided by the Contractor to support completion of the work included under these specifications.

The Contractor shall provide all labor, supervision, materials, equipment, vehicles, supplies, and services necessary to provide field tests and adjustments required to demonstrate that electrical systems are correctly installed, tested, and calibrated.

18031.3.3 Tools and Test Equipment

The Contractor shall provide all required tools and test equipment to perform the work in accordance with these specifications and the project schedule. The test equipment shall be periodically certified. Any test equipment found out of tolerance during certification shall be replaced or repaired.

The Contractor shall provide as many items of each category as are required to perform the work in accordance with the project schedule. The Contractor shall provide the Owner with a copy of all certifications for test equipment used on the project including any recertifications or replacement certifications.

18031.3.4 Test Instrument Certification

The Contractor shall provide and maintain an onsite facility to perform periodic certification of test instruments and equipment. Test instruments subject to drift or non-obvious miscalibration shall be certified at least weekly. The Contractor's QA program shall be capable of providing verification that the certification is being performed.

Certification methods shall follow recommendations of the test instrument manufacturers.

The Contractor's personnel performing certification shall be specially trained in the methods and procedures for carrying out these calibration certifications.

18031.3.5 Calibration or Testing Certification Sticker

The Contractor shall furnish and affix a self-adhesive label to each device calibrated or adjusted. The label shall indicate the date and the name of the person performing the calibration or adjustment.

18031.3.6 Checkout and Test Report Forms

The Contractor shall complete a Checkout and Test Report Form for all instruments, mechanical devices, and electrical devices that are tested or calibrated. The blank forms to be used by the Contractor will be

furnished by the Owner or alternately, the Contractor's standard forms may be used if accepted in writing by the Owner. No increase in contract price will be allowed for not using the Contractor's standard forms. Completed forms shall be submitted to the Owner as part of the turnover package. Forms shall be submitted to the Owner as part of the turnover package.

18031.3.7 Startup

Startup will be under the jurisdiction of the Contractor throughout the startup period.

The Owner will place WPA (LOTO) on any existing plant equipment or any new equipment that has been turned-over and accepted by the plant in order for the Contractor to perform any work. While under local control WPA the Contractor may operate the equipment but must coordinate with Plant Operations.

Except as stated elsewhere, the Contractor shall render all services and do all work required to place each item of equipment installed by him, including all auxiliaries, in operating condition to the satisfaction of the Owner. All equipment shall be prepared for operation as recommended by the equipment manufacturer, and as verified by the Owner's Operations personnel. It is anticipated that extended hours will be required during the startup phase of the facility. The Contractor shall include in the scheduling of the work and allocation of manpower, appropriate allowances for the additional requirements of startup and extended hours. These allowances shall include all regular and overtime payrolls and all other contingencies in connection with the plant startup and initial operation in the base Contract price.

Individual systems and items of equipment shall be completed in a sequence that will permit systematic checkout and trial operation of each such component before it is incorporated in the initial operation.

The Owner will furnish operations personnel during startup to support the Contractor's Startup personnel. The Owner will be the only party authorized to operate permanent plant equipment. This, however, does not relieve the Contractor from the responsibility of ensuring that all equipment is being operated correctly and in accordance with the manufacturer's instructions. The Contractor shall provide all other workers required to make adjustments, couple equipment, and correct deficiencies during the equipment and plant checkout and operation.

The Contractor shall provide, install, maintain, and then remove (if applicable) all temporary instrumentation and gauging devices required during checkout and trial operation of the equipment and systems.

18031.3.7.1 Equipment Checks and Calibration. Preoperational checks and inspections shall be performed on all equipment as specified herein and in accordance with the equipment manufacturer's recommendations. A representative of the Owner will be present during equipment checks at the discretion of the Owner. The sequence of preoperational checks will vary with the system being tested and shall be as directed by the Contractor and according to the approved schedule. Motor coupling shall not normally be performed until preoperational electrical and control testing has been completed.

The Contractor shall verify in writing that all work and preoperational checkouts have been completed and, when the services of equipment manufacturers' field service representatives are specified, the Contractor shall also include verification by such representatives that the equipment is ready for trial operation.

18031.3.8 Electrical and Instrumentation Checkout

This article defines the scope of checkout for electrical and all instrumentation devices and equipment which shall be calibrated in-place, adjusted, or checked out by the Contractor as part of the work covered by these specifications.

18031.3.8.1 Equipment Checks. Preoperational checks and inspections shall be performed on all equipment as specified herein and in accordance with the equipment manufacturer's recommendations. A representative of the Contractor shall be present during the equipment checks. All field tests shall be witnessed by the Owner at the Owner's discretion.

Preoperational checks shall include, but not necessarily be limited to, the following:

Safety Equipment.

All bolting shall be securely tightened to the correct torque as recommended by the equipment manufacturer.

All temporary shipping braces, blocks, or tie rods shall be removed.

Instrumentation and Controls.

Interlock jumpers shall be removed.

Panel instrumentation shall be turned on.

Lighting and Receptacle Checkout.

The Contractor shall test and check out the lights and receptacles furnished and installed under this Contract. Lights shall be energized as soon as circuits are certified complete so as to facilitate increasing the lighting level for construction and checkout. Immediately before energizing a lighting or receptacle circuit, the Contractor shall make the following checks:

The transformer neutral supplying the source panelboard is solidly connected to ground.

The phase and neutral conductors to be energized are free from grounds.

All covers are on lighting fixtures, pull boxes, and junction boxes so exposed conductors will not be energized.

The ground conductor (if required) is solidly grounded.

After completing the pre-energization checks, the Contractor energize the circuit.

All metering, including panel meters and transducers, shall be calibrated to within the manufacturer's accuracy.

Panel instrumentation indicating lights, switches, and relays shall be adjusted and checked out as part of the checkout of the Contractor-installed electrical equipment. Electric metering for volts, watts, amperes, and other electrical quantity functions shall be checked out as described in this article and the following article.

Panel indicators shall initially be calibrated by simulating the electronic signal normally received by the indicator. The final calibration shall be performed using the actual transmitter, signal converter, or system output that is to be connected to the indicator. The transmitter-receiver combination shall be calibrated to read out accuracy tolerance no greater than twice the average tolerance of the individual devices throughout the range from 0 percent to 100 percent of total scale. In certain instances for specific equipment, the Owner will specify a range of interest. In these cases, the Contractor shall calibrate the transmitter-receiver combination to read exactly correct within the stated range of interest with the calibration standard being utilized.

Electrical panel instrumentation shall be calibrated.

Unless specified otherwise, all meters shall be tested and calibrated with equipment of no more than 50 percent of the manufacturer's stated accuracy instrument being tested.

All meters shall be visually inspected for damage, and wiring connections shall be verified in accordance with the three-line diagrams.

Every instrument utilizing a plastic lens or window shall be given a static effect check. The static check shall consist of wiping the lens or window vigorously with a dry cloth of a type recommended by the manufacturer which will not harm the surface. If the needle or pointer holds up-scale or below zero set for more than 15 seconds, the surface of the lens or window shall be treated with a clear antistatic compound recommended by the manufacturer.

The Contractor shall verify that direct grounds do not exist on any dc or 480 volt powered systems. Should a ground be detected, the Contractor shall locate the ground source and inform the Owner.

Measurement of resistance to ground shall be made of all motors, switchgear, isolated phase bus, cable bus, panelboard bus, nonsegregated phase bus, and MCC bus immediately prior to placing in service. Measurement of resistance will be with a line operated tester. Voltage of testing device shall be in accordance with the following table or the equipment manufacturer's recommendation, as directed by the Owner: The Contractor shall remove the ground source at the direction of the Owner:

Table 18031-2 Equipment Testing Voltage and Test Current

Equipment Voltage	Voltage, dc	Test Current, max, mA
480 volts	1000 volts	3
4.16 kV	2 kV	1
Above 4.16 kV	5 kV	1

For each transformer rated 500 kVA or larger, measurement of resistance to ground and the polarization index of each winding with all other windings grounded shall be made. Measurements shall be made with a winding tester. Measurements for each transformer shall be made immediately prior to placing in service. If a transformer winding has a resistance to ground or polarization index less than recommended by the manufacturer, the transformer shall not be placed in service. The voltage of the testing device shall be in accordance with the preceding table.

All 5 kV and above power cable shall be hi-pot tested in accordance with IEEE and ICEA standards.

Complete check of all field wiring shall be made after installation and connection to verify that field wiring is as indicated on the drawings and schematic wiring diagrams. Equipment jumpers as indicated on the schematics shall be checked. Discrepancies shall be resolved and the drawings and schematic wiring diagrams shall be updated accordingly.

Shielded cable ground check should be made after termination is complete using a volt-ohm meter to determine that each is grounded only at the points indicated on the drawings.

All instrument transformers, including bushing current transformers, shall be tested.

Ratio and polarity tests shall be performed on all instrument transformers. Current transformer ratio and polarity tests shall be voltage ratio tests using a digital voltmeter or current ratio tests using high current injection test equipment.

The external circuit for each current transformer shall be completely tested before the shorting devices are removed from the current transformer secondary terminals. The tests shall include the following:

Continuity check of the circuit external to the current transformer by application of current.

Phase check to verify correct phase relationship at each device connected in the current transformer circuit.

All protective and alarm devices associated with all power transformers with primary voltage of 4160 volts or higher shall be tested for correct operation and adjusted as required according to the manufacturer's recommendations. This work shall include, but not be limited to, the following:

Transformer sudden pressure relays.

Transformer pressure relief device.

After all equipment testing has been completed, the electrical equipment such as switchgear, MCCs, control panels and cabinets, etc. shall be cleaned of dust, dirt, debris, and other foreign matter prior to turn-over to the Owner. The Contractor shall verify that any air filters on the panels have been properly installed and are in good condition.

The Contractor shall verify in writing that all work and checkouts have been completed, and when the services of equipment manufacturer's field service representatives are specified, the Contractor shall include verification by such representatives that the equipment is ready for trial operation.

18031.3.8.2 Corrected Drawings. The Contractor shall furnish three sets of the following drawing categories to the installing staff or subcontractor for markup purposes:

Electrical schematic and wiring diagrams.

Electrical one-line and three-line diagrams.

Circuit and raceway lists.

Equipment and instrument lists.

I/O lists.

The Contractor shall neatly and legibly mark each set, in triplicate, including all field corrections performed during calibration and checkout. One copy of each drawing shall be submitted to the Owner as a part of the completed forms returned with each subsystem startup package. A second set shall be turned over to the Owner for use by Startup and Operations personnel during commissioning. The third copy shall be retained by the Contractor until the conclusion of the project. The Contractor' shall update the drawings and lists that have marks and submit final record copies to the Owner at the conclusion of the project.

18031.3.9 Operational Control (Lock Out/Tag Out)

Prior to turnover to the Owner, the Contractor shall use their own lock-out/tag-out (LOTO) system. The LOTO system used by the Contractor will be reviewed and approved by the Owner.

After the equipment is turned over to the Owner, the Owner will establish a system of control to protect personnel and equipment as the equipment and systems are completed and capable of energization.

The system will consist of placing appropriate tags on equipment and system components to indicate their status and requiring mandatory clearances from designated personnel to operate, energize, or remove from service the equipment or systems. The controls established will encompass the following phases:

Equipment or systems completed to the point where they may be energized, pressurized, or operated, but that have not yet been checked out, shall be locked/tagged, and the sources of their power or pressure will be turned off and tagged. The affected components shall not be operated without clearance.

Following initial operation of the equipment or system, locking/tagging shall be performed as stated above and the affected components shall be operated only by the personnel designated by the Owner.

Equipment and systems released for service shall be so tagged for Commissioning only. Only the personnel designated by the Owner shall operate or remove from service such systems or equipment. When a request to remove a system from service is made, all controls and sources of power and pressure affecting that system shall be tagged out and

shall not be operated under any circumstances. Only the personnel originally tagging the system shall be allowed to clear the system for service.

The Contractor shall establish the procedures and details of the LOTO control system and the Owner will approve the procedures and details.

Once each piece of equipment is fully commissioned and the equipment is turned over to the Owner, the equipment shall be locked and tagged out using the Owner's Workers Protection Assurance (WPA) program, which is the Owner's Lock-out Tag-out (LOTO) system.

All notifications of status and requests for clearances or operation shall be made to the Owner. To protect the equipment or systems from damage, and to ensure the safety of all personnel, the procedures established shall be strictly followed and adhered to.

APPENDIX A - SAFETY AND CONTRACTOR REQUIREMENTS

1.0 GENERAL CONTRACTOR SAFETY REQUIREMENTS

Contractor and their employees are responsible for their safety.

1.1 Contractor General Requirements

1.1.1 Contractor supervision and personnel shall obtain site-specific training. This will include, but not be limited to:

- Workman's Protection Assurance (WPA) / Hold Tag Equipment Lock-out
- Hot Works
- Confined Spaces
- Commissioning WPA Procedure
- Other Safety Requirements listed in this specification

Note: Contractor employees may be barred from Ameren property for failure to comply with WPA procedures. Contract may be terminated or Contractor may lose future work for failure to enforce WPA. See Attachment A9 – WPA Authorization Form for sign-on access to the Ameren automated WPA system at each plant site.

1.1.2 Contractor administers appropriate disciplinary action if their employees violate Job Working Rules.

1.1.3 Contractor must hold daily job briefings.

1.1.4 All rolling equipment must be inspected prior to use.

1.1.5 Ameren reserves the right to bar any individual from Company property.

1.2 Rules to Live By

Rules to Live By is focused on activities that have the potential to produce a fatality or serious injury. While there are many hazards that can produce serious injuries, the items listed below are so significant that a single violation warrants immediate intervention by the Contractor. Actions determined to be in violation of these rules may result in permanent barring from all Ameren facilities. Ameren may conduct an independent investigation as necessary.

- Fall Protection – Failure to use proper fall protection when there is a risk of a fall that is greater than 6 feet
- WPA (Lock Out / Tag Out) – Violation of a tag, lock or tag-out device that is used for employee and contractor protection.
- Electrical Safety – Failure to follow the proper procedures and wear proper personal protective equipment when working on energized equipment.
- Confined Space Entry – Failure to evaluate a confined space and perform air monitoring checks prior to entry.
- Rigging / Hoisting – Walking or working under a suspended load.
- Trenching and Shoring – Entering an excavation greater than 5 feet deep that has not been properly sloped or shored.

1.2.1 It is the expectation that the Contractor will enforce our RTLB program and discipline the RTLB violators. All violators will be removed immediately from the site, after which the Contractor will be required to formally submit on their letterhead a detailed report on the incident, noting internal meeting(s), additional training that was conducted, and what will be done to prevent a reoccurrence, prior to return of the employee.

1.2.2 Violations of other safe work practices also may result in permanent barring from all Ameren Facilities.

1.2.3 Contractors will be assessed $2,000 per RTLB violation that Ameren personnel find during the project. Contractor is to donate assessment to a mutually agreed-upon charity.

1.3 Safe Work Practices

1.3.1 Hard hats with bill facing forward, appropriate safety shoes and foam-lined safety glasses with side shields **must be worn at all times in all locations** past the Construction Gate. Safety shoes must be compliant with ANSI Z41 effective January 2008. Safety glasses must be compliant with ANSI Z87.1 or equivalent. Supervisors may permit the removal of hard hats and safety glasses in areas such as trailers, or training rooms.

1.3.2 Wear a hardhat, safety glasses, and a welding hood when welding.

1.3.3 Wear foam-lined safety goggles over non-safety rated prescription eyewear.

1.3.4 Foam-lined safety glasses shall be worn at all times. Contractor employees who wear prescription safety eyewear shall also have the foam-lined feature.

1.3.5 Face shields must be worn over safety glasses when grinding, chipping, jack hammering, power sawing, handling hazardous chemicals, or performing other tasks that could result in a face or eye injury.

1.3.6 Wear appropriate gloves to protect hands from cuts, burns, temperature extremes, chemicals, biological agents or other hazards.

1.3.7 Wear hearing protection when performing noisy work, such as jack-hammering, or where posted.

1.3.8 Hair must be cut or contained above shoulder length and must not interfere with protective headgear.

1.3.9 Shorts, shirts without sleeves or with sleeves rolled up above the shoulder are not permitted.

1.3.10 Gas bottles must be secured to prevent tipping. Gas bottles must be capped or have a regulator installed. Oxy/acetylene bottles must be separated by at least 20-foot or a 5-foot barrier with a one-hour fire rating while in storage.

1.3.11 During welding or “burning”:

- Use temporary shielding to protect personnel beside, above and below the work; free falling of sparks below a cutter/welder’s feet is not allowed
- Contain slag, sparks, etc.
- Place weld rod stubs in containers after removal from stingers, and place all other trash in appropriate containers.

1.3.12 Safety harnesses are required when working on surfaces over six (6) feet high that do not have guardrails or other fall protection. Attach lanyards and lifelines to structural members capable of supporting the load requirement (5000 lbs. anchor point).

1.3.13 On portable man lifts, fall protection is required per manufacturer’s instructions. The lift must be secure and stable prior to use.

1.3.14 For overhead work rolling scaffolds, mechanical lift platforms are preferred over ladders.

1.3.15 If straight or extension ladders must be used, one worker must hold the ladder until another worker has tied the top to a substantial anchor point. Prior to working above 6 feet off the straight or extension ladder, worker is to don fall protection harness with lifeline, using or establishing an anchor point overhead for clip attachment, as required by Rules to Live By.

1.3.16 If a step ladder must be used when the worker’s feet are on or above the fifth rung, the top of the ladder must be tied to a substantial anchor or a second worker must hold the ladder. Prior to working above 6 feet off the step ladder, worker is to don fall protection harness with lifeline, using or establishing an anchor point overhead for clip attachment, as required by Rules to Live By.

1.3.17 Daily clean-up of the work area is required. Keep stairways and aisles clear at all times. Tie extension cords, welding leads, air hoses, etc., to middle rail of the handrail and/or route overhead.

1.3.18 Barricade at least 6 feet from the hole or edge if grating or handrail sections are being removed or installed.

1.3.19 Barricade below lifting/hoisting activities.

1.3.20 All electrical junction boxes, duct panels, etc., are to be kept closed whenever possible.

1.3.21 Vent gas-powered equipment, such as welders, generators, compressors or power tools, to the outdoors. Exhaust from equipment near doors must not enter the plant when the doors are opened.

1.3.22 Plant Fire System Equipment is NOT for routine work unless specifically authorized by the Plant.

1.3.23 If the plant allows Contractor employees to use elevators, observe the following rules:

- No equipment on elevators may extend through the roof access opening.
- Transport bulk materials in freight elevators and obey the posted weight limits.
- Only tools and materials that can be carried by hand are allowed on passenger elevators.

1.3.24 Qualified electricians are required to wear fire-retardant (FR) clothing or 100% natural fibers when working on exposed, energized circuits. FR clothing must meet arc flash labels and be appropriate for the tasks being performed.

1.3.25 Reflective safety vests must be worn by all personnel who work on or near active highways, roads, or parking lots. Vests are also required for other work that places personnel near motor vehicles such as flaggers, riggers, survey crews, etc. ANSI/ISEA 107, Class III high-visibility reflective safety vests shall be worn for maximum visibility. Ameren may require vests on other projects.

1.3.26 We want this to be a SAFE job. YOU CAN HELP. Report all unsafe acts and conditions to your Supervisor. Consult a Contractor or Ameren Supervisor if there are any questions about work rules or safety requirements

1.3.27 Ground Fault Circuit Interrupters (GFCI's) shall be used to protect all 120 VAC electrical equipment including electric hand tools and cord sets. The use of 480 VAC GFCI's is required when working in wet locations.

1.4 Other Safety Requirements

1.4.1 If outages are required, the Contractor shall coordinate with the SPOC to obtain lock-outs and releases in accordance with the Plant's WPA/Hold Card procedures and operating practices. Equipment with a WPA/Hold Card tag shall never be serviced or removed.

1.4.2 Contractors must comply with all Federal, State and Local laws, regulations and ordinances for work in permit-required confined spaces. Contractors shall obtain information from the plant designee on the location and other pertinent information regarding confined space entry. Any entry involving both Contractor and Ameren employees shall be coordinated through the SPOC.

1.4.3 Only qualified and authorized persons should work on energized electrical equipment.

1.4.4 All lifting/hoisting activities near overhead, high tension power lines must include awareness of and observance of the following safe working clearances:

Voltage	Clearance
13.8 kV	10 feet
69 kV	11 feet
138 kV	13 feet
161 kV	14 feet
230 kV	16 feet
345 kV	29 feet

1.4.5 Ameren must review contractor qualifications before contractor employees may work in high voltage areas.

1.4.6 Contractor shall coordinate hot work, (i.e., welding, brazing, heating and cutting), with Company personnel to assure that Ameren safety requirements are met as outlined on Attachment A8 - Hot Work Permit.

1.4.6.1 A Hot Work Checklist/Permit must be utilized when performing hot work such as welding, cutting, grinding, or any other activity that produces sparks. Contractor may use their own forms or Ameren's but work should be coordinated through the SPOC.

1.4.7 Plant equipment identified with a nuclear radiation symbol (as seen below) is NOT to be serviced by unauthorized personnel):

1.4.8 All equipment on the project shall be used in accordance with Federal, State, and Local ES&H requirements in addition to the manufacturer's instructions and guidelines. Equipment shall not be modified in any way for use other than what the manufacturer intended.

1.4.8.1 Any alterations must be approved by the manufacturer in writing. Only trained and authorized persons shall operate machinery or equipment.

1.4.8.2 Use hand-held power tools only for their intended purpose. Do not use tools that are broken, have dull blades, dull bits, have damaged cords, or have damaged/missing guards. Hand-held power tool switches should not be modified by any means to maintain power without constant trigger pressure. (Ref. OSHA 29CFR1910.243.

1.4.8.3 All Grinders guards/handles must remain on grinders at all times. If a guard or handle is required to be removed because of a tight work area, a permit must be completed and maintained at work location. See Attachment A6 - Grinder Plan.

1.4.9 Ameren expects that all Electrical Contractors will follow the common work practice that a check of all wires being demoed is performed to ensure that all wires are dead and de-terminated before wrecking. If wires are found live, verification will be made prior to wires being terminated or cut.

1.4.10 Barricades

NOTE: Do not rely on barricade tape and flags to prevent a fall that is more than 6 feet.

- **When attended, install barricade tape no less than 6 feet from opening.**
- **Use fall protection if personnel are working closer than 6 feet to the opening.**
- **When unattended, cover the floor opening with a temporary cover, or temporary handrails 42 inches in height that include a mid-rail and toe board. Temporary covers must be able to support at least twice the load to which they will be subjected (including people, equipment and/or vehicle traffic).**
- **Temporary covers must be secured when installed in such a way as to prevent accidental movement by wind, traffic, or employees.**

1.4.10.1 Barricades must be used to warn employees about a hazard or restrict employees' access to a hazardous area. Barricades must have an information tag listing the responsible person, date of erection, and purpose. Barricade signs should indicate the Contractor, reason, and expiration date/time. Remove the barricade when work is completed. See Attachment A4 - Barricade Tag.

1.4.10.2 Any employee may erect a barricade. The person responsible for the barricade must remove it when the hazard no longer exists.

NOTE: Any time red Barricade tape is to be used, the Contractor must inform the Construction Project Lead/SPOC, who in turn will notify the Shift Supervisor.

- **Red barricade tape** shall be used to warn personnel DO NOT ENTER dangerous areas. These areas may only be entered with authorization from the person who erected the barricade.

- **Yellow and magenta tape** shall be used to warn personnel DO NOT ENTER an area because radiography is creating a radiation hazard.

- **Yellow barricade tape** shall be used to warn personnel of immediate hazards that have the potential to cause injury. Areas barricaded with yellow may be entered once the hazard is identified and can be avoided.

- **Green barricade tape** shall be used to warn personnel of possible exposure to hexavalant chromium. Respiratory protection is required in these areas.

Contractors are responsible for compliance with the OSHA Regulation on Hexavalant Chromium. "Regulated Areas" should be clearly demarcated with **Green** barricade tape with a caution tag that clearly states the hazard in the work area, e.g. "Hex Chrome Exposure – Respiratory Protection Required." In general, regulated areas should be established a minimum distance from the activity as described below;

1. 5 Feet – Welding on boiler tubes, steam piping and other materials that contain 2.5% chromium or less

2. 10 Feet – Welding on Stainless steel and other materials that contain more than 2.5% chromium.

3. 20 Feet and/or Visible plume – Plasma arc cutting, air arc cutting, chamfer-trodes, cut-trodes and other processes lacking sufficient air monitoring data by Ameren for the protection of our employees.

Contractors are responsible for air monitoring as required for their employee protection and validation of engineering controls. The guidelines for barricading are based on employee exposures based on collection of data by Ameren. These distances are guidelines and may be increased or decreased based on air monitoring data. Ameren Safety Department will request air monitoring data at the beginning of each job, especially if the process is new or not sufficiently monitored in the past.

- A Nuclear Radiation Sign (see Item 1.4.7 above) is used to warn unauthorized personnel not to tamper with or remove instruments or equipment.

- Flashing yellow lights may be used with barricades.

- Other barricades may be used for roadwork and for other special situations.

1.4.11 Incident/Accident Reporting

1.4.11.1 In the event of a incident/injury to a Contractor or Subcontractor employee, the SPOC shall be notified ASAP, and a written report provided no later than 24 hours after the incident/injury.

1.4.11.1.1 This notification shall include a detailed description of the accident or injury, including the names of those involved. Incident/Accident Investigation Report (Attachment A1) and Witness Statement (Attachment A2) must be utilized to provide the required notification.

1.4.11.1.2 OSHA Recordable injuries and minor injuries requiring first aid must be recorded using the First Aid Register (Attachment A3), which must be forwarded to the SPOC.

1.4.11.1.3 On Ameren Coordinated Insurance Program (ACIP) projects, copies of all first reports of injury and supporting investigation information should be faxed to the designated claims manager and ACIP broker (see Ameren Safety Supv. for contact numbers).

1.4.11.2 **For any serious incident or injury:**

- **First — Notify the Plant Shift Supervisor or designee immediately**. The Shift Supervisor will make the Emergency call and implement appropriate Plant Emergency Response procedures.
- **Second — Provide First Aid for the injured** as required until professional Emergency Responders arrive.
- **Third — Secure the area** to ensure safety of other personnel.
- **Fourth — Notify the SPOC** via phone, PA, radio, or in person.

1.4.11.3 The accident scene must be secured for the accident investigation. Equipment or material can only be moved to prevent further injury until a review of the accident is completed.

1.4.11.4 Follow up verbal messages to the SPOC with written notifications within 24 hours as directed in Sect. 1.4.11.1.

1.4.12 Imminent Danger Situations

1.4.12.1 Contractor must suspend work immediately upon discovery of any situation that may, in their opinion, reasonably be expected to cause serious physical harm, illness, death, or significant environmental or equipment damage.

1.4.12.2 ES&H concern(s) must be corrected, to the satisfaction of the Contractor and Company, before work may resume.

1.4.12.3 Examples of “imminent danger” situations may include, but are not limited to the following:

- Falls from elevations,
- Excavations not properly sloped or shored,
- Radiation hazards,
- Electrocution hazards,
- Injury to the public,
- Unsafe operation of vehicles, machinery or heavy equipment,
- Improper or non-existent WPA/Hold Card equipment lockout,
- Release of hazardous substances (OSHA 40CFR Part 302) into the environment in excess of the reportable quantity.

2.0 WORKERS PROTECTION ASSURANCE PROCEDURE FOR OUTSIDE CONTRACT OR CONSTRUCTION PERSONNEL

GENERAL

It is necessary to assure the safety of outside contract personnel and Ameren personnel throughout construction of new system equipment and/or modification of existing system equipment. The following is a brief outline of procedures, to guide outside contract personnel in dealing with Ameren operating authorities to obtain Worker's Protection Assurances (WPA).

2.1 Definition

2.1.1 Worker's Protection Assurance:

WPA is the name given to the process used by Ameren to ensure the safety of those who work on generation, transmission and substation equipment.

2.1.1.1 It's primary purpose is to ensure the SAFETY of the worker.

2.1.1.2 The Ameren WPA system uses a series of Tags and a Sign-On procedure.

2.1.1.3 The reliability and integrity of the WPA process relies upon all persons on the plant site understanding and honoring the WPA Tags and Sign-On procedure.

2.1.1.4 WPA is the Operating Authority's assurance to the person obtaining Worker's Protection Assurance that: (see Operating Authority below)

Either 1) The equipment covered by the Worker's Protection Assurance has been completely isolated from energy sources (see Out of Service below)

Or 2) The equipment is placed in a special status requested by the person receiving the Worker's Protection Assurance (see Local Control below)

2.1.2 Types of WPA Authorities

2.1.2.1 Custody Authority

2.1.2.1.2 The Custody Authority is the person who is responsible for and "in charge" of all of the equipment in a system or power plant (usually the Plant Manager).

2.1.2.2 Jurisdictional Authority

2.1.2.2.1 The Jurisdictional Authority is the individual or group of individuals, responsible for the overall direction and coordination of the Ameren system equipment.

2.1.2.2.2 The Jurisdictional Authority of Plant Equipment (coal pile to turbine) is the Plant Operating Supervisor.

2.1.2.2.3 The Jurisdictional Authority (generator to Electrical System) is the Transmission Dispatcher / Power Dispatcher.

2.1.2.3 Functional Authority

2.1.2.3.1 The Functional Authority is the individual or group of individuals, who perform or direct someone else to perform detailed operations, such as switching or valving.

2.1.2.3.2 The Functional Authority of Most Plant Equipment (coal pile to turbine) is the Operating Supervisor.

2.1.2.3.3 The Functional Authority (Electrical System) is the Transmission Dispatcher.

In a power plant, one person, the Operating Supervisor in the Control Room, approves and issues the WPA.

2.1.2.4 Functional Agents

2.1.2.4.1 One type of Functional Agent is the Unit Operating Engineer (UOE) He creates the documentation.

2.1.2.4.2 Another type of Functional Agent is the Plant Operating Engineer (POE). He performs the work and hangs the tags.

The Plant's UOE and the POE always perform the above duties, never Contractor personnel.

2.1.3 WPA Isolation Point:

2.1.3.1 A WPA Isolation Point may be any of the following energy-isolating devices:

- Switch
- Circuit Breaker
- Valve
- Coupling
- Drive Belt
- Chain

2.1.4 Boundary:

2.1.4.1 A Boundary is a collection of energy-isolation devices that form a "zone of protection or control" around the equipment to be serviced.

- The status of equipment within a WPA Boundary can only be changed after the Holder has Signed-Off the WPA and the WPA tag(s) have been removed.

2.2 Equipment Covered By Worker's Protection Assurances

2.2.1 All system equipment under the jurisdiction of an Operating Authority must be covered by Worker's Protection Assurance when it is to be worked on or tested.

2.2.2 The only equipment that can be covered by Worker's Protection Assurance is equipment under an Operating Authority's jurisdiction.

2.2.2.1 Equipment connected to energy sources but not released to the jurisdiction of an Operating Authority can only be protected by Worker's Protection Assurance on the isolating device (or devices) between the energy source and the equipment.

In this case it is only possible for the Operating Authority to assure the person receiving Worker's Protection Assurance that the particular isolating device (or devices) connecting the new equipment to his energy sources is protected and he cannot assure the person receiving the Worker's Protection Assurance that the equipment is completely isolated. Therefore, it is better for all new equipment to be released to the jurisdiction of an Operating Authority as soon as possible.

2.3 Description and Purpose of Tags

2.3.1 General Notes:

2.3.1.1 When you see a WPA tag on equipment, it is telling you to stay clear of the equipment and keep hands off (violating WPA tags will result in disciplinary action up to and including termination).

2.3.1.2 Only the Functional Authority of the equipment may order tags to be placed or removed.

2.3.1.3 Tags will ordinarily be executed and attached by an Operator or his agent.

2.3.1.4 Tags, record sheets and WPA sheets will have the equipment name, etc., along with the serial number of the WPA record.

2.3.2 Function Authority's Hold Off Tag

2.3.2.1 Definition:

2.3.2.1.1 The Hold Off is an inviolable order of a Functional Authority that the disconnect device(s) which it is intended to cover must not be closed (or opened in the case of valves) under any circumstances unless definitely ordered or approved by him and then only if the Hold Off tag is first ordered removed.

2.3.2.2 Issued to:

2.3.2.2.1 Only to the Functional Authority (never to a worker).

2.3.2.3 Usage:

2.3.2.3.1 The Hold Off is an Operating Authority's tool which he may choose to use any time he feels it would contribute to a safer working environment.

2.3.2.3.2 To properly isolate equipment from all sources of normal energy and tag them with Hold Off tags so the Functional Authority may issue an Out of Service or Restraint to a supervisor or workman so work on designated equipment may proceed.

2.3.2.4 Equipment Status:

2.3.2.4.1 Operator must obtain the approval of, or be acting under the orders of, his Functional Authority before changing the status of, or working on any equipment bearing a Hold Off tag.

2.3.3 Worker's Hold Off Tag

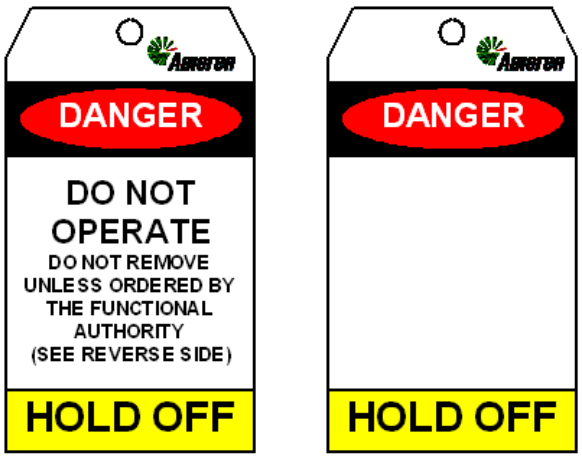
2.3.3.1 Definition:

The Worker's Hold Off is the method by which the Holder of a Local Control isolates equipment he is working on under the Local Control.

2.3.3.2 Workers will create their own Worker's Hold Off tag by legibly signing a blank Power Plant Hold Off Tag. If the Holder of a Local Control wants to work on the equipment, it must first be isolated from its energy supplies. The Holder would open the breaker, close the valves, etc. to isolate the equipment. The Holder must then hang a Worker's Hold Off on top of the Local Control to ensure the breaker or valves remain in the de-energized position. A Worker's Hold Off tag when placed has the same meaning as a Functional Authority's Hold Off. The Holder would need to remove the Worker's Hold Off prior to closing the breaker or opening the valves and operating the equipment.

2.3.3.3 A Worker's Hold Off can only be placed over a Local Control Tag. It cannot be placed by itself.

EXAMPLE OF HOLD OFF TAG



EXAMPLE OF WORKER'S HOLD OFF TAG

Worker's Hold Off

Worker's Hold Off tag to be placed over plant-issued Local Control

2.4 Types of Worker's Protection Assurances

The following types of Worker's Protection Assurances are issued during construction at power plants:

2.4.1 Out of Service (Issued under Hold Off Tag)

2.4.1.1 Definition:

- The Operating Authority's assurance that the equipment designated is properly isolated from all known energy sources and is appropriately tagged so that it will remain de-energized until the Out of Service is released.

2.4.1.2 Energy Status:

- Isolated from all normal sources and emergency back-up energy sources.
- (This does not relieve the person obtaining the protection of the responsibility of making prescribed tests or observations to assure himself that the equipment is safe to work on. Points of isolation and points not to be changed are tagged, where possible, and those points cannot be changed while the Out of Service is in effect. However, equipment inside the zone of protection and not tagged, may be manually operated or tested, since it is in a de-energized state.)

2.4.1.3 Usage:

- Maintenance, including complete removal and disassembly.

2.4.1.4 Issued to:

- Supervisors or Workers when authorized by Custody Authority.

2.4.1.5 Persons Covered:

- Holder and anyone working directly for or with the Holder.

2.4.1.6 Physical Location of Holder:

- Does not have to remain on Plant property.

2.4.1.7 Duration:

- No time limitations. Remains in effect until equipment is ready to be restored to service.

2.4.1.8 Predominance:

- Unlimited number of Out of Services may be issued on a single piece of equipment by various people for various reasons. Multiple tags may be required for isolation.

2.4.2 Restraint

2.4.2.1 Definition:

- The Restraint, which is issued on the Functional Authority's Hold Off, is an assurance given by the Functional Authority to the person to whom it is issued that the equipment it covers has been properly isolated from its energy sources and that normal voltage will not be applied while the Restraint is in effect.

2.4.2.2 Energy Status:

- Isolated from all normal sources and emergency back-up energy sources.

2.4.2.3 Usage:

- The person to whom the Restraint is issued shall have control of the application of test energy in that his consent must be obtained before applying external energy of any magnitude, and he must be informed when the test is completed. Thus, the person should be familiar with the status of the equipment at all times, and to this extent the person shall be responsible for seeing that other persons working on the equipment with that person or under that person's specific direction are protected against the application of test energy.

- The operator of the high-energy source will direct test and connections required following established standards or procedures or in special cases, specific instructions of the Functional Authority. The operator of the high-energy test source will communicate directly with the person who has the Restraint, but the operator may at no time apply energy until the Holder of the Restraint has given the operator permission to proceed.

2.4.2.4 Issued to:

- Supervisors or Workers when authorized by Custody Authority. In cases where several workers will work on the equipment tested, a qualified worker or supervisor shall be designated to act a coordinator on the job, and that person shall obtain the Restraint.

2.4.2.5 Persons Covered:

- Holder and anyone working directly for and with the Holder.

2.4.2.6 Physical Location of Holder:

- Must remain on Plant property and in control of the job. If the Holder leaves the site of the test, he must remain "on-call." The Holder shall not release the Restraint until all persons are removed from the equipment and informed of the intended release.

- The performance of maintenance will be permitted simultaneously with testing on equipment, provided that adequate safety can be maintained between the two jobs.

- If electrical testing is required, the procedures set forth in the System Operating Manual under Restraint, Item 207, will be followed.

2.4.2.7 Duration:

- Released before Holder goes off duty for the day.

2.4.2.8 Predominance:

- Only one Restraint and no other WPA.

2.4.3 Local Control

2.4.3.1 Definition:

- An authority granted to a person (other than a regular operator) that permits him to operate or direct operation of equipment and gives him the assurance that no operations will be performed on the equipment unless requested or personally approved by him.

2.4.3.2 Energy Status:

- May or may not be de-energized. This is why different tags are used. The Functional Authority's Hold Off is not in place for this type of WPA.

2.4.3.3 Usage:

- Short duration maintenance or troubleshooting.

2.4.3.4 Issued to:

- Supervisors or Workers when authorized by Custody Authority. Worker must give the reason for the request. Worker must specify if equipment is to be energized or isolated for him.

2.4.3.5 Persons Covered:

- Holder and anyone working directly for or with the Holder.

2.4.3.6 Physical Location of Holder:

- Must remain on Plant property and in direct control of the job since he is responsible for the safety of his workers.

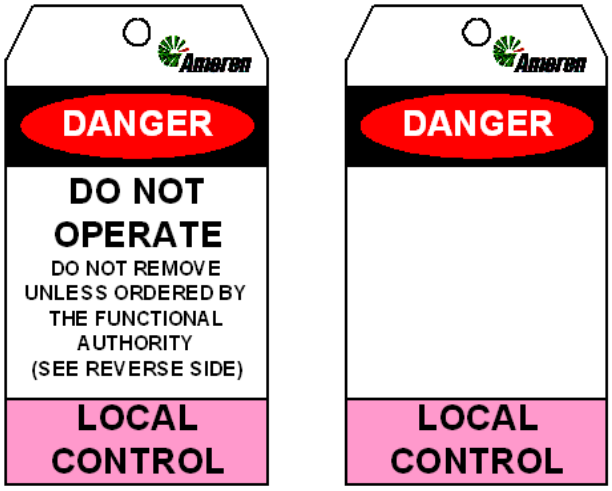
2.4.3.7 Duration:

- Released before Holder goes off duty. New equipment before acceptance has no time limit.

2.4.3.8 Predominance:

- Only one Local Control and no other WPA.

EXAMPLE OF LOCAL CONTROL TAG



2.4.4 Clearance

2.4.4.1 Definition:

- A Clearance is the assurance to the Holder that the system or equipment for which it is issued has been properly isolated from its normal energy sources (including any emergency back-up energy sources) and will remain isolated as long as the Clearance is in effect.

2.4.4.2 Usage:

- It is used whenever it is necessary to completely isolate a system or a piece of equipment from its normal energy sources (including any emergency back-up energy sources) to perform the desired work.

2.4.4.3 Issued to:

- Supervisors or Workers when authorized by Custody Authority.

2.4.4.4 Persons Covered:

- Holder and anyone working directly for or with the Holder

2.4.4.5 Physical Location of Holder:

- Must remain on Plant property and in direct control of the job since he is responsible for the safety of his workers.

2.4.4.6 Duration:

- Released before Holder goes off duty.

2.4.4.7 Predominance:

- None. An unlimited number of Clearances may be issued concurrently on a system or a piece of equipment. Clearances may also be issued concurrently with Out of Services.

2.5 Exception

2.5.1 If a person holding Worker's Protection Assurance on a piece of equipment is not available and it is necessary because of plant or system emergency to place that piece of equipment in service, the Worker's Protection Assurance can be released to the Operating Authority by a person designated by the Holder of the Worker's Protection Assurance provided:

2.5.1.1 Every attempt has been made to contact the holder of the Worker's Protection Assurance

and

2.5.1.2 A thorough examination by the person releasing the equipment reveals the equipment to be in proper operating order.

3.0 COMMISSIONING JURISDICTIONAL CONTROL AND EQUIPMENT TAGGING

3.1 Commissioning Team Leader, Commissioning Engineer and Specialist

3.1.1 Ensure the following once Construction Turnover Acceptance Form is signed by commissioning team leader.

- Any activities on the turned over system not authorized by a member of the Commissioning Team will promptly cease.

- Any Construction Cards within the boundaries of the turn over are promptly removed.

NOTE

Plant based WPA will be used if commissioning an existing system in the plant or if the new system is tied to existing plant systems. The sole WPA authority would be the control room.

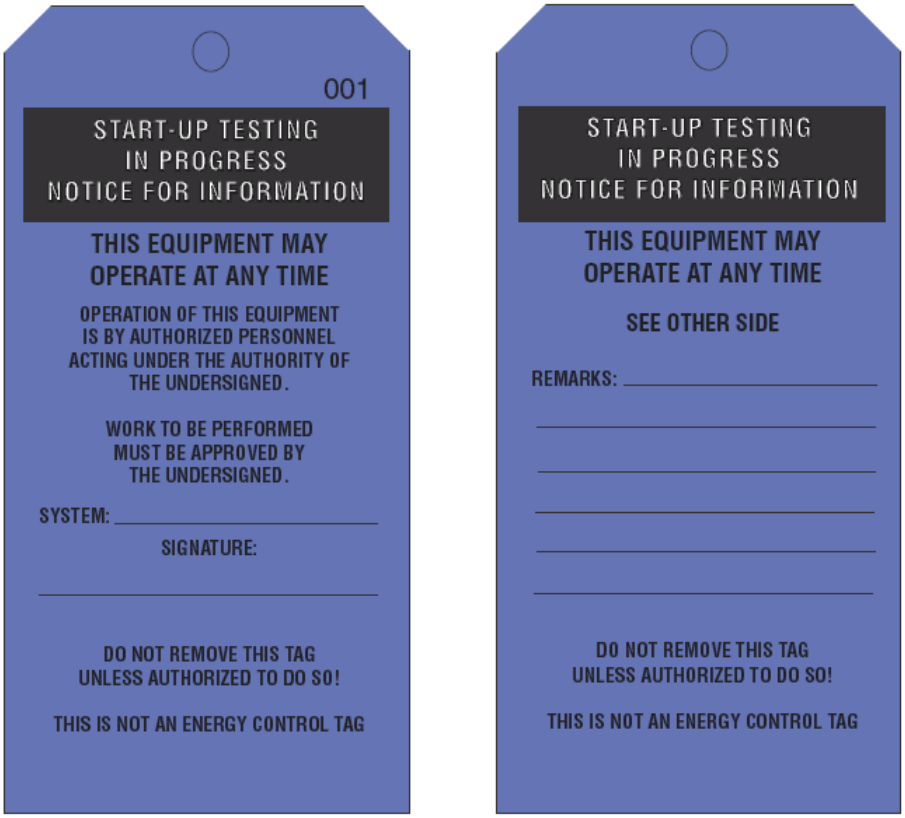
3.1.2 Request "System Under Test" card or applicable WPA based on boundaries turned over to commissioning.

NOTE

In case the new system is independent of the existing plant. "System Under Test" card will be used and administered by commissioning.

3.1.3 Maintain GEN-FRM-ADM-2155-07, *System Under Test Card Log.*

3.1.4 In the event that a positive isolation device does not exist in a system being turned over, that system's boundary will be extended into the adjacent system to the first point of positive isolation.



4.0 ENVIRONMENTAL, SAFETY AND HEALTH

4.1 Contractor shall ensure worker and public safety during the course of this project.

4.1.1 Contractors must comply with all applicable Company, Federal, State, and Local health, safety and environmental regulations including, but not limited to, those concerning:

- Appendix A, Safety & Contractor Requirements and Appendix B, Job Working Rules
- Public and worker health and safety
- Public's "Right to Know"
- Fire safety

- Air and water quality
- Flammable materials storage
- Spill control, response and cleanup
- Hazardous and non-hazardous waste handling, identification and disposal

NOTE: Ameren's policies and procedures applicable to Contractors are available on www.ameren.com, Business Partners tab under Supplier.

4.1.2 Refer to Ameren's Contractor's Substance Abuse Policy AUE-07-01 (Attachment A16) for minimum substance abuse testing requirements.

4.2 Contractor must have a full-time company corporate Safety Director who oversees and maintains the site safety program and site safety personnel, unless waived by the Ameren Managing Supervisor of Construction. This person must also be available for safety related questions and concerns. A full time company safety personnel must also be onsite for each shift for the entire duration of the project. The cost for the safety personnel shall be broken out in the bids. Resumés of the safety personnel who will be associated with the project must be submitted with the bid.

4.2.1 Ameren reserves the right to request the safety representative be removed from the project and be replaced with a more competent individual, if they are not fulfilling expectations.

4.3 With contract bid, Contractors shall submit:

- Attachment A10 - Contractor Environmental, Safety & Health Data Form, (unless specifically exempted from this provision by Company).
- Their company's ES&H program manual

4.4 After award, Contractor shall submit:

- A project-specific ES&H Action Plan, including an Emergency Response Action Plan that is in accordance with Ameren, Federal, State & Local requirements

4.5 At mobilization, Contractor shall:

- Appoint a competent onsite ES&H representative who will coordinate Contractor ES&H activities, hazardous material and waste handling. The ES&H representative will work with Ameren personnel on ES&H related issues, and implement ES&H rules necessary for safe execution of the project.
- Supply to the SPOC the frequencies of all walkie-talkie 2-way radios they intend to use. Frequencies must be listed to four (4) decimal places. Attachment A15 - Authorization for Two-Way Radios must be submitted to the designated SPOC.

4.6 Contractor shall be responsible for tool inspection/maintenance in accordance with the requirements of OSHA standards and manufacturer's recommendations/instructions.

4.7 Handling of Materials and Waste

4.7.1 If project involves use or presence of chemicals or products that are regulated under Section 112 (r) of the Clean Air Act, Sections 302 & 304 of Emergency Planning & Community Right to Know Act, OSHA 29CFR1926.65 or 29CFR1910.120, then Contractor has the choice of adopting the plant's Health and Safety Plan (HSP) or developing a similar plan that is at least as protective and compliant

If Contractor is responsible for arranging to dispose of a hazardous or otherwise regulated waste where Ameren is identified as the generator of the waste, Company shall review, and approve or reject the waste disposal method and/or facility.

Contractor site personnel shall read and acknowledge by signature that they will comply with the applicable HSP.

Certification of individual training is required prior to hazardous waste operations as defined by OSHA 29CFR1910.120 or equivalent applicable state regulations.

4.7.2 Contractor shall identify as part of the bid, and be prepared to discuss upon award of Contract, the quantities, timetables and characterization, of wastes generated during project.

4.7.3 Contractor shall minimize amount of waste generated and shall discuss waste handling, manifest preparation, record keeping, and disposal with the SPOC in advance of these activities. Contractor should coordinate waste handling Vendors/Subcontractors with Company personnel.

4.7.4 Contractor shall handle, package, label and store wastes in accordance with Ameren, Federal, State and Local requirements.

4.7.5 Contractor shall remove such wastes from the premises in a timely manner for treatment, storage, and/or disposal in full compliance with applicable laws, regulations and ordinances, including documentation requirements.

4.7.6 If Contractor is considered the sole generator of waste, then, such waste is sole responsibility of Contractor and Ameren assumes no responsibility for Contractor's compliance with applicable regulations.

4.7.7 Contractor shall notify the SPOC before using chemical/material that could create noxious or toxic fumes.

4.7.8 For materials brought onto jobsite, Contractor shall make copies available (upon request) of the Material Data Safety Sheets (MSDS) to the appropriate personnel on the worksite.

Contractor shall provide written notification to the SPOC of any material requiring an MSDS that is brought onsite by Contractor in quantities in excess of that material's Superfund Amendments and Reauthorization Act (SARA) Threshold Planning Quantity. Such notification is required for SARA Tier II reporting purposes. Appendix I – Chemical of Interest Reporting in this specification must be filled out and submitted to the SPOC.

4.7.9 Contractor shall ensure that hazardous chemicals or materials are properly contained and labeled, and that employees are adequately trained to recognize, handle and use hazardous chemicals safely

Small quantities (i.e. <10 gal.) of hazardous liquids, such as gasoline, diesel fuels or solvents, brought onto site shall be stored in properly labeled safety containers with flame arrestors and self-closing lids. All container labels must include contents information and display hazard symbols clearly on exterior of each container in accordance with NFPA 704M, OSHA 29CFR1910.1200 or other applicable standard.

4.8 Asbestos-Containing Material (ACM) and Lead

4.8.1 In structures built prior to 1981, thermal system insulation, sprayed-on surfacing, and vinyl or asbestos floor tile shall be presumed to be ACM.

- Non-ACM will be labeled as such or otherwise identified by the SPOC and communicated to Contractor.
- Areas containing abatement activities will have warning signs, be barricaded, and access will be limited.

4.8.2 Ameren ES&H Management Instruction Asbestos Exposure Controls and Work Practices, ES-REG-203, specifies policies and procedures for contractors performing asbestos abatement work. Hardcopies may be requested from the SPOC.

Proposals for an ACM abatement project must designate:

- Scaffolding needs

- Glove bag and containment areas
- Potable water and shower requirements and locations
- Methods to protect scaffolding tubing from contamination after containment is removed
- Methods to minimize non-ACM dust outside the containment areas
- Methods to move ACM bags from containment areas to ACM receptacles

4.8.3 Ameren ES&H Lead Management Instruction, ES-REG-211, specifies policies and procedures for Contractors performing lead abatement work. Hardcopies may be requested from the SPOC.

4.9 ES&H Training Requirements

4.9.1 Documentation of OSHA training for Contractor craft workers and supervisors must be maintained onsite and made available to Ameren. Effective September 1, 2006, the minimum training standard is OSHA 10 for Contractor craft workers and OSHA 30 for Contractor supervisors.

4.9.2 Contractor will maintain documentation of ES&H training on project and must provide requested documentation of training to Company. Contractor shall retain verification of satisfactory training for as long as required by law or six months after completion of contract, whichever is greater.

4.9.3 Job safety awareness meetings will be held with Company and applicable contractors on a frequency determined by Company. The meetings will address industrial safety issues from Contractor job safety reviews.

4.10 Environmental, Safety & Health Surveys

4.10.1 The SPOC and Ameren ES&H personnel will conduct periodic ES&H surveys of the project. Any discrepancies will be reported to Contractor management for immediate correction.

4.10.2 These ES&H surveys do not relieve Contractors of their responsibility to self-inspect their work and equipment and to conduct their work in a safe and environmentally compliant manner.

4.11 Reporting and Investigating Incidents/Accidents

4.11.1 Contractor shall make an immediate report by telephone to the SPOC of any accident involving injury, death, fire, spill, mishandling of oil, regulated/hazardous waste spill, or any other emergency.

4.11.2 In the event of an emergency, Company has authorized the Plant Shift Supervisor and the SPOC to act as emergency coordinators. Contractor shall proceed with appropriate emergency response measures as directed by Plant Shift Supervisor and the SPOC, and take full responsibility for clean-up and disposal of any wastes or materials.

4.11.3 Contractor shall indemnify Company for all related costs and liabilities.

4.11.4 Contractor shall submit a Monthly Contractor Accident Statistics Report (Attachment A11) by the second day of each month for the preceding month's activities.

4.11.5 Contractor shall investigate all types of events listed in Section 17.10.1, whether they result in an injury or not, and provide the results of said investigation to Company. An accident investigation does not assign blame; it does determine how to eliminate similar accidents in the future. Company reserves the right to monitor Contractor's investigation, and Contractor shall provide the SPOC with all necessary information to all required Company personnel to perform this monitoring function.

4.11.6 Ameren reserves the right to investigate any accidents that occur on its property or in completing work being performed by a Contractor's employee whether they result in an injury or not. Ameren will conduct further investigations for accidental environmental releases or spills, etc.

4.11.7 A signed Witness Statement (Attachment A2) must be completed by each witness providing factual observations.

4.11.8 An Incident/Accident Investigation Report (Attachment A1) must be submitted to the SPOC within 24 hours to document the investigation. Accident facts, causes, and corrective action should be documented and communicated to employees through ES&H meetings.

4.12 Certifications, Inspections, and Permits

4.12.1 Operations may require a Company permit. Such activities may include but are not limited to: hot work, confined space/vessel entry, excavations, asbestos abatement, lead abatement, etc. Contractor shall determine from the SPOC if any of Contractor's activities require a Company permit or Contractor permit.

4.12.2 Some states and local authorities require permits for activities such as: excavations, heavy lifts, asbestos/lead abatement, air permits, water permits, hazardous waste generation, etc.

4.12.3 Contractors shall be responsible to secure and comply with these permits, unless the SPOC has delegated this to others in writing.

4.12.4 A third-party-certified Competent Person shall make a thorough annual inspection of cranes and powered hoisting equipment. Cranes shall be inspected and have deficiencies corrected prior to being put into service. Documentation of crane inspections must be maintained onsite by Contractor.

- Crane hooks should be inspected by a Competent Person prior to use. Rigging should be inspected by a Competent Person before each shift. Defective components shall be removed from service immediately. Anti-Two-Block devices, that automatically disengage crane hoist/boom functions when the hook or block approaches the jib or boom tip, shall be used on all cranes.

- All outriggers on mobile cranes must be fully extended and fully deployed when crane is used to lift or support a load.

- If, due to configuration or physical location, all outriggers cannot be fully deployed, calculations must be made from the "on-rubber" section of the load chart. A certified crane specialist must have written calculations and lift instructions reviewed by Ameren. The SPOC may make an exception for light-weight, lift-and-carry operations.

4.12.5 Operators of forklifts, boom lifts, buses, and other mobile equipment must be trained and certified on the operation of the specific equipment.

4.12.6 Operators of cranes must be trained and certified by National Commission for Certification of Crane Operators (CCO), or Operating Engineers Certification Program (OECP). Crane operators must be qualified on each crane type and rating they operate.

4.12.7 Operators of cranes are responsible for completing the Crane Maintenance Safety Checklist (Attachment A17).

4.12.8 A Competent Person shall design and a Competent Person shall erect scaffolding. Only the authorized scaffolding erector can make changes to scaffolding.

4.12.9 A Competent Person must inspect and tag scaffolding prior to initial use, before each work shift, and after any event that could affect its structural integrity. Untagged scaffolds must not be used.

4.13 Critical Lifts

4.13.1 Critical Determination

Contractor shall submit a Critical Lift Plan for any critical lift. Ameren reserves the right to designate any lift as critical. A lift shall be designated as a critical lift if any one of the following conditions exists:

4.13.1.1 Lifting over 50 tons.

4.13.1.2 Lift exceeds 75% of the rated capacity of the crane.

4.13.1.3 Lift requires the use of more than one crane.

a. In no case shall a multiple crane lift be performed in excess of 75% of any one of the crane's individual load rated capacity at the planned radius.

4.13.1.4 Lifting a non-rigid object.

4.13.1.5 Lifting over equipment or material that Ameren believes to be critical for unit operation.

4.13.1.6 Lifting over equipment or material that could cause or result in a release of hazardous material to the environment.

4.13.1.7 The item to be lifted requires exceptional care in handling because of size, weight, close-tolerance installation, high susceptibility to damage or other unusual factor.

4.13.1.8 The lifted item, although non-critical, requires exceptional care in handling because it is being lifted above a critical item.

Any lifts proposed by the contractor that meet the above criteria or determined to be critical by the Project Engineer will be subject to a Critical Lift Plan. Examples of lifts that are generally considered critical are: boiler tube panels, feedwater heaters, conveyor systems, coolers and pump skids.

4.13.2 Critical Lift Plan

Contractor shall provide a detailed lifting and rigging plan for all lifts identified as critical. All critical lifts will require a Professional Engineer's seal. Prior to executing lift, lift plans must be submitted to the Project Engineer, reviewed and accepted by a structural engineer in the POS Civil/Structural Group. Ameren will review submittals for general design features. Contractor is responsible for accuracy of calculations. Also prior to executing lift, any changes made in the field to the approved lift plan must be approved by the contractor's engineer and accepted by the Ameren POS Project and Structural engineers. A copy of the lift plan must be onsite during the lift and must have been reviewed with all personnel involved with the lift, including the Ameren Construction Supervisor. Ameren's Construction Supervisor shall be provided sufficient notice to allow him/her to witness the critical lift. A critical lift plan shall contain the following, as applicable:

4.13.2.1 Identify the items to be lifted.

4.13.2.2 Weight of the lifted item and total weight of the load (for mobile cranes, see the manufacturer's instructions regarding components and attachments that must be considered as part of the load).

4.13.2.3 Center of gravity location.

4.13.2.4 Documented step-by-step instructions.

4.13.2.5 Special precautions, if any (such as outrigger or track cribbing for mobile cranes).

4.13.2.6 Evaluation of hazards associated with the lift that include ground support, soil conditions, allowable soil bearing capacity, underground utilities that could be damaged or suddenly collapse, maximum permissible wind speed and any other physical obstruction.

4.13.2.7 A list of each piece of equipment (e.g., crane, hoist, fork truck), accessory, and rigging component (e.g., slings, shackles, spreader bars, yokes) to be used for the lift. (This list shall identify each piece of equipment by type and rated capacity).

4.13.2.8 Designated checkpoints, hold points and estimated instrument readings, as relevant, so that job progress can be checked against the plan.

4.13.2.9 Rigging sketch(es), which include the following:

a. Lift point identification

b. Method(s) of attachment

c. Load vectors

d. Sling angles

e. Accessories used

f. Other factors affecting the equipment capacity

g. Rated capacity of equipment in the configuration(s) in which it will be used. (For cranes, many factors affect rated capacity, including boom length, boom angle and work area.)

h. If rigging points are attached to existing structural steel, it is the responsibility of the contractor's engineer to confirm that the additional loads do not overstress the existing structure, and to design additional bracing/reinforcement if required. Supporting calculations sealed by a Missouri Professional Engineer shall be included with the critical lift plan.

4.13.2.10 A load-path sketch that shows the load path and height at key points in the job. (For lifts with mobile cranes, include the crane position(s) relative to the load and relative to surrounding obstructions.) Where appropriate, include floor-loading diagrams.

4.13.2.11 A sketch indicating lifting and travel speed limitations. (This may be noted on the load path sketch or on a separate sketch.)

4.13.2.12 A sign-off sheet to verify that all inspections/tests required by OSHA are current for all equipment and rigging.

4.13.2.13 The lift plan shall provide specific information for each lift when multiple items of varying weights and/or shapes are included in the lift plan unless an exception is approved by the Ameren structural engineer.

4.14 Respiratory Protection

4.14.1 Contractors must provide a copy of their Respiratory Protection Program to the SPOC before they use respirators. The program must comply current Ameren, Federal, State and local requirements including OSHA 29CFR1910.134. The program must properly address the following:

- Respirator selection
- Respirator training and required test fit procedures
- Respirator cleaning, sanitizing, inspection and maintenance
- Respirator user's medical clearance

4.15 ES&H Adherence Policy

4.15.1 **Action Level One** – The SPOC will issue a written Notice of ES&H Non-Compliance (Appendix A12) and Warning Letter for ES&H Non-Compliance (Appendix A13) to Contractor's management and site ES&H representative if Contractor fails to comply with an applicable ES&H standard.

4.15.2 **Action Level Two** – The SPOC will issue a Written Notice of Temporary Job Suspension (Appendix A14) to Contractor if ES&H non-compliance is not corrected by Action Level One, or if Contractor repeatedly fails to comply with applicable ES&H regulations. The appropriate Ameren Manager and Contractor's Division Manager, or equivalent, must meet and agree on corrective actions acceptable to Company before Work may resume. Actions may include, but are not limited to:

- Removal of certain Contractor personnel from project.
- Alteration of Contractor's job procedures.

- Having Ameren implement corrective action and backcharge Contractor.

Contractor shall not resume Work until Ameren accepts the proposed corrective actions. Ameren will retain meeting minutes documenting the agreement.

4.15.3 **Action Level Three** – Ameren Management may terminate the contract for cause, if **Action Level One** and **Action Level Two** do not result in Contractor's ES&H compliance.

ATTACHMENT A1

INCIDENT/ACCIDENT INVESTIGATION REPORT

Date of Accident: _____ Time of Accident: _____ Job Number: _____

Contractor Company Name: _____ Date of Investigation: _____

Location of Accident: _____

Did injury result? Yes/No,: _____ Involved Employee Name(s): _____
Involved Employee SS Number _____

Employee Job Classification or Skill: _____ Years In this Skill: _____ Years With Company: _____

Describe Type of Injury: _____

Body Part(s) Involved, If applicable: _____

Injury Classification per OSHA 29CFR1904: _____

Was property damaged? Yes/No _____ Describe damage/owner: _____

Is damaged property secured/maintained? Yes/No _____ Person Maintaining _____

Names of Witnesses/Co-workers (With Social Security No.): _____

Weather/Wind Conditions: _____

List/Describe personal Protective Equipment (PPE) in use by person exposed or injured.

_____

Chemicals Involved:

Name(s) of Chemicals Encountered: _____

_____

Form of Chemicals (Solids, Liquid, Dust, Mist Fume): _____

Describe Radiological Materials (if any): _____

Volume or Quantity Released: _____

Description of Accident: _____

_____

_____

_____

(continued on next page)

INCIDENT/ACCIDENT INVESTIGATION REPORT (continued)

Contributing Factors: _____

What **Corrective Actions** Were Taken to Secure the Scene? _____

Corrective Actions Being Taken to Prevent Recurrence:

Action Item:	List Responsible Person & Target Date for Implementation Name:	Date:

Job being performed at time of incident/accident: _____

Was permit required for task being performed? Yes/No _____

If so, was permit issued? Yes/No _____ If yes, attach a copy of permit in effect at time of accident.

Indirect cause of accident: _____ _____ _____

Investigation Team Members:

Injured/Involved:	_____ Name	_____ Signature	
Supervisor:	_____ Name	_____ Signature	
Ameren SPOC	_____ Name	_____ Signature	
ES&H Representative	_____ Name	_____ Signature	
_____ Name (Others)	_____ Title	_____ Signature	
_____ Name (Others)	_____ Title	_____ Signature	

Contractor Representative(s) Contacted: _____

Ameren Representative(s) Contacted: _____

*Attach additional sheets and supplemental data & information as necessary.

**Distribution: Original must be filed on-site; 1 copy must be sent promptly to the Corporate ES&H Dept.
Must Notify: CCMI and Huntleigh McGehee

ATTACHMENT A2

WITNESS STATEMENT

Name: _____ Title: _____

Social Security Number: _____ Date: _____ Time: _____

Temporary Address: _____ Phone: _____

_____

Permanent Address: _____ Phone: _____

_____

Location at Time of Accident: _____

Describe to the best of your knowledge, what happened just before, during and just after the accident:

_____
Signature

ATTACHMENT A3

FIRST AID REGISTER

Company: _____ Project Name /Number: _____ Jobsite Location: _____

Month /Year: _____ Site Manager: _____ Page: _____ of _____

Date	Time	Name	Supervisor/Foreman	Type of Injury, Body Part, and Brief Description of Accident	*Class

***Class** = Classification **FAV** = First Aid Visit **E1=** Doctor's Visit **REC** – OSHA Recordable **Other**:

ATTACHMENT A4

BARRICADE TAG

ATTACHMENT A5

CONSTRUCTION WORKER'S PROTECTION ASSURANCE AUTHORIZATION

Date: _____

Operating Supervisor: _____

The following person(s) has authorization to receive W.P.A.: _____

Project Name: _____

Company Name: _____

Company Address: _____

Name	Title	Office	Cell	Home	E-Mail

	Beginning		Ending	
	Date	Time	Date	Time
Expected Duration:				

Training is Required for Automated WPA System.

_____
Plant Manager or Designee

(Designee: Admin. Supt., Operations Supt., Maintenance Supt., Planning/Scheduling, or Operations Supv. {Watch})

ATTACHMENT A6

GRINDER SAFETY PLAN

Grinder Guard and Handle Removal PRE-PLAN

Date:	**Job #:**
Customer/Site:	**Location of Work/Unit:**
Description of Task:	**Equipment Identification:**

SCOPE OF WORK AND SCHEDULE (Please list complete description of task)

HAZARD ASSESSMENT TO DETERMINE ALTERNATE TOOL

procedures require a pre-plan whenever personnel remove the guard and handle on a grinder.

Reason:

- Grinding wheel cannot access point of work with guard and handle attached due to narrow gap for welding.

Alternate Methods to Removing Guard and/or Handle:

- Rotary file and die grinder?
- Conical grind stone and pole grinder?
- Other?

SAFETY PRECAUTIONS

- ❑ Cutting wheel CANNOT be used while guard and handle are detached.
- ❑ Grinder must be unplugged when removing guard and handle and when re-attaching.
- ❑ Guard and handle are only to be removed for this specific point of work. All other grinding in the work area must have safety devices attached.
- ❑ Pre-plan will only apply until the weld depth improves to allow for standard grinding operation, i.e. all safety devices attached.
- ❑ Wear face shield and sealed eyewear.
- ❑ Maintain control of grinder at all times, use two hands when operating the grinder.
- ❑ Keep hands/fingers clear of upper portion of the grinder near the wheel.
- ❑ Be aware of body positioning.

AFFECTED PERSONNEL INVOLVED IN WORK MUST READ AND SIGN THIS PRE-PLAN

PRE-PLAN REVIEW SIGN-IN

Employee Classification/Craft	Name (Print)	Signature	Date
1.			
2.			
3.			
4.			
Supervisor/Foreman			
Safety Representative			

ATTACHMENT A7

CONTRACTOR REDUCTION IN FORCE REPORT

Contractor Name:	
Contractor Supervisor:	
Date Submitted:	
Time Submitted:	

Name of Employee (Please Print)	Badge #	Date of Reduction	Time of Reduction

ATTACHMENT A8

POWER OPERATIONS HOT WORK CHECKLIST
(EXAMPLE)

1. DESCRIPTION – JR# _____

Location _____ Elevation _____
Work to be done: Welding _____ Brazing _____ Open Flame Cutting / Heating _____
Equipment _____

NOTE: Before authorizing welding, cutting, heating, and brazing, this checklist must be completed.

2. PRE-WORK INSPECTION

Hot Work shall not be performed in the following situations:

a. In areas not authorized by Management.

b. In sprinklered buildings while such protection is impaired, unless authorized by Management.

c. In the presence of explosive atmospheres or explosive atmospheres that may develop inside unclean or improperly prepared tanks, pipes or equipment.

d. In areas near the storage of large quantities of exposed, readily ignitable materials.

Prior to welding, cutting heating, and brazing (W/C/H/B), you shall perform these basic precautions:

a. Move the object to be W/C/H/B to an area free of hazards.

b. If the object to be W/C/H/B cannot readily be moved, then you shall remove all movable fire hazards within the vicinity to a safe place.

c. If the object to be W/C/H/B cannot be moved and if all the fire hazards within 35 feet cannot be removed (including cable trays), then, immovable fire hazards shall be shielded and a fire watch provided.

IF THESE BASIC PRECAUTIONS ARE NOT FOLLOWED, WELDING, CUTTING HEATING AND BRAZING SHALL BE PERFORMED. COMPLETE CHECK LIST.

3. ADDITIONAL FIRE WATCH PROVISIONS

N/A	YES	NO		
			a.	Can more than a minor fire develop?
			b.	Are combustible materials closer than 35-ft. to the point of operations?
			c.	Are combustible materials more than 35-ft. but easily ignitable by sparks?
			d.	Do wall or floor openings with a 35-ft. radius expose combustible materials in adjacent areas, including concealed spaces in walls or floors?
			e.	Are combustible materials adjacent to the opposite side of metal partitions, walls, ceilings, or roofs and are they likely to be ignited by conduction or radiation?

NOTE: If you answered yes to any of the above, a fire watch is required. Complete checklist. All of the following conditions must be met, if applicable.

(continued on next page)

4. PRECAUTIONS

N/A	YES	NO		
			a.	A fire watch will be provided during and for 30 minutes following welding, cutting, heating and brazing.
			b.	The fire watch shall be supplied with a proper portable fire extinguisher in addition to installed operable plant equipment.
			c.	Cutting and welding equipment is in good condition.
			d.	Combustible materials are protected with covers, guards, or metal shields, or material is removed prior to start of work.
			e.	Nearby workers are suitably protected against heat, sparks, slag and flash.
			f.	Wall or floor openings are covered or enclosures provided. For elevated work, covers are suspended beneath to collect sparks or area below is free of combustibles.
			g.	Enclosed equipment is cleaned of all combustible material and purged of flammable vapors.
			h.	Ducts and /or conveyors are suitably protected or shutdown.
			i.	For work near walls, partitions, ceiling or roofs, proper precautions have been taken to prevent ignition of combustibles inside the barrier of adjacent areas.
			j.	For work on pipes or other metal in contact with combustible walls, partitions, ceilings, or roofs, precautions have been taken to prevent ignition by conduction of heat.
			k.	Other

PRE-WORK INSPECTION

Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____

POST-WORK INSPECTION

Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____
Supervisors Initials	_____	Date	_____	Time	_____

DEFINITIONS

1. Combustible Material: Any material that, if in the form and under the conditions used, could ignite and burn.

2. Minor Fire: A fire which, if no action is taken to extinguish it, will self-extinguish (burn out), will not propagate (spread to other materials through the continuity of combustibles), and will not damage any permanent plant equipment.

ATTACHMENT A9
DESIGN FOR SAFETY CHECKLIST

OBJECTIVE

If the Contractor is involved in design, he will be responsible to develop and maintain design guidelines to ensure engineering designs, and reduce safety risks for construction, operations, and maintenance of equipment and facilities.

These Guidelines reflect Ameren's commitment to incorporate safety into all designs. The designer of record is ultimately responsible for adherence to all governing Federal, State, and Local code requirements.

While attempts will be made to follow the recommendations in this guideline during the engineering phase there will be occasions where conditions and physical constraints may render some recommendations impractical or unattainable.

Several of the Design for Safety recommendations are subjective and can vary from plant to plant (i.e., serviceable access for equipment, pipe labeling & color coding). Ameren Engineering and contracted consultants must engage plant stakeholders during the design phase to accommodate plant specific safety and operating requirements.

GENERAL FACILITY SAFETY DESIGN

YES	NO	N/A	
☐	☐	☐	General Arrangement layouts shall provide for adequate serviceable access for operation, maintenance and replacement (i.e., personnel, tool, cart, vertical lift, fork truck).
☐	☐	☐	Stairs shall not be used as access platforms. No valves, controls, equipment, etc., shall be positioned/designed to be accessed by personnel standing on stairs.
☐	☐	☐	Permanent, well identified and load rated fall protection tie-offs should be incorporated into the building structure at removable handrails and access hatchways.
☐	☐	☐	Self-closing swing gates are to be used instead of chains and clips at all personnel access openings for fall protection guarding where elevated surface is used as a work platform or walkway.
☐	☐	☐	Non-slip "Mebac" ladder rung covers should be used on all fixed access ladders.
☐	☐	☐	The distance between the end of fall protection guarding and a wall or vertical surface shall not be more than 3".

YES	NO	N/A	
☐	☐	☐	OSHA required clearance to handrails on stairs (3”) must be maintained. Structural bracing, electric conduit, or mechanical piping is not located within the required clearance space.
☐	☐	☐	No more than a 3" open gap is maintained between a walking surface and the side of a piece of equipment penetrating the walking surface.
☐	☐	☐	When practical, valves should be located to allow for ergonomically correct operation.
☐	☐	☐	When practical, provide stairs rather than ladders to equipment, valves, etc., that requires routine access for operations and/or maintenance.
☐	☐	☐	Provide chain wheel operators for valves that cannot be accessed from a permanently installed ladder or platform.
☐	☐	☐	When possible, design stairs with lower angle of stairway rise (6½” R, 11” T). Stair landings are provided every 10 to 12 treads.
☐	☐	☐	When possible, no low mounted equipment, piping, ducting, conduit, etc., are to be in travels paths. No “duck-unders.” Use a minimum design head clearance of 7'-0".
☐	☐	☐	All 90 degree corners of structural steel members must be plate trimmed/clipped where close to personnel access areas.
☐	☐	☐	Maintenance and replacement access must be considered when locating lighting fixtures (especially on stairways, over tops of equipment, and high overhead locations).

YES	NO	N/A	
☐	☐	☐	Underground utilities should be designed and installed with warning and location indicators for future excavations in areas of buried utilities.
☐	☐	☐	Underground utilities should be designed and installed at shallowest depth possible (while maintaining freeze protection and surface surcharge loads) to minimize deep trenching hazards.
☐	☐	☐	Thermal protection guarding must be incorporated into design where required.
☐	☐	☐	Utilize above-ground liquid containments or rigid structural underground containment. Avoid below-grade lined pits.
☐	☐	☐	Incorporate seismic shut-off valves for gas service lines entering buildings and at meter locations. (Application mostly at non-power plant and off-site buildings/facilities).
☐	☐	☐	Walkways shall be clear of protruding obstructions and bump hazards. No valves, valve stems, valve handles, controls, equipment, etc., should be positioned/designed within the normal walking path within personnel walkways.
☐	☐	☐	Utilize yellow warning striping along edges of personnel walkways to guide/warn walking personnel of potential obstructions, ramps, bump hazards, and/or grade/slope changes.
☐	☐	☐	Provide personnel access to all roofs for inspection and maintenance purposes.
☐	☐	☐	Provide permanent fall protection tie-offs that are well identified, load rated, and incorporated into the building structure on roofs where there are no parapets or guard railing. (Review the need for fall protection tie-offs on specific roof areas on a case-by-case basis).

YES	NO	N/A	
☐	☐	☐	To eliminate the need for fall protection tie-offs, when practical, design/build the roof parapets high enough to meet OSHA fall protection guarding requirements.
☐	☐	☐	Where possible, roof mounted equipment shall not be designed and installed closer than 15’ to open, unguarded edge of roof.
☐	☐	☐	Provide fall protection guarding at edge of roof (without parapet) where roof mounted equipment is installed closer than 15’ to open edge of roof.
☐	☐	☐	Provide fall protection guarding on both sides of a fixed roof access ladder onto roofs with no parapet or guard railing.
☐	☐	☐	Provide fall protection guarding or tie-off point at all personnel access roof hatches.
☐	☐	☐	Provide fall protection guarding at roof mounted skylights (many commercial skylights are available with security grills that will act as fall protection guarding).
☐	☐	☐	Design roof mounted equipment, ducting, and piping with adequate clearance for roof maintenance and replacement. Design clearances shall meet the NRCA recommendations for equipment to roof clearances.
☐	☐	☐	Provide service power for roof mounted equipment.
☐	☐	☐	Eliminate tripping hazards on roofs/floors. No low to roof/floor mounted electric conduits and drain pipes.

YES	NO	N/A	
☐	☐	☐	Utilize safety balls on lightning protection air terminals. Eliminate impalement hazard of pointed air terminals on roofs.
☐	☐	☐	"Roof Slippery When Wet" signs shall be installed at all personnel access points onto roofs.
☐	☐	☐	Provide lighting on roofs in areas of personnel access for maintenance of equipment.
☐	☐	☐	Design mechanical/electrical equipment and components to be watertight for wash-down cleaning.

COMMENTS TO GENERAL FACILITY SAFETY DESIGN:

ELECTRICAL SAFETY DESIGN

YES	NO	N/A	
☐	☐	☐	Walk down conduit and cable tray routes before installation to identify hazards such as tripping, head, thermal, chemical, etc.
☐	☐	☐	Location, cable tray material and conduit shall be designed for identified hazards for that specific location.
☐	☐	☐	Place electrical equipment in accessible locations.
☐	☐	☐	Electrical Room Egress: Provide at least two exit paths even if Code allows one exit for "unoccupied space." These spaces frequently become temporary Control Centers during construction, commissioning and start-up.
☐	☐	☐	Cabinet/enclosures shall be designed to allow sufficient space for maintenance if maintenance is to be performed inside the cabinet/enclosure.
☐	☐	☐	Provide sufficient space to allow for cabinet/enclosure access doors to fully open.
☐	☐	☐	Provide sufficient space for electrical equipment as defined by NEC in walkways, in area between cabinets, etc., for forklifts, routine maintenance, etc.
☐	☐	☐	All control switches should be accessible from outside of cabinet.
☐	☐	☐	Provide the manufacturer's recommended spacing for equipment cooling.
☐	☐	☐	Obtain arc flash incident energy level and labels for any equipment rated 480V and higher or greater than 125KVA at 120VAC & above per NFPA 70E.

YES	NO	N/A	
☐	☐	☐	Consider extra guarding of high voltages (plexiglas) in electrical cabinets to reduce PPE requirements.
☐	☐	☐	Switchgear shall be specified to provide “Lock Out” capability.
☐	☐	☐	Equipment shall be designed for the ratings for which it will be subjected to (i.e., maximum voltage, short circuit current, continuous current, ambient temperature, etc.).
☐	☐	☐	Equipment, cable, conduit, tray, etc., shall be labeled with the voltage level.
☐	☐	☐	Equipment shall be labeled with normal power feed and backup power feed (if applicable). Equipment labeling shall follow plant standards/convention.
☐	☐	☐	Consider backup power feed for systems where failure of normal power feed would result in a hazardous event.
☐	☐	☐	Label all equipment with appropriate equipment description (if applicable). Equipment labeling shall follow plant standards/convention.
☐	☐	☐	When possible, critical conduits shall be installed in a duct bank rather than direct buried.
☐	☐	☐	Control cabinets and wiring termination cabinets should be accessible from platforms or at grade level. Ladders should be avoided.
☐	☐	☐	Provide fall protection tie-off points at tops of transformers. A fall arrest post should be provided with a mounting flange (Ameren stock #71-90-973) welded to the top of the transformer. The top of the transformer should be coated with a non-slip coating.
☐	☐	☐	Electrical equipment such as power panels should be designed to accommodate "Tags-Plus."

YES	NO	N/A	
☐	☐	☐	Consideration should be given to the need for accessing cable trays for future cable pulls where design tray runs. Design should include tie off points, catwalks, platforms, etc.

COMMENTS TO ELECTRICAL SAFETY DESIGN:

MECHANICAL SAFETY DESIGN

YES	NO	N/A	
☐	☐	☐	Walking or climbing surfaces are sheltered or maintained in a manner to avoid slippery surfaces from rain or ice. (Review on a case-by-case basis).
☐	☐	☐	Emergency drainage systems are provided to direct flammable liquid leakage to a safe location.
☐	☐	☐	Provide eye wash stations at locations where liquids are sampled or “open fluids” are otherwise handled.
☐	☐	☐	Stairs, ladders, or ramps are provided at all locations where equipment design or maintenance actions require personnel to abruptly change elevation by more than 12 inches.
☐	☐	☐	Fixed ladders designed with a slope of 75 degrees or more where practical.
☐	☐	☐	Whenever practical, provide adequate access for maintenance personnel to all mechanical components, small-bore piping, ducts, valves, thermowells, flow meters and other appropriate instrumentation on piping runs and equipment units which require inspecting, testing, servicing, adjusting, greasing, removal, replacement, or repair.
☐	☐	☐	When practical, locate instruments, sample points, valves, etc., that require frequent readings, calibration, operation, etc., to allow for walk-up access.
☐	☐	☐	Specify equipment to include handling features that will aid in grasping, removing, and carrying equipment.
☐	☐	☐	Labeling and coding is provided for service and adjustment points to clearly identify the key aspects of the maintenance activity.

YES	NO	N/A	
☐	☐	☐	Equipment and components shall be labeled with weights for lifting and removing for later maintenance or replacement. When modifying existing equipment, determine the weight of the existing equipment plus modifications and label or revise the existing labels accordingly. When possible, the label should include references to the calculation, project and/or drawing number.
☐	☐	☐	Provide lifting devices (lifting lugs, beams, monorail, etc.) for maintenance and replacement of equipment. Lifting devices shall be labeled with the rated lifting capacity.
☐	☐	☐	Provide indicators for convenient and reliable determination of fluid levels.
☐	☐	☐	Drain fittings are provided to support fluid removal readily and safely.
☐	☐	☐	Ensure design basis application for failure modes on all positioned equipment (i.e., loss of air, loss of DC, etc.).
☐	☐	☐	Standardize parts, maintenance and adjustment points as much as possible. For example, use the same size and type of bolts to eliminate special wrenches/tools. Utilize common rigging points to minimize types of rigging connections, etc. If standardization is not possible, clearly differentiate specialized items with signs, markings, etc.
☐	☐	☐	Minimize steam hazards, heat hazards, sharp corners, edges, and projections on equipment.
☐	☐	☐	Equipment should be placed on concrete housekeeping pads, especially where standing water might accumulate.
☐	☐	☐	Add equipment protection features to guard against hazards that cannot be removed or designed out of the system.
☐	☐	☐	Specify that equipment vendor technical manuals deal with one specific equipment model rather than with many different equipment models.

YES	NO	N/A	
☐	☐	☐	Valves shall be provided with “Lock Out” devices.
☐	☐	☐	Provide adequate isolation valving and venting for WPA, maintenance, etc., on piping systems and equipment. Follow applicable code/standard section requirements.

COMMENTS TO MECHANICAL SAFETY DESIGN:

CHEMICAL SAFETY DESIGN

YES	NO	N/A	
☐	☐	☐	Insure that bulk chemical tanks have separate containment areas. Containment areas shall be washable and have the ability to be drained.
☐	☐	☐	All materials used to construct storage tanks, containment, piping, etc., must be verified to be compatible for use with the chemicals used in each specific application.
☐	☐	☐	Lengths of chemical piping runs should be minimized. Chemical supply tanks and pumps should be designed to be as close to injection points as possible. Overhead chemical piping runs should be minimized. When used, labels shall be affixed to the floor beneath the piping with proper hazard communication. Chemical lines must be labeled a minimum of every 10 feet. All PVC/CPVC chemical piping must be protected from foot traffic.
☐	☐	☐	Chemical day tanks shall be properly sized to minimize the number of drums in work area.
☐	☐	☐	Designate storage areas for each type of chemical, taking into account compatibility of each.
☐	☐	☐	Provide sufficient room for servicing instruments around bulk chemical storage tanks.
☐	☐	☐	Drains to sump shall be located around all chemical feed equipment. Local washdown water must be provided in chemical feed area. Include hose and hose reels for local washdown water.
☐	☐	☐	All laboratory areas must contain proper first-aid kit(s).
☐	☐	☐	Material for chemical spill control (pigs, pads, soda ash, etc.) shall be located in a designated area close to chemicals.
☐	☐	☐	Personal protective equipment shall be located in a designated area close to chemicals.

YES	NO	N/A	
☐	☐	☐	Chemicals shall be transferred to equipment (mixing tanks or day tanks) in a way to minimize chances of contacting personnel and avoid manual dumping of bottles and drums.
☐	☐	☐	Chemical containers must be labeled with chemical names and HAZCOM placards.
☐	☐	☐	All safety showers shall be supplied with tepid water. Safety showers located outside shall also be covered and protected from wind. Safety shower activation shall signal an alarm in the control room.
☐	☐	☐	All concrete and equipment exposed to chemicals shall be coated with an appropriate chemical-resistant coating.
☐	☐	☐	PA shall be located convenient to all chemical use areas, but beyond the area that could be engulfed by a chemical spill.
☐	☐	☐	Operating and Maintenance personnel shall be isolated from all chemical pumps and feed systems by plastic screens or curtains.

COMMENTS TO CHEMICAL SAFETY DESIGN:

ATTACHMENT A10

CONTRACTOR ENVIRONMENTAL, SAFETY & HEALTH DATA FORM

1. ES&H PERFORMANCE HISTORY

A. Interstate or Intrastate Worker's Compensation Experience Modification Rate (EMR), as shown on Workers Compensation Insurance Policy for three most recent years.

Year	EMR	*WH/CL

*If self-insured, provide employee Work Hours per Claim. (WH/CL)

THE FOLLOWING DATA FOR LAST THREE (3) YEARS FROM CONTRACTOR'S OSHA LOG

		Year		
B-1.	Employee hours worked			
B-2.	Fatalities (Column G of OSHA 300 log). Attach explanation for any fatalities.			
B-3.	Cases involving days away from work (Column H of the OSHA 300 Log)			
B-4.	Job transfer or restricted duty cases (Column J of OSHA 300 log)			
B-5.	Cases defined as other recordable cases (Column J of OSHA 300 Log)			
B-6.	Total # of cases for B-2, 3, 4 & 5 above.			
B-7.	"OSHA Incidence Rate" – Formula: Total Recordable Cases x 200,000 / Total # of work hours.			
B-8.	Citations by OSHA and/or other ES&H regulatory agencies in past 3 years (provide details of each)			
C-1.	Motor vehicle accidents.			
C-2	Miles driven per year, total fleet.			

(continued on next page)

		Yes	No
2.	Do you have a written hazard communication program?	☐	☐
	Do you have a written ES&H program?	☐	☐
	Do you have a written company substance abuse program?	☐	☐
	Do you have a written respiratory protection program?	☐	☐
3.	Do you have one or more full time:		
	A. Physicians	☐	☐
	B. ES&H Professionals	☐	☐
	C. Industrial Hygienists	☐	☐
4.	Do you have a new employee orientation program?	☐	☐
	I it include the following?		
	A. Company ES&H Policy	☐	☐
	B. Company ES&H Rules	☐	☐
	C. ES&H Meeting Attendance	☐	☐
	D. Company ES&H Record	☐	☐
	E. Hazard Recognition	☐	☐
	F. Hazard Reporting	☐	☐
	G. Injury Reporting	☐	☐
	H. Personnel Protective Equipment	☐	☐
	I. Respiratory Protection	☐	☐
	J. Fire Protection	☐	☐
	K. Housekeeping	☐	☐
	L. Toxic Substances	☐	☐
	M. Electrical Safety	☐	☐
	N. Safety Harnesses and Lifelines	☐	☐
	O. First Aid	☐	☐
	P. Driving Safety	☐	☐
	Q. Lockout/Tagout	☐	☐
	R. Ladder/Stairway Safety	☐	☐
	S. Hearing Conservation	☐	☐
	T. Trenching and Excavation	☐	☐
5.	Do you have a training program for newly hired or promoted first line supervisors?	☐	☐
	I it include the following?		
	A. Hazard Recognition	☐	☐
	B. Safe Work Practices	☐	☐
	C. ES&H Supervision	☐	☐
	D. New Employee Orientation	☐	☐
	E. Tailgate/Toolbox ES&H Meetings	☐	☐
	F. First Aid Procedures	☐	☐
	G. Emergency Procedures	☐	☐
	H. Incident Reporting	☐	☐
	I. Accident Investigation	☐	☐

(continued on next page)

6. How often do you hold periodic ES&H meetings for your foremen/supervisors?

   A. Weekly ☐ C. Bi-Weekly ☐

   B. Monthly ☐ D. Less Often, As Needed ☐

7. Do you conduct field ES&H inspection of work in progress? Yes ☐ No ☐

   A. If yes, who conducts the inspection? _____

   B. How often? _____

		Yes	No
8.	Are accident reports circulated to your management?	☐	☐
9.	Is ES&H a (documented) weighted factor in evaluating the performance of:		
	A. Foreman	☐	☐
	B. Supervisor	☐	☐
	C. Management	☐	☐
10.	Does your firm hold “Toolbox ES&H Meetings?	☐	☐

How often?

A. Weekly ☐

B. Bi-Weekly ☐

C. Monthly ☐

D. Less Often, As Needed ☐

11. List the most senior staff ES&H professional at your company.

Name: _____ Title: _____ Phone: _____

12. List the person to contact to discuss the details of the information contained in this document.

Name: _____ Title: _____ Phone: _____

ATTACHMENT A11

MONTHLY CONTRACTOR ACCIDENT STATISTICS REPORT

Month: _____ Project Name: _____

Contractor Name: _____

Work hours for the month: _____ Work hours year-to-date: _____

Number of First Aid only cases: _____

Number of injuries & illnesses that received treatment by a physician: _____

Total number of OSHA Recordable injuries & illnesses for the month: _____

Number of restricted duty cases: _____ Number of lost time (days away) cases: _____

Number of motor vehicle accidents: _____ Number of miles driven: _____

Please list injuries and illnesses, which have occurred to employees of your company on the above project this month. Include accident cause, injury/illness suffered and current disposition of injured/ill employee (i.e., returned to work, still off work, awaiting surgery, etc.):

_____

_____

_____

_____

_____

_____

_____

_____

Person completing report: _____ Title: _____

Date: _____ Signature: _____

Please submit this report to the SPOC on above project by the second business day of each month, for the preceding month's work activities.

ATTACHMENT A12

NOTICE OF ENVIRONMENTAL, SAFETY & HEALTH NON-COMPLIANCE

To: _____ Site Representative for: _____

Your company has been found to be in non-compliance with one or more Federal, State, or Ameren ES&H requirements as specified below. This ES&H con-compliance must be corrected immediately for your company to meet the requirements of your contract.

Item # Item of non-compliance

_____ _____

_____

_____

Applicable ES&H Requirement _____

_____

_____

_____

Applicable ES&H Requirement _____

_____

_____

_____

Applicable ES&H Requirement _____

_____

Issued By: _____ _____
Signature of the SPOC Date

Received By: _____ _____
Signature of Representative Receiving Notice Date

cc: Superintendent-Construction Management Services
Safety Supervisor
Plant Outage Manager

ATTACHMENT A13

WARNING LETTER OF ENVIRONMENTAL, SAFETY & HEALTH NON-COMPLIANCE

Project Name and Number _____

Your firm, _____, has been found to be in violation of your contract by non-compliance with applicable Federal, State, or Ameren ES&H requirements.

On _____ , in accordance with the Ameren ES&H Adherence Policy, your representative, _____ , was given a Notice of ES&H Non-Compliance (copy attached). This notice specifies areas where your company does not comply with Federal, State, or Ameren ES&H requirements, and requests that these items be corrected immediately. If they are not corrected, more stringent measures will be taken in accordance with Ameren ES&H Adherence Policy.

Thank you for your prompt attention to this matter.

_____ _____

Signature of the SPOC Date

cc: Superintendent-Construction Management Services
Safety Supervisor
Plant Outage Manager

ATTACHMENT A14

WRITTEN NOTICE OF TEMPORARY JOB SUSPENSION

Your company, _____, while working on the _____ project, has been notified of ES&H performance deficiencies in accordance with Ameren's ES&H Policy. Despite these written notifications requesting that immediate corrective action be taken to improve your ES&H performance, improvement has not occurred.

Therefore, in accordance with Action Level Two of the Ameren ES&H Adherence Policy, we are hereby notifying you that after securing your equipment, job activities on the project named above are to cease. Activities on this project may be resumed only after your company meets requirements set forth in the Ameren Adherence Policy.

_____	_____	_____
Signature of the SPOC	Time	Date

cc: Superintendent-Construction Management Services
Safety Supervisor
Plant Outage Manager

ATTACHMENT A15
AUTHORIZATION FOR CONTRACTOR TWO-WAY RADIOS

AUTHORIZATION FOR CONTRACTOR TWO-WAY RADIOS (SAMPLE)

All frequencies must NOT fall between the two ranges of frequencies:

463.5500 to 463.5700 MHz (Plant-Specific)

464.5500 to 464.5700 MHz (Plant-Specific)

- When reporting the frequency, you must include digits four places past the decimal point (e.g., 123.4567).
- If a repeater is being used, you must report both transmit and receive frequencies.
- If no repeater is being used, receive and transmit frequencies will be the same.
- You must submit all frequencies to be used.

CONTRACTOR	
CONTRACTOR REPRESENTATIVE	Print Name
RADIO MANUFACTURER OR MAKE	
HOW MANY CHANNELS BEING USED?	
FCC License “Call Sign” e.g. WPUP269	

CHANNEL		RECEIVE FREQ (MHz)	TRANSMIT FREQ (MHz)
1			
2			
3			
4			
5			
6			
7			
8			

Ameren SPOC: _____ Contractor Rep: _____

Date: _____ Date: _____

ATTACHMENT A16
CONTRACTOR'S SUBSTANCE ABUSE POLICY

Policy No. AUE-POL-000001, Rev. 0

Owner	*Sponsor*	*Approval*
Safety Supervisor	Manager Gen Cons & Outage Mgmt	VP Power Operations
Signature on File	*Signature on File*	*Signature on File*
12-17-2007	12-17-2007	12-17-2007

1.0 INTRODUCTION

1.1 In an effort to provide a drug- and alcohol-free workplace, Ameren establishes the following policy for Contractors:

2.0 SCOPE

2.1 Working on an Ameren work site and being under the influence of drugs or alcohol creates safety risks for all personnel who work on our work sites.

2.2 The term Contractor refers to all non-Ameren personnel hired to perform a service for Ameren who will be on Ameren property and includes all Contractors, their subcontractors and all other non-Ameren persons who are employed by them with active badges for site access. Visitors and delivery drivers are excluded from these requirements.

2.3 This Policy supersedes GP-06-01, Contractor Substance Abuse Policy.

3.0 IMPLEMENTATION

3.1 Contractors shall establish and maintain a confidential drug and alcohol testing program for each of their employees assigned to work on Ameren property, which shall meet the following minimum requirements.

3.1.1 All employees of a Contractor who are assigned to an Ameren site shall be subject to Contractor's drug and alcohol testing program. Contractor's program shall prohibit employees from buying, selling, consuming, or distributing alcohol or drugs while working for Ameren or while on Ameren property. The program shall also prohibit Contractor employees from reporting to an Ameren site or being on Ameren property while under the influence of alcohol or drugs.

3.1.1.1 Contractor's program shall provide for drug testing for substances listed in Section 3.1.4 of this Policy under the following circumstances: pre-assignment testing; random testing; testing for reasonable cause based on observations by Ameren or Contractor supervisor; and testing after any accident or incident that involves injury to personnel or damage to property.

3.1.2 Contractor shall require pre-assignment drug testing, or will assure that each person who will be assigned to an Ameren location has been tested for drug use within the 120-day period immediately prior to the start of work on Ameren premises. Contractor shall provide written documentation from the testing authority to Ameren Construction Project Lead or Plant Station Point of Contact that its employees are either compliant or non-compliant with this Policy. Contractor employees, who are not in compliance with this Policy, will be subject to Section 3.1.6 of this Policy. To maintain confidentiality, Ameren will not accept actual test results. A previous random drug test or drug test conducted for another reason is sufficient to satisfy the pre-assignment testing requirement if test was conducted during the 120-day period prior to working on Ameren premises, and otherwise satisfies the drug testing requirement in Section 3.1.4 of this Policy. Contractor employees who have taken a pre-assignment drug test will be allowed to work pending test results for no more than 5 working days. Testing may be waived pending Ameren management approval for Contractor employees who are working less than 40 hours annually providing site labor.

3.1.2.1 In lieu of pre-assignment testing, Contractor may accept a certificate signed by Department of Health and Human Services (DHHS), Substance Abuse Mental Health Service Administration (SAMHSA) DHHS/SAMHSA-certified drug testing laboratory indicating the results of drug test performed within the 120-day period immediately prior to working on Ameren premises. Identification cards, which indicate employee's name and date of his/her most recent drug test, may also be accepted if they are traceable to the certification from the DHHS/SAMHSA -certified drug-testing laboratory, which performed the test, and are attested to by Contractor management.

3.1.3 Contractor shall provide site specific random substance abuse testing for each of its employees and its subcontractors' employees assigned to be on Ameren premises. The random testing shall be conducted at a frequency such that a minimum of one test is performed for hours up to the first 2,000

man-hours worked and one additional test for every 2,000 man-hours worked by Contractor, or any of its subcontractors, on Ameren premises. Contractor shall establish a random selection process to ensure that each individual will have an equal chance of being selected and tested each time a random test is scheduled. The random testing pool will include all crafts under the direction of the prime Contractor, including subcontractors. Employees selected for random testing shall not be informed of test until immediately prior to test and shall be accompanied to testing site by a responsible Contractor supervisor as soon as practical on the same day selected. Contractor shall notify Construction Project Lead or Plant Station Point of Contact of random selection results and an Ameren representative may exercise the option of being present during the selection process.

3.1.4 Samples used to comply with this policy shall be analyzed by a NIDA-certified laboratory or quick cup and/or instant cup method. Tests must screen at a minimum for the following substances and levels, however some labor consortium testing programs will be accepted for initial site access only pending Ameren approval. A confirmed positive drug testing will be considered a violation of this policy.

Substance	Initial Level	Confirmed Level
Amphetamines	1000 ng/ml	500 ng/ml
Barbiturates	200 ng/ml	200 ng/ml
Benzodiazepines	300 ng/ml	200 ng/ml
Cocaine	300 ng/ml	150 ng/ml
Marijuana	50 ng/ml	15 ng/ml
Methadone	300 ng/ml	200 ng/ml
Opiates	2000 ng/ml	2000 ng/ml
Oxycodone	100 ng/ml	100 ng/ml
Propoxyphene	300 ng/ml	200 ng/ml
Methamphetamine	1000mg/dl	500mg/dl

3.1.5 Contractor's program shall provide for alcohol testing under the following circumstances: random testing; testing for reasonable cause based on observations by Ameren or Contractor supervisor; and testing after any accident or incident that involves injury to personnel or damage to property. Pre-assignment alcohol testing shall not be required. A test result of .04% blood alcohol concentration or greater as indicated by a breathalyzer or similar test will be considered a violation of this Policy.

3.1.6 Individuals who fail a test, refuse to test or otherwise violate this Policy will be denied site access from all Ameren premises. In addition, Contractor shall notify the applicable consortium to remove employee from the active pool. A Contractor employee who is determined to have violated this policy will be denied site access for a period of one year. After a period of one year, if the individual can demonstrate successful completion of a required treatment program based on Contractor's consortium policy, the individual will be given a last-chance opportunity. However, site access will not be permitted unless the individual has a satisfactory return-to-duty drug test. If at any time an individual is found to have a second violation of this Policy, the individual will be permanently denied site access to all Ameren premises. Contractor shall document all non-compliance on a reduction force report and forward the report to Construction Project Lead or Plant Station Point of Contact. The reduction force report shall include the person’s name, craft and reason stated “Non-Compliance with Ameren Substance Abuse Policy.”

3.1.7 Contractors shall require all of their subcontractors to comply with all provisions of this Substance Abuse Policy. Failure of Contractor or any of its subcontractors to comply with the requirements of this Policy shall be grounds for removal from consideration for any future work and/or termination of the current contract at the discretion of Ameren. Ameren reserves the right to audit Contractor’s drug and alcohol testing program at any time to verify compliance with this policy.

3.1.8 Ameren will not be responsible for any expense or loss of wages due to non-compliance with this Policy.

3.1.9 Ameren retains the right to change or modify this Policy at any time. Ameren also retains the right to waive this Policy for any Contractor that is badged as a visitor.

3.1.10 Any documents relating to this Policy will be maintained in confidence and will not be released without written authorization unless otherwise required by law.

ATTACHMENT A17

CRANE OPERATOR SAFETY CHECKLIST

DATE: _____ CRANE: _____

JOB NUMBER/ LOCATION: _____

TASK: _____

☐ Has a Total Hazard Analysis (THA) been completed today? YES ☐ NO ☐

Comments: _____

☐ Is access to work area established? YES ☐ NO ☐

Comments: _____

☐ Is all safety equipment on hand and functioning properly? YES ☐ NO ☐

Comments: _____

☐ Have lines of communication between operator and affected employee(s) been established (visual &/or verbal)?

Comments: _____

☐ When servicing the crane (including crane lubrication), the operator must lower all loads to the ground, and move all controls to OFF. The engine MUST be stopped before the crane is serviced. The operator is to attach a WARNING sign to the engine start control to warn personnel that crane is being serviced and must not be started.

Comments: _____

☐ Do not operate crane until all safety guards and covers are securely reinstalled and all maintenance equipment is removed.

Comments: _____

☐ Before operator enters cab of crane, the affected employee(s) must be at a minimum safe distance of two feet from any moving parts.

Comments: _____

Additional Comments: _____

CREW SIGNATURES:

_____ _____

_____ _____

ATTACHMENT A18
CONTRACTOR AGREEMENT OF UNDERSTANDING
(Form CONMGT0)

All Contractors and Subcontractors will be required to sign and submit this form prior to entering and/or starting work on any Ameren property.

- I have been informed of all expectations regarding Ameren Safety / Work rules and ZERO TOLERANCE policies and will immediately investigate and enforce all such rule and policy violations when they are reported or observed.
- I will cooperate to the fullest extent with any Ameren management or security person in investigating ZERO TOLERANCE policy violations.
- I am aware that Ameren plants contain asbestos, lead and flyash. Where necessary, I will abide by all Ameren, OSHA, State and Local policies, procedures and ordinances in all abatement, containment, waste-disposal, employee protection and reporting activities.
- I will obtain and promptly submit all of the required permits to the Ameren-designated Station Point of Contact (SPOC) prior to starting work.
- I will promptly forward all of the required submittals to the Ameren SPOC.
- I will not allow any employee to enter and / or start work on Ameren property before first conducting a Safety / Work Rules orientation and ensuring they have all required personal protective equipment.
- I will report all violations / actions taken to the Ameren SPOC, on form CONMGT1, each Friday before 9:00 AM.
- I will inform the Ameren SPOC of any sub-contractors in my employ and ensure that they are aware of and meet the conditions of this agreement before they enter and / or start work on Ameren property and will have them complete this Contractor Agreement of Understanding Form.
- Any employee found to have violated a ZERO TOLERANCE policy may be removed and barred immediately from Ameren property and will not be allowed to return to any Ameren property in the future.
- I understand that repeated violation of the Work / Safety rules or ZERO TOLERANCE policies may result in my company's removal from Ameren property.

Contractor Company (Print) _____

Contractor Representative (Print) _____

Representative's Signature _____ Date _____

ATTACHMENT A19
HOUSEKEEPING SCORECARD

PROJECT NAME: _____

CONTRACTOR NAME: _____

DATE: _____

HOUSEKEEPING SCORECARD						
CATEGORY	**RATING**					**COMMENTS**
	POOR				**EXCELLENT**	
General Cleanup	1	2	3	4	5	
Cords & Hoses (are out of the way)	1	2	3	4	5	
Barricades & Caution Tape (used & taken down appropriately)	1	2	3	4	5	
Other (e.g., material stored/staged appropriately, no tools on running equipment, no hazardous conditions, etc.)	1	2	3	4	5	
Total Housekeeping Score:						
Total Points (Total Housekeeping Score x 4) :						

ATTACHMENT A20
SAFETY SCORECARD

SAFETY SCORECARD			
Notwithstanding the provisions below, a "work-related fatality" will result in maximum KPI reduction to the contractor regardless of any other safety criteria.			
KPI payment will be based on criteria that are equally weighted as follows:	Section 1	OSHA recordable rate	33⅓ %
	Section 2	"Rules to Live By" infraction	33⅓ %
	Section 3	Safety observation program	33⅓ %

SECTION 1	OSHA RECORDABLES		
OSHA rate is calculated by the following:			
		2 or more =	0%
		less than 2 =	100% of Section 1
Note: Review based on specific job criteria (i.e., duration of project). Ameren POS safety supervisor has final call on OSHA recordable determination.			

SECTION 2	"RULES TO LIVE BY" OBSERVATIONS		
		1 or more =	$2,000 penalized assessment per Appendix A
		less than 1 =	(add)
Note: Observations that are self-reported by contractor do not apply to this. Only observations by Owner or Owner's representative apply.			

SECTION 3	COMPLETED CARDS		
An agreed-upon safety observation card program will be developed as part of site safety process. Observations are based on number of fully completed, meaningful cards generated by contractor's employees and submitted to Ameren designated representative. These observation cards may show positive coaching as well as corrective coaching. Observation cards completed by Ameren will not be utilized KPI of this section.		< 70 cards =	(deduction)
		70 - 90 cards =	$0
		> 90 cards =	(add)

ATTACHMENT A21
GUIDELINE FOR ABANDONING PIPING AND DEMOLISHING ABANDONED PIPING

1.0 GENERAL GUIDELINE FOR PROPERLY ABANDONING PIPING

The division of responsibility for the following actions to be decided at assignment of work:

1.1 A Competent Person shall pre-plan the job prior to the start of the work.

1.2 Determine pipe to be abandoned. Review P&ID's and piping isometrics to determine isolation points and material conveyed in piping.

1.3 If a JR is not already in EMPRV, Ameren Single Point of Contact (SPOC) shall create a JR in EMPRV.

1.4 Review WPA requirements with the Responsible Engineer listed on the JR.

1.5 Conduct a pre-job briefing to discuss site specific safety plan and the following:

1.5.1 PPE required

- Chemical Protection
- Eye & Face Protection
- Foot Protection
- Hand Protection
- Head Protection
- Hearing Protection
- Respiratory Protection

1.5.2 Atmospheric conditions if working in enclosed spaces

1.5.3 WPA

1.6 Ensure proper WPA is in place to isolate lines. As part of WPA, drain lines and confirm all low spots have been drained.

1.7 Take special precautions to ensure environmental spills do not occur.

1.8 At extreme ends of pipe, remove at least a one foot section of pipe from equipment or process piping still in use to ensure complete isolation, and cap end of process piping that will remain in service.

1.9 Permanently tag abandoned pipe in at least three locations (Steel or Brass tag wired to pipe), designating the pipe to be "Abandoned in Place", applicable JR number, and material pipe conveyed.

1.10 Update P&ID's and piping isometrics as applicable identifying the pipe to be "Abandoned in Place".

2.0 GENERAL GUIDLINE FOR DEMOLISHING ABANDONED PIPING

The division of responsibility for the following actions to be decided at assignment of work:

2.1 A Competent Person shall pre-plan the job prior to the start of the work.

2.2 Determine pipe to be demolished. Review P&ID's and piping isometrics to determine isolation points and material conveyed in piping.

2.3 If a JR is not already in EMPRV, Ameren Single Point of Contact (SPOC) shall create a JR in EMPRV.

2.4 Review WPA requirements with the Responsible Engineer listed on the JR. Ensure proper WPA is in place to isolate lines.

2.5 Conduct a pre-job briefing to discuss site specific safety plan and the following:

2.5.1 PPE required

- Chemical Protection
- Eye & Face Protection
- Foot Protection
- Hand Protection
- Head Protection
- Hearing Protection
- Respiratory Protection

2.5.2 Atmospheric conditions if working in enclosed spaces

2.5.3 WPA

2.6 Ensure proper WPA is in place to isolate lines. As part of WPA, drain lines and confirm all low spots have been drained.

2.7 Take special precautions to ensure environmental spills do not occur.

2.8 At extreme ends of pipe, remove at least a one foot section of pipe from equipment or process piping still in use to ensure complete isolation, and cap end of process piping that will remain in service.

2.9 Remove piping and dispose of properly.

2.10 Update P&ID's and piping isometrics as applicable (i.e. remove).

END OF APPENDIX A

APPENDIX B– JOB WORKING RULES AND CONTRACT WORK LIMITATIONS
CONTRACTOR REQUIREMENTS - POWER PLANTS

1.0 JOB WORKING RULES

1.1 Contractor must enforce the Ameren Job Working Rules, included in this specification here as Appendix B, as well as the Contractor's own work rules. If the rules conflict, the more restrictive rule applies.

2.0 PLANT ACCESS, PARKING AND SECURITY

2.1 Contractor employees must enter the plant ***only*** at the entrance where their company name is posted. Security cameras monitor entrances to inform supervisors of violations.

2.2 The speed limit is 10-MPH unless otherwise posted.

2.3 Contractor personnel may not ride in the back of a truck on company property or to/from/between job sites unless properly seated with a seat belt.

2.4 Contractor employee vehicles must park in Construction Parking lot or in areas designated for Contractor use.

2.5 Contractor employees must enter and leave through the designated Construction gate.

2.6 Contractor employees must check in and out of project with their immediate Foreman or General Foreman.

2.7 Security will issue an identification badge to Contractor employees after site orientation training. Badges must be visible at all times while on the site.

2.8 If the site has an electronic badge reader, a green LED light indicates that arrival/departure times have been recorded and the gate is unlocked.

2.8.1. If a badge reader is not available, employees must sign the gate register when arriving or departing.

2.9 Lunch boxes, toolboxes, coolers and other containers are subject to inspection when entering or leaving Ameren premises.

2.10 An Ameren Material Pass (Form 5532NS) signed by the Ameren Station Point of Contact (SPOC) and a Contractor supervisor must be presented to Security when tools or materials are taken off site.

2.11 The Security Guards can:

- De-activate / activate a badge when changing plant locations
- Replace a damaged badge or lost badge
- Update the employee name, Contractor company, or craft.

2.12 Cameras and video recording devices are prohibited unless specifically authorized by Ameren management.

3.0 GENERAL REQUIREMENTS

3.1 The more restrictive rule will govern in the event of any conflict between Ameren and Contractor work rules.

3.2 All Contractor/Subcontractor employees must not leave their work areas during assigned work periods. Any reasonable break periods will be established by the Contractor/Subcontractor.

3.3 Only drink water from drinking fountains or lavatories, other outlets may contain river water.

3.4 Certain plant locations, including cafeterias, locker rooms, and washrooms, may be posted as OFF LIMITS to construction or Contractor personnel.

3.5 Written permission is required before using Ameren equipment or tools, except for public pay phones.

3.6 Radios or “boom boxes” are not allowed because they can disrupt communication and distract workers.

3.7 Smoking is permitted in designated areas only.

3.8 Daily cleanup of the work area is required. Ameren reserves the right to clean up Contractor's area if Contractor is not fulfilling their housekeeping requirements. Any and all costs associated with the cleanup will be deducted from Contractor's base contract.

4.0 EVACUATION

4.1 If there is an emergency, an evacuation announcement may be made over the plant’s public address system. The evacuation assembly area should be communicated during orientation training.

4.2 In the event of severe weather, an announcement to seek shelter may be made over the public address system. The location of the plant tornado shelter should be communicated during orientation training.

4.3 To report an emergency, contact the Shift Supervisor immediately using the plant’s public address system. Do not hang up. Wait for instructions.

5.0 WORKER’S PROTECTION ASSURANCE OR HOLD CARD PROCEDURE

WARNING: Violation of Workers Protection Assurance (WPA) procedures can cause serious equipment damage, personal injury or death.

When WPA is present, verify that equipment is actually de-energized or in the designated state. Always walk down the job, check voltages, temperatures, pressures, etc. to confirm status.

5.1 WPA is Ameren’s procedure to tag equipment or systems that have been de-energized or put in a specified state, to allow for service or testing. The energy in a system may be electrical, mechanical, pneumatic, hydraulic, chemical, kinetic or nuclear.

5.2 All employees should receive site-specific WPA training including descriptions of the tags and their functions. Workers must sign on and off WPA protection as directed by their supervisor.

5.3 Contractor/Subcontractor employees shall observe all WPA rules and comply with WPA tags at all times. Never use an elevator that has a WPA card on the call button.

6.0 SUBSTANCE ABUSE

ATTENTION: Employees who refuse to take a drug test or have been found to be non-compliant will be escorted off-site immediately and may be subject to permanent barring from Ameren facilities.

6.1 Possession, and/or use of alcohol or drugs, is STRICTLY PROHIBITED.

6.1.1 Drugs, stimulants, “pep pills,” tranquilizers, and similar substances are allowed only if prescribed by a doctor.

6.2 Ameren’s Contractor’s Substance Abuse Policy requires pre-employment and random drug testing of Contractor employees.

7.0 HARASSMENT AND WORKPLACE VIOLENCE POLICIES

7.1 Ameren Corporation has a zero-tolerance policy for behavior that is prohibited under Ameren’s EEO & Anti-Harassment Policy and Ameren’s Workplace Violence Policy Statement. These policies apply to Ameren employees and Contractor/Subcontractor employees.

7.2 Ameren intends that employees, contractors, customers, vendors, and visitors, never feel threatened, intimidated, harassed, offended or demeaned by any individual’s actions, presence, conduct, or communication while they are on Ameren property.

7.3 The following behaviors and actions are **STRICTLY PROHIBITED** anywhere on Company property and may result in permanent barring from all Ameren facilities:

- Willful violation of safety rules or safe working practices
- Possession of unauthorized firearms, weapons or explosives and/or materials/components that could be used to make explosive devices
- Damaging, mutilating, or willful abuse of supplies, equipment & tools, vandalism of company property, or property of others
- Gambling or stealing
- Urinating in an undesignated area
- Harassment by anyone and in any form
    - Harassment includes, but is not limited to, unwelcome or unsolicited conduct or hostility based on or directed at a person or group because of race, color, religion, sex, national origin, ethnicity, age, disability, veteran status, pregnancy, marital status, sexual orientation or any other protected factor.
    - Conduct that may be considered offensive, hostile, demeaning, or derogatory, regardless of whether it is physical, verbal, or graphic in nature and whether it is done in person, or delivered via phone, fax, e-mail, text message, over a PA system, company mail, or by any other means.
    - Examples of Prohibited Physical Conduct:
        - → Bullying, wrestling, fighting, horseplay, or spitting on an individual,
        - → Sexual conduct such as rape, sexual battery, molestation, stalking, or attempts to commit such assaults, unwelcome touching, hugging, massaging, etc.
    - Examples of Prohibited Verbal Conduct:
        - → Threatening/intimidating someone (both explicit and implied),
        - → Verbal abuse, jokes, derogatory comments, references, or derogatory slurs of a sexual, racial, ethnic, or religious nature.
    - Examples of Prohibited Non-Verbal Conduct:
        - → Wearing of offensive clothing, hats, patches, etc.
        - → Displaying stickers, drawings, or posters that depict nooses, confederate “Rebel” flags, KKK paraphernalia, swastikas, or magazines, books, pictures or videotapes with sexual content.
        - → Drawing/displaying graffiti, specifically graffiti that is sexual, racial, or otherwise offensive, hostile, demeaning or derogatory to any individual/group or known to incite anger/violence.
        - → Using gestures that are obscene, or known to incite anger/violence.

7.4 Other behaviors and actions, not specifically set forth in this list, may violate Ameren zero tolerance policies.

8.0 <u>WORKPLACE HAZARDS</u>

8.1 Work near coal dust, fly ash, lime, or ferric/lead paint removal projects can create airborne contaminates. Do not use compressed air to clean surfaces or clothing. Use properly equipped vacuum, wet methods or other approved methods for cleaning.

8.2 All plants have asbestos-containing insulation and building materials (ACM). Treat all suspect materials as if they are asbestos.

8.3 Asbestos abatement projects may be in progress. Barricades will restrict access to areas with abatement projects. Only trained personnel using Personal Protection Equipment (PPE) may handle asbestos.

8.4 Personnel who are medically required to use syringes should take them home, properly packaged for disposal. Only trained employees using PPE should handle items contaminated with blood or other body fluids. Report any bloodborne related issues to the SPOC.

9.0 FOREIGN MATERIAL EXCLUSION (FME)

9.1 Foreign Material Exclusion protects critical plant components and systems, from contamination or damage. Systems such as feed water, condensate, steam, oil, and electrical controls and motors may suffer significant damage from foreign materials. See Appendix X for additional requirements and details.

9.2 Foreign material contamination can come from sources such as:

- Welding and gas cutting debris,
- Metal chips, shavings and filings,
- Corrosion that produces flakes of metallic substances,
- Cleaning materials, such as shot from blasting, rags & lint,
- Forgotten tools or any material that falls out of worker's pockets,
- Water leaks/spills, cutting fluids, solvents, etc.

9.3 To prevent damage from foreign objects follow these work practices:

- Clean dirt, oil and fly ash from around covers, caps and other devices before opening.
- Remove welding electrodes, stubs and broken flux coating material from internal work areas in closed systems.
- Cover openings on turbines, generators, pumps, pipes, tubes, electrical cabinets/motors and other critical components during maintenance activities.
- Track tools, parts and materials allowed in an FME work area.
- Allow only materials necessary for the task into the work area; do not allow personal items such as jewelry or change.
- Secure all tools, safety glasses, badges, gloves and other loose items with lanyards, tape or other means.
- Catch clippings from cable ties, stripped wires, etc.
- Vacuum or wipe out electrical cabinets after repairs/modifications to remove moisture, metal chips, knockouts, clippings, etc.

I, the undersigned, have read the Job Working Rules. I have completed site orientation training and I understand:

- The Job Working Rules
- Site-specific instructions, including Worker's Protection Assurance procedures
- Safety requirements

I acknowledge that a violation of any of these provisions will be grounds for immediate removal from Ameren property and I may be subject to permanent barring from all Ameren facilities.

Date _____

Employee Name (Print) _____

Employee Signature _____

Contractor _____

END OF APPENDIX B

APPENDIX E
MATERIAL SAFETY DATA SHEETS
CONTRACTOR AFFIDAVIT PURCHASE ORDER NO.

As the responsible party for the firm of _____, I do here state that I have requested, received, read, understand, and will abide by and enforce the guidelines and conditions set forth in the Material Safety Data (MSD) Sheets provided by the product manufacturer for each hazardous chemical product delivered to and/or used in connection with the work specified in _____.

I further state that I am aware of, understand, and will fully implement the requirements of the OSHA Hazard Communication Standard (CFR 29, Part 1910.1200) and other workers' right-to-know laws.

I further state that I will maintain copies of the required MSD Sheets for each hazardous chemical in the workplace, including Company's hazardous materials, listed in this Specification; and will insure that the MSD Sheets are readily accessible during each work shift to employees when they are in their work areas.

I further state that the information contained within the MSD sheets has been disseminated to all parties who have a right or need to know; and that all workers and other effected parties have received adequate and appropriate training in the hazards, handling, and use of hazardous chemicals.

_____ _____
Contractor's Representative/Title Date

_____
Notary Public Signature & Seal

END OF APPENDIX E

APPENDIX F
LEADED PAINT DISTURBANCE

Laboratory testing of bulk paint samples taken in the work area covered by this specification has revealed that the coating contains lead. The results, or a summary of results, from this testing is included as a part of this appendix. On the basis of these test results, any and all disturbance of the leaded coatings (unless specifically noted elsewhere as being non-lead containing coatings) must be performed in accordance with the OSHA Construction Lead Standard 29CFR1926.62.

Leaded coating disturbance constitutes any operation which results in the leaded coating being removed, eroded, abraded; or which results in the generation of a lead containing waste product that could become air-borne. The extent of the disturbance, or volume of waste generated, does not remove or mitigate the necessity of comply with 29CFR1926.62.

It is solely the responsibility of the Contractor to select and implement work practices and procedures which comply with the above requirements. All such operations must be designed, scheduled, and performed in a manner which will insure the health and safety of all Contractor and Company personnel at the facility and/or in the vicinity of the coating disturbance.

The determination that the coatings to be disturbed contain lead will invoke the provisions of other laws and requirements in addition to 29 CFR1926.62. These requirements include, but are not limited to: waste evaluation, identification of proper waste handling and disposal alternatives, worker right-to-know issues, etc. It is the Contractor's responsibility to comply with these additional requirements as well as those imposed by 29CFR1926.62. These additional requirements may be detailed under other appendices or specification sections.

END OF APPENDIX F

APPENDIX G
AMEREN REQUIREMENTS FOR CONTRACTOR ASBESTOS PROJECTS

1.0 INFORMATION AND REFERENCE

Due to the potentially toxic and hazardous nature of asbestos, properly trained personnel working under the supervision of a "Competent Person," special work practices and disposal procedures must be exercised to control exposure to airborne asbestos fibers and to assure that the removal or encapsulation project is carried out without creating any health hazards from the spread of asbestos contamination in and around the project area. Thermal System Insulation and sprayed on fireproofing shall be treated as asbestos containing material unless it has been proven otherwise. This document does not constitute a project design but is intended to provide a scope of work for Contractor. If a project design is necessary it is the responsibility of Contractor to utilize a Licensed Project Designer.

All work performed by Contractor shall conform to the requirements of the following standards and publications:

1.1 OSHA, U.S. Department of Labor, Code of Federal Regulations, Title 29, Section 1910.1001, Section 1926.1101, Section 1910.134 and Section 1910.1200.

1.2 U.S. Environmental Protection Agency, Code of Federal Regulations, Title 40, Part 61 as amended, Subpart M - National Emissions Standards for Hazardous Air Pollutants; Asbestos.

1.3 U.S. Environmental Protection Agency, Code of Federal Regulations, Title 40, Part 763, Appendix C to Subpart E - Asbestos Model Accreditation Plan.

1.4 Missouri Department of Natural Resources regulations 10 CSR 10-6.020, Definitions; 10 CSR 10-6.250 Asbestos Abatement Projects - Certification, Accreditation and Business Exemption Requirements.

1.5 Illinois Department of Public Health regulation 77 Ill. Adm. Code 855 – Asbestos Abatement for Public and Private Schools and Commercial and Public Buildings in Illinois.

1.6 EPA's Guidelines Series Publication No. EPA 560/5-85-024 "Guidance for Controlling Asbestos-Contaminating Materials in Buildings."

2.0 BID PROPOSAL

The bid proposal submitted by Contractor to the Company Purchasing Department shall include the following:

2.1 A list and brief description of all asbestos projects completed or currently involved with covering the last three year period, and the name of a reference for each project.

2.2 An informational package setting forth the methods Contractor will use to perform the abatement activities that ensures compliance with all governmental regulations. At a minimum, this package will include training certification of project supervisors and workers, air sampling strategies, asbestos removal techniques, and the laboratory that will be performing the air sampling analyses.

2.3 A list of all chemicals to be used and the respective Material Safety Data Sheets (MSDS).

2.4 The methods of sampling and ventilation during solvent usage in the case of mastic or paint removal.

3.0 SPECIFIC PROCEDURES AND WORK PRACTICES

In addition to the governmental standards and publications listed on page 1 of this attachment, Contractor, at a minimum, shall follow these procedures and work practices.

4.0 NOTIFICATION TO AGENCIES

Contractor shall notify appropriate regulatory agencies of the asbestos project. These notices shall include the amount of asbestos to be removed, Contractor's onsite supervisor and phone number, the work location, the dust prevention practices to be followed, work schedule, analysis of samples of the asbestos materials to be removed, the asbestos disposal site, and payment of the project notification fee, if required. Contractor

shall be responsible for payment of the site inspection fees, if required. Work shall not begin until Contractor provides proof that registration and notification requirements have been met.

5.0 WORK AREA SET-UP AND OTHER NON-ABATEMENT ACTIVITIES
Contractor shall:

5.1 Establish a control area around the affected work area using rope and/or barricade tape and warning signs. The barrier shall be placed at a distance sufficient to provide protection and notification to personnel on the job site not employed by Contractor. ALL personnel including foremen, visitors, inspectors, etc. shall wear required protective equipment when entering the control area.

5.2 Display asbestos signs and warnings in accordance with OSHA requirements. In addition, employers in the adjacent area shall be informed of the nature of the work being performed.

5.3 Ensure that if disposable clothing is worn outside the regulated area, it is a color and/or style that can easily distinguish it as being different from the clothing worn inside the regulated area.

5.4 Ensure negative pressure enclosures have at least one viewing window of a minimum 18 inches square. Additional viewing windows may be requested by the Company representative. These enclosures shall maintain at least 0.02" water negative pressure, as verified by the use of a manometer.

5.5 Ensure equipment and floors are covered with plastic tarpaulins to assure clean-up and avoid spread of contamination. However, there may be some exceptions depending on the nature of the floor and/or specific project requirements.

6.0 WORK PRACTICES AND PROCEDURES
Contractor shall:

6.1 Utilize EPA certified workers, EPA certified supervisors, EPA certified inspectors and EPA certified project designers (when a design is necessary) on asbestos abatement projects, in accordance with the ASHARA accreditation requirements.

6.2 Use wet methods during asbestos abatement. Residual pieces of asbestos insulation on walls, pipes and fittings shall be removed by wetting and scraping or by other feasible techniques which will not generate dust. Cleaning up debris by dry sweeping or blowing shall not be allowed. Absolutely no work shall be carried out which generates visible dust clouds.

6.3 Maintain the work areas as to not allow accumulations of asbestos containing materials on the floors or other surfaces. Asbestos contaminated wastes removed during a shift shall be placed into proper containers prior to the end of the shift.

6.4 Remove pipe insulation in manageable lengths and place these wastes directly into proper containers.

6.5 Use industrial type vacuums equipped with high efficiency particulate air filters when performing asbestos vacuuming.

6.6 Dispose asbestos contaminated protective clothing in proper containers and treat as asbestos contaminated waste. Contaminated clothing shall not be worn outside the controlled area.

6.7 Ensure all asbestos contaminated wastes are collected and sealed in proper containers such as impermeable bags. These containers shall be labeled in accordance with OSHA and EPA requirements. Care shall be exercised not to overload containers. If containers are likely to break or tear, they should be placed into fiber drums.

6.8 Remove all asbestos bearing containers and transport to a suitable disposal facility which is approved by proper authority for asbestos disposal and/or storage. Contractor shall provide the Company with documentation identifying the disposal site and prove that material was disposed at the approved site.

6.9 Perform a visual inspection of all areas to verify clean-up. Limited hose down procedures may be used as necessary in the clean-up.

6.10 Galbestos Siding

6.10.1 Verify with the Ameren SPOC, the schedule for the galbestos siding removal is acceptable to mitigate conflicts with other Contractors working in the area.

6.10.2 Verify with the Ameren SPOC, the saw cutting of the galbestos siding is the preferred method of removal versus the removal of full sheets. Galbestos siding is to be removed from wall, and saw cutting activities to take place in an area away from other work activities.

6.10.3 Verify with the Ameren SPOC, containment enclosures are properly set up to assure clean-up and avoid spread of contamination during the saw cutting process.

7.0 AIR SAMPLING

7.1 During asbestos removal, representative full-shift AND 30 minute excursion samples shall be obtained. These samples will be collected and evaluated as required by 29 CFR 1926.1101. Results shall be reported as fibers per cubic centimeter and as an 8-hour time-weighted average, where applicable. It is the responsibility of Contractor to ensure this sampling is conducted, and that all results are reported to the Company Representative within 72 hours after collection.

7.2 Company representative may take samples outside the control area at various times during the removal of asbestos materials and will notify Contractor's representative that sampling is being done or to be done.

7.3 After clean-up, final air samples will be taken. A clearance level of <0.01 f/cc (or the level obtained from background monitoring, whichever is greater) must be achieved before clean-up is considered complete and the enclosure is dismantled. For Missouri NESHAPS jobs performed inside an enclosure, final clearance air monitoring shall be performed by a third party air sampling professional selected and under the control of the Company. If at any time the final visual clearance fails by the third party air sampling professional, the Contractor shall be responsible for the costs related to the final visual clearance. For Illinois indoor asbestos projects final air clearance shall be conducted by an Air Sampling Professional. A Company representative will provide the final approval to dismantle enclosures.

8.0 RECORDKEEPING AND REPORTING

8.1 The "Competent Person" employed by Contractor shall complete a daily activity report. This report will include, at a minimum, the names of the employees working inside the enclosure, the personal protective equipment used, air sampling results, and an inspection indicating that the enclosure integrity was ensured and the negative pressure reading(s) within the enclosure. These daily reports will be made available to the Company representative

8.2 Contractor will provide the Company representative with a copy of the post-job notification to regulatory agencies within 60 days after project completion (Missouri jobs only).

8.3 A final technical report covering the implementation of this plan and air sampling results will be prepared by Contractor upon completion of this project. This report will include a summary of air monitoring conducted, a log of employees who worked the project, and certification that their employees received required training, medical evaluations and respirator fit-tests. Contractor shall provide the Company Representative with a copy of this report.

END OF APPENDIX G

APPENDIX H
FERC AFFILIATE RESTRICTIONS AND STANDARDS OF CONDUCT
POLICY AUE-ADM-5476, REV. 2

ADMINISTRATIVE PROCEDURE	
AUE-ADM-5476	**FERC Affiliate Restrictions and Standards of Conduct**

Power Operations

Approved By: *Signature on File* Date: 12/3/12

Chuck D. Naslund
SR VP Generation & Environmental Projects

Responsible Department – POS / Quality Management Services

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Revision Number	Revision Date	Revisions (reference page/section numbers)
0	9/15/2008	New AUE business line procedure
1	10/29/2009	Replaced previous Code of Conduct procedure with Affiliate Restrictions and Standards of Conduct.
2	2/24/2011	Added sections 3.1, 4.8.1.1, 4.8.1.2, & Attachments E, F
3	11/26/12	Procedure periodic review updates; locations and contacts
3.1	1/22/13	Clarification on contractor training requirements section 4.8.1

For more information about revisions, refer to Procedure Revision Request form or procedure history files.

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1.0 INTRODUCTION

1.1 Purpose

1.1.1 This procedure implements the Federal Energy Regulatory Commission (FERC) Affiliate Restrictions and Standards of Conduct (18 C.F.R. part 35.39, Affiliate Restrictions) and Standards of Conduct (18 C.F.R. part 358 Standards of Conduct) for Ameren Missouri Power Operations.

1.2 Scope

1.2.1 This procedure provides direction and guidance on Affiliate Restrictions requirements for employees of Ameren Missouri Power Operations. The Standards of Conduct are a separate set of rules that apply to the relationship between the Transmission Provider's transmission function employees and its affiliated marketing function employees. Ameren Missouri Power Operations employees are also subject to the Standards of Conduct; these rules are addresses in Section 2.1.12 of this procedure.

1.2.2 This is an Ameren Missouri Power Operations implementing procedure. Lower level implementing procedures may be developed when required, but they must support and fully implement the requirements and processes described in this procedure. These procedures will be reviewed by the Chief Compliance Officer or designee.

2.0 INFORMATION

2.1 Terms and Definitions

2.1.1 **Affiliate Restrictions** – Affiliate Restrictions is a set of rules that FERC imposes on a power seller when granting it market-based rate authority. The FERC Affiliate Restrictions rules are included as Attachment B to this procedure. The Affiliate Restrictions govern the relationship between a franchised public utility with captive customers ("utility") and its market-regulated power sales affiliates ("non-utility"). The Affiliate Restrictions require utility employees to operate separately from non-utility employees to the maximum extent practical. It also prohibits the sharing of the utility's Market Information with non-utility employees if the information can be used to the detriment of captive customers.

2.1.2 **Franchised Public Utility with Captive Customers** – Franchised Public Utility with Captive Customers ("Utility" or "Regulated Business

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Segment") means a public utility with a franchised service obligation under state law. For Ameren this includes Ameren Missouri (including its generating assets) and Ameren Illinois.

2.1.3 **Market Information** – Non-public market information related to the electric energy and power business including, but not limited to, information regarding sales, cost of production, generator outages, generator heat rates, unconsummated transactions, historical generator volumes, brokering activities, past sales and purchase activities, and the availability or price of inputs to generation. Market Information includes information from either affiliates or non-affiliates. Unless simultaneously disclosed to the public, the Utility may not share market information with a Non-utility employee if the sharing could be used to the detriment of captive customers. (See Attachment C).

2.1.4 **Market-Regulated Power sales Affiliate** – Market-Regulated Power Sales Affiliate ("Non-utility" or "Non-regulated Business Segment") means any power seller affiliate other that a franchised public utility, including a power marketer, exempt wholesale generator, qualifying facility or other power seller affiliate, whose power sales are regulated in whole or in part at market based rates. For Ameren this includes all Ameren non-regulated generators (AERG, AEG, MEPI and EEInc.) AER and AEM.

2.1.5 **No Conduit Rule** – The No Conduit rule prohibits all employees, including shared employees, from acting as a conduit to provide Market Information to employees that are not otherwise permitted access to that information.

2.1.6 **Non-regulated business segment and plant employees** – Non-regulated business segment employees (aka: Non-utility) means employees employed by Ameren's non-regulated sales affiliates, including AEM, AER and all non-regulated plant employees (AERG, AEG, MEPI and EEInc.).

2.1.7 Non-regulated facilities:

- Elgin Energy Center
- Duck Creek Plant
- Edwards Plant
- Sterling Avenue Facility
- Coffeen Plant
- Newton Power Plant
- Gibson City Power Plant
- Grand Tower Power Plant
- Joppa 7B Combustion Turbine Generators
- Electric Energy Inc (EEI) Joppa Generating Station

- Midwest Electric Power

2.1.8 **OASIS Posting** – Internet website location where Ameren may post information for public disclosure: http://www.ameren.com/source/FERC/Pages/home.aspx. For information that requires public disclosure, contact the Chief Compliance Officer or designee. See Section 4.5.1.2 of this document for contact information.

2.1.9 **Regulated business segment and plant employees** – Regulated business segment employees (aka: Utility) means employees employed by Ameren's regulated public utility business segments (Ameren Missouri and Ameren Illinois) and includes regulated plant employees.

2.1.10 Regulated facilities:

- Labadie Plant
- Meramec Plant
- Rush Island Plant
- Sioux Plant
- Audrain Power Station
- Goose Creek Power Station
- Kinmundy Power Plant
- Peno Creek Power Plant
- Pinckneyville Power Plant
- Raccoon Creek Power Station
- Venice Power Station
- Kirksville Plant
- Viaduct Plant
- Keokuk Plant
- Osage Plant
- Taum Sauk Plant
- Howard Bend Plant
- Fairgrounds Plant
- Moberly Plant
- Mexico Plant
- Moreau Plant
- Callaway Nuclear Plant

2.1.11 **Shared Employee** - A shared employee in a support role is permitted access to Market Information without being required to simultaneously disclose such information to the public. However, shared employees cannot serve as an improper conduit of Market Information. The following are examples of shared employees:

- Consultants and contractor management personnel
- Information Technology
- Business Services

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- Legal
- Human Resources
- Corporate-wide Risk Management
- Security
- Financial and Accounting
- Ameren's Executive Leadership Team (ELT). A current list of the Ameren ELT can be found on the FERC Regulatory Policy page in Scholar.

2.1.12 **Standards of Conduct** – The following is an excerpt from the written standard that this procedure is required to include.

The Standards of Conduct are a set of rules and regulations that apply to the relationship between the Transmission Provider's transmission function employees and its marketing function employees. The Standards of Conduct require that a Transmission Provider's transmission function employees must operate independently of its marketing function employees. The Standards of Conduct prohibit the Transmission Provider from providing non-public transmission information to its Affiliates that engage in marketing functions unless such information is simultaneously disclosed to the public. The Standards of Conduct are intended to provide for non-discriminatory access to transmission service and transmission system information.

(a) *Affiliate* of a specified entity means:

(1) Another person that controls, is controlled by, or is under common control with, the specified entity. An affiliate includes a division of the specified entity that operates as a functional unit.

(2) For any exempt wholesale generator (as defined under §366.1 of this chapter), affiliate shall have the meaning set forth in §366.1 of this chapter, or any successor provision.

(3) "Control" as used in this definition means the direct or indirect authority, whether acting alone or in conjunction with others, to direct or cause to direct the management policies of an entity. A voting interest of 10 percent or more creates a rebuttable presumption of control.

(b) *Marketing functions* means in the case of public utilities and their affiliates, the sale for resale in interstate commerce, or the submission of offers to sell in interstate commerce, of electric energy or capacity, demand response, virtual transactions, or financial or physical transmission rights, all as subject to an exclusion for bundled retail sales, including sales of electric energy made by providers of last resort (POLRs) acting in their POLR capacity.

(c) *Marketing function employee* means an employee, contractor, consultant or agent of a transmission provider or of an affiliate of a

transmission provider who actively and personally engages on a day-to-day basis in marketing functions.

(d) *Transmission functions* means the planning, directing, organizing or carrying out of day-to-day transmission operations, including the granting and denying of transmission service requests.

(e) *Transmission function employee* means an employee, contractor, consultant or agent of a transmission provider who actively and personally engages on a day-to-day basis in transmission functions.

(f) *Transmission function information* means information relating to transmission functions.

(g) *Transmission provider* means:

(1) Any public utility that owns, operates or controls facilities used for the transmission of electric energy in interstate commerce; or

(2) Any interstate natural gas pipeline that transports gas for others pursuant to subparts B or G of part 284 of this chapter.

(3) A transmission provider does not include a natural gas storage provider authorized to charge market-based rates.

2.2 Acronyms

2.2.1 **AEG** – Ameren Energy Generation (GENCO)

2.2.2 **AEM** – Ameren Energy Marketing

2.2.3 **AER** – Ameren Energy Resources (Ameren Illinois)

2.2.4 **AERG** – Ameren Energy Resources Generating (CILCO)

2.2.5 **EEI** – Electric Energy Inc. (Joppa)

2.2.6 **FERC** – Federal Energy Regulatory Commission

2.2.7 **MEPI** – Midwest Electric Power Inc.

2.2.8 **OASIS** – Open Access Same-Time Information System

2.2.9 **POLR** – Provider of Last Resort

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3.0 RESPONSIBILITIES

3.1 Ameren Management /Supervision

3.1.1 Ensure procedure compliance within assigned area of responsibility

3.1.2 Ensure training compliance, initial and annual renewal, for persons of responsibility, including record completion for those trained outside the CBT.

3.2 Affected Ameren Missouri Power Operations employees, Contractors, and Consultants (Persons of Responsibility)

3.2.1 All personnel with access to Market Information shall comply with the provisions of this procedure.

4.0 PROCEDURE

4.1 Business Segment Operations

4.1.1 Ameren Missouri Power Operations employees are members of the regulated business segment and are not shared employees.

4.1.2 An Ameren Missouri Power Operations employee may interface with other Ameren affiliates subject to the Affiliate Restrictions rules.

4.1.3 Consultants and contractor management personnel are considered shared employees and may perform support for both regulated and non-regulated business segments subject to the No Conduit rule (section 2.1.6).

4.2 Conducting Meetings and Other Communications

4.2.1 Prior to beginning any meeting with mixed participants (e.g., non-regulated plant personnel, regulated plant personnel) the Standards of Conduct and Affiliate Restrictions Meeting Reminder Language (Attachment A) will be read or provided to the participants as determined by the meeting organizer.

4.2.2 AUE Power Operations and AER Generation Technical Services and plant employees may share information concerning the safe and reliable operation of the generation facilities (e.g. best practices, lessons learned, safety improvements, technical information, and corrective actions) without having to simultaneously disclose such information to the public if such information does not contain Market Information.

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4.3 Marking of Documents

4.3.1 AUE Power Operations generated documents that may be viewed as containing Market Information should have an applicability statement in bold and capital letters as a header at the top of each page of the document. Example statements are shown below:

PER FERC AFFILIATE RESTRICTIONS THIS DOCUMENT IS FOR USE BY REGULATED AND AMS PERSONNEL

PER FERC AFFILIATE RESTRICTIONS THIS DOCUMENT IS FOR USE BY AMS PERSONNEL OR AMEREN ELT

4.4 Separation of Functions

4.4.1 Regulated business segment employees and shared employees may have physical and electronic access to regulated plant Market Information.

4.4.2 Regulated business segment employees should be prohibited access to non-regulated Market Information, except for certain field and maintenance employees described in Attachment D, Sharing of Technical Resources.

4.4.3 Upon an individual's transfer, termination, or retirement; access to Market Information shall be appropriately adjusted to reflect the change. Such changes in employee status will be reported to Human Resources in a timely manner.

4.5 Exchange of Market Information

4.5.1 Employees of the regulated business segment may not share Market Information with the non-regulated business segment (AEM, AER, AERG, AEG, MEPI and EEInc.) if the sharing could be used to the detriment of captive customers, unless simultaneously disclosed to the public (e.g. posted on OASIS, public release, etc.)

4.5.2 Shared information includes verbal, electronic (e.g. e-mail, internet, etc), written, printed, audio, visual or graphic communications. [Order 697]

4.5.3 **If** there is an inadvertent disclosure of Market Information, **then** immediately notify Ameren's Chief Compliance Officer (Joe Power) or Ameren's Compliance contact Tamara Evey at:

- Telephone number: 202-783-7604 or 314-206-1865
- E-mail : compliance@ameren.com

4.5.4 The following types of information sharing shall **not** require a posting:

4.5.4.1 Exchanges of Market Information among shared employees.

4.5.4.2 Exchanges of Market Information associated with the regulated plants between shared employees and all regulated business segment employees.

4.5.4.3 Information that is publicly available.

4.5.4.4 Information concerning the safe and reliable operation of the generation facilities such as best practices, lessons learned safety improvements, technical information, and corrective actions.

4.6 Computer Access to Market Information

4.6.1 Market Information is available within several computer systems.

4.6.1.1 Regulated business segment employees should only have access to Regulated plant information.

4.6.1.2 **If** a computer system malfunction occurs that allows access to prohibited information, **then** the employee should not view that information and should immediately notify the Chief Compliance Officer (Joe Power) or designee (compliance contact Tamara Evey) of the malfunction.

4.7 Guidelines for the Execution of Contracts

4.7.1 Purchase contracts with outside vendors for power plant projects will contain a clause that acknowledges the contractors obligation to comply with the FERC Affiliate Restrictions.

4.8 FERC Affiliate Restrictions Training

4.8.1 Specified AUE Power Operations employees, consultants, contractor management employees, and contractor non-management employees with supervisory/managing duties that have access to Market Information shall complete appropriate Ameren training requirements related to the Affiliate Restrictions.

4.8.1.1 Badged persons with Ameren network rights are to complete the training CBT annually. The latest version of the CBT can be found on the FERC Regulatory Policy page located under the Business Segments tab in Scholar.

4.8.1.2 Badged persons without Ameren network rights and unbadged persons are to complete the required annual training in 1 of the following 2 ways:

- Read a printed copy of the current CBT training slides.
- Read the Focused FERC Compliance Training. See Attachment E.

4.8.2 Completed training other then online CBT requires completion of the FERC Compliance Training Certification Form, Attachment F.

4.8.3 The Chief Compliance Officer or designee maintains the records of Affiliate Restrictions training.

5.0 RECORDS

The following documents are Records, as a result of performing this procedure. Records are stored electronically in the DMS unless otherwise noted.

5.1 Records Generated

5.1.1 FERC Compliance Training Certification Form (Attachment F)

6.0 REFERENCES

6.1 Source Requirements

6.1.1 Ameren Corporation Corporate Compliance Policy

6.1.2 Ameren Corporation Corporate Compliance Guidebook

6.2 Development References

6.2.1 Ameren FERC Compliance Training

6.2.2 18 C.F.R. part 358, Standards of Conduct for Transmission Providers

6.2.3 FERC Order 679 and 679-A, 18 C.F.R. part 35.39, Affiliate Restrictions.

7.0 ATTACHMENTS/APPENDICES

7.1 Attachment A – Standards of Conduct and Affiliate Restrictions Meeting Reminder Language

7.2 Attachment B – FERC Affiliate Restrictions

7.3 Attachment C – Explanation of the Scope of Market Information

7.4 Attachment D – Sharing of Technical Resources

7.5 Attachment E – Focused FERC Compliance Training Material

7.6 Attachment F – FERC Compliance Training Certification Form

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ATTACHMENT A:
Meeting Reminder

The following Statement may be read before meetings in order to help ensure compliance with the rules and reduce the chance of an inadvertent disclosure of market or transmission information. The statement can be used as a handout to those attending meetings as an additional reminder.

Standards of Conduct and Affiliate Restrictions Meeting Reminder Language

Ameren is subject to FERC rules which prohibit the sharing of certain types of market information unless such information is disclosed to the public at the same time. The Standards of Conduct restrict the Transmission Provider (owner or operator of the transmission system) from providing transmission information to its Marketing Function Employees (employees who engage in day-to-day marketing activities) unless the information is "simultaneously" disclosed to the public.

The term "transmission information" includes, but is not limited to, information about available transmission capability, price, curtailments, storage, ancillary services, balancing, maintenance activity, capacity expansion plans or similar information. Non-Marketing Function Employees may have access to transmission information for business purposes but, must comply with the no-conduit provision of the rule.

The Affiliate Restrictions prohibit the sharing of Utility Market Information with non-Utility employees if the sharing could be used to the detriment of captive customers, unless such information is "simultaneously" disclosed to the public.

The term Market Information means non-public information related to the electric energy and power business including, but not limited to, information regarding sales, cost of production, generator outages, generator heat rates, unconsummated transactions, brokering activities, past sales and historical generator volumes, purchase activities, and the availability of price inputs to generation. Market Information includes information from either affiliates or non-affiliates. Shared employees such as IT, HR, Accounting, and Legal may have access to Market Information but, must comply with the no-conduit provision of the rule.

Complying with the no-conduit provision means not sharing Transmission Function Information or Market Information with any Ameren employee/affiliate not otherwise authorized access to such information.

The topics and discussions at this meeting will comply with these rules including the "no conduit" rule. Is there anyone who does not understand the requirements of these rules?

If you have any other questions about these rules or there is a breach of the rules, contact Ameren's Chief Compliance Officer (Joe Power) or designee Nick Shea at:

- Telephone number: 202-783-7604 or 314-554-2237
- E-mail : compliance@ameren.com

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ATTACHMENT B:
FERC Affiliate Restrictions

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Affiliate Restrictions Rule

§ 35.39 Affiliate restrictions.

(a) General affiliate provisions. As a condition of obtaining and retaining market-based rate authority, the conditions provided in this section, including the restriction on affiliate sales of electric energy and all other affiliate provisions, must be satisfied on an ongoing basis, unless otherwise authorized by Commission rule or order. Failure to satisfy these conditions will constitute a violation of the Seller's market-based rate tariff.

b) Restriction on affiliate sales of electric energy or capacity. As a condition of obtaining and retaining market-based rate authority, no wholesale sale of electric energy or capacity may be made between a franchised public utility with captive customers and a market-regulated power sales affiliate without first receiving Commission authorization for the transaction under section 205 of the Federal Power Act. All authorizations to engage in affiliate wholesale sales of electric energy must be listed in a Seller's market-based rate tariff.

(c) Separation of functions.

(1) For the purpose of this paragraph, entities acting on behalf of and for the benefit of a franchised public utility with captive customers (such as entities controlling or marketing power from the electrical generation assets of the franchised public utility) are considered part of the franchised public utility. Entities acting on behalf of and for the benefit of the market-regulated power sales affiliates of a franchised public utility with captive customers are considered part of the market-regulated power sales affiliates.

(2) (i) To the maximum extent practical, the employees of a market-regulated power sales affiliate must operate separately from the employees of any affiliated franchised public utility with captive customers.

(ii) Franchised public utilities with captive customers are permitted to share support employees, and field and maintenance employees with their market-regulated power sales affiliates. Franchised public utilities with captive customers are also permitted to share senior officers and boards of directors with their market-regulated power sales affiliates; provided, however, that the shared officers and boards of directors must not participate in directing, organizing or executing generation or market functions.

(iii) Notwithstanding any other restrictions in this section, in emergency circumstances affecting system reliability, a market-regulated power sales affiliate and a franchised public utility with captive customers may take steps necessary to keep the bulk power system in operation. A franchised public utility with captive customers or the market-regulated power sales affiliate must report to the Commission and disclose to the public on its Web site, each emergency that resulted in any deviation from the restrictions of section 35.39, within 24 hours of such deviation.

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(d) Information sharing.

(1) A franchised public utility with captive customers may not share market information with a market-regulated power sales affiliate if the sharing could be used to the detriment of captive customers, unless simultaneously disclosed to the public.

(2) Permissibly shared support employees, field and maintenance employees and senior officers and board of directors under §§ 35.39(c)(2)(ii) may have access to information covered by the prohibition of § 35.39(d)(1), subject to the no-conduit provision in § 35.39(g).

(e) Non-power goods or services.

(1) Unless otherwise permitted by Commission rule or order, sales of any non-power goods or services by a franchised public utility with captive customers, to a market-regulated power sales affiliate must be at the higher of cost or market price.

(2) Unless otherwise permitted by Commission rule or order, sales of any non-power goods or services by a market-regulated power sales affiliate to an affiliated franchised public utility with captive customers may not be at a price above market.

(f) Brokering of power.

(1) Unless otherwise permitted by Commission rule or order, to the extent a market-regulated power sales affiliate seeks to broker power for an affiliated franchised public utility with captive customers:

(i) The market-regulated power sales affiliate must offer the franchised public utility's power first;

(ii) The arrangement between the market-regulated power sales affiliate and the franchised public utility must be non-exclusive; and

(iii) The market-regulated power sales affiliate may not accept any fees in conjunction with any brokering services it performs for an affiliated franchised public utility.

(2) Unless otherwise permitted by Commission rule or order, to the extent a franchised public utility with captive customers seeks to broker power for a market-regulated power sales affiliate:

(i) The franchised public utility must charge the higher of its costs for the service or the market price for such services;

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(ii) The franchised public utility must market its own power first, and simultaneously make public (on the Internet) any market information shared with its affiliate during the brokering; and

(iii) The franchised public utility must post on the Internet the actual brokering charges imposed.

(g) No conduit provision. A franchised public utility with captive customers and a market-regulated power sales affiliate are prohibited from using anyone, including asset managers, as a conduit to circumvent the affiliate restrictions in §§ 35.39(a) through (g).

(h) Franchised utilities without captive customers. If necessary, any affiliate restrictions regarding separation of functions, power sales or non-power goods and services transactions, or brokering involving two or more franchised public utilities, one or more of whom has captive customers and one or more of whom does not have captive customers, will be imposed on a case-by-case basis.

[Order 697, 72 FR 40038, July 20, 2007, as amended by order 697-A, 73 FR 25912, May 7, 2008]

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ATTACHMENT C:
Market Information

Explanation of the Scope of Market Information:

Note
Information that is publicly available can be shared across the company without restriction.

1.0 Market Information

Market Information means non-public market information related to the electric energy and power business including, but not limited to, information regarding sales, cost of production, generator outages, generator heat rates, unconsummated transactions, historical generator volumes, brokering activities, past sales and purchase activities, and the availability or price of inputs to generation. Market Information includes information from either affiliates or non-affiliates. Unless simultaneously disclosed to the public, the Utility may not share market information with a Non-utility employee if the sharing could be used to the detriment of captive customers.

1.1 Non-public information relating to any other entities' electric energy or power business is also subject to the sharing of market information restriction if such information could be used to the detriment of captive customers.

2.0 Market Information Examples

Following are additional examples of the types of information that may constitute Market Information. The list is not exclusive, and the omission of a type of information from this list does not indicate that it is not Market Information.

- Wholesale electric marketing prices, including prices for consummated sales, offers to sell and offers that have been rejected.

- Market information may include brokering activities, past sales and purchase activities, and the availability or price of inputs to generation such as natural gas supply if such information could be used to the detriment of captive customers. A public utility is restricted from disclosing to its market regulated affiliate any non-public information about a non-affiliated generator's upcoming maintenance or outage schedules or information about the non-affiliated generator's historical generation volumes, unless such information is simultaneously disclosed to the public.

- Ameren's generator operation data, including information on scheduled and unscheduled outages and information on the in-service date of new generation.

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ATTACHMENT D:
Sharing of Technical Resources

1.0 Technical Resources

Technical and engineering personnel employed by AUE engaged in generation-related activities may share their skills and knowledge with employees of non-regulated (AER, AERG, AEG, EEInc, MEPI.), generation facilities (and vice versa), provided that such employees do not themselves: (1) buy or sell energy; (2) make economic dispatch decisions; (3) determine (as opposed to implement) outage schedules; or (4) engage in power marketing activities. Such technical and engineering employees are subject to the No Conduit rule.

2.0 Resource Sharing

2.1 The sharing of this expertise is subject the following restrictions:

- The employee's time charges must reflect the services provided and be appropriately charged to the recipient's cost center. Any other expenses related to the technical assistance should be charged to the appropriate recipient's cost center.
- The technical expertise is not available within the recipient's business unit.
- As described above in 1.0 Technical Resources, the employee may not (1) buy or sell energy; (2) make economic dispatch decisions; (3) determine (as opposed to implement) outage schedules; or (4) engage in power marketing activities.
- The employee would be subject to the No Conduit rule with regard to sharing of Market Information.
- Notwithstanding any other restrictions set forth herein, in emergency circumstances affecting system reliability, such employee may take the necessary steps to keep the bulk power system in operation. This can include ordering the de-rate or shutdown of equipment. Any such actions would subject to after-the-fact disclosure to the Commission and posting on each company's OASIS or website within 24-hours of the event. [18 C.F.R. part 35.39 (c) (2) (iii)]

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ATTACHMENT E:
Focused FERC Compliance Training for Unbadged Consultants

A copy of the Focused FERC Compliance Training for unbadged consultants is available on the FERC Regulatory Policy page located under the Business Segments tab in Scholar. *From the Business Segments tab in Scholar locate the heading "Ameren Services." Click on FERC Regulatory Policy and then FERC Compliance Training for Consultants.*

http://corporatecompliance/WebForms/IntroPage.aspx

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ATTACHMENT F:
FERC Compliance Training Certification Form

Consultants that are subject to the FERC Compliance Training and are unable to take the training through the CBT must acknowledge that they have read the training by completing a certification form. The "FERC Compliance Training Certification Form" form can be found on the FERC Regulatory Policy page located under the Business Segments tab in Scholar.

From the Business Segments tab in Scholar locate the heading "Ameren Services." Click on FERC Regulatory Policy and then FERC Compliance Training for Consultants.

http://corporatecompliance/WebForms/IntroPage.aspx

https://acmsmain/mainp/groups/public/@public051/documents/document_other/gob069649.pdf

APPENDIX I
CHEMICAL OF INTEREST REPORTING

Contractor must complete the table below, "Department of Homeland Security Chemicals of Interest to be Brought on Site," which requires Contractor to list any materials being brought onsite which are identified in Appendix A of the DHS Chemical Facility Anti-Terrorism Standard Chemical (Facility Anti-Terrorism Standards (CFATS), 6 CFR Part 27.)

MSDS for all COI must be submitted with Contractor's bid.

During the work, Contractor must inform the SPOC of any additional COI brought onsite or if the maximum amount of any material identified in Sheet I-2 below.

AFFIDAVIT

A. AUTHORIZED REPRESENTATIVE

I HEREBY AFFIRM THAT:

I am the [title]_____ and duly authorized representative of [name of business]_____ and that I possess legal authority to make this Affidavit on behalf of the business for which I am acting.

B. CERTIFICATION OF CORPORATION REGISTRATION

I FURTHER AFFIRM THAT:

1. The business named above is a corporation registered in the state or commonwealth of _____ and is in good standing with said state or commonwealth's Department of Assessments and Taxation, and that the name and address of its resident agent is:

Name _____

Address _____

_____

C. CERTAIN AFFIRMATIONS VALID

I FURTHER AFFIRM THAT:

To the best of my knowledge, information, and belief, each of the affirmations, certifications, or acknowledgments contained in this Chemicals of Interest appendix is true and correct in all respects on the date of this Affidavit and as fully set forth herein.

I DO SOLEMNLY DECLARE AND AFFIRM UNDER THE PENALTIES OF PERJURY THAT THE CONTENTS OF THIS AFFIDAVIT ARE TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE, INFORMATION, AND BELIEF.

Date_____ By_____
(Authorized Representative and Affiant)

DEPARTMENT OF HOMELAND SECURITY CHEMICALS OF INTEREST TO BE BROUGHT ON SITE

Contractor: _____ Site: _____ Project: _____

Product/Chemical	COI Identified in Product/Chemical (Appendix A, 6 CFR 27)	Maximum Amount of Product On Site at Any Time (pounds)	Weight Percent COI in Product

END OF APPENDIX I

APPENDIX J
VENDOR DRAWING TRANSMITTAL / CAD REQUIREMENTS

The purpose of this document is to specify the procedures and method of transmittal of Computer Aided Drafting (CAD) electronic files and other design file requirements for drawings generated by vendors/architectural engineering firms working for Ameren Missouri.

PROCEDURES FOR TRANSMITTING FILES

A/E-Vendor Originated Drawings:
When engineering a project for Ameren Missouri, the Ameren engineer responsible for the project should contact Kim Jones, Drafting Supervisor of Power Operations Services, at 314-957-3394 or kjones5@ameren.com; to coordinate the transmittal of electronic CAD drawing files for the project.

CAD SOFTWARE DESIGN REQUIREMENTS

Ameren Missouri will provide a workspace to utilize when creating or modifying drawings. This can be obtained by contacting DLMODrawingControl@ameren.com. Ameren Missouri utilizes Microstation and DesCartes to create and modify both vector and hybrid CAD drawings. Ameren Missouri requires the following versions of software:

- Vector design files to be Microstation (.dgn) files.
- Raster design files to be in .tif format. Scanned file compression will be in the CCITT Group 4 format. In order to maintain minimal file size, drawings are scanned at as low a dpi as necessary to produce quality scanned drawings. The dpi is determined by the respective vendor firm in a range of 100-400dpi. The scanned files are to be cleaned-up as necessary prior to transmitting to Ameren Missouri.

DELIVERABLES

Vendor will furnish full size, as-built plots of CAD files for all projects. Quantities of copies for project drawings will be determined by the project engineer.

Ameren Missouri maintains an original of drawings in St. Louis, MO. A/E's and vendors are to furnish Ameren Missouri Power Operations Services with one full size, reproducible, 20# bond plot of all CAD generated drawings in addition to the CAD file. Plots should be transmitted to:

Nancy Underwood
Document Control Supervisor
Ameren Missouri
3700 S. Lindbergh Blvd.
St. Louis, MO 63127

Vendor will enclose all necessary documentation associated with as-built CAD files as applicable (i.e., file names, reference files and any other necessary information). All original drawings sent to vendors, all voided drawings and all manual drawings that have been redrawn are to be returned to Ameren Missouri.

Electronic files for all CAD drawings will be delivered to Kim Jones, Drafting Supervisor, by one of the following transmittal methods:

- Ameren approved file transfer protocol site – Citadon or Sharepoint (BPOS)
- CD-ROM

Virus protection is paramount with any of the above methods. All corporate procedures will be followed to ensure transmittals will be free of viruses. All files supplied to Ameren Missouri should be compatible in format and file structure as outlined in these requirements. Incompatible or incomplete files will be returned for further refinement before acceptance will be granted.

Samples of CAD files in an intermediate state can be submitted for approval of conformance to Ameren Missouri's drafting standards and is encouraged in the early stages of project development. Seed files are available and recommended to ensure compliance to Ameren Missouri drafting standards.

RESERVING NUMBERS FOR NEW AMEREN MISSOURI DRAWINGS

Power Operations Services is responsible for reserving numbers for vendors to use for new drawings for construction projects. The drawing class will be necessary to assign new numbers. (see Attachment C) Form GEN-FRM-ADM2105-03, Drawing Number Request, should be completed and submitted to the Ameren Missouri approved File Transfer Site (i.e. Sharepoint, Citadon) One drawing number will be assigned for each class of drawing needed. Sheet numbers will utilized in lieu of additional drawing numbers in the same class up to 999 sheets.

RESERVING FOREIGN PRINT DRAWING AND FOREIGN PRINT MANUAL NUMBERS

Power Operations Services is responsible for reserving numbers for vendors to use for new foreign print drawings and manuals for construction projects. It will be necessary to request the number of foreign prints by class, drawing or manual. Form GEN-FRM-ADM2105-03, Drawing Number Request, should be completed and submitted to the Ameren Missouri approved File Transfer Site (i.e. Sharepoint, Citadon)

FILE NAMING CONVENTIONS

To properly identify files it is necessary to adhere to several rules. Most of the drawing file extensions will be **.dgn, .cit** or **.tif** as the CAD system default file extensions.

The following special characters should not be used in file names:

- ! * / ({ < > }) & ? $ # @ ” ’ + [ ] ~

Ameren Drawings Numbers

- The CAD file is named the drawing number followed by the sheet number indicated by three characters. Examples:
    - 123456 sh. 1 is indicated as 123456001.dgn
    - 123456 sh. 123 is indicated as 123456123.dgn

Foreign Prints Manuals:

- The CAD file is to be named the 6 digit foreign print number preceded by FPM Example:
    - FPM-123456.pdf

Foreign Prints Drawings:

- The CAD file is to be named the 6 digit foreign print number preceded by the FPD and followed by the sheet number Example:
    - FPD-123456001.dgn, and FPD-123456001.cit

DRAWING REQUIREMENTS:

Titling – The title should begin on the second line since the first line of the drawing title is the drawing classification. Abbreviations when necessary should follow the ANSI standard of abbreviations and Acronyms for Use on Drawings and Related Documents.

Fonts – Ameren Missouri uses Microstation **Fonts 1, 10 and 30 (Ameren user font)** for all CAD drawings. A copy of **uefont.rse** is included with this procedure document. Font 10 is used for electrical and piping flow diagrams where differentiation is necessary for the letter “l” and the number “1.” See Attachment B, Font Library memo, for more font information. All lettering on new drawings should be a minimum of 1/8" when plotted and weight = 0 when plotted with the following exceptions:

a. Title block lettering is TX = 3/16" and WT = 2

b. Date in drawn by block is TX = 3/32" and WT = 0

c. Date in revision block is TH = 1/8" and WT = 0 Do not use dashes between month, day and year.

d. Drawing number is TX = 3/16" and WT = 2

Working units – Microstation drawings are drawn in real-world full size working units of measurement and are scaled when plotted. Borders are scaled to the appropriate size to ensure proper scale when plotted.

The working unit parameters in the design file settings for files should be:

Design File Settings Menu	PHYSICAL DRAWINGS	ELECTRICAL DRAWINGS
UNIT NAMES		
Master Units (MU) Sub Units (SU)	FT 12 in	IN 10^{th}
RESOLUTION		
"Per '	12	10
Pos Units Per " (PU)	1000	1000

Fraction display – stacked (i.e., 1½")

Dimension readout – feet and inches (not metric or in decimal form)

Angular Measurement – decimal degrees

Line weight – 1, or to match existing drawing for bold lines and good drafting practice

Patterning – as specified on each drawing

Revision number and date – required in title block area of each drawing. Revisions to existing drawings are numeric and increase by one each revision (i.e., Revision 2 would increase to 3). **All new drawings are issued at zero "0", revision. New drawings when revised increase to "1" for the first revision**. For vendors wanting to do multiple revisions to drawings prior to returning to Ameren Missouri, it is acceptable to use an alphanumeric numbering series (i.e., Drawing is sent to vendor at revision "1". Vendor creates "1A", "2A" , "3A" revisions and then issues final revision of "2" to Ameren Missouri).

Scoping – All revisions to existing drawings will have a revision balloon (scoping) placed around the areas revised. Vendors are to use a stream curve, line code = 7, line weight = 3, level = 63, and color = 7.

Reference files – Vendors are requested to supply any reference file that is attached to the set of Microstation drawings to be delivered to Ameren Missouri. The reference files, except for the border files, are to be numbered in the same fashion as the drawings.

Vendors using raster reference files are required to save active layer and attach active layers in the IRAS command menu before exiting Microstation.

Graphic Scales – All drawings that are drawn to scale should have a graphic scale so that any proportional blow-back from the original can be scaled. All drawings should note the scale in the title block. "NONE" should be indicated if no scale is used.

Drawing Levels – Mechanical/Structural drawings**.** See Attachment D, Ameren Missouri–Power Operations Services Drafting Manual, Drawing Level Scheme for mechanical and structural drawing level schemes.

Drawing Levels – Electrical drawings. Electrical drawings shall be drawn on level 5 with the exception of the border.

Operating Diagram – See Attachment E Instructions for Operating Diagram Issuance.

BORDER FILES/CELL LIBRARIES/SEED FILES:

Electrical borders are found in the file **EABORDER.DGN** (levels 59-63). Physical drawings shall use the attached level scheme. Physical borders are found in the file **SABORDER.DGN**. Both **EABORDER.DGN** and **SABORDER.DGN** are supplied with this package. Please ensure that all elements in the files are placed between levels 1 and 63 inclusively. Do not place elements, text, cells or any other graphic information on level 0 or any level greater than level 63.

It will be necessary to place vendor proprietary information in each CAD file rather than the border file. Reference the borders to the CAD file using the file names supplied with the files (i.e., **EABORDER.DGN**).

CABLE/CONDUIT/EQUIPMENT AND VALVE INFORMATION

Cable schedule, conduit schedule, equipment and valve numbers are in databases. All new cable and conduit information should be entered into Excel or Access data files and submitted to Drawing Control. Please contact Ameren Missouri Drawing Control at DLMODrawingControl@ameren.com for equipment and valve numbers and additional questions.

Questions concerning the transmittal of files should be directed to:

Kim Jones, Drafting Supervisor
Ameren Missouri
3700 S. Lindbergh Blvd.
St. Louis, MO 63127
314-957-3394
kjones5@ameren.com

ATTACHMENTS

A – Ameren Missouri - Power Operations Services - Border Size Chart
B – Ameren Missouri - Power Operations Services - Lettering Convention for Wire/Cable
C – Ameren Missouri - Power Operations Services - Drawing Class Types
D – Ameren Missouri - Power Operations Services - Drafting Manual, Drawing Level Scheme (mechanical/structural)
E – Ameren Missouri - Power Operations Services - Instructions of Operating Diagram Issuance

ATTACHMENT A

Ameren Missouri – Power Operations Services

BORDER SIZE CHART

Border	(ANSI)	Drawing Size	Half Size
A	(A)	8½ x 11	X
G	(B)	11 x 17	X
J		23¼ x 11½	X
Z	(C)	17 x 22	X
O		11½ x 36	X
P		11½ x 44	X
Y		34½ x 26	17 x 22
X		44 x 26	17 x 22
XX	(E)	44 x 34	17 x 22
SY	(D)	36 x 24	17 x 22
W	(Custom)	Up to 36 x 144	X

ATTACHMENT B
Ameren Missouri – Power Operations Services
LETTERING CONVENTION FOR WIRE/CABLE

W = White

B = Black

BR = Brown

R = Red

G = Green

BL = Blue

V = Violet

O = Orange

GR = Gray

Y = Yellow

R/B = Red – Black

G/B = Green – Black

BL/B = Blue – Black

BL/R = Blue – Red

BL/G = Blue – Green

O/G = Orange – Green

R/Y = Red – Yellow

R/BR = Red – Brown

Y/B = Yellow – Black

Y/BL = Yellow – Blue

BR/Y = Brown – Yellow

BR/G = Brown – Green

G/Y = Green – Yellow

V/Y = Violet – Yellow

BL/BR = Blue – Brown

ATTACHMENT C

Ameren Missouri – Power Operations Services

AMEREN DRAWING CLASS TYPES

1. Building
    a. Architectural Plan
    b. Building Services
    c. Concrete, Brick, Stone and Reinforcing
    d. General
    e. Piling, Foundations, Excavation
    f. Roofing, Flashing
    g. Stairs, Walkways, Floors, Partitions, Elevators and Grating
    h. Steel Framing and Details, Column Schedules
    i. Stress, Clearance Loading Diagrams
2. Conduit; Tray Cable
    a. Boxes
    b. General
    c. Hangers
    d. Installations, Details & B/M
    e. Plan
    f. Schedules
3. Duct
    a. General
    b. Installation, Details
    c. Plans
4. Equipment
    a. Brush Specifications
    b. General
    c. Installation, Details, Assembly, B&M
    d. Plan and Arrangements
5. Foreign Print
    a. None
6. Grounding
    a. General
    b. Installation, Detail, B and M
    c. Plans
7. Line Construction
    a. Configuration Diagrams
    b. Data Sheets
    c. Foundations Concrete
    d. Foundations Steel Frame
    e. Foundations Steel Tripods
    f. General
    g. Grounding
    h. Guying/Staking
    i. Insulator and Hardware Details
    j. Maps
    k. Phasing Diagrams
    l. Plan and Profiles
    m. Steel Poles
    n. Stress Diagrams
    o. Tower Lighting and Paining
    p. Tower Steel Framing and Details
8. Panel

a. General
b. Installation, Details and B/M
c. Layout – Front or Rear View
d. Nameplate Bill of Material

9. Piping

a. Control
b. Flow Diagrams, Isometrics, Composites, P&ID
c. General
d. Hangers, Anchors
e. Installations – Details – Air
f. Installation – Details – Misc.
g. Installation – Details – Oil
h. Installation – Details – Steam
i. Installation - Details – Water
j. Plan

10. Property Site

a. Engineering Records
b. Engineering Data
c. Organization Charts
d. Forms and General Drawings
e. Plats
f. Sewers
g. Yard Plans
h. Grading Levees
i. Roadways
j. Surveys
k. Fences

11. Schematic/Wiring

a. General
b. One Line and Meter Relay Diagrams
c. Panel Wiring Diagrams
d. Schematic Diagram – 11KV and above
e. Schematic Diagram – 2.3KV to 11KV
f. Schematic Diagram - Below 2.3KV
g. Schematic and Logic Diagrams
h. Wiring Diagram – 11KV and above
i. Wiring Diagram – 2.3KV to 11KV
j. Wiring Diagram - Below 2.3KV
k. Wiring and Interconnection Diagrams

12. Structure

a. Assembly and Details
b. Concrete, Reinforcing ad Inserts
c. General
d. Lighting, Yard Lighting, and Piping
e. Piling, Excavation
f. Plans
g. Steel Framing and Details

ATTACHMENT D

Ameren Missouri - Power Operations Services

DRAFTING MANUAL, DRAWING LEVEL SCHEME (MECHANICAL/STRUCTURAL)

	LEVELS									
Level Class 01010 Property	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Sewers	X									
Grounding		X								
Cables & Conduit			X							
Fdns Below Grade				X						
Property Lines – Street Survey					X					
Fence						X				
Grading Surfacing Contours							X			
Parking and/or Easement								X		
Common Overall Dim									X	
Drawing Title & Notes										X
Level Class 030 Building	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Heating Piping 03080	X									
Motors 03080		X								
Power & Recep. 03080			X							
Lighting 03080				X						
Arch Elevations					X					
Arch Details 03020 03090					X					
Furniture 03020						X				
Patterning							X			
Common Overall Dim (Cols)								X		
Overall Dimensions									X	
Dwg Title & Notes										X
Level Class 030 Building	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
Class 05031 Steam Plan	X									
Elev. & Det.		X								
Class 05032 Water Plan			X							
Elev. & Dets				X						
Class 05033 Air Plan					X					
Elev. & Det.						X				
Class 05034 Oil Plant							X			
Elev. & Det.								X		
Level	**41**	**41**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
Class 05030 Misc. Plan	X									
Elev. & Det.		X								
Class 05040 Hangers & Anchors			X							
05050 P. & I. D.				X						
Spare Spare Spare Spare Common Dimensions									X	
Title & Notes										X

ATTACHMENT E

Ameren Missouri – Power Operations Services

INSTRUCTIONS FOR OPERATING DIAGRAM ISSUANCE

OPERATING DIAGRAMS (Ameren Drawings and Vendor/Foreign Prints):

After field installation and drawings are corrected to an "As-Built" condition, the following classifications of drawings are designated as "Operating Diagrams."

CLASS NUMBER

09020 One Line Diagrams (Except Maximum Equipment and Relaying and Metering) (Power Plants, Substations and Customer Substations).

09030 Schematic Diagrams (Power Plants, Substations, and Customer Substations).

09010 Block Diagrams (All).

09010 Equipment Options Drawings for Load Dispatch System (LDS)

The drawings are identified with this "Operating Diagrams Sticker"

OPERATING DIAGRAM	
Issued by	Date

OPERATING DIAGRAMS – PREPARATION FOR ISSUING

1. Revise per field marked prints.
2. Add revision if drawing was changed per Note 1. Revision to read "Changed as installed on WO_____."
3. Remove circles from back of drawing for current work order (WO)/construction revision only. Before removing circles for other WO's check with Ameren Project Engineer to verify that work has been completed.

END OF APPENDIX J

APPENDIX K
PLANT ACCESS, PARKING & SECURITY

1.0 Plant Access, Parking and Security

1.1 Contractor employees, visitors and vendors must enter the plant *only* at the entrance where their company name is posted. Security cameras monitor entrances to inform supervisors of violations.

1.2 Security will direct contractor employees to work rules training the first time employees report to the site.

1.3 Employees must document their completion of site specific work rules training before they are allowed unescorted access to the site.

1.3.1 Computer Based Training (CBT) is typically used for work rules orientation and to document training.

1.3.2 Contractor employees must read and sign a hard-copy of the Job Working Rules if an orientation video or oral presentation is used for training.

1.3.3 If alternative training has been used due to a temporary CBT malfunction, then employees must take the CBT training when the system is restored.

1.4 Contractor's Employee Identification

1.4.1 Ameren Contractor ID badges containing the Contractor employee's name and Contractor ID number are issued when work rules training is completed.

1.4.2 Security will re-activate an existing badge if the employee has completed the site work rules orientation within the last 12 months.

1.4.3 Security will de-activate badges at the end of each job.

1.4.3.1 The Contractor should inform the Single Point of Contact (SPOC) when employees will complete their work on the site using the Reduction in Force Report (Attachment A7).

1.4.4 Daily gate logs will be used to validate invoices and may be provided to the Contractor upon request. If the plant has electronic badge readers, employee arrival and departure times are automatically recorded.

1.4.5 The Contractor shall provide employees with hard hats of the same color. The hard hats must have the Contractor's name or company logo on either the sides or the front of the hard hat.

1.4.6 Security will apply labels with the employee's first and last names to the front and back of each hard hat.

1.4.7 The Contractor may provide a hard hat storage container at the Construction gate. PPE is required to access the site.

1.5 Contractor Access

1.5.1 Business agents, vendor/sales representatives, contractor executives and other contractor visitors should park in the construction parking lot and be escorted on-site.

1.5.2 Consultant badge holders may park in either the construction parking lot or the Ameren employee parking lot visitor space, depending on the purpose of the visit.

1.5.3 A contractor employee who has completed CBT/Work Rules training may escort visitors and ensure Ameren work rules are followed.

1.5.4 Contractor visitors are issued a Visitor's badge and are required to wear a hard hat and safety glasses.

1.6 Vehicles Beyond the Security Gate

1.6.1 Only contractor work vehicles with an Ameren mirror tag are permitted beyond the security gate. The Contractor can request a mirror tag for vehicles necessary to complete the Work by submitting an Authorization for Site Vehicle Pass form.

1.6.1.1 Vehicles must have the Contractor name or Logo on each side and must have an insurance certificate verifying $1,000,000.00 minimum liability coverage.

1.6.1.2 Contractor work vehicles, commercial vehicles, or contract carrier vehicles without a mirror tag will be held at the gate until cleared by the SPOC.

1.6.2 Vehicle drivers and all passengers must swipe/sign-in at the construction gate.

1.6.3 Contractor vehicles leaving the plant will be inspected by Security.

1.6.3.1 Tools and materials being removed on Contractor vehicles must have an Ameren Material Pass (Form 5532NS) signed by the SPOC and a Contractor supervisor for Security to retain.

1.7 Use of Plant Facilities

Note: The policies are on Scholar, the Ameren intranet. Go to *Employee Center, Corporate Policies, Policies by Topic, Technology*.

1.7.1 Contractors who have Ameren computers, phones and fax machines are “Privileged Users” and must comply with the following policies.

- Electronic Mail Policy
- Facsimile Machine Usage Policy
- Information Resources Acceptable Use Policy
- Internet/Intranet Usage Policy
- System Access Control Policy
- Wireless Communication Policy

1.7.2 Work areas must be restored to a condition that is approved by the SPOC.

END OF APPENDIX K

APPENDIX M

Schedule of Contract Submittals

Appendix M: Schedule of Contract Deliverables

Section 1	Pre-Construction	Details	Delivery date (after award of contract)	Ameren	
				Info Only	Approval
A	Project Status Reports	Project Status Reports including Earned Value	Monthly (length of project)	x	
B	Schedule	Update Schedule and Earned Value	Weekly	x	
C	Design Data Collection	Initial Kick-off Meeting/Conference Call meeting minutes	24 hr after meeting	x	
D	Design Data Documentation	Collection of Design Input from Subteams and Summarization	30 days		x
E	Deleted	Deleted			
F	Procurement plan draft	Preliminary Equipment Selection and Justification	30 days		x
G	Proposed Design	Site layout	20 days		x
H	Permits and Permit applications	List of all required permits (operating and build permits)	20 days	x	
O	Deleted	Deleted			
J	Design Basis Report**	Basis of Design Report - completion of Appendix 1E - draft	60 days		x
K	50% Design Review	50% Design - Formal Engineering Design Review and Approval with Ameren - Meeting mintues and approval signatures of review -Site Soils/Geotechnical Report - Site Resistivity Survey -Site Baseline Survey and Topographical Survey -Civil/Structural/Architectrual E&D documents and drawings -Mechanical E&D documents and drawings -Electrical E&D documents and drawings -Instrumentation & Control E&D documents and drawings -Process/System Engineer -Environmental Engineering -Vendor Data/Drawings -Detailed Drawing Submittal (see List of Drawings) -Updated schedule and earned value criteria -Support documentation (Equipment and Subcontractor Quotes) to validate Total Cost Estimate	Per schedule		x
L	Specifications	Specifications review with Ameren -combiners - transformers - recombiners - PV solar panels - Inverters -Switchgear - all voltages - PLC, Digitial Control System data collection/alarming - Facility Construction Specificaitons - Other equipment specificaiton for plant equipment or construction	Per schedule		x
M	Deleted	Deleted			
N	Procurement Plan	Equipment and Subcontractor final selection and justificaiton along with associated Division of Responsibility	30 day prior to construciton or procurment activity		x

O	100% Design Review	100% Design - Formal Engineering Design Review and Approval with Ameren - Meeting mintues and approval signatures of review -Site Soils/Geotechnical Report - Site Resistivity Survey -Site Baseline Survey and Topographical Survey -Civil/Structural/Architectrual E&D documents and drawings -Mechanical E&D documents and drawings -Electrical E&D documents and drawings -Instrumentation & Control E&D documents and drawings -Process/System Engineer -Environmental Engineering -Vendor Data/Drawings -Detailed Drawing Submittal (see List of Drawings) - Independent drawing and design review documentation -Updated schedule and earned value criteria -Support documentation (Equipment and Subcontractor Quotes) to validate Total Cost Estimate	Per schedule		x
P	Construction Plan	Includes: General Info, communication plan, documentation control and records management plan, Project reports, Change management, Quality plan.	60 day prior to construction		x
R	Transportation Plan	Communication of Schedule of delivery, responsible party, route.	30 day prior to first delivery	X	
U	Rigging and Lifting Plan	Plan defining equipment lifts, responsible parties, lifting procedures, lift classification (critical, serious, standard), hazards, rigging sketches, emergency action, contact information.	15 days prior to start of associated lifting work	x	
V	Contractor and Sub-contractor contact list	Vendor list including all subcontractors with contact names, phone numbers, e-mail addresses and business addresses	30 days	X	
W	Detailed schedule (Level III schedule)	Level III – resource loaded schedule with Earned Value measures	30 days		X
X	Quality Assurance Plan and implementing documents	Documentation to address quality control of measures to be implemented during design, procurement, construction, closeout, and commissioning	60 days		X
Y	Health and Safety Plan & Site security	Detailed plan including responsibilities, reporting, safety requirements in accordance with AmerenUE standards. Plan includes site security Plan to handle site security and procedures site admittance,	30 day prior to any work beginning on site		X
AA	Major Subcontractor Health and Safety Plan	Includes responsibilities, reporting, safety requirements in accordance with AmerenUE standards	30 day prior to any work beginning on site	x	
BB	LOTO Procedure	Lockout tagout	90 day		
CC	Deleted	Deleted			
DD	Permits and Permit applications	Copy of all obtained permits or applications developed	60 day	X	
EE	Design Basis Report** - revision		90 day		X
FF	Pre-Construction Meeting Minutes	Meeting minutes taken during each pre-construction meeting with Ameren, sub contractors and vendors.	1 week following meeting	X	
GG	Contractor qualifications	All qualifications such as welding certifications, crane certifications, specialty certifications, etc.	2 week prior to start of related work	X	
	Contractor design documents for piping, electrical, instrumentation, structural, etc.	All design documentation produced by subcontractors for construction.	30 days prior to start of work	X	
HH	Laydown Plan	Plan detailing staging, assembly, storage, and work areas.	120 days	X	

II	Arc Flash Study		60 days	X	
JJ	Equipment Siesmic Calculations	Calculations or summaries performed to determine the correct support system for all systems in the plant in accordance with Code requirements..	60 days	X	
KK	Relay Settings (at 100%) and Test Values in spreadsheet		30 months prior to commissioning		X
LL	Commissioning, Start-up, and Training Plan (CSTP).	Details and deliverables per commissioning, startup and training activities by system/component in level of priority.	Draft - March 2014 Final - July 2014		X
OO	Instrument List - following shop drawing reviews (Inverter, Panel, weather station, building)	Complete spreadsheet of instruments shown on P&ID's or one-lines by type (i.e. pressure, temp, etc.) with equipment ID, system designation, manufacturer, model #, units, range, calibration data.	120 days		X
PP	Plant Control System I/O List				X
QQ	Alarm List	A list of all plant alarms, by equipment, including units, hi/low values, tag number, associated instrument, location.	30 days following completion of SCADA and control design		X
RR	Final Facility energy balances		30 day after comissioning		X
SS	Voltage Drop Study		90 days	X	
TT	Short Circuit Study		90 days	X	
UU	Equipment Foundation Dynamic Analysis Report	Seismic analysis of all equipment foundation pedestals to ensure equipment meets all Code and Regulatory requirements.	90 days	X	
VV	Civil/Structural Design Calculations	Calculation for all structures, buildings or supports used within the facility to show the appropriate design was applied and utilized.	as required	X	
WW	Hanger calculations	Calculations performed to determine the correct support location, size, load, displacement, design, and structural attachment in accordance with Code requirements.	if required	X	
XX	Vendor Calculations	All calculations performed by equipment vendors including such things, as capacities, allowable limits, seismic loads, electrical and mechanical parameters, etc.	60 day prior to equipment shiping	X	
YY	I&C Functional Description		90 days		X
Section 2	**Construction**				
A	Detailed training materials	Organized training materials including course outlines, presentations, technical materials, handouts, schedules, field walk downs and presenters.	As detailed in final CSTP		X
B	Operating, Maintenance, and Emergency Procedures	Detailed step-by-step procedures for maintenance of equipment, operating and emergency conditions including startup, shutdown and off-normal conditions.	As detailed in final CSTP		X
C	Material Safety Data Sheets (MSDS)	By manufacturer	As-needed	X	
D	Commissioning procedures and turnover sequence	Detailed step-by-step commissioning procedures, including acceptance criteria and schedule with sequence of turnover activities.	As detailed in final CSTP		X
E	Engineering Field Changes *	All changes made to the plant during construction.	At time of change	X	X
F	Contract Changes	All changes made to the contract during construction.	At time of change		X
G	Documented monthly meeting minutes	Meeting minutes taken during monthly progress meetings with all handouts and attachments (as-applicable)	24 hrs after meeting	X	
H	Correspondence	All correspondence between Contractor and Ameren Missouri	As agreed	X	
I	Spare Parts and Special Tools List	Complete list of spare parts and special tools received or required in accordance with specifications.	90 days prior to commissioning	X	
J	Equipment List (final)	Complete spreadsheet of equipment shown on P&ID's, by type (i.e. valve, pump, etc.) with equipment ID, system designation, manufacturer, and model #, setpoints as applicable.	90 days prior to commissioning		X

K	Instrument List (final)	Complete spreadsheet of instruments shown on P&ID's by type (i.e. pressure, temp, etc.) with equipment ID, system designation, manufacturer, model #, units, range, calibration data.	90 days prior to commissioning		X
L	Plant Control System I/O List (final)		90 days prior to commissioning		X
M	Alarm List (final)	A list of all plant alarms, by equipment, including units, hi/low values, tag number, associated instrument, location.	90 days prior to commissioning		X
N	Control Graphics (vendor) O&M manual	A color copy of each of the HMI graphic screens in actual display size. This will include all of the graphic screens available from the main HMI and each remote HMI in the plant.	90 days prior to commissioning	X	
Section 3	**Construction Turnover and Closeout**		**Delivery date (before Construction Complete)**		
A	Plant Operation and Maintenance Manual	A complete compilation and summary list of all manuals provided by all equipment vendors.	30 days	X	
B	Vendor manuals and as-built vendor drawings	Revised and up-to-date vendor manuals and drawings to include any changes made during construction.	30 days	X	
C	Vendor cut sheets and datasheets	All up-to-date vendor data and cut sheets	30 days	X	
D	Inspection Reports		1 day	X	
E	Material Certifications	May be actual CMTR or certificate of conformance (C of C)	30 days	X	
F	Test Reports	Per Specifications	1 week following test	X	
G	Warranties		30 days	X	
H	Calculations	All original or revised calculations specified in this document or other contract documents	30 days	X	
Section 4	**Startup and Commissioning**		**Delivery Date (after commissioning complete)**		
A	Revised as-built drawings	All drawings described on drawing list, including contractor drawings, as-built to reflect actual plant configuration.	30 days		X
B	Revised design basis document**	Revised design basis to include any changes made during plant construction and to accurately reflect as-built plant conditions.	30 days		X
C	Formal correspondence between contractor and other parties (RFI's..)	All documented correspondence between contractor and equipment suppliers and contractors.	45 days	X	
D	Certificates of Occupancy and/or Inspection		10 days	X	
E	Completed vendor startup reports	All equipment supplier and contractor commissioning and work completion reports	10 days	X	
F	Contractor Completed startup reports and commissioning documents	All contractor commissioning and work completion reports	10 days	X	
G	Completed Construction Punch lists	All completed construction punch lists with signoffs	30 days	X	
H	All documentation identified in attached construction/equipment specification		30 days	X	

I	All documentation identified in the Startup, Commissioning and Training Plan		30 days	X	
F	Test Reports	Per Specifications	72 hrs following test completion	X	

Deliever dates above may be changed if mutually agreed upon by Owner and Contractor

* Engineering changes that affect the design basis, major equipment locations and/or orientations, or operational matters will require approval by Ameren.

** This document should include the following:

Description of each major plant system
System functions
Description of critical components in the system
System/equipment design operating parameters, values, and basis for values
Formated per Specificaiton Section 1E: Design Basis

APPENDIX N

List of Drawing Submittals

Appendix N: List of Drawings

Est. Quantity (sht #)	Description	Preliminary Design Submittal	50% Detail Design Submittal	100% Final Design Submittal	As-Built
	Engineer Supplied Drawings				
	General				
	Cover Sheet	X	X	X	X
	Drawing Index	X	X	X	X
	Abbreviations	X	X	X	X
	General Information	X	X	X	X
	Equipment and Components List	X	X	X	X
	Plant General Arrangement Plans	X	X	X	X
	Plant General Arrangement Sections and Details		X	X	X
	Equipment Location Plans	X	X	X	X
	Vendor and Shop Equipment Fabrication and Assembly Drawings		X	X	X
	Vendor and Shop Equipment Installation Drawings			X	X
	Civil Site Work				
	Civil Legend and Notes	X	X	X	X
	Site Plans	X	X	X	X
	Access Road Plan and Profile	X	X	X	X
	Access Road Typical Section		X	X	X
	Site Utilities	X	X	X	X
	Site Prep/Clearing/Grubbing		X	X	X
	Site, Grading and Drainage Plans, Sections and Details		X	X	X
	Transformer Spill Containment		X	X	X
	Erosion Control Plan		X	X	X
	Survey Plan		X	X	X
	Area Paving and Drainage Drawings		X	X	X
	Landscaping				
	Landscaping Plan		X	X	X
	Landscaping Details		X	X	X
	Landscaping Schedules and Details		X	X	X
	Architectural				
	Architectural Legend and Symbols	X	X	X	X
	Building Codes		X	X	X
	First Level Floor Plan	X	X	X	X
	Roof Level Plan	X	X	X	X
	Elevations	X	X	X	X
	Sections		X	X	X
	Enlarged Plans		X	X	X
	Building Details		X	X	X
	Roofing Details		X	X	X
	Door and Window Schedules and Details		X	X	X

Appendix N: List of Drawings

Est. Quantity (sht #)	Description	Preliminary Design Submittal	50% Detail Design Submittal	100% Final Design Submittal	As-Built
	Door, Window, and Louver Details		X	X	X
	Room Finish Schedule			X	X
	Signage Plan and Details			X	X
	Project Renderings	x	x	X	X
	Contractor Furniture Schedule			X	X
	Structural				
	General Information and Standard Notes	X	X	X	X
	Standard Details	X	X	X	X
	Foundation Plan	X	X	X	X
	First Level Framing Plans		X	X	X
	Roof Framing Plan		X	X	X
	Equipment Foundations and Supports		X	X	X
	Wall Sections		X	X	X
	Foundation Details		X	X	X
	Framing Details		X	X	X
	Miscellaneous Details		X	X	X
	Panel Support Structural Details - racking		X	X	X
	Structural Steel Shop Drawing		X	X	X
	Mechanical				
	HVAC Details		X	X	X
	HVAC Schedules		X	X	X
	Potable Water Details				
	Electrical				
	Electrical Symbols and Abbreviations	X	X	X	X
	General Electrical/I&C Notes	X	X	X	X
	Overall One-Line Diagram	X	X	X	X
	Medium Voltage One-Line	X	X	X	X
	Low Voltage One-Line	X	X	X	X
	Secondary Power Feed One-Line	X	X	X	X
	Electrical Three Line Diagrams			X	X
	Overall Electric Site Plan	X	X	X	X
	Power Plans		X	X	X
	Circuit Routing Plans		X	X	X
	Grounding Grid Plans and Details		X	X	X
	Control Schematic & Loop Diagrams			X	X
	Control Panel Layout Drawings (via vendor)		X	X	X
	I&C Functional Description			x	x
	I&C Plans and Installation Details		X	X	X
	Fire Protection Plans and Section (if required)		X	X	X
	Security Plans and Sections			X	X

Appendix N: List of Drawings

Est. Quantity (sht #)	Description	Preliminary Design Submittal	50% Detail Design Submittal	100% Final Design Submittal	As-Built
	SCADA System Drawings		X	X	X
	Electrical Detail			X	X
	I&C Details			X	X
	Lightning Protection Plans and Details		X	X	X
	Control Wiring Diagrams			X	X
	Lighting Plans and Details		X	X	X
	Lighting Schedule		X	X	X
	Conduit and Cable Schedules		X	X	X
	Panel Board Schedules		X	X	X
	Switchgear Lineup Elevation (via switchgear manufacturer)			X	X
	Site Network Diagram/Plant Control System Architecture		X	X	X
	Control Room Layout		X	X	X
	Instrument Schedule/List with data (names, tags, calibration data)			x	x
	Instrumentation Installation Details			X	X
	Plant Control System I/O List			x	x
	Alarm List			x	x
	Control Graphics			x	x
	Console/HMI Plan			X	X
	Substation (if required)				
	Electrical Layout Plan and Section Drawing	X	X	X	X
	Electrical Material List		X	X	X
	Structural Steel - 34.5 kV Dead End Structure		X	X	X
	Foundation Plan and Details		X	X	X
	Grounding Plan and Material List		X	X	X
	Control Cable Plan, Cable Schedule and Material List		X	X	X
	Electrical Details		X	X	X
	Plant/Substation Interface Wiring Diagram		X	X	X
	Phasing diagram			x	x
	= subtotal				
	Misc. Documents				
	Equipment Foundation Dynamic Analysis Report			X	X
	Short Circuit Study	X	X	X	X
	Arc Flash Study			X	X
	Voltage Drop Study			X	X
	Plant Operation and Maintenance Manual			x	x
	Procurement Inspection Plan			X	X
	Construction Inspection Plan			X	X
	Start-up Commissioning and Testing Plan and Procedures			x	x
	Spare Part and Special Tool Inventory List	x	x	x	x
	Facility energy balances		X	X	X
	Equipment O&M Manuals			x	x
	Relay Settings (at 100%) and Test Values			X	X

Appendix N: List of Drawings

Est. Quantity (sht #)	Description	Preliminary Design Submittal	50% Detail Design Submittal	100% Final Design Submittal	As-Built
	Calculations, Preparations and Assembly				
	Arc Flash			X	X
	Siesmic calculations			X	X
	Wind loading design calculations			X	X
	Civil/Structural Design Calculations			X	X
				X	X
				X	X

X = Engineer Submitted Documents
UE = AmerenUE Submitted Documents

#REF! ***= est total dwgs***

APPENDIX O

Division of Responsibility

Appendix O: Division of Responsibility

Item	Sub Item	Description	Responsibility
		Engineering - Services	
		Interconnect Agreement with Utility	UE
		MPSC Permit (if required)	UE
		Project Management	ENG
		Project Coordination	ENG
		Solar Plant and Substation Design and Engineering	ENG
		Basic Engineering	ENG
		Civil/Structural/Architectural E&D	ENG
		Mechanical E&D	ENG
		Electrical E&D	ENG
		Instrumentation & Control E&D	ENG
		System Engineering	ENG
		Design Documentation	ENG
		Drafting	ENG
		Vendor and Shop Drawing Review	ENG
		Procurement and Related Services	ENG
		Environmental Engineering	ENG
		Logistics/Transport/Traffic	ENG
		Testing and Reporting	ENG
		Project Status Reporting	ENG
		Scheduling	ENG
		Substation Design	ENG
		Vendor Service Representative	ENG
		Development of Warranties	ENG
		All temporary facilities, services, and utilities	ENG
		Security	ENG
		Taxes	ENG
		Personal and Corporate Income Tax	ENG
		All other taxes	ENG
		Sales tax	ENG
		Insurance	ENG
		Commercial General Liability	ENG
		Worker Compensation	ENG
		Professional Liability	ENG
		Comprehensive Auto Liability	ENG
		Commercial Umbrella Liability	ENG
		Pollution Exposure	ENG
		Subcontractor Insurance	ENG
		Balance of Plant (BOP) / Equipment	
		Electrical	
		Substation Equipment and Switchgear	ENG
		Transformers/Switch Gear/Motor Control Centers	ENG
		Plant Step-Up (GSU) transformer	ENG
		Station Auxiliary transformer	ENG
		Construction/Maintenance Power	ENG
		Balance of Plant Equipment and Transformers	ENG
		Equipment Switch Gear	ENG
		Motor Control Centers	ENG
		Conductors	ENG
		Medium Voltage cable	ENG
		Secondary feed - 480 volt power and control cable	ENG
		Low voltage power and control cable	ENG
		DC voltage power and control cable	ENG
		All other low voltage power and control cable	ENG
		Raceways	ENG
		Electrical Conduit and Cable Tray	ENG
			ENG
		Miscellaneous Electrical Systems	ENG
		Station Grounding Cable and System	ENG
		Outdoor Lighting Systems	ENG
		Site Communications Systems	ENG
		Lightning Protection	ENG
		Solar Equipment	
		Solar Panels	ENG
		Combiner Boxes	ENG
		Recombiner (if required)	ENG
		Inverters	ENG
		Wiring	ENG
		Wire management system	ENG
		DC Disconects	ENG
		Fuses	ENG
		Breakers	ENG
		Weather Stations	ENG
		BOP Controls System	ENG
		PLC Equipment	ENG
		PLC Application Programming	ENG
		Relaying/Metering/Protection	ENG
		Relaying /Protection/Control Panels	ENG
		Utility Metering Package	ENG
		Substation interface cables	ENG
		BOP Instrumentation	ENG
		Temperature Sensors	ENG

Appendix O: Division of Responsibility

Item	Sub Item	Description	Responsibility
		Process Switches	ENG
		Local Gauges	ENG
		Local Controllers	ENG
		Environmental sensors (explosion/fire)	ENG
		Civil/Structural	
		Site Work	ENG
		Initial clearing and leveling	ENG
		Final grading	ENG
		Demolition	ENG
		Dewatering	ENG
		Earthwork (foundation overexcavation)	ENG
		Grading	ENG
		Cut/Fill	ENG
		Excavations	ENG
		Rock excavation/Blasting	ENG
		Backfill	ENG
		Spread Footings	ENG
		Special Shoring	ENG
		Site Drains	ENG
		Sanitary Sewer	ENG
		Crushed Stone Surfacing	ENG
		Concrete Paving	ENG
		Aggregate Surfaced Roads	ENG
		Perimeter Fencing and Gates	ENG
		Landscaping	ENG
		Curbed Containment	ENG
		Storm Water Detention	ENG
		Earthen Berm	ENG
		Parking Area	ENG
		Asphalt Paving	ENG
		Easements and Rights of Ways	ENG
		Miscellaneous Civil Systems	ENG
		Sumps	ENG
		Pip/Utility Trenches	ENG
		Duct banks	ENG
		Concrete Work	ENG
		Foundations	ENG
		Auxiliaries Foundations	ENG
		Equipment Foundations	ENG
		Buildings and Enclosures	ENG
		Trenches	ENG
		Containment Walls and Open Vaults	ENG
		Fire Walls	ENG
		Encased Conduits	ENG
		Drilled Piers / Deep Foundations	ENG
		Footings	ENG
		Grade Beams	ENG
		Embedments	ENG
		Anchor Bolts	ENG
		Sole Plates	ENG
		Finishing Work/Concrete Floors	ENG
		Solar Equipment	
		Racking	
		Miscellaneous Structural Steel	ENG
		Anchor bolts and Embedments	ENG
		Stairs, Walkways, Ladders and Handrails	ENG
		Lifting and handling equipment (cranes, hoist..)	ENG
		Building Specialties	ENG
		Furnishings	ENG
		Lighting	ENG
		HVAC	ENG
		Fire Protection and/or Sprinklers for Building	ENG
		Building and Enclosures	ENG
		Commuincation and Storage Building	ENG
		Miscellaneous Items	
		Painting, Color Coding and Identification	ENG
		Final Painting: CTG, BOP, Equipment and Materials	ENG
		Plant Piping, Cable and Equipment Labeling	ENG
		Structural Steel	ENG
		Chemicals and Gases, Oils and Greases	ENG
		Initial Fills of all equipment	ENG
		Dress Out and Initial Fills - transformers	ENG
		Consumables	ENG
		Start-up spares	ENG
		Start-up materials	ENG
		Special Tools	ENG
		Spare Parts	ENG
		Plant Equipment maintenance spares (1-year operations)	ENG

Appendix O: Division of Responsibility

Item	Sub Item	Description	Responsibility
		Spare Parts List (5-yr operations)	ENG
		Spare Panels for life of plant	
		Instruction Manuals (Turnover Packages)	ENG
		Plant Systems	ENG
			ENG

ENG = Engineer/Contractor
UE - Ameren Missouri

APPENDIX R
RADIOGRAPHY SAFETY REQUIREMENTS
for Ameren Missouri Power Plants

1.0 Immediately upon entering the power plant the radiographer must report to the control room and notify the shift supervisor of his presence and intended scope of work.

2.0 Radiography shall be carried out only during the time frame and at the locations stated on the Radiography Notification.

3.0 All restricted radiation area (2 mr) boundaries shall be established using barrier tape, rope, chain or other suitable material. The use of duct tape, masking tape or other similar materials is not acceptable. When radiography is to be performed inside a boiler, the restricted radiation area boundary shall include, as a minimum, the stairways (both internal and external stairways) one elevation above and one elevation below the elevation where radiography will occur.

4.0 The radiographer must ensure that no unauthorized personnel are inside the radiographer's restricted area and positive control of the access is established prior to the use of the radiography camera.

5.0 Two (2) minutes prior to the initial start of radiography and every thirty (30) throughout the duration of the radiography, the radiographer shall make an announcement over the plant public address system. The announcement shall identify where the radiography is occurring and expected duration, If the restricted radiation area is changed the radiographer shall make an announcement prior to commencement of radiography. When radiography is completed, an announcement shall be made over the plant public address system.

6.0 When multiple radiation sources are used the radiographers shall coordinate their efforts. Two-way radios are available in the control rooms or from the various contractors on site.

7.0 Upon completion of the radiography, all barricades shall be removed and all radiation hazard signs retrieved and accounted for. Any radiation hazard signs not removed or found lying on the ground will be considered a serious safety violation requiring a written corrective action plan prepared by the radiographer or his employer.

8.0 At the conclusion of all radiographic activities (equipment secured and the restricted area boundary removed), the radiographer must report to the shift supervisor to confirm the completion of the radiography.

END OF APPENDIX R

APPENDIX W
WELDING AND NDE

1.0 TECHNICAL REQUIREMENTS

1.1 General

All welding and welding related activities including NDE on boiler pressure parts, attachments and boiler external piping shall be performed under the Contractor's ASME or National Board "R" Stamp Quality Control program in accordance with the ASME Boiler and Pressure Vessel Code, the ASME Power Piping Code, B31.1 and the National Board Inspection Code, NB-23. All structural welding shall be done in accordance with the latest revision of the AWS Structural Welding Code, D1.1 except that welders may be qualified to the ASME Code in lieu of D1.1.

1.1.1 Recommended Weld Practices (RWP)

1.2 Welding – Ferritic Materials

Open root pressure part welds shall be made with a GTAW (gas tungsten arc welding) root pass unless otherwise specified. SMAW (shielded metal arc welding) welds on ferritic materials (carbon, carbon-moly and chrome-moly alloys) shall be made with low hydrogen electrodes. GMAW (gas metal arc welding) or FCAW (flux core arc welding) is not permitted for joining pressure parts. Subject to Ameren approval, these processes may be used for non-pressure part welding such as membrane or skin casing. Welding progression for all processes shall be uphill. Membrane shall be welded from both sides unless otherwise approved.

Filler materials, preheat and postheat temperatures shall be as shown in Table 1.2 unless otherwise approved. For joints between differing P-numbers, the PWHT temperature shall not exceed the Maximum PWHT temperature shown in Table 1.2 for the lower P-number material being joined. Welds in Grade 91 material shall be allowed to cool to 100°F after welding before beginning postweld heat treated.

Table 1.2

P- No.	Nominal Composition	Preheat Temp. (°F)	PWHT Temp. (°F ± 25)	Maximum PWHT Temp (°F)	Welding Process	
					SMAW	GTAW
P1	Carbon steel	300*	1150	1300	E7018	ER70S-2
P3	C, 1/2 Mo Grade T1	300	1150	1300	E7018-A1 E801X-B2	ER70S-A1 ER80S-B2
P3	1/2 Cr, 1/2 Mo Grade T2	300	1150	1350	E801X-B2	ER80S-B2
P4	1-1/4 Cr, 1/2 Mo Grade T11	450	1225	1350	E801X-B2	ER80S-B2
P5A	2-1/4 Cr, 1 Mo Grade T22	450	1350	1375	E901X-B3	ER90S-B3
P5B	9 Cr, 1 Mo Grade T9	450	1350	1375	E801X-B8	ER80S-B8
P15E	9 Cr, 1 Mo, 1/4 V Grade T91	450	1375	1400	E901X-B9	ER90S-B9

*300°F preheat required only for material whose thickness exceeds ¾". 50°F preheat required if ¾" or less.

Note: The Maximum PWHT Temp applies when joining materials with different P- numbers.

1.3 Welding – Austenitic Materials

Open root pressure part welds shall be made with a GTAW (gas tungsten arc welding) root pass and an inert backing gas unless otherwise specified. The use of a flux or flux coated filler wire to prevent oxidation of the root pass is not permitted. 65°F minimum Preheat required for Stainless to Stainless welds. Interpass temperatures shall not exceed 350°F. When joining austenitic stainless steel materials of different nominal chrome content, the filler material shall have a chrome content of the higher chrome alloy.

1.4 Welding – Dissimilar Metal Welds

Welds between austenitic stainless steel materials and ferritic materials shall be made with ENiCrFe-2 or ENiCrFe-3 electrodes. Butt welds joining pressure parts shall have a weld joint geometry as shown in Figure 1.4 (a). The weld cap on the ferritic side of the weld shall extend past the edge of the weld prep as shown in Figure 1.4 (b).

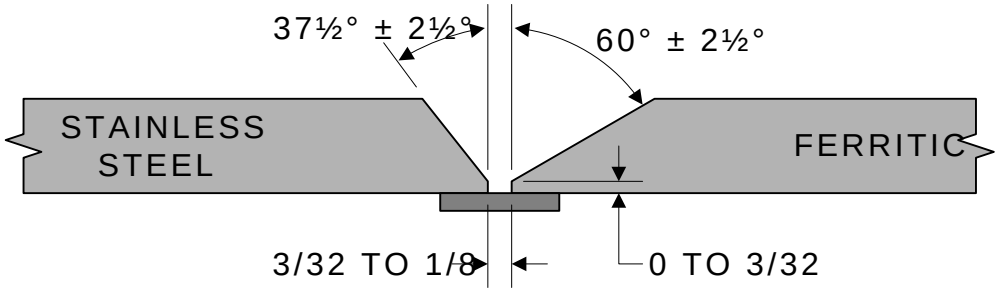


Figure 1.4 (a)

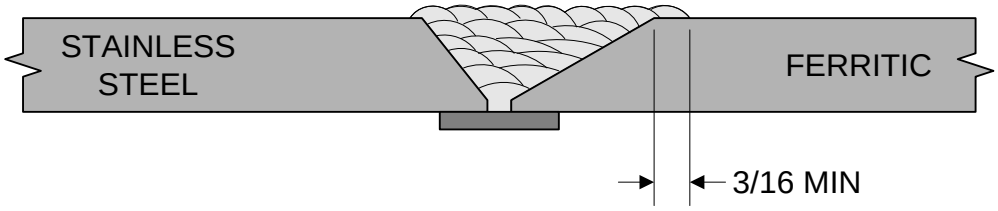


Figure 1.4 (b)

1.5 Filler Material Handling and Storage

Following is for Low Hydrogen electrodes:

Electrodes shall be stored in hermitically sealed containers until used. Opened containers and loose electrodes shall be maintained in portable heated rod caddies or rod ovens. Electrodes which are cold to the touch are not acceptable for use and shall be discarded. Rebaking is not permitted.

Electrodes stored in rod ovens shall be segregated and labeled by classification number. Only one (1) classification of electrode is permitted in each portable rod caddy.

Bare filler materials shall be stored in a clean dry area to prevent contamination and physical damage. Each straight length of bare filler material shall be marked with the classification number. Filler materials without the required markings are not acceptable for use and shall be discarded.

1.6 Weld Traceability

Each pressure boundary weld shall be traceable to the welder or welders who made the weld. Traceability shall be maintained through use of written documentation. Stamping of welds is not permitted.

1.7 Preheat and Post Weld Heat Treatment

When preheat is required by the welding procedure specification (WPS), the preheat shall be applied prior to tack welding. Oxy-fuel torches may be used for preheating tubing or pipe with a specified chrome content of 3% or less and not exceeding 4½" in diameter and ½" in wall thickness. All other preheating shall be done using resistance heating. When using oxy-fuel torches for preheat a means to verify preheat temperature, such as temperature indicating crayon, is required.

Postweld heat treatment shall be done using resistance or induction heating unless otherwise Ameren approved. Welds in Grade 91 (T91, P91) material shall be allowed to cool to 100°F after welding before beginning postweld heat treated. Induction heating will be considered on a case by case basis by the Ameren Engineer.

1.8 Preheat and Post Weld Heat Treatment Procedure Submittal and Record Keeping

All PWHT information (heating/cooling rates, soak time and temperature) shall be provided to the Ameren Engineer by the engineering submittal milestone date. The Contractor shall provide a copy of the approved procedure to the PWHT technician. A copy of the current calibration data for the heating equipment shall be supplied by the Contractor for approval by Ameren Quality personnel. Each weld shall be clearly identified on the recording charts. The PWHT zone shall be centered on the weld and the width shall be at least 5 times the thickness of the material. A minimum of two thermocouples, located 180 degrees from each other, are required unless otherwise approved by Ameren. The rates of heating and cooling shall not exceed 400°F per hour, unless approved by Ameren. At 600°F the equipment may be turned off and the weldment allowed to slowly cool in still air. After completion of the PWHT, the Contractor shall submit copies of the time versus temperature strip charts for each weld within 24 hours.

1.9 Interruption of Welding

Welding may be interrupted on materials with a maximum specified chromium content not exceeding 3.0% provided the lesser of 3/8" or 25% of the groove thickness has been filled and the joint is allowed to slowly cool to room temperature.

Welding may not be interrupted on materials with a maximum specified chromium content exceeding 3.0%.

Welding on P No's 1, 3, 4, and 5 materials with a maximum specified chromium content not exceeding 3.0% may be interrupted provided:

1) The joint is welded out at least 3/8" or 25% of the groove weld thickness, whichever is less.

2) The weld is allowed to cool slowly to room temperature.

3) A visual inspection by an Ameren welding inspector is performed prior to resumption of welding to ensure that no cracks have occurred.

4) The required preheat is reapplied and any cracks are repaired before welding resumes.

Welding on P No. 5 materials (with specified chromium content greater than 3%) and P No. 6 materials may be interrupted and the weld allowed to cool prior to heat treatment provided:

1) An intermediate heat treatment and a controlled cooling rate are applied as specified by an Ameren Engineer.

2) A visual examination of the weld by an Ameren Welding Inspector is performed prior to resumption of welding to ensure that no cracks have occurred.

3) The required preheat is reapplied and any cracks are repaired before welding is resumed.

Activities such as slag removal, lunch breaks, shift change and visual inspections are not considered interruptions provide the required preheat is maintained.

1.10 ID Counterbores and Tapers

ID counterbores shall be no longer than necessary to promote complete fusion of the root. There shall be a minimum 1/8" diameter radius between the counterbore and the transition taper. A 4-to-1 taper is preferred but in no case shall the taper exceed 3-to-1.

1.11 Backing Rings

Backing rings are not permitted unless otherwise specified or approved.

1.12 Dimensional Verification

Prior to any demolition, the contractor shall establish datum points and reference measurements to establish physical dimensions and location of the boiler in the "as found" condition.

2.0 CONTRACTOR QUALITY CONTROL

2.1 General

To ensure quality, Contractor will be required to designate a person or persons (multiple shift coverage) to monitor all welding related activities and maintain compliance with this specification and the applicable Code. The designated person shall be an AWS Certified Weld Inspector (CWI) or have welding experience credentials that per Ameren approval can substitute for certification. The designated person shall not have dual job responsibilities that include supervision of qualified welders on job. The designated person will be responsible for performing visual weld inspections, monitoring rod control and Foreign Material Exclusion (FME), and must have the authority to correct unsatisfactory conditions when they occur.

2.2 Weld Procedures

Contractor shall furnish at the time of Contractor mobilization (after award of a contract but before the start of welding) all applicable Welding Procedure Specifications (WPS). Any differences in preheat, postweld heat treatment or filler materials between those listed in Table 1.4 and Contractor's proposed WPS's shall be noted in Contractor's proposals at the time of bid. Procedure Qualification Records (PQR) shall be available for review by Ameren personnel upon request. A copy of the applicable WPS's shall be posted at job site providing the welders specific welding instructions.

2.3 Weld Map

Contractor shall furnish a weld schedule on or before the required engineering submittal milestone that provides as a minimum; a description of the weld joint; the material specification and grade, diameter and joint thickness for each of the two materials being joined; throat thickness for fillet welds; NDE required; preheat and postweld heat treatment temperatures, welding procedure; and filler metal.

2.4 Welder Qualification and Identification

Contractor shall furnish Ameren with qualification records (WQR's and welder continuity records) for each welder prior to the start of welding. All welder qualification records shall be accompanied by a photograph of the welder to whom they pertain unless waived by Ameren. Contractor shall assign a number and/or letter to each welder. This identification symbol shall be unique to each individual welder and shall not be assigned to any other welder during this work. To maintain traceability of weld joints to specific welders, a written record or log shall be maintained by Contractor.

2.5 Control of Material Supplied by Ameren Missouri

Contractor shall establish a temporary controlled storage facility for the safekeeping of materials supplied by Ameren during work. Materials that are to be used on boiler pressure parts shall be handled and stored in accordance with Contractor's approved Quality Control Manual and this specification. At end of job, Contractor is responsible for returning unused material in good condition and includes all Code markings. The Contractor shall attach Form 4983, "Return Material Tag" to all returned material along with an inventory list. Form 4983 will be provided by the Company. Any material not returned in good condition, or that cannot be accounted for, shall be replaced by the Contractor at their expense.

2.6 Materials furnished by Contractor

"Non-Code" materials, including attachments, that are supplied by Contractor shall as a minimum meet ASTM requirements. Material supplied for repairs performed under a Code Symbol Stamp, shall be ASME material and the proper documentation must accompany the material (i.e., certified material test report, P-4 Forms, etc.) Attachment lug material must be A36 or other material approved by Ameren.

3.0 QUALITY ASSURANCE PLAN

3.1 The Company intends to visually inspect 100% of all weldments and other non-welding areas throughout the course of this work. The Company personnel will make these inspections in a manner as timely and expediently as possible. **Ameren's quality assurance program does not relieve Contractor from primary responsibility of quality control and Contractor shall not, in any way, relax his own quality assurance program because of Ameren's inspection activities**. Contractor shall keep Ameren personnel informed of all quality and welding related matters and be responsible for insuring that all work is acceptable. Workmanship quality shall be in accordance with Contractor's approved Quality Control Plan and this specification.

3.2 When Company personnel perform visual inspections they will focus on dimensional as well as weldment related discontinuities. Contractor's QC person will be responsible for visual inspections and for providing a dialogue with Ameren regarding these activities.

3.3 **All slag must be removed from welds before inspections will be performed.** Welds shall be free of course ripples, grooves, overlap and shall merge smoothly with surfaces being joined. The undercut on finished welds shall not exceed 1/32" or 10% of the wall thickness, whichever is less. **Filing toe of weld thus creating an undercut is not permitted under any circumstances.** Porosity, cracks, suck or blow holes, arc strikes, lack of fusion open surface defects, excessive push through and burn through on backing rings are not permitted.

3.4 Dimensional discontinuities including misalignment (doglegs), distortion, incorrect weld size and/or weld profile, incorrect final dimensions and excessive weld reinforcement are not acceptable. Maximum reinforcement shall be as listed in appropriate ASME Code Section or as specified elsewhere in Ameren specification.

3.5 Radiography

3.5.1 All radiographic examination, when specified by Code or Ameren, shall be performed in accordance with Article 2 of ASME Code, Section V and interpreted in accordance with acceptance criteria set forth in applicable Code Section. If a difference of opinion exists between Ameren and Contractor on quality of weld, **Ameren will have the final word**. Note that unless otherwise stated in this specification or field weld schedules, 10% of all butt welds shall be radiographed. All indications shall be marked on the material surface by NDE technician.

3.5.2 If the rejection rate of radiographed welds exceeds five (5) percent, the Company shall have the option to require radiography of all welds made and this shall be done at Contractor's expense. All radiographs and interpretation reports become Company property. Radiographs for T&M work will be billed to the Company at applicable rates.

3.5.3 Contractor shall provide written notification to Ameren's Construction Supervisor and onsite Ameren Missouri welding inspector at least 24 hours prior to any radiography. All radiography shall be done in accordance with "Radiography Safety Requirements for Ameren Power Operations (Appendix R of this specification)." Welder qualification coupons shall **not** be radiographed inside plant building.

3.5.4 When radiography is required, Ameren will specify the type of shot to be taken. Each radiograph will be reviewed and approved by Ameren. Once film has been processed and interpreted by testing facility, Contractor shall provide Ameren with results and a copy of the film within 24 hours of processing. In applications where Computed Radiography (Digital Radiography) has been specified, the Contractor shall provide both a hardcopy and an electronic copy of the shots in a format approved by the Ameren Engineer.

3.5.5 In addition to the requirements outlined in ASME Code sections, excessive penetration, burn through or melt through shall be considered as a rejected weld. Ameren shall determine locations of welds to be radiographed. The criteria for selection of these weld locations shall be to monitor welder performance (i.e., at least one weld for each welder performing this work shall be selected) and to ensure weld quality in known problem locations.

3.6 Ultrasonic Testing

All ultrasonic weld examinations, when specified by Code or Ameren, shall be performed in accordance with Article 4 of the ASME Code, Section V and interpreted in accordance with the acceptance criteria set forth in applicable Code section. If a difference of opinion exists between Ameren and Contractor on quality of weld, **Ameren will have the final word**. All indications shall be marked on the material surface by NDE technician.

3.7 Dye Penetrant Testing and Magnetic Particle Inspection

All dye penetrant examination and magnetic particle examinations, when specified by Code or Ameren, shall be performed in accordance with Articles 6 and 7 respectively of ASME Code, Section V and interpreted in accordance with acceptance criteria set forth in applicable Code section. If a difference of opinion exists between **Ameren and Contractor, Ameren will have the final word**. All indications shall be marked on the material surface by NDE technician.

3.8 Weld Repairs

All welds which are rejected by any of the above listed inspection techniques will be repaired at Contractor's expense. Upon completion of weld repairs, Contractor will retest each of them unless otherwise specified by Ameren personnel.

4.0 WORKMANSHIP

The following general procedures shall be followed by Contractor when welding activities are being performed.

4.1 Welding

4.1.1 All pressure containing welds shall be made with a minimum of two passes. Starts and stops shall be staggered on successive layers.

4.1.2 All welding activities shall comply with Ameren's Foreign Material Exclusion (FME) guidelines.

4.2 Attachment Welds

4.2.1 Contractor shall not make any attachment welds to any pressure parts piping, headers, drums, peg-fins or tube membrane without written authorization from the Ameren Engineer. All attachment material shall be A36 unless otherwise approved by Ameren.

4.2.2 Prior to any attachments being welded, the appropriate preheat as specified on approved WPS shall be applied. Any lifting lugs, pad eyes, etc. welded to any equipment by Contractor shall be washed off and/or ground flush to the base material and inspected by MT or PT methods. The results of the NDE shall be reviewed by the Ameren Weld Inspector. Permanent lifting lugs supplied by the material manufacturer shall be left on any new components unless the Contractor is specifically instructed by Ameren Engineer to remove them.

4.2.3 Removal, installation and replacement of all furnace wall membrane shall be performed in accordance with Ameren Missouri's "Recommended Welding Practice for Membrane Removal and Replacement" (RWP-12.)

4.3 Tube Removal

When removing tubes, the Contractor shall cut the tube first using a saw or cut-off wheel to minimize debris entering inside the tube. On vertical tubing runs, the Contractor shall place a piece of steel sheet metal in the lower cut before making the upper cut. With the sheet metal securely in place, thermal cutting may be used to make the upper cut. All open tube ends shall be covered securely with metal caps or plate at all times. Any debris in the tube or header shall be removed at contractor's expense.

4.4 Pipe Removal

Saw or clam-shell cutting are the preferred methods for pipe removal. However, flame or plasma cutting maybe used provided it meets with the approval of Ameren Construction Supervisor and Ameren Weld Inspector. Care should be taken to prevent any debris from falling in the piping. Any debris in the piping shall be removed at contractor's expense. All open ends of pipe shall be securely covered.

4.5 Cleaning

Prior to any welding, all surfaces shall be cleaned thoroughly. The base metal adjacent to the joint shall be free of oil, grease, dirt, moisture, paint or other contaminants that would affect integrity of weld, for a minimum of ¾" on each side of weld joint (inside and outside), unless otherwise specified. The cleaning may be done by filing, grinding, wire brushing and/or solvent cleaning. When cleaning stainless steel, only new, uncontaminated stainless steel brushes, burrs or abrasives are allowed.

4.6 Butt Welding

All weld joint preparation shall be performed in accordance with Ameren Missouri's "Recommended Welding Practice for Butt Weld Replacement of Tube or Pipe Sections" (RWP-4). Refer to detail drawing for allowable tolerances. If joint design is other than that shown in recommended practice, it must have prior approval by Ameren Engineer.

4.7 Socket Welds

All socket welded fittings shall be made in accordance with Ameren Missouri's "Recommended Practice for Socket Welded Fittings" (RWP-5). Refer to detail drawing for allowable tolerances. Socket welds shall have a gap of approximately 1/8" between bottom of socket and end of pipe prior to welding. Scribe lines must be marked on pipe to indicate the 1/8" gap. Contractor shall not use inserts on socket welds to obtain the required 1/8" gap.

4.8 Padwelding

All padwelding of boiler pressure parts shall be performed in accordance with Ameren Missouri's "Recommended Welding Practices for Padwelding" (RWP-2).

4.9 Tube Shields

Installation of all protective tube shields and clips shall be performed in accordance with Ameren Missouri's "Recommended Welding Practice for Tube Shields and Clips" (RWP-6).

4.10 Window Welds

The use of "window welds" is not permissible unless authorized by the Ameren Missouri Engineer. If window welds are authorized, Contractor should provide proof of welders ability to perform. Proof of proficiency will be determined by Ameren Quality personnel.

4.11 Component Replacement

For the removal, replacement, and installation of major boiler components, the Contractor shall note the following:

The elevations and dimensions shown on the general arrangement and reference drawings included with the specification are based on the original design, and do not reflect any deformation due to long term operation or undocumented changes performed during original construction or subsequent repair of the boiler. Therefore, prior to demolition the Contractor shall measure and document the location and elevation of the components to be replaced as well as those components used for reference for the subject replacement. This record shall be submitted to the Ameren Engineer prior to commencing removals. These same dimensions shall be recorded during installation of the new components and after the work is complete to document the as-built condition. All dimensional records shall be formally submitted to the Ameren engineer in accordance with the milestone schedule and shall be QC hold points depicted in the Contractor's schedule. Any deviations shall be reported immediately to Ameren for deposition. If necessary, Ameren will provide/designate a datum or reference point in which to use for the required measurements. Ameren will also provide/identify critical dimensions to be maintained for proper installation and operation of the unit.

4.12 Water Soluble Purge Dams

All use of Water Soluble Purge Dams shall be performed in accordance with Ameren Missouri's "Recommended Welding Practice for Water Soluble Purge Dams" (RWP-11).

END OF APPENDIX W

APPENDIX X

FOREIGN MATERIAL EXCLUSION (FME) REQUIREMENTS

for Non-Ameren Contract Construction Personnel

1.0 PURPOSE

A. Power plant systems must remain free of foreign material contamination to operate properly. The following is an outline of required practices that outside contract personnel must follow to prevent foreign material contamination.

2.0 PRIORITY

A. Foreign material contamination in critical power plant components is very serious and must be addressed. Failure to do so may result in millions of dollars of equipment damage and lost revenue. The consequences could be so great that Ameren will be compelled to recover damages from the Contractor.

B. In the event that foreign material is known to have entered a critical system, contact the Construction Project Lead (SPOC) immediately.

3.0 DEFINITION

A. Foreign Material Exclusion (FME) is the practice of preventing the contamination of components in power plant systems.

4.0 EQUIPMENT COVERED BY FOREIGN MATERIAL EXCLUSION PROCEDURES

A. Contractor shall follow FME practices, particularly on systems and components that are critical to the power plant such as the feedwater, condensate, steam, lubricating oil, turbine, and generator. This equipment is likely to suffer component damage if contaminated by foreign material.

B. Examples of critical components include, but are not limited to:

- Boiler tubes, headers and drums
- Condensers
- All lube oil reservoirs
- Pumps
- Generators and seal oil systems
- Electrical cabinets
- Transformers
- In-line flow elements
- Feedwater heaters
- Flash tanks
- All piping systems
- Turbine shells and piping
- Large electric motors
- Switchgear
- Compressed air systems
- Bulk storage tanks

5.0 SOURCES OF FOREIGN MATERIAL CONTAMINATION

A. Common contaminates include, but are not limited to:

- Welding & gas cutting debris
- Corrosion
- Metal chips, shavings & filings created by machining and repair operations
- Materials used for cleaning
- Improper lubricants
- Dirt, fly ash & coal dust
- Contaminants found on shoes & clothing
- Pens, rulers, coins, keys & other typical contents of a shirt pocket
- Tools
- Trash

B. Typical activities that produce foreign material include, but are not limited to:

- Drilling, cutting, grinding, machining, filing and lapping
- Welding thermal cutting activities
- Lubricants or cutting oils
- Use of tape, plugs or seals that may leave a residue
- Sandblasting
- Confined space entry
- Sweeping or using air or water to clean
- Any activity including equipment inspection and testing that requires opening a normally sealed component

6.0 GENERAL FOREIGN MATERIAL EXCLUSION PRACTICES

A. Ameren requires that all Contractors and Subcontractors have an Ameren (SPOC) approved FME plan prior to working on a critical power plant system.

B. Ameren requires that the Contractor and Subcontractors discuss FME practices with craft labor at the weekly safety meetings.

C. The Contractor and Subcontractor shall maintain good housekeeping practices on the entire construction site.

This will promote a safe work environment plus promote good FME practices. Contractors that work for Ameren should realize that it is not cost effective to allow construction debris to accumulate, create a safety hazard, which could cause a lost time accident, or could cause foreign material to enter a critical system. Employ craft labor to continually keep the work site clean, not just at the end of the project.

D. The following are the Ameren minimum requirements for any Contractor foreign material exclusion plan.

1) Cover all unattended openings into components.

2) Clean dirt, coal, fly ash, or any other form of debris from around covers, caps, and other devices before opening for inspection or servicing.

3) When opening critical components, ensure areas above these components are clean so no debris will drop into openings of these components. If work will be done overhead while the component is open, cover with tarps, etc. to prevent debris that is dislodged or dropped from entering the component.

4) Ensure that welding electrodes, stubs, and broken flux coating material is removed from components.

5) Clean the work area before beginning work; this may include wash down or vacuuming of the area.

6) Orient work so that debris will not drop into components.

7) Openings on the main turbine, generator, hotwell pumps, boiler circulating pumps, high-pressure boiler feed pumps, etc., shall be covered during maintenance activities.

8) All piping and tubing must be free of foreign material before and after installation.

9) Do not introduce material into components that may produce corrosion.

10) Shot and sand blasting will only be done in areas that can be adequately cleaned.

11) Use only approved solvents for cleaning.

12) Use only approved lubricants.

13) Use approved tapes, plugs, or seals. Some tapes may leave residue (adhesive) that can cause damage.

14) Use approved procedures when flushing systems.

15) Define a “FME work area” around turbines, generators, lube oil tanks, or other areas specifically designated by the specification with barricade tape and limit access of personnel, tools and materials to these areas.

16) Track all tools, parts, and materials that are allowed into the FME work area. If something cannot be accounted for, follow a systematic procedure to insure that missing item can be accounted for without causing further problems.

17) Do not allow personal items such as jewelry, change, pens, etc. into the FME area. No material should be allowed in the FME area unless it is absolutely necessary.

18) Secure all tools, safety glasses, badges, gloves, and other loose items with lanyards, tape, or other devices.

19) Stage tools, parts, and materials outside the FME area. Remove all packaging and other unnecessary material before entering the FME area.

20) Inspect tools for parts that might come off the tool during use. Look for items such as loose handles, splintered wood parts, loose wire brush bristles. Clean all tools, materials, and parts before they are allowed into the FME area.

21) Limit the use of clear materials such as face shield visors in the FME area. They will be difficult to see if they are misplaced.

22) Use vacuum or exhaust systems to remove any generated airborne debris from painting, blasting, grinding, etc.

23) When cutting wires, control the ends that are snipped off.

24) Control all metal debris (screws, connectors, wire strippings, etc.) in all electrical enclosures.

25) Account for all rags, cushions, cardboard, etc., that are used in an FME area.

26) Do not use excessive lubricants. The excess lubricants may collect dirt, ash and other debris.

27) Use a video camera or other means of inspection prior to closing components to ensure FME.

28) Follow Ameren welding practices for removal of tubes and piping.

29) All open pipes, tubes or systems, regardless of whether they are new, to be re-used or wrecked out, must have FME covers in place. This rule applies to material lying on the floor, hanging in place or staged in racks, store rooms or lay down areas. The only exception is when the tube or pipe is completely disconnected from the system and color coded with bright orange or pink paint indicating that it is scrap.

30) FME covers, when subject to high traffic, abrasion or other situations that would cause them to fall off or become damaged (such as condensate or residual water draining out of the tube, pipe or system) shall be made of steel, or aluminum (excludes soda cans). For large diameter openings (12" or larger) plywood, canvas or nylon bags shall be used and marked as “NO STEP”. For openings subject to fire fall, grinding, arc air, or any other thermal operation, steel caps shall be used. Large diameter FME covers subject to the support of human weight shall conform to OSHA standards.

31) Water soluble paper, if properly utilized may be used as FME protection during tube or pipe joint prep operations. Sponges may also be used as FME protection during tube or pipe joint operations so long as a sponge log is maintained and implemented. Water soluble cones shall not be used as FME prevention during joint prep operations.

32) On vertical runs of tube or pipe, the first cut must be at the bottom using an abrasive cutoff wheel or other non-thermal means. Then a piece of sheet metal shall be inserted into the kerf created. The upper cut can then be made using a thermal method

33) When thermal cutting is to be used to penetrate a sealed system such as headers, tanks, water boxes or large piping, it should be included in the FME plan (6.0A) and presented to the quality Inspection or Construction Project Lead (SPOC) for approval prior to the start of work.

34) FME plan requires the use of a FME Barrier Log, Foreign Material Drop List, and Final Closure Inspection signoff record per AUE-FRM-ADM4217-01 and AUE-FRM-ADM4217-02 provided below.

FME BARRIER LOG

JR # _____ Equipment _____

FME Barrier	Location Installed	Date & Time Installed	Date & Time Removed	Removed By (Initial)

All FME Control Devices must be retrieved and accounted for.

FOREIGN MATERIAL DROP LIST

JR # _____ Equipment _____

Item Dropped	Location	Date & Time Dropped	Date & Time Retrieved	Retrieved By (Initial)

All dropped items have been retrieved and accounted for.

FINAL CLOSURE INSPECTION		
I certify that the system/equipment has been inspected prior to closure and all foreign material has been removed.		
	SIGNATURE	DATE
Craft Employee:		
Supervisor:		
Forward to Planning when work is complete.		

35) Failure to follow FME procedure will be addressed through the Deficiency Reporting system described here:

Ameren

Deficiency Notification and Corrective Action Process

The following paragraphs describe the system used by Ameren's Quality Inspection Supervisors to correct deficiencies identified during a major boiler outage. Depending on the urgency and severity of the infraction, one or more of the steps may be bypassed.

- 1st Violation: When a deficiency is identified, a verbal request for corrective action will be given to the first line supervisor and general foreman. A full accounting of issues will be documented in the weld inspector's daily log.
- 2nd Violation: If compliance has not been achieved through the first verbal request for corrective action, a second verbal request will be directed to the General Forman, job site Superintendent and the Ameren Construction Supervisor. A full accounting of issues will be documented in the weld inspector's daily log.
- 3rd Violation: Upon the third violation a deficiency report will be generated. A deficiency report describes the violation and may include digital images documenting the violation. The deficiency report requires a written response from the contractor within the time frame noted on the deficiency report. The deficiency report will require the contractor to describe in writing the immediate remedial corrective action(s) taken and the long term steps taken to prevent a recurrence. Deficiency reports will be distributed electronically to the job site superintendent and the following Ameren management personnel: Manager-Quality Management Services, Manager-Project Management, Supervising Engineer-Technical Support, plant manager, plant technical support superintendent, boiler engineer(s), QC coordinator, PCM superintendent, project engineer (Project Engineering), Project Engineering supervising engineer, construction supervisors, and quality inspection supervisor (opposite shift). All deficiency reports issued will become part of the contractor appraisal.
- 4th Violation: If the deficiency report fails to bring about the desired corrective action, work will be stopped until issues are adequately addressed.

END OF APPENDIX X

APPENDIX Y
PLATFORM AND SCAFFOLDING GUIDELINES FOR CONTRACTORS WORKING IN AMEREN MISSOURI ENERGY CENTERS

SAFETY REQUIREMENTS FOR WORKING ON ELEVATED PLATFORMS
Ameren Missouri – Power Operations

The following requirements must be followed by the contractor to assure employee safety while working on elevated platforms and scaffolding. The contractor shall submit a plan to implement safety requirements if his personnel will be working on elevated platforms. The plan should provide a cost breakdown for temporary and permanent safety measures.

Contractor Superintendent shall place special emphasis on two areas to address guardrail safety.

1. Conduct periodic walk-downs and inspections of elevated platforms to ensure proper guardrails are in place.

2. Apply additional measures to designated areas within 6' of guardrails with a potential fall distance of greater than 6' to a lower level where or when work is taking place that could result in being struck or otherwise result in falling over or between rails of guardrail.

3. Barriers shall be provided to prevent materials from falling from the platform.

Contractor, Construction Supervisor or Ameren Project Engineer can identify areas where additional measures on a permanent basis are to be implemented. Target areas include:

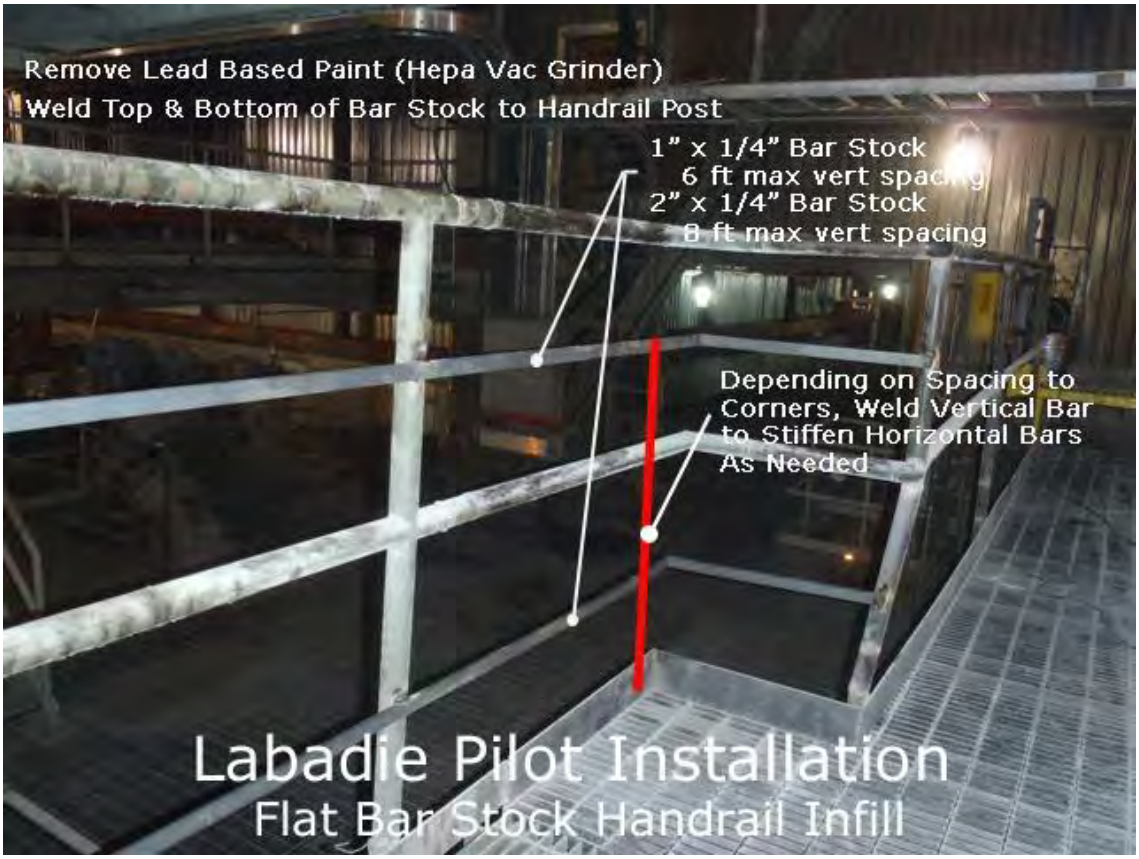
- Stair landings
- Crosswalks between units
- Areas as identified by engineering/plant safety personnel where work activities are performed that could result in being knocked through or falling over a guardrail
- Ladders where the base is within 6' of a guardrail and a potential fall to a lower level exists, (install railing/cage to prevent fall to lower level)
- Areas where ladders lead to a platform and a swing gate does not currently exist (ensure swing gates are installed in these areas)
- Other specified areas within 6' of a guardrail as approved by engineering/energy center safety personnel where work is performed that involves probability of sudden movement impact, or where forces are exerted that could result in falling through a guardrail (e.g., some long lance platforms and some large valve locations)

Various permanent solutions may be acceptable. The Ameren Project Engineer may specify permanent solutions in scope of work section of the specification. The contractor may also submit for approval permanent alternatives based on the best application. The Construction Supervisor or Project Engineer will review and approve the temporary and alternative permanent solutions submitted by the contractor. Examples of permanent solutions are:

- Welding flat stock horizontally midway between the top & mid rail and midway between the mid rail and top of toe plate. Size of the flat bar stock is based on max spacing of the vertical guardrail/handrail posts.

  - Max 6'-0 spacing between vertical guardrail/handrail posts (Labadie)
    Use 1" x ¼" flat carbon steel bar stock (refer to photo below)

  - Max 8'-0 spacing between vertical guardrail and handrail posts
    Use 2" x ¼" flat carbon steel bar stock (refer to photo below)



- Chain link fencing

  NOTE: Several installation issues were encountered during a trial application of this option, at Labadie. This option is NOT RECOMMENDED.

- Flat or smooth expanded metal

- Other designs as approved by the Construction Supervisor or Project Manager

In cases where permanent solutions are not installed, the contractor must apply temporary solutions per his plan to address identified elevated platform hazards while conducting work.

Examples of temporary solutions include:

- Pre-fabricated portable safety guard rail (refer to drawing on page 3 of this appendix)

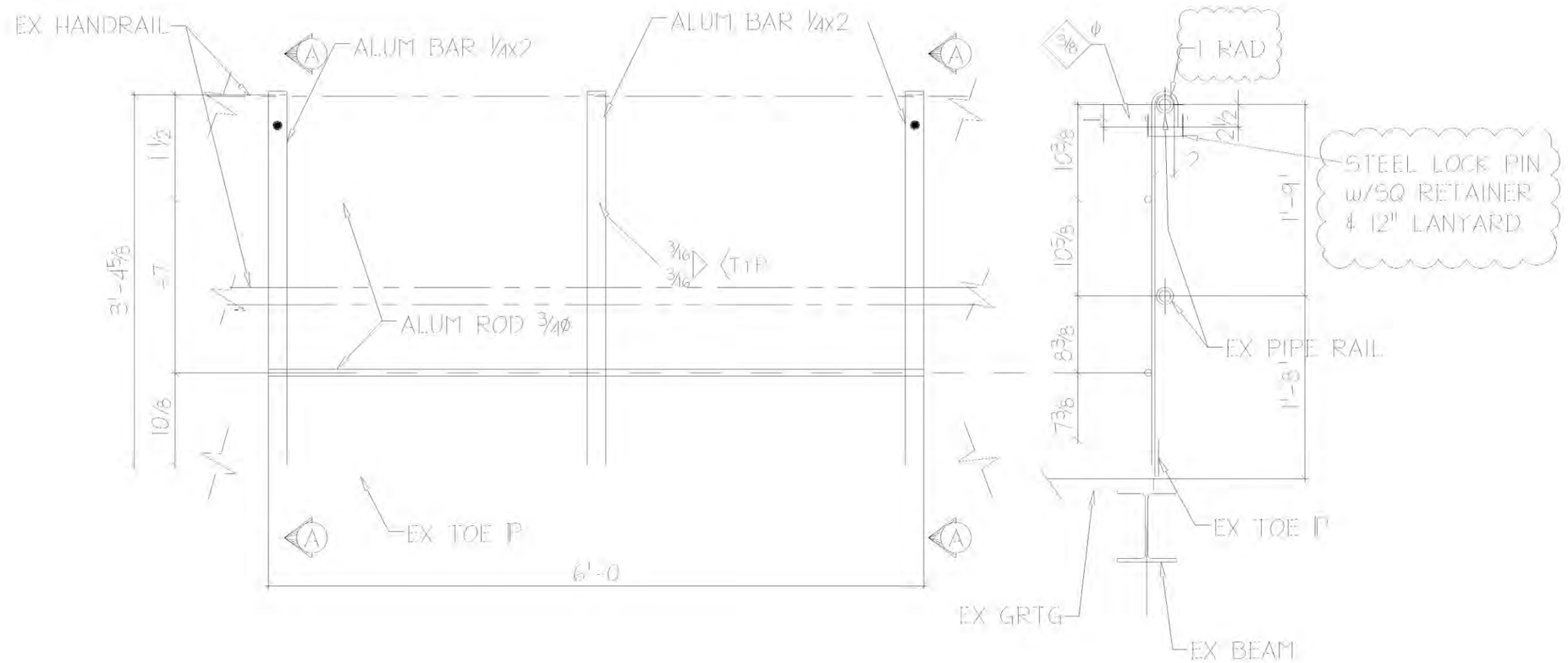
- "J" Clamp-on flat stock design, providing an additional lower-middle and upper-middle rail

- Cargo or "snow" fence

- Netting consisting of the 3/8" approximate mesh

- Clamp-on type solutions, such as flat stock clamped on with U-type clamps

- Utilizing fall protection opposed to barriers, as determined by local safety personnel



TEMPORARY - Portable Safety Guard Rail

SECTION A-A

NOTE:
This portable safety guard rail system shall ONLY be used for TEMORARY fall protection where a permanent option has not been installed. If work activity requiring additional fall protection is expected to be reoccurring, a permanent option shall be installed as soon as practical.

DRAWING RECORD									
REV.	DATE	PROJECT NO.	AMEREN SUPV ENGR	DRAFTING DRFTR	DRAFTING CHK'D	DRAFTING SUPV	ENGR APPROVAL AMEREN	ENGR APPROVAL OTHER	DESCRIPTION
–	–	–	–	–	–	–	–	–	–

NOTICE OF LIMITED RESPONSIBILITY

THE RESPONSIBILITY OF THE UNDERSIGNED ENGINEER IS LIMITED TO THE DESIGN WORK SHOWN ON PROJECT DRAWINGS AND DOCUMENTS BEARING HIS/HER SEAL, SIGNATURE OR INITIALS. HE/SHE DOES NOT HAVE AUTHORITY OVER THE PROJECT AS A WHOLE. THE UNDERSIGNED DISCLAIMS ANY RESPONSIBILITY FOR WORK DONE UNDER SUBSEQUENT REVISIONS AND ANY OTHER DOCUMENTS ASSOCIATED WITH THE PROJECT WHICH DO NOT BEAR HIS/HER SEAL, SIGNATURE OR INITIALS.

MARK UP DRAWING NO.	REV.
----------	---

SHEET NO. ---

SCALE –

UNIT NO. –

DWG. SIZE 11X17

SUB CLASS –

ATTACHMENT 2
TEMPORARY – PORTABLE SAFETY GUARD RAIL

SITE: TEXT HEIGHT

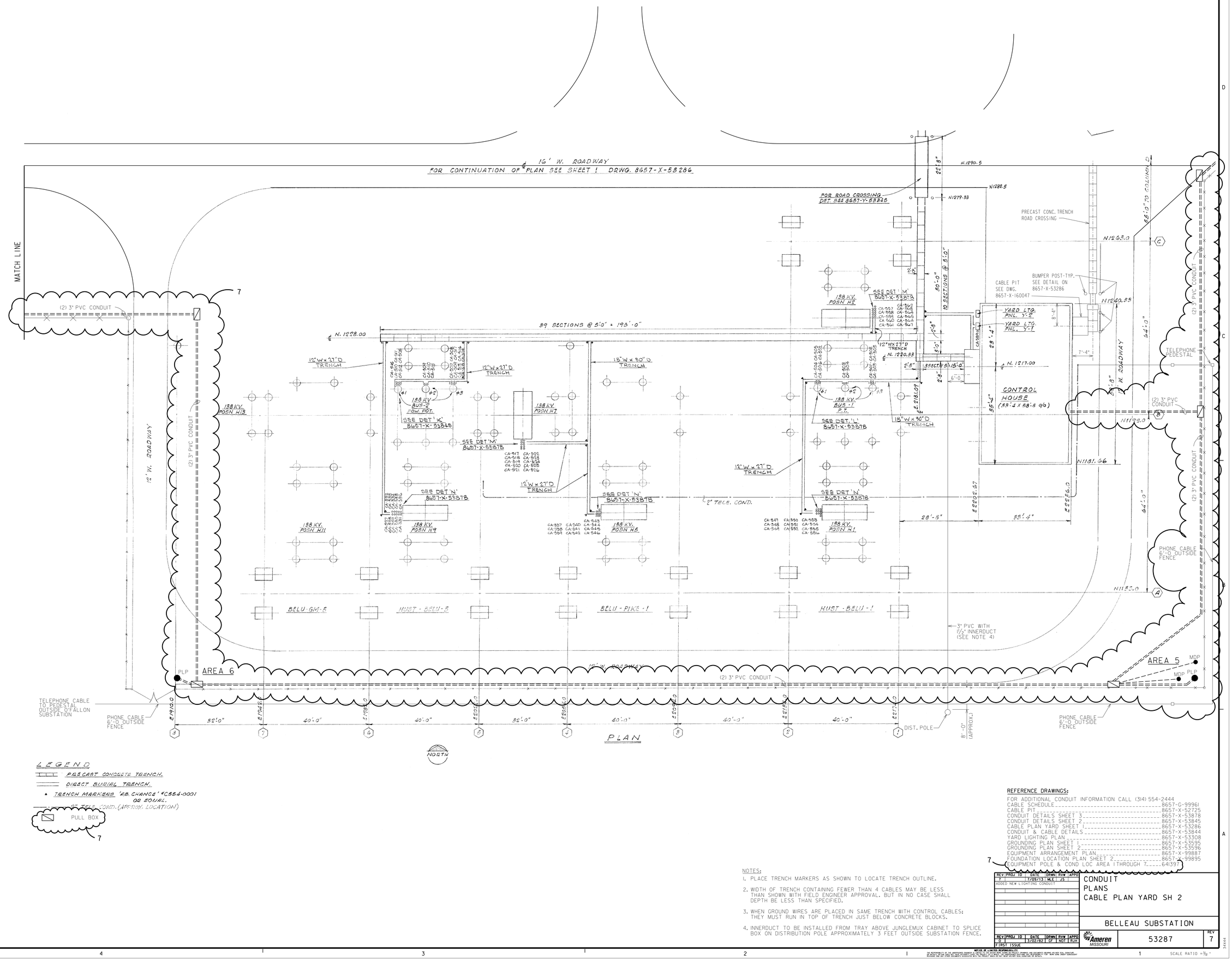
DRAWING NO.	REV.
XX-XXX-XXXX-XXXXXX	000

SHEET NO. 001

END OF APPENDIX Y

APPENDIX Z

Drawings



BELU-GM-5 HUST-BELU-3 BELU-PIK5-1 HUST-BELU-1

LEGEND

- PRECAST CONCRETE TRENCH.
- DIRECT BURIAL TRENCH.
- ▲ TRENCH MARKERS 'KB CHANCE' #C554-0001 OR EQUAL.
- 2" TELE. COND. (APPROX. LOCATION)
- PULL BOX 7

NOTES:

1. PLACE TRENCH MARKERS AS SHOWN TO LOCATE TRENCH OUTLINE.
2. WIDTH OF TRENCH CONTAINING FEWER THAN 4 CABLES MAY BE LESS THAN SHOWN WITH FIELD ENGINEER APPROVAL. BUT IN NO CASE SHALL DEPTH BE LESS THAN SPECIFIED.
3. WHEN GROUND WIRES ARE PLACED IN SAME TRENCH WITH CONTROL CABLES; THEY MUST RUN IN TOP OF TRENCH JUST BELOW CONCRETE BLOCKS.
4. INNERDUCT TO BE INSTALLED FROM TRAY ABOVE JUNGLEMUX CABINET TO SPLICE BOX ON DISTRIBUTION POLE APPROXIMATELY 3 FEET OUTSIDE SUBSTATION FENCE.

REFERENCE DRAWINGS:

FOR ADDITIONAL CONDUIT INFORMATION CALL (314) 554-2444

CABLE SCHEDULE	8657-G-99961
CABLE PIT	8657-X-52725
CONDUIT DETAILS SHEET 3	8657-X-53878
CONDUIT DETAILS SHEET 2	8657-X-53845
CABLE PLAN YARD SHEET 1	8657-X-53286
CONDUIT & CABLE DETAILS	8657-X-53844
YARD LIGHTING PLAN	8657-X-53308
GROUNDING PLAN SHEET 1	8657-X-53595
GROUNDING PLAN SHEET 2	8657-X-53596
EQUIPMENT ARRANGEMENT PLAN	8657-X-99887
FOUNDATION LOCATION PLAN SHEET 2	8657-X-99895
EQUIPMENT POLE & COND LOC AREA 1 THROUGH 7	641397

REV	PROJ ID	DATE	DRWN	RVW	APPD
7		7/09/13	MLE	JS	
ADDED NEW LIGHTING CONDUIT					

REV	PROJ ID	DATE	DRWN	RVW	APPD
0		3/02/82	CF	NOT	RJH
FIRST ISSUE					

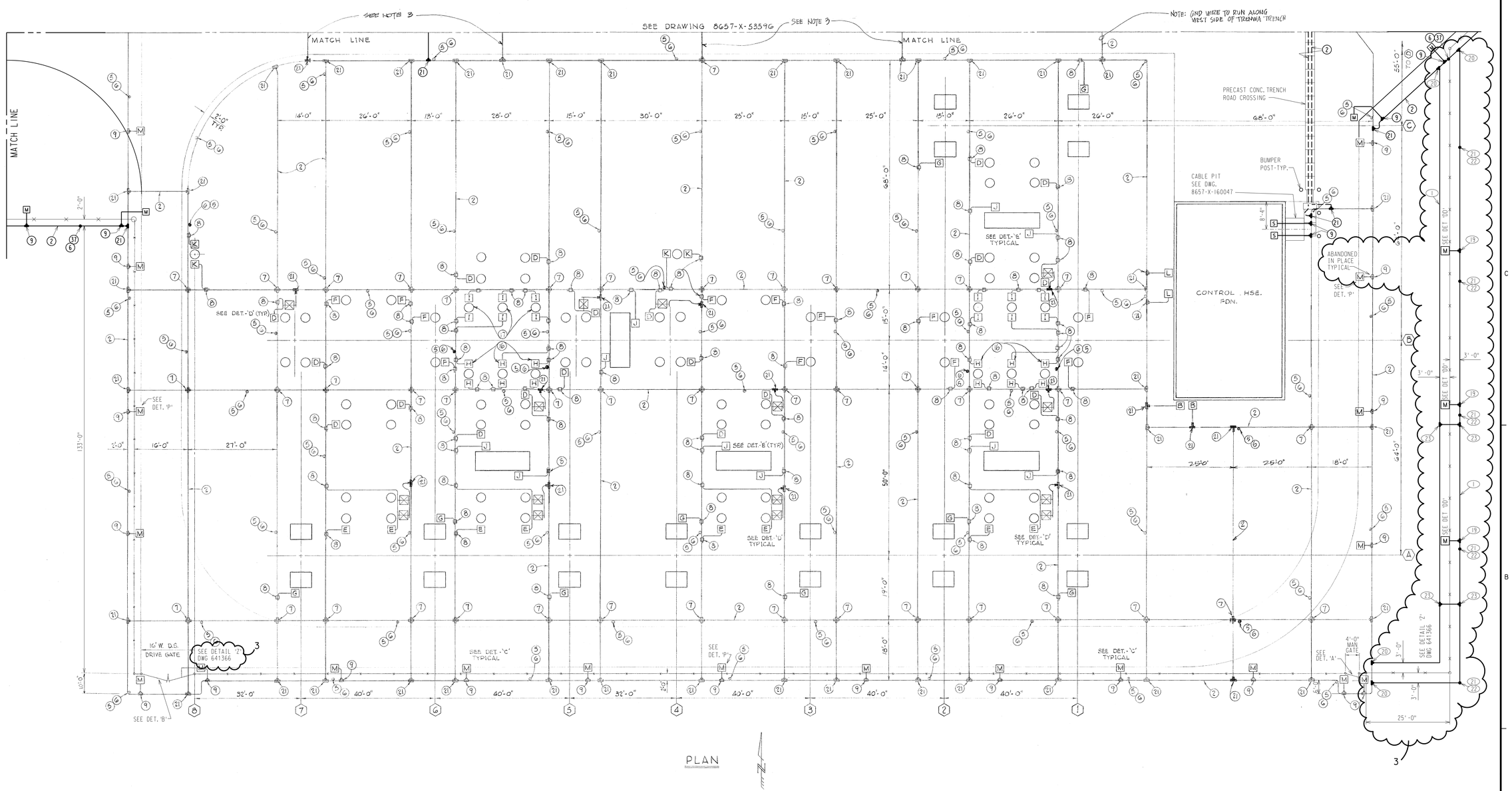
CONDUIT PLANS
CABLE PLAN YARD SH 2

BELLEAU SUBSTATION

Ameren MISSOURI | 53287 | REV 7

SCALE RATIO = ½"

FILE: c:\pw_work\dgn\pro}ect\wiseucopy of security59228\dms848801\53281_002.i0N
PRINTED BY: C26864
TIME: 07/31/2013 2:11:18 PM



PLAN

NOTES:
1. FOR DEFINITION OF SYMBOLS SEE GND. PLAN SH2 DWG. Nº X-53596.
2. FOR GENERAL NOTES, TYPICAL DETAILS AND BILL OF MATERIAL SEE DWG. Nº X-53597 OR 641366.
3. PLACE GND WIRES IN DUCT WHERE ROADWAY SUPPORT FABRIC HAS BEEN CUT
4. ⬭ -REPRESENTS GROUNDING B/M ITEM SHOWN ON DWG. 641366

REFERENCE DRAWINGS:
EQUIP. DETAILS-MISC. _____ 8657-Y-99890
GROUNDING DETAILS _____ 8657-X-53597
GROUNDING PLAN SH 2 _____ 8657-X-53596
GROUNDING DETAILS-FENCE EXPANSION _____ 641366

REV	PROJ ID	DATE	DRWN	RVW	APPD
3		7/09/13	MCE	JS	AEC
ADDED GROUNDING FOR ADDITIONAL FENCING					
2					
1					
0		6/11/82	DW	NOT	WD
FIRST ISSUE					

GROUNDING
PLANS
GROUNDING PLAN SH 1

BELLEAU SUBSTATION

Ameren MISSOURI | 53595 | REV 3

SCALE RATIO =

SEE DETAIL 'Z' DWG 641366

SEE DET. 'O'-TYP. (EXCEPT WHERE NOTED AS DET. 'P')

SEE DET. 'P'

SEE DETAIL 'Z' DWG 641366

NEW ALVARADO MAIN GATE SEE DETAIL 'J' DETAIL 'M' SEE DETAIL 'J' DWG 641366

18'-0" DRIVE GATE SEE DET. 'O'

ABANDON EXIST. 4/0 GND. RISERS THAT REMAIN AFTER PORTIONS OF EXIST. FENCE ARE REMOVED-TYP.

BUMPER POST TYP.

PRECAST CONC. TRENCH-ROAD CROSSING

ABANDON EXIST. 4/0 GND. RISERS THAT REMAIN AFTER PORTIONS OF EXIST. FENCE ARE REMOVED-TYP.

4'-0" MANGATE

MATCH LINE

SEE DRAWING 8657-X-53595

SEE NOTE 2

NOTE: GND. WIRE TO RUN ALONG WEST SIDE OF TRENWA TRENCH

SEE DET. 'O'-TYP. (EXCEPT WHERE NOTED AS DET. 'P')

SEE DETAIL 'Z' DWG 641366

SEE DETAIL 'Z' DWG 641366

SYMBOLS

- COPPERWELD GROUND ROD 5/8"ø x 15'-0" LG. OR 3/8" ø X 8'-0" LG.
- CADWELD PROCESS
- COPPERWELD GROUND MAT 4'x4'
- GROUND WIRE, 500 MCM COPPER, TO BE PLACED IN CABLE TRENCH (345KV PORTION ONLY)
- ▲ INDICATES THE SIDE OF CABLE TRENCH IN WHICH TO PLACE THE GROUND WIRE. SEE TYP. CABLE TRENCH SECTS. ON 8657-X-53286.

PLAN

16' 8' 0' 16' 32'

SCALE IN FEET

- [A] 750 MCM GND. RISER TO XFMR CASE GROUND, EXTEND 5'-0" ABOVE GROUND.
- [B] 500 MCM GND. RISER TO STA. SERV. XFMR CASE GND., EXTEND 8'-0" ABOVE GROUND.
- [C] 500 MCM GND. RISER TO DISC. SW. STAND & OPER. ROD W/GND. BLADES AND HIGH SPEED GND. SWITCH, EXTEND 8'-0" ABOVE GROUND
- [D] 750 MCM GND. RISER TO DISC. SW. STAND & OPER. ROD W/OUT GND. BLADES, EXTEND 8'-0" ABOVE GROUND.
- [E] 750 MCM GND. RISER TO DISC. SW. STAND & OPER. ROD W/GND. BLADES, EXTEND 8'-0" ABOVE GROUND.
- [F] 750 MCM GND. RISER TO BUS SUPPORT COL. STEEL GND., EXTEND 4'-0" ABOVE GROUND.
- [G] 750 MCM GND. RISER TO ANCHOR STEEL GND. EXTEND 4'-0" ABOVE GROUND.
- [H] 750 MCM GND. RISER TO L.A.'S & STL. STAND GND., EXTEND 8'-0" ABOVE GROUND.
- [I] 750 MCM GND. RISER TO P.T.'S & SUPPORT STL. GND. EXTEND 8'-0" ABOVE GROUND.
- [J] 750 MCM GND. RISER TO O.C.B. GND., EXTEND 8'-0" ABOVE GROUND.
- [K] 750 MCM GND. RISER TO LIGHTING MAST, EXTEND 8'-0" ABOVE GROUND.
- [L] 500 GND. RISER TO CONTROL HSE. GRID, EXTEND 20'-0" ABOVE GROUND.
- [M] 4/0 GND. RISER TO FENCE GND., EXTEND 8'-0" ABOVE GROUND.
- [N] 500 MCM GND. RISER TO FORMER WAVE TRAP & CPLG. CAP STAND GND, EXTEND 8'-0" ABOVE GROUND.
- [O] 500 MCM GND RISER TO LAS & STL. STAND GND., EXTEND 8'-0" ABOVE GROUND.
- [P] 500 MCM GND. RISER TO EXTEND 4'-0" ABOVE GROUND.
- [R] 500 MCM GND. RISER TO EXTEND 6'-0" ABOVE GROUND.
- [S] 4/0 GND. RISER TO CONTROL HOUSE TRAY GND. EXTEND 20'-0" ABOVE GROUND.

CONTINUED ON DRAWING 641366 4

NOTES:

1. FOR GENERAL NOTES, TYPICAL DETAILS AND BILL OF MAT'L. SEE DWG. NR. X-53597.
2. PLACE GROUND WIRES IN THE LOCATIONS WHERE THE ROADWAY SUPPORT FABRIC HAS ALREADY BEEN CUT

REFERENCE DRAWINGS:

EQUIP. DET. M156 ..... 8657-Y-99890
GROUNDING DETAILS 8657-X-53597
GROUNDING PLAN SH 1 ..... 8657-X-53595
GROUNDING DETAILS-FENCE EXPANSION 641366 4

REV	PROJ ID	DATE	DRWN	RVW	APPD
4		11/09/13	MLE	JS	
ADDED PERIMETER GROUNDING					
0		6/11/82	DW	NOT	MO
FIRST ISSUE					

GROUNDING PLANS GROUNDING PLAN SH 2

BELLEAU SUBSTATION

Ameren MISSOURI

53596

REV 4

SCALE RATIO = 1/16

Union Electric Company
P. O. Box 149
St. Louis, Mo. 63166

Schedule C

Gentlemen:

We have completed soil test borings for you at:

BELLEAU SUBSTATION - HWY 79 - ST. PETERS, MISSOURI

The results of these borings are shown on the enclosed boring log forms. Jar samples and rock cores will be retained in our yard for a period of 90 days after completion of drilling pending notification of proper disposition.

WABASH DRILLING COMPANY

Soil test boring results

SB WD

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-10-81
Finished 11-12-81

Boring No. 1
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'						
0'10"					Moist, brown, top soil	Advanced boring with 4" augers
2'2"					Moist, med. stiff, light brown silt	
					Damp, stiff, brown, clayey silt	
5'0"	3.8					
	4.5+	1	7-11-14	6-6-6		
	4.5+				Dry to damp, very stiff, light brown to brown silt, a trace of clay	
10'0"	1.1					
	1.8	2	5-7-9	6-6-6		
12'6"	2.0					
15'0"	2.2					
	2.5	3	5-8-11	6-6-6		
	3.6					
20'0"	3.2					
	4.4	4	6-10-14	6-6-6		
	4.5+				Damp, very stiff, brown, reddish-brown and light gray mottled clay, a trace of sand and fine gravel	
25'0"	4.0					
	4.5	5	10-14-17	6-6-6		
	4.5+					
30'0"	3.8					
	4.1	6	7-11-14	6-6-6		
31'6"	4.5+					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-10-81
Finished 11-10-81

Boring No. 2
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'5"					Moist, soft, brown top soil	Advanced boring with 4" augers
1'0"					Moist, medium stiff, brown silt	
					Moist to damp, medium stiff to very stiff, brown silt, a trace of clay and gray silt	
	3.75					
5'0"	3.5	1	6-7-9	6-6-6		
	2.75					
8'9"						
	2.7					
10'0"	3.1	2	5-9-16	6-6-6	Damp, very stiff, brown and gray clay	
	2.9					
13'0"						
	2.8					
15'0"	3.2	3	4-7-10	6-6-6	Damp, very stiff, brown and gray mottled clay, a trace of sand and very fine gravel, glacial till	
	3.3					
	4.1					
20'0"						
21'0"	4.1	4	8-12-18	6-6-6		
	4.5+				Damp, hard, reddish-brown clay, a trace of sand	
	4.5+					
25'0"						
	4.5+	5	14-23-30	6-6-6	Damp, hard, brown, clayey silt	
	3.5					
27'6"						
					Damp, hard, dark brown to brown clay	
	2.9					
30'0"	4.4	6	8-14-19	6-6-6		
31'6"	4.5+					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-12-81
Finished 11-12-81

Boring No. 3
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'						Advanced boring with 4" augers
0'11"					Moist, brown, top soil	
1'6"					Moist, medium stiff, brown silt	
					Damp to moist, stiff, brown, silty clay to clayey silt	
4'6"	2.5					
5'0"	2.0	1	4-5-7	6-6-6		
	1.0					
					Damp, stiff, brown silt, a trace of gray silt and clay, soft and moist 7' to 8'	
	1.1					
10'0"	2.0	2	3-4-6	6-6-6		
	1.4					
13'2"						
	2.5					
15'0"	2.2	3	4-6-9	6-6-6		
	2.7					
	2.6					
20'0"	3.1	4	5-8-14	6-6-6		
	3.9				Damp, stiff to hard, light brown and gray mottled clay, a trace of sand and very fine gravel, glacial till	
	2.4					
25'0"	4.5+	5	10-16-20	6-6-6		
	4.5+					
	3.2					
30'0"	3.4	6	7-13-18	6-6-6		
31'6"	4.3					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-12-81
Finished 11-12-81

Boring No. 4
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation Client's Job No.

Job Location Hwy 79 City St. Peters State Mo.

Casing O.D. I.D. Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer lbs. fall Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'						
0'9"					Moist, brown, top soil	Advanced boring with 4" augers
1'8"					Moist, medium stiff, brown silt	
					Damp to moist, stiff, brown to light brown, silty clay to clayey silt	
5'0"	1.0					
6'0"	2.0	1	3-5-6	6-6-6		
	1.1					
					Moist, stiff, light brown and gray mottled silt, soft area 7'6" to 8'6"	
10'0"	2.2					
	2.0	2	3-6-7	6-6-6		
	2.35					
12'9"						
15'0"	2.0					
	2.15	3	4-5-8	6-6-6		
	2.4					
20'0"	2.85					
	3.0	4	5-8-12	6-6-6	Damp, stiff to hard, light brown and gray to brown clay, a trace of silt, a trace to a little fine gravel and sand, glacial till	
	3.5					
25'0"	3.9					
	3.6	5	7-13-18	6-6-6		
	4.5+					
30'0"	3.75					
	4.2	6	8-13-17	6-6-6		
31'6"	3.75					
					Total depth of boring 31'6"	

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Schedule 5C

Date of Drilling: Started 11-10-81 Finished 11-10-81

Boring No. _____ Coordinates _____ Surf. Elev. _____ Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation Client's Job No. _____

Job Location Hwy 79 City St. Peters State Mo.

Casing O.D. _____ I.D. _____ Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer _____ lbs. _____ fall Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton Client's Inspector _____

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'					Moist, soft, brown, top soil	Advanced boring with 4" augers
0'11"					Damp, med. stiff, brown, silty clay	
2'0"						
	0.4					
5'0"	0.5	1	2-4-4	6-6-6		
	0.5				Moist, medium stiff to stiff, yellowish-brown silt, a little clay, silt, soft & very moist 7' to 9'	
	1.5					
10'0"	1.8	2	3-6-8	6-6-6		
	1.5					
13'6"						
	1.75					
15'0"	1.75	3	4-6-10	6-6-6	Damp, very stiff, brown and gray to gray clay, a trace of rust stains	
	1.85					
	2.75					
20'0"						
20'4"	3.25	4	5-10-15	6-6-6		
	4.4					
	3.15					
25'0"	4.5+	5	8-14-18	6-6-6	Damp to dry, very stiff to hard, gray to brown and gray mottled clay, a trace of sand and very fine gravel, glacial till	
	4.5+					
	4.5+					
30'0"						
	4.5+	6	13-19-30	6-6-6		
31'6"	4.5+					
					Total depth of boring 31'6"	

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Schedule 6

Date of Drilling: Started 11-13-81 Finished 11-13-81

Boring No. _____ Coordinates _____ Surf. Elev. _____ Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation Client's Job No. _____

Job Location Hwy 79 City St. Peters State Mo.

Casing O.D. _____ I.D. _____ Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer _____ lbs. _____ fall Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton Client's Inspector _____

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'					Moist, brown, top soil	Advanced boring with 4" augers.
0'11"					Moist, med. stiff, brown silt	
1'6"					Damp to moist, stiff to medium stiff, light brown, silty clay to clayey silt	
	0.8					
5'0"	0.3	1	2-3-4	6-6-6		
5'10"	1.1				Moist to damp, stiff, light brown and gray mottled silt, a trace of clay from 10'	
	0.8					
10'0"	1.3	2	3-5-6	6-6-6		
	1.3					
12'9"						
	1.3					
15'0"	1.9	3	3-4-7	6-6-6		
	2.3					
	2.3					
20'0"	2.5	4	4-7-11	6-6-6		
	3.25				Damp, stiff to hard, light brown and gray to light gray clay, mottled with traces of sand and fine gravel	
	3.3					
25'0"	4.5	5	8-14-17	6-6-6		
	4.25					
	3.0					
30'0"	4.5+	6	10-15-19	6-6-6		
31'6"	4.5+				Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-13-81
Finished 11-13-81

Boring No. 7
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation Client's Job No.

Job Location Hwy 79 City St. Peters State Mo.

Casing O.D. I.D. Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer lbs. fall Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
					Moist, brown, top soil	Advanced boring with 4" augers.
10"						
8"					Moist, medium stiff, brown silt	
					Damp to moist, stiff, brown to light brown, silty clay to clayey silt	
	0.55					
'0"						
'8"	1.4	1	4-6-7	6-6-6		
	0.9					
					Moist to damp, stiff, light brown and gray silt, alittle clay from 10', very moist, soft silt 7'6" to 9'0"	
	1.25					
'0"	1.5	2	3-5-7	6-6-6		
	1.3					
'3"						
	1.7					
'0"	2.0	3	3-5-8	6-6-6		
	2.2					
	2.7					
'0"	3.0	4	5-8-12	6-6-6		
	3.5					
					Damp, stiff to hard, light brown and gray mottled clay, a trace to a little sand and fine to medium chert gravel, glacial till	
	4.2					
'0"	3.9	5	8-13-17	6-6-6		
	4.5					
	2.4					
'0"	2.9	6	13-15-18	6-6-6		
'6"	4.2					
					Total depth of boring 31'6"	

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Schedule C

Date of Drilling: Started 11-14-81 Finished 11-14-81

Boring No. 8
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters — State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" — I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'					Damp, brown, top soil	Advanced boring with 4" augers
0'10"					Damp, medium stiff, brown silt	
1'8"					Damp, stiff, brown to light brown silty clay to clayey silt	
4'8"	1.0					
5'0"	1.0	1	3-4-5	6-6-6	Damp to moist, stiff, light brown silt, a trace of light gray silt, very moist and medium stiff 7' to 8'6"	
	1.0					
	1.5					
10'0"	1.5	2	4-6-7	6-6-6		
	2.5					
12'10"						
	1.6				Damp, stiff to hard, light brown and gray mottled clay, a trace to a little sand and fine gravel, glacial till	
15'0"	2.2	3	4-5-9	6-6-6		
	2.6					
	2.8					
20'0"	4.0	4	6-12-14	6-6-6		
	3.9					
	4.5+					
25'0"	4.5+	5	9-14-18	6-6-6		
	4.5+					
	4.5+					
30'0"	4.5+	6	9-14-19	6-6-6		
31'6"	4.5+				Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-12-81
Finished 11-12-81

Boring No. 9
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters — State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" — I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'					Moist, brown, top soil	Advanced boring with 4" augers.
8"10"						
1'6"					Moist, medium stiff, brown silt	
					Damp to moist, stiff, brown to light brown, silty clay to clayey silt	
5'0"	3.5					
	3.1	1	4-7-8	6-6-6		
	3.7					
					Damp, stiff, brown and light gray to brown silt, moist and soft 7' to 9'	
10'0"	1.1					
	1.6	2	3-5-7	6-6-6		
	1.4					
13'6"						
15'0"	1.75					
	2.0	3	3-5-8	6-6-6		
	2.0					
					Damp, stiff to hard, light brown and gray mottled clay, a trace to a little sand and fine gravel	
20'0"	3.0					
	3.6	4	5-8-12	6-6-6		
	3.8					
25'0"	4.5+					
	3.5	5	9-14-21	6-6-6		
	4.5+					
29'0"						
30'0"	4.5+				Damp, hard, light brown silt, a trace of sand	
	4.5+	6	15-21-31	6-6-6		
31'6"	4.5+					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-14-81
Finished 11-14-81

Boring No. 10
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'					Damp, brown top soil	Advanced boring with 4" augers.
0'11"					Damp, med. stiff, light brown silt	
1'10"					Damp to moist, stiff, brown to light brown silty clay to clayey silt	
	1.1					
5'0"	1.6	1	3-5-6	6-6-6		
5'6"	1.6				Moist, stiff, light brown and gray mottled silt, very moist and medium stiff 7' to 9', a little clay 11' to 13'	
	1.5					
10'0"	1.55	2	3-5-6	6-6-6		
	1.8					
13'0"						
	1.5					
15'0"	2.0	3	3-6-8	6-6-6		
	2.1					
	2.0					
20'0"	1.8	4	5-7-10	6-6-6		
	2.8				Damp, stiff to very stiff, light brown and gray to light gray clay, a trace to a little sand and fine gravel; glacial till	
	4.0					
25'0"	4.4	5	6-11-16	6-6-6		
	4.5+					
	4.5					
30'0"	4.2	6	8-12-17	6-6-6		
31'6"	4.3					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-13-81
Finished 11-14-81

Boring No. 11
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'					Damp, brown, top soil	Advanced boring with 4" augers.
0'10"					Damp, med. stiff, light brown silt	
1'8"					Damp to moist, stiff, brown to light brown, silty clay to clayey silt	
5'0"	1.7					
6'0"	1.2	1	3-4-6	6-6-6		
	1.1				Moist, stiff, light brown and gray mottled silt, very moist, medium stiff 7' to 9'	
10'0"	1.0					
	1.6	2	3-5-6	6-6-6		
12'9"	1.6					
15'0"	1.9					
	2.1	3	3-4-8	6-6-6		
	2.1					
20'0"	2.0					
	2.8	4	5-10-12	6-6-6	Damp, stiff to hard, light brown and gray mottled clay, a trace to a little sand and fine gravel, glacial till	
	2.6					
25'0"	2.5					
	4.3	5	8-13-17	6-6-6		
	4.5					
30'0"	2.25					
	3.5	6	8-14-18	6-6-6		
31'6"	4.2				Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-14-81
Finished 11-14-81

Boring No. 12
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'						
0'10"					Damp, brown, top soil	Advanced boring with 4" augers.
2'1"					Damp, medium stiff, brown silt	
					Damp to moist, stiff, brown to light brown silty clay to clayey silt	
5'0"	1.1					
6'0"	0.8	1	3-4-6	6-6-6		
	0.8					
					Moist, stiff, light brown and gray to brown silt, very moist and medium stiff 7'6" to 9'6", a little clay from 11'6"	
10'0"	1.2					
	1.8	2	4-6-8	6-6-6		
12'8"						
15'0"	2.0					
	2.4	3	4-6-9	6-6-6		
	2.7					
20'0"	3.2					
	3.3	4	5-8-11	6-6-6		
	3.4				Damp, stiff to hard, light brown and gray mottled clay, a trace to a little sand and fine gravel, glacial till	
25'0"	3.75					
	3.5	5	7-11-16	6-6-6		
	3.5					
30'0"	4.4					
	4.5+	6	8-15-17	6-6-6		
31'6"	4.5+					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-14-81
Finished 11-14-81

Boring No. 13
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company

Job Name Belleau Substation — Client's Job No.

Job Location Hwy 79 — City St. Peters State Mo.

Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"

Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall

W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'						
0'11"					Damp, brown, top soil	Advanced boring with 4" augers
2'2"					Damp, medium stiff, brown silt	
					Damp, stiff, brown to light brown, silty clay to clayey silt	
5'0"	1.0					
5'9"	1.15	1	3-4-5	6-6-6		
	1.1				Moist, stiff, light brown and gray to brown silt, very moist and medium stiff 7'6" to 9'6"	
10'0"	1.3					
	1.7	2	4-5-7	6-6-6		
13'2"	1.7					
15'0"	1.5					
	1.75	3	3-6-9	6-6-6		
	2.0					
20'0"	2.5					
	2.5	4	5-7-11	6-6-6	Damp, stiff to hard, light brown and gray mottled clay, a trace to a little sand and fine gravel, glacial till	
	2.75					
25'0"	3.4					
	3.8	5	6-9-12	6-6-6		
	3.8					
30'0"	3.5					
	4.1	6	7-12-19	6-6-6		
31'6"	4.4					
					Total depth of boring 31'6"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 11-13-81
Finished 11-13-81

Boring No. 14
Coordinates
Surf. Elev.
Gr. Water Elev. None

Client Union Electric Company
Job Name Belleau Substation — Client's Job No.
Job Location Hwy 79 — City St. Peters State Mo.
Casing O.D. — I.D. — Sampler O.D. 2" I.D. 1-3/8"
Casing Hammer — lbs. — fall — Sampler Hammer 140 lbs. 30" fall
W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0'						
0'11"					Damp, brown top soil	Advanced boring with 4" augers.
1'10"					Damp, medium stiff, brown silt	
					Damp, stiff, brown to light brown, silty clay to clayey silt	
4'9"						
5'0"	1.7					
	1.4	1	4-5-6	6-6-6		
	1.6					
					Moist to damp, stiff, light brown and gray mottled silt, a trace of clay from 10'	
10'0"	0.7					
	1.6	2	4-5-7	6-6-6		
12'8"						
15'0"	2.0					
	2.1	3	4-5-9	6-6-6		
	2.2					
20'0"	2.25					
	2.5	4	5-7-11	6-6-6	Damp, stiff to hard, light brown and gray to light gray clay, mottled with a trace to a little sand and fine chert gravel, glacial till	
25'0"	3.3					
	4.5+	5	10-15-22	6-6-6		
	4.2					
30'0"	3.8					
	3.6	6	8-15-18	6-6-6		
31'6"	4.0					
					Total depth of boring 31'6"	

Schedule C

8657-X-52336

NO.	DATE	BY
0	10-64	

FIRST ISSUE

1 10-64 JS

DWG. 4-65

LOCATE TEST BORINGS & ADD LEGEND

TWR 159A E 3' S15
142 N 4 S25'

N

LEGEND

◎ - TEST BORING LOCATIONS

Base Line
Property Line

S 89°00' E 1114.74' Rec.

S. 89° 10' E

Approx. Location of 8657-X-52335

Note: Boring Elev. Top of Concrete Pile Found +120 Elev. 118.37 Below Ground Surface Elevation

A

PROPERTY PLAN
CROSS SECTIONS

DRAWN
CHKD
APPD
SURV

DRAWING NO. 020035 BELLEAU SUB

SHEET NO. 12010

UNION ELECTRIC COMPANY
ST. LOUIS, MO.

8657-X-52336

REV. 1

Union Electric Company
P.O. Box 149
St.Louis, Missouri 63166

Gentlemen:
We have completed soil test borings for you at:

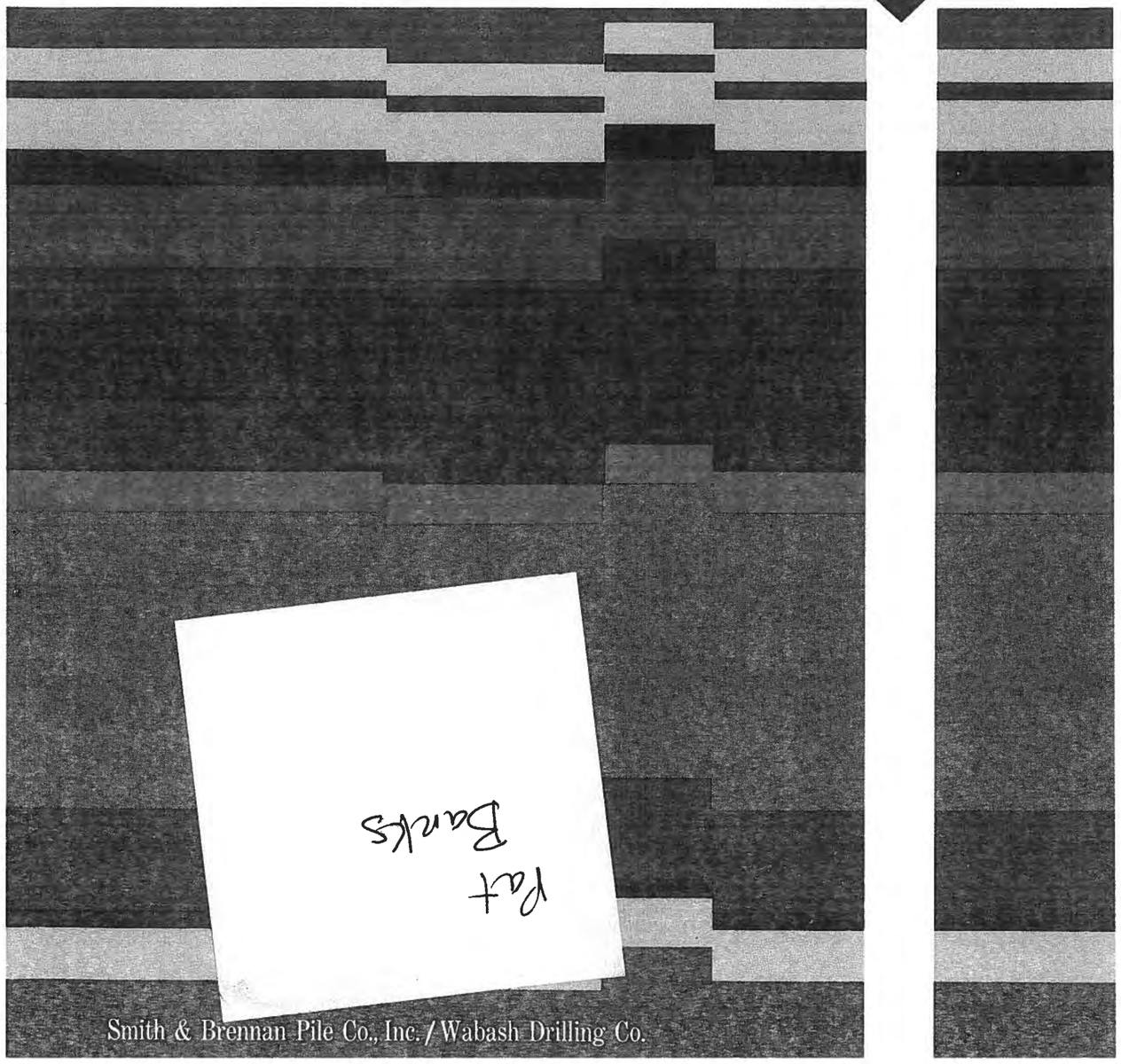
O'FALLON SUBSTATION - O'FALLON, MISSOURI

The results of these borings are shown on the enclosed boring log forms. Jar samples and rock cores will be retained in our yard for a period of 90 days after completion of drilling pending notification of proper disposition.

WABASH DRILLING COMPANY

Soil test boring results

SB WD



Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-8-71
Finished 2-8-71

Boring No. # 1
Coordinates
Surf. Elev. Surface
Gr. Water Elev.

Client Union Electric Company
Job Name O'Fallon Substation Client's Job No.
Job Location Highway 79 City O'Fallon State Mo.
Casing O.D. - I.D. -
Casing Hammer - lbs. - fall
Sampler O.D. 2" I.D. 1-3/
Sampler Hammer 140 lbs. 30" fa
W. D. Co. Foreman Dorl Thornton Client's Inspector

Depth Below Ground Surface	Penetrometer Blows-Or Tester Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0						
1'4"					Moist,brown silt top soil	Advanced boring with 6" auger
2'6"					Moist,med.stiff brown & lt.gray silt	
					Damp,medium stiff,yellow and brown clay silt-trace of gray clay silt	
5'0"						
5'3"	.6	1	2-3	6-6	Moist to wet,medium stiff to soft light brown and gray mottled silt	
8'10"						Water began seepi in boring at 8'0" and caving in at to 11'.
10'0"	1.4	2	3-4	6-6	Moist, medium stiff, light brown clayey silt	
12'0"						
14'6"					Damp medium stiff brown clay,mottled with lignite-a little gray clay	
15'0"	1.9	3	3-4½	6-6	Damp medium stiff to stiff light gray to brown and gray plastic clay Trace of rust stains.	
20'0"	2.4	4	4-7	6-6		
23'0"						
25'0"					Damp,very stiff gray and brown sandy clay-trace of fine gravel	
26'0"	3.75	5	7-9	6-6	Total depth of drilling at 26'0"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-3-71
Finished 2-3-71

Boring No. #2
Coordinates
Surf. Elev. Surface
Gr. Water Elev. -7'7"

Client Union Electric Company
Job Name O'Fallon Substation
Client's Job No.
Job Location Highway 79
City O'Fallon State Mo.
Casing O.D. - I.D. -
Sampler O.D. 2" I.D. 1-3/
Casing Hammer - lbs. - fall
Sampler Hammer 140 lbs. 30" fa
W. D. Co. Foreman Dorl Thornton
Client's Inspector

Depth Below Ground Surface	Penetrometer Blows-On Gauge Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0					Moist,light brown silt(top soil)	8" frozen ground
1'6"					Damp,medium stiff brown silt with trace of clay	Advanced boring with 6" auger
3'2"						
5'0	.75	1	2½-2½	6-6	Damp to moist, medium stiff light brown,yellow and gray mottled clayey silt. Some rust stains.	
6'9"						
8'9"					Wet, soft, light brown and gray mottled silt with traces of rust stain	
10'0	.9	2	3-4	6-6	Moist, medium stiff light brown silt Trace of clay and rust stains	Some water began seeping in boring at 8'0"
11'9"						
13'0"					Damp,med.stiff brown clay-some lignite	Boring caved in t
15'0	1.80	3	3-5	6-6		11 ft. after 24 h
20'0	2.80	4	4-6	6-6	Damp, stiff, gray to brown and gray plastic clay	
25'0	3.75	5	6-8	6-6		
27'8"						
30'0	-	6	7-11	6-6	Damp, very stiff, yellow,brown and gray mottled sandy clay. a few scattered flint gravel.	Sample too hard t get a penetrometer reading
33'0"						
35'0	-	7	11-17	6-6	Damp, very stiff brown silt	
38'6"						
40'0"					Damp, very stiff reddish brown clay	
41'0	4.30	8	9-12	6-6	Total depth of drilling at 41'0"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-3-71
Finished 2-4-71

Boring No. # 3
Coordinates
Surf. Elev. Surface
Gr. Water Elev. -7'2"

Client Union Electric Company
Job Name O'Fallon Substation — Client's Job No.
Job Location Highway 79 — City O'Fallon State Mo.
Casing O.D. - I.D. - — Sampler O.D. 2" I.D. 1-3/
Casing Hammer - lbs. - fall — Sampler Hammer 140 lbs. 30" f
W. D. Co. Foreman Dorl Thornton — Client's Inspector

Depth Below Ground Surface	Penetrometer Blows On ~~xxxx~~ ~~xxxx~~ Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0						
1'6"					Moist, brown silt top soil	Advanced boring w a 6" auger. 8" of frost
3'0"					Moist, med. stiff silt-trace of clay	
5'0"	.50	1	2½-3	6-6	Damp to moist, medium stiff brown, yellow and gray mottled clayey silt. Trace of rust stains	
6'6"						
8'0"					Wet, very soft brown and gray silt	Some water seepin in boring at 8'0"
10'0"	1.0	2	3-4	6-6	Very moist, medium stiff, light brown silt with traces of clay.	
12'0"						
13'0"					Damp, stiff brown clay mottled w/lignite	
15'0"	2.10	3	5-6	6-6	Damp, stiff light gray plastic clay mottled with light brown clay. Trace of rust stains	
20'0"	2.10	4	4-5	6-6		
25'0"	2.75	5	5-7	6-6		
27'10"						
30'0"	2.10	6	6-7	6-6	Damp, stiff to very stiff yellow, brown and gray mottled sandy clay. Some small gravel	
35'0"	-	7	13-18	6-6		
36'0"					Damp, very stiff brown clay silt	
37'6"						
40'0"	-	8	13-16	6-6	Damp, very stiff reddish-brown clay- a trace of sand	
41'0"					Total depth of drilling at 41'0"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-4-71
Finished 2-4-71

Boring No. # 4
Coordinates
Surf. Elev. Surface
Gr. Water Elev. -5'0

Client Union Electric Company
Job Name O'Fallon Substation
Job Location Highway 79
Client's Job No.
City O'Fallon State Mo.
Casing O.D. - I.D. -
Sampler O.D. 2" I.D. 1-
Casing Hammer - lbs. - fall
Sampler Hammer 140 lbs. 30" f
W. D. Co. Foreman Dorl Thornton
Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0						
					Moist, brown silt top soil	Advanced boring with a 6" auger
2'6"						
					Moist to damp, medium stiff yellow & brown clayey silt. Some rust stains	
4'0"						
5'0"	.30	1	1½-2	6-6	Wet, soft light brown and gray silt- trace of rust stains	
7'2"						Some water began seeping in boring at 6'0" caved in 12'0"
					Moist, medium stiff, light brown silt Trace of clay and rust stains	
10'0"	1.5	2	2½-4½	6-6		
11'8"					Damp, med. stiff brown clay some lignite	
13'3"						
					Damp, medium stiff to stiff, gray to brown and gray plastic clay.	
15'0"	1.80	3	3-4	6-6		
20'0"	2.0	4	4-6	6-6		
21'9"					Damp, very stiff, brown and gray mottled sandy clay. A few scattered gravel.	
25'0"	2.6	5	8-10	6-6		
28'3"						
					Moist, medium stiff, light brown sandy clay.	
30'0"	1.3	6	3½-4½	6-6		
32'6"						
					Dry, hard brown clayey silt with a trace of sand	
35'0"	-	7	17-28	6-6		
37'0"						
					Damp, hard, reddish brown clay with a trace of sand.	
40'0"	3.5	8	12-18	6-6		
41'0"					Total depth of drilling at 41'0"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-5-71
Finished 2-5-71

Boring No. # 5
Coordinates
Surf. Elev. Surface
Gr. Water Elev. None

Client Union Electric Company

Job Name O'Fallon Substation

Job Location Highway 79 Client's Job No.

City O'Fallon State Mo.

Casing O.D. - I.D. -

Sampler O.D. 2" I.D. 1-3/

Casing Hammer - lbs. - fall

Sampler Hammer 140 lbs. 30" f

W. D. Co. Foreman Dorl Thornton Client's Inspector

Depth Below Ground Surface	Penetrometer Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0						
1'2"					Moist, brown silt top soil	Advanced boring with 6" auger
2'8"					Damp,medium stiff brown & gray silt	
4'8"					Damp, medium stiff yellow and brown clayey silt	
5'0	1.75	1	2½-4½	6-6	Damp to moist,medium stiff to soft light brown and gray silt. Trace of rust stains	
8'4"						
10'0	1.2	2	2½-4	6-6	Moist,medium stiff light brown clayey silt.	
11'10"					Damp,medium stiff brown clay some lignite	
13'0"						
15'0	2.2	3	3-5	6-6	Damp, medium stiff to stiff, light gray plastic clay mottled with brown clay.	
20'0	2.75	4	5-7	6-6		
21'8"					Damp,stiff, gray to brown and gray sandy clay. A few scattered gravel-fine.	
25'0	3.0	5	6-9	6-6		
28'0"						
30'0	1.9	6	4-6	6-6	Moist,stiff dark to light brown very sandy clay mottled with fine gravel.	
32'6"						
35'0	-	7	13-23	6-6	Dry, hard brown clayey silt with a trace of sand	
38'0"						
40'0"					Damp,very stiff reddish brown clay Trace of sand and fine gravel.	
41'0"	4.0	8	8-13	6-6	Total depth of drilling at 41'0"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-4-71
Finished 2-4-71

Boring No. # 7
Coordinates
Surf. Elev. Surface
Gr. Water Elev. -4'6"

Client Union Electric Company
Job Name O'Fallon Substation
Client's Job No.
Job Location Highway 79 City O'Fallon State Mo.
Casing O.D. - I.D. -
Sampler O.D. 2" I.D. 1-3/8
Casing Hammer - lbs. - fall
Sampler Hammer 140 lbs. 30" fa
W. D. Co. Foreman Dorl Thornton Client's Inspector

Depth Below Ground Surface	~~Penetrometer Blows On Casing~~ Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0					Moist,medium stiff brown silt topsoil	Advanced boring with 6" auger
1'3"					Damp, medium stiff yellow and brown clayey silt	
4'3"						
5'0"	.50	1	1½-2	6-6	Wet, soft, gray and brown silt with trace of rust stains	
7'0"					Moist, medium stiff, light brown and gray silt - some traces of clay	
10'0"	1.5	2	3-5	6-6	Moist,medium stiff brown clay - some lignite	
12'0"						
15'0"	2.0	3	4-6	6-6	Damp, stiff gray to gray and brown plastic clay	
20'0"	2.75	4	5-8	6-6		
22'0"					Damp, brown and gray, very stiff, sandy clay. A few scattered gravel	
25'0"	2.10	5	7-9	6-6		
26'0"					Total depth of drilling at 26'0"	

Schedule C

SUBSURFACE EXPLORATION DATA

by

WABASH DRILLING COMPANY

110 Angelica St. • St. Louis, Mo. 63147 • 421-2460

Date of Drilling:
Started 2-5-71
Finished 2-5-71

Boring No. # 6
Coordinates
Surf. Elev. Surface
Gr. Water Elev. -9'6"

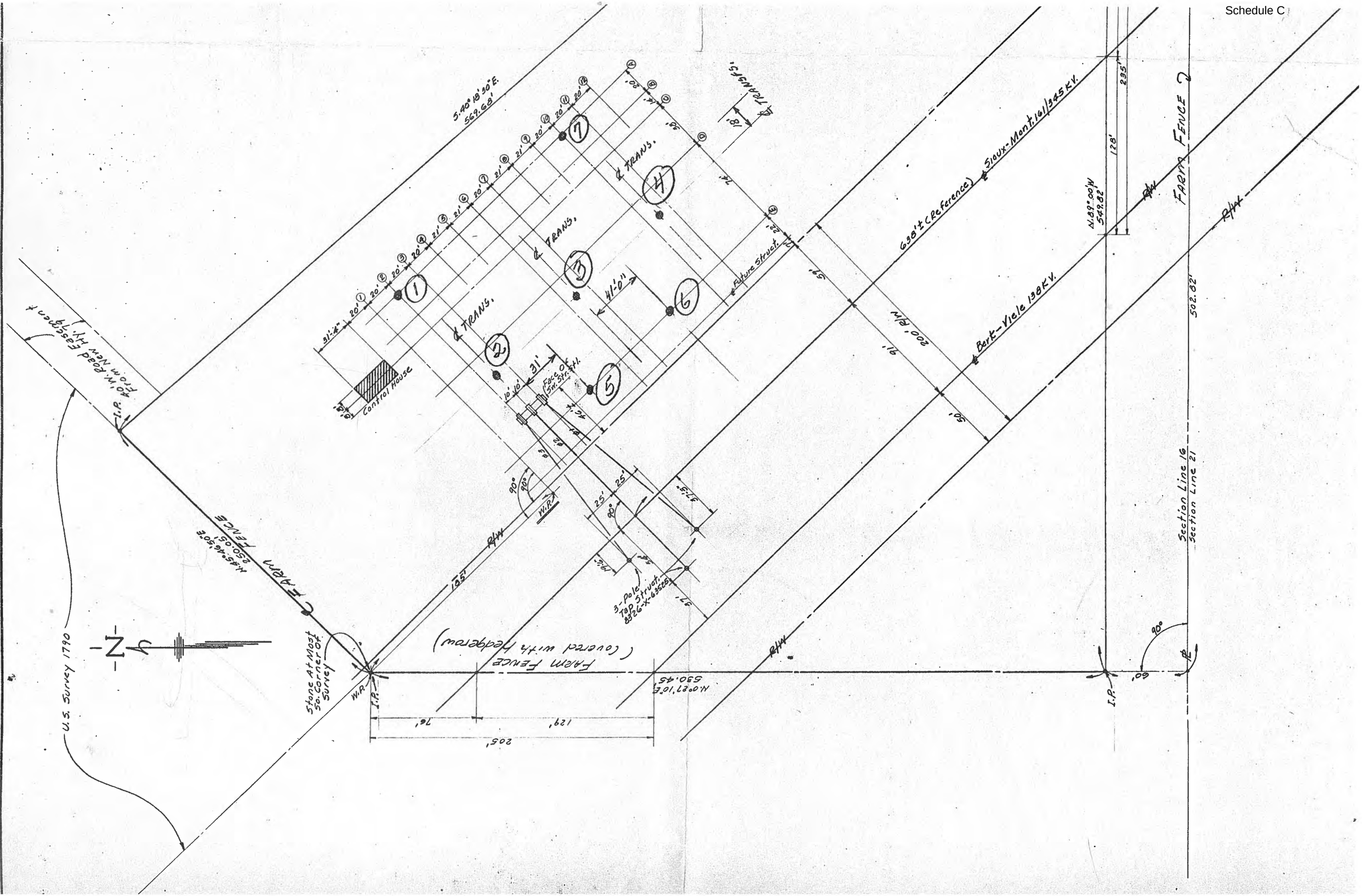
Client Union Electric Company
Job Name O'Fallon Substation
Job Location Highway 79 City O'Fallon State Mo.
Client's Job No.

Casing O.D. - I.D. -
Casing Hammer - lbs. - fall

Sampler O.D. 2" I.D. 1-3/8
Sampler Hammer 140 lbs. 30" fa

W. D. Co. Foreman Dorl Thornton Client's Inspector

Depth Below Ground Surface	Penetrometer ~~Borehole Casing~~ Reading	Sample Number	Blows On Sampler	Penetration Of Sampler (inches)	FIELD IDENTIFICATION OF SOIL (Include relative firmness, relative moisture, color, mention all soil constituents, etc.)	REMARKS
0						
1'6"					Moist brown silt top soil	
2'10"					Moist medium stiff silt-trace of clay	Advanced boring with 6" auger
4'6"					Damp,medium stiff yellow and brown clay silt	
5'0"	.80	1	2-3	6-6	Moist to wet, medium stiff to soft light gray and brown silt	
8'4"						
10'0"	1.2	2	3-4	6-6	Moist, medium stiff light brown clayey silt	Boring caving in 9' to 11'
11'9"						
13'3"					Damp medium stiff brown clay-some lignite	
15'0"	1.6	3	3-5	6-6	Damp, medium stiff to stiff light gray plastic clay mottled with brown clay	
20'0"	2.5	4	4-6	6-6		
23'0"					Damp,stiff gray sandy clay mottled with brown clay. A few small gravel	
25'0"	3.0	5	6-8	6-6		
27'3"						
30'0"	1.75	6	5-7	6-6	Damp stiff brown,very sandy clay mottled with fine gravel	
34'6"						
35'	-	7	10-19	6-6	Damp,very stiff brown clayey silt	
38'5						
40'0"	4.25	8	10-13	6-6	Damp,very stiff reddish brown, slightly sandy clay.	
41'0"					Total depth of drilling at 41'0"	


S.40°18'30"E.
569.68'
Future Struct.
℄ Trans.
℄ Trans.
℄ Trans.
℄ Trans.
41'-0"
31'-4"
20'
21'
Control House
10'
10'
31'
Face of Str. Str. ftn.
1.2'
4'
2'
90°
W.P.
25'
25'
90°
97.6'
3-Pole Tap Structure 8826-X-63525
97.6'
105'
R/W
Farm Fence
(covered with hedgerow)
N.0°27'10"E.
530.45'
76'
129'
205'
I.P.
Stone at West Sec. Corner of Survey
U.S. Survey 1790
Farm Fence
N.85°46'30"E.
250.05'
40' W. road Easement from New Hwy.
698'± (Reference)
Sioux-Mont. 161/345 KV.
Bert-Viele 138 KV.
200' R/W
16'
96'
N.89°00'W.
549.82'
128'
295'
R/W
Farm Fence
502.82'
R/W
Section Line 16
Section Line 21
90°
60'
I.P.

FLOOD ZONE AE

(OWNER: DANIEL DIDION)

EXISTING AERIAL TELEPHONE CABLE

0.16 MI. TO PERIQUE CREEK ROAD

2.8 MI. TO INT.-70

HWY. 79

HWY. R.O.W.

111.01'

142.06'

N 61° W

133' E

N 33° E

741.8'

PROPERTY LINE

FLOOD LIMITS

(OWNER: ADOLPHUS A. BUSCH IV)

S 45° 45' W

2665.74'

EXISTING DIRECT BURIED 12 PR. 19 GA. TELEPHONE CABLE

FLOOD ZONE X

PROPOSED ZONE R-1

OWNER: UNION ELECTRIC CO.

(OWNER: HOMEFIELD ESTATES, PHASE 1111)

160.96'

N 5° 15' W

N 1° 34' E

1110.0'±

ENTRANCE ROAD
SEE: 8657-X-52623

1200' NORTH OF SOUTH PROPERTY LINE

PROPERTY LINE

PERIQUE CREEK RD.

OLD HWY.-79

BELLEAU ENT. RD.

BELLEAU SUBSTATION

HWY.-79

OLD HWY.-79

INTERSTATE-70

KEY PLAN

NO SCALE

EXISTING R.O.W. 200 FT.

TWR.#142 EMAD

STR.#141A

STR.#141

569.68'

S 40° 18' 30" E

PROPERTY LINE

BELU-MIDY-6

STR.#140A

(OWNER: THOMAS R. HUGHES)

STR.#159 ANG.STR.

STR.#159 CPT

OWNER: MISSOURI EDISON CO. O'FALLON SUBSTATION

STR.#115B D.E. ANG.

STR.#115A D.E. ANG.

138KV BELU-SIKE-2

138KV BELU-SIKE-1

DIRECT BURIAL 12 PR. 19 GA. TELEPHONE CABLE

N 00° 27' 10" E

530.45'

2.80'

S 0° 27' W

(OWNER: FORT ZUMWALT SCHOOL DISTRICT)

549.82'

N 89° W

PROPERTY LINE 59.64' SOUTH

PROPERTY LINE

1114.74'

STR.#158A CPLA

STR.#158A CPLA

STR.#158 CPDE

STR.#158 CPDE

STR.#158A ANG.STR.

STR.#158B ANG.STR. S 89° E

21 22

(OWNER: BRIGHT STAR LP)

SECTION CORNER

(OWNER: SUMMIT POINTE LC)

PROPOSED ZONE C-2

D.E. TERM. STR. (TO BE REMOVED)

STR.#140

SIOUX-BELU-6

CONTROL HOUSE

TELEPHONE PEDESTAL RELOCATED 25' TO EAST

DIRECT BURIAL 12 PR. 22 GA. TELEPHONE CABLE RELOCATED 25' TO EAST

NEW FENCE LINE

368'-0"

25'-0"

STR.#157B TAN.STR.

STR.#157A TAN.STR.

PROPERTY LINE

1161.6'

S 89° 10' E

345KV SIOUX-BELU-6

138KV HUSTE-BELU-3

138KV HUSTE-BELU-1

STR.156 TYPE G

TWR.#139A EMAD

PROPERTY LINE

851.7'

N 1° E

770.6'

N 89° 14' W

PROPERTY LINE

EXISTING TOWER #139

EXISTING STRUCTURE #155

EXISTING R.O.W. 100 FT.

PLAN

SCALE IN FEET

0 100 200 300

NOTES:

1. FLOOD ZONES PER F.I.R.M MAP 29183C0235 E, PANEL 235 OF 525, EFFECTIVE DATE AUGUST 2, 1996.

PLANNING & ZONING
FILE NO. 4403.02

REV. 5 SEALED BY

STATE OF MISSOURI REGISTERED PROFESSIONAL ENGINEER

BRUCE L. CALLAWAY NUMBER E-20724

REV	PROJ ID	DATE	DRWN	RVW	APPD
7		7/09/13	MLE	JS	JAB
ADDED ALVARADO MAN. GATE & RELOCATED FENCE					
1					

REV	PROJ ID	DATE	DRWN	RVW	APPD
0		3/09/81	RK	JRT	RJH
FIRST ISSUE					

PROPERTY

SITE PLAN

BELLEAU SUBSTATION

Ameren MISSOURI

99886

REV 7

SCALE RATIO = 100

FILE: c:\dw_working\projects#\set\copy of security5932861dms9487999886.DGN
PRINTED BY: C2686K
TIME: 07/31/2013 1:16:34 PM

34X44

PRINT DIST.

REVISIONS

REV.	W.O.
0	27570

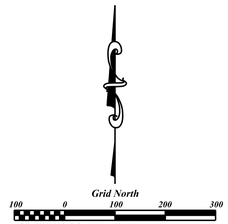
FIRST ISSUE

591609

Schedule C

Plat of Survey
Prepared for
Ameren Missouri

Being part of the Southwest Quarter of Fractional Section 15, part of the Fractional Southeast Quarter of Fractional Section 16 and part of U.S. Survey No. 3070, all in Township 47 North, Range 3 East of the Fifth Principal Meridian

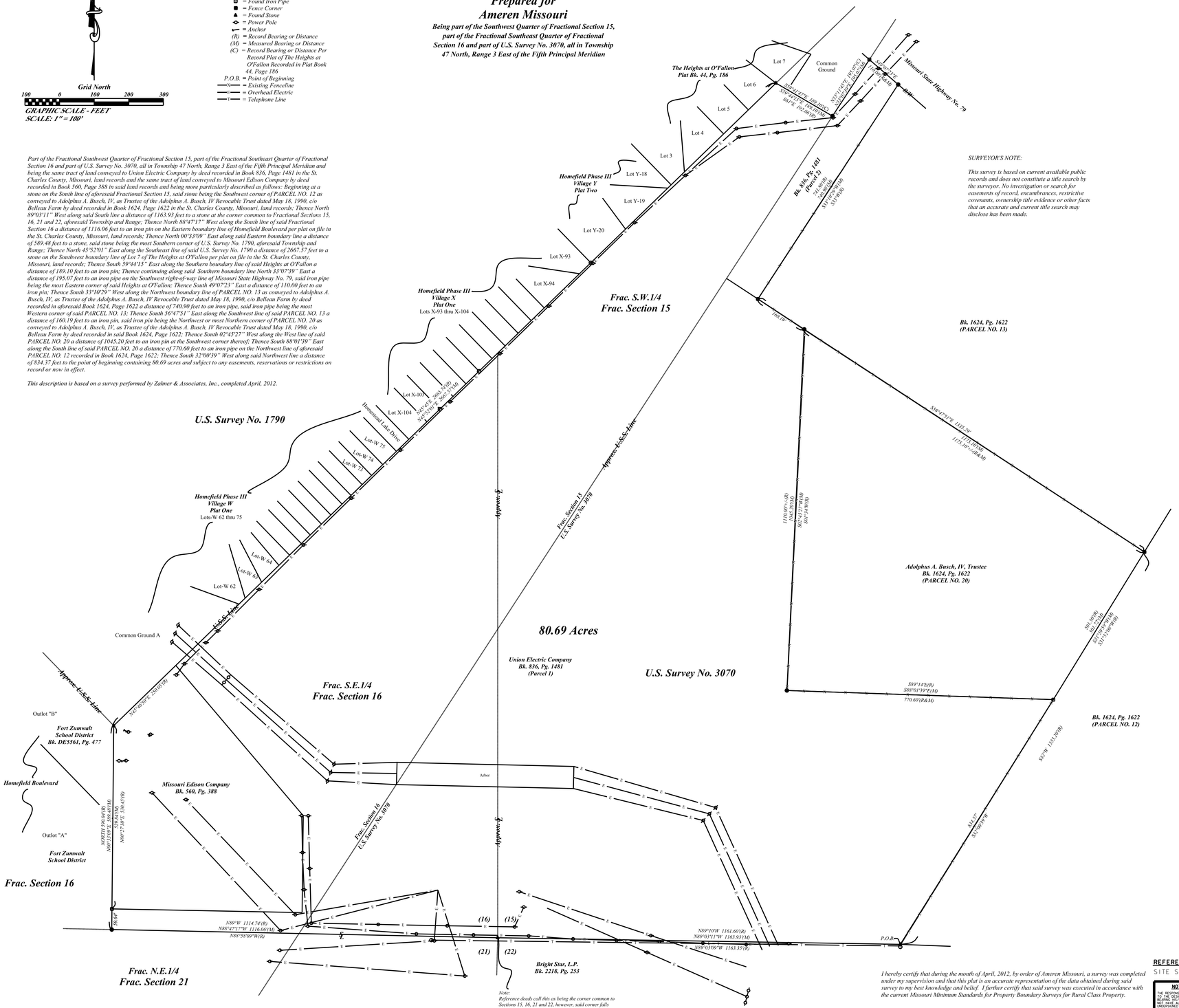


LEGEND

- = Set Iron Pin
- = Found Iron Pin
- = Found Iron Pipe
- = Fence Corner
- = Found Stone
- = Power Pole
- = Anchor
- (R) = Record Bearing or Distance
- (M) = Measured Bearing or Distance
- (C) = Record Bearing or Distance Per Record Plat of The Heights at O'Fallon Recorded in Plat Book 44, Page 186
- P.O.B. = Point of Beginning
- X = Existing Fenceline
- E = Overhead Electric
- T = Telephone Line

Part of the Fractional Southwest Quarter of Fractional Section 15, part of the Fractional Southeast Quarter of Fractional Section 16 and part of U.S. Survey No. 3070, all in Township 47 North, Range 3 East of the Fifth Principal Meridian and being the same tract of land conveyed to Union Electric Company by deed recorded in Book 836, Page 1481 in the St. Charles County, Missouri, land records and the same tract of land conveyed to Missouri Edison Company by deed recorded in Book 560, Page 388 in said land records and being more particularly described as follows: Beginning at a stone on the South line of aforesaid Fractional Section 15, said stone being the Southwest corner of PARCEL NO. 12 as conveyed to Adolphus A. Busch, IV, as Trustee of the Adolphus A. Busch, IV Revocable Trust dated May 18, 1990, c/o Belleau Farm by deed recorded in Book 1624, Page 1622 in the St. Charles County, Missouri, land records; Thence North 89°03'11" West along said South line a distance of 1163.93 feet to a stone at the corner common to Fractional Sections 15, 16, 21 and 22, aforesaid Township and Range; Thence North 88°47'17" West along the South line of said Fractional Section 16 a distance of 1116.06 feet to an iron pin on the Eastern boundary line of Homefield Boulevard per plat on file in the St. Charles County, Missouri, land records; Thence North 00°33'09" East along said Eastern boundary line a distance of 589.48 feet to a stone, said stone being the most Southern corner of U.S. Survey No. 1790, aforesaid Township and Range; Thence North 45°52'01" East along the Southeast line of said U.S. Survey No. 1790 a distance of 2667.57 feet to a stone on the Southwest boundary line of Lot 7 of The Heights at O'Fallon per plat on file in the St. Charles County, Missouri, land records; Thence South 59°44'15" East along the Southern boundary line of said Heights at O'Fallon a distance of 189.10 feet to an iron pin; Thence continuing along said Southern boundary line North 33°07'39" East a distance of 195.07 feet to an iron pipe on the Southwest right-of-way line of Missouri State Highway No. 79, said iron pipe being the most Eastern corner of said Heights at O'Fallon; Thence South 49°07'23" East a distance of 110.00 feet to an iron pin; Thence South 33°10'29" West along the Northwest boundary line of PARCEL NO. 13 as conveyed to Adolphus A. Busch, IV, as Trustee of the Adolphus A. Busch, IV Revocable Trust dated May 18, 1990, c/o Belleau Farm by deed recorded in aforesaid Book 1624, Page 1622 a distance of 740.90 feet to an iron pipe, said iron pipe being the most Western corner of said PARCEL NO. 13; Thence South 56°47'51" East along the Southwest line of said PARCEL NO. 13 a distance of 160.19 feet to an iron pin, said iron pin being the Northwest or most Northern corner of PARCEL NO. 20 as conveyed to Adolphus A. Busch, IV, as Trustee of the Adolphus A. Busch, IV Revocable Trust dated May 18, 1990, c/o Belleau Farm by deed recorded in said Book 1624, Page 1622; Thence South 02°45'27" West along the West line of said PARCEL NO. 20 a distance of 1045.20 feet to an iron pin at the Southwest corner thereof; Thence South 88°01'39" East along the South line of said PARCEL NO. 20 a distance of 770.60 feet to an iron pipe on the Northwest line of aforesaid PARCEL NO. 12 recorded in Book 1624, Page 1622; Thence South 32°00'39" West along said Northwest line a distance of 834.37 feet to the point of beginning containing 80.69 acres and subject to any easements, reservations or restrictions on record or now in effect.

This description is based on a survey performed by Zahner & Associates, Inc., completed April, 2012.



SURVEYOR'S NOTE:

This survey is based on current available public records and does not constitute a title search by the surveyor. No investigation or search for easements of record, encumbrances, restrictive covenants, ownership title evidence or other facts that an accurate and current title search may disclose has been made.

Note:
Reference deeds call this as being the corner common to Sections 15, 16, 21 and 22; however, said corner falls within U.S. Survey No. 3070.

I hereby certify that during the month of April, 2012, by order of Ameren Missouri, a survey was completed under my supervision and that this plat is an accurate representation of the data obtained during said survey to my best knowledge and belief. I further certify that said survey was executed in accordance with the current Missouri Minimum Standards for Property Boundary Surveys for Rural Class Property.

Michael D. Zahner
Missouri Land Surveyor No. 2294
Zahner & Associates, Inc.

Prepared for:
Ameren Missouri
Being part of Frac. Sec. 15, Frac. Sec. 16 and U.S.S. No. 3070, all in T 47 N, R 3 E of the 5th P.M.

Zahner & Associates, Inc.
Professional Land Surveyors
26 North Jackson Street
Perryville, MO 63775
(573) 547 - 1771 (Office)
zahner@zahnerinc.com

Job No.: AM12154
File No.: AM12154
Drawn By: LH/AY
Checked By: MZ
Horiz. Datum: NAD83 SPC-MO E(CORS96) Modified
Vert. Datum: NAVD88

REFERENCE DRAWINGS:
SITE SURVEY ____ 609162

NOTICE OF LIMITED RESPONSIBILITY
THE RESPONSIBILITY OF THE UNDERSIGNED ENGINEER IS LIMITED TO THE DESIGN WORK SHOWN ON PROJECT DRAWINGS, AND DOCUMENTS PREPARED BY THE UNDERSIGNED ENGINEER. THE UNDERSIGNED DOES NOT HAVE AUTHORITY OVER THE PROJECT AS A WHOLE, THE UNDERSIGNED DISCLAIMS ANY RESPONSIBILITY FOR WORK DONE UNDER OTHER DRAWINGS AND SPECIFICATIONS AND FOR ANY CHANGES MADE TO THE PROJECT WHICH DO NOT BEAR HIS/HER SEAL, SIGNATURE OR INITIALS.

PREPARED FOR Ameren MISSOURI

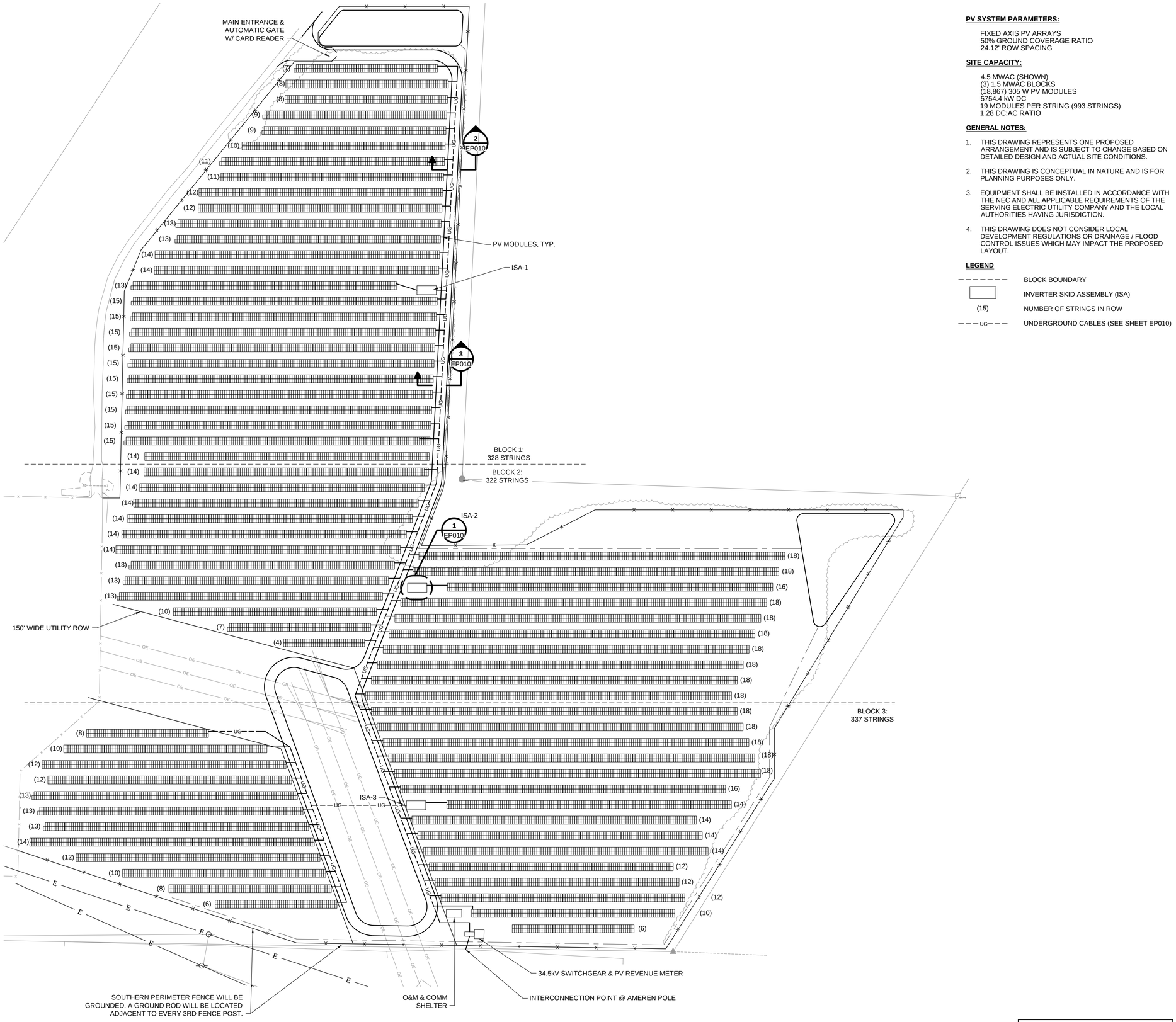
DRAWN	042512 MIKE LOWRY	PROPERTY-SURVEY PLAT OF SURVEY	
CHKD/VFY	051112 ENGLUND		
SUPV.	051112 SANDERS		
APPD.	051112 LINENFELSER	LOCATION 020035 BELLEAU SUBSTATION	CLASS 02010
Ameren	ST. LOUIS, MISSOURI	609165	REV. 0

37-13-070 Rev. 9-85

Schedule C


Homefield Ridge Dr
Homefield Grove Dr
Bullpen Dr
Homefield Gardens Dr
Homefield Meadows Dr
Batters Box Ct
Homefield Winds Ct
79
O'Fallon Substation
Belleau Substation
Solar Installation - open field
Homefield Blvd
Pinewood Pl Dr
TR Hughes Blvd
© 2013 Google
Google earth
Imagery Date: 8/6/2012
1990
38°49'40.66" N 90°40'35.65" W elev 572 ft
Eye alt 5767 ft

Schedule C



SITE PLAN

0 60' 120'

SCALE IN FEET

NORTH

PV SYSTEM PARAMETERS:

FIXED AXIS PV ARRAYS
50% GROUND COVERAGE RATIO
24.12' ROW SPACING

SITE CAPACITY:

4.5 MWAC (SHOWN)
(3) 1.5 MWAC BLOCKS
(18,867) 305 W PV MODULES
5754.4 kW DC
19 MODULES PER STRING (993 STRINGS)
1.28 DC:AC RATIO

GENERAL NOTES:

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LEGEND

- BLOCK BOUNDARY
- INVERTER SKID ASSEMBLY (ISA)
- (15) NUMBER OF STRINGS IN ROW
- UG UNDERGROUND CABLES (SEE SHEET EP010)

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
A	09/04/13	MJG	-	ISSUED FOR REVIEW
B	09/06/13	MJG	-	ISSUED FOR REVIEW
C	09/11/13	MJG	-	ISSUED FOR REVIEW
D	09/11/13	MJG	-	ISSUED FOR PROPOSAL
E	09/16/13	MJG	-	ISSUED FOR PROPOSAL

Burns & McDonnell SINCE 1898
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PHOENIX, AZ 85004
602-977-2623

date	detailed
29 AUGUST 2013	M.GONZALEZ
designed	checked
M.GONZALEZ	K.EKSTROM

AMEREN COG BID

4.5 MWAC PV POWER PLANT
ELECTRICAL PLAN

project	contract
2270	5.04.001

drawing **EP001 – E**

sheet of sheets

file MRKTGEP001.DWG

Scale For Microfilming
Millimeters
Inches

Schedule C

no.	date	by	ckd	description
A	08/29/13	MJG	-	ISSUED FOR REVIEW
B	08/30/13	MJG	-	ISSUED FOR REVIEW
C	09/04/13	MJG	-	ISSUED FOR REVIEW
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IMPROVE ACCESS ROAD PER PROJECT SPECS

MAIN ENTRANCE & AUTOMATIC GATE W/ CARD READER

18" CMP CULVERT

PROPOSED RETENTION BASIN 6' DEEP, 2,300 CY

PV MODULES, TYP.

ISA-1

SPREAD SPOILS ACROSS SITE. GRADE TO DRAIN.

16' WIDE PERIMETER ROAD W/ 30' INNER TURNING RADIUS TYPICAL

2' DEEP V-DITCH, 1:1 SLOPE

80.69 Acres

SMOOTH OUT THIS SLOPE

1,000 CY CUT

EXISTING TREELINE, TYP.

PROPOSED RETENTION BASIN 4' DEEP, 2,400 CY

S89°14'E(R)
S88°01'39"E(M)
770.60'(R&M)

2' DEEP V-DITCH, 1:1 SLOPE

S22°W 1333.20'(R)

834.37'
S32°00'39"W

ISA-2

SPREAD SPOILS ACROSS SITE. GRADE TO DRAIN.

ISA-3

150' UTILITY ROW

1' DEEP V-DITCH, 1:1 SLOPE

N89°10'W 1163.00'(R)
N89°03'11"W
1163.93'(M)
N89°03'09"W
1163.33'(R)

P.O.B.

34.5kV SWITCHGEAR & PV REVENUE METER

O&M & COMM SHELTER

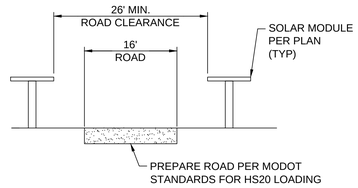
INTERCONNECTION POINT @ AMEREN POLE

SITE PLAN

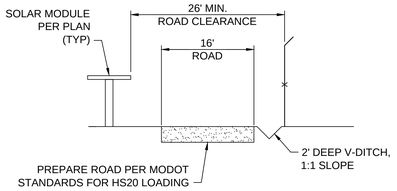
0 60' 120'

SCALE IN FEET

NORTH



SECTION A - NOT TO SCALE



SECTION B - NOT TO SCALE

PRELIMINARY - NOT FOR CONSTRUCTION

Burns & McDonnell
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date	detailed
29 AUGUST 2013	M.GONZALEZ
designed	checked
M.GONZALEZ	T.DOWELL

AMEREN COG BID
4.5 MWAC PV POWER PLANT
SITE PLAN

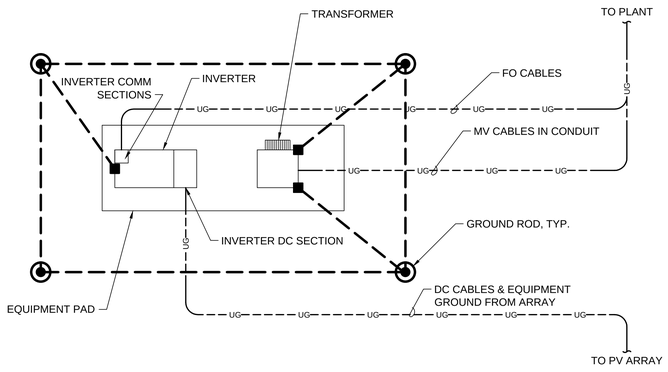
project	contract
2270	5.04.001

drawing **CS001 – F** rev.

sheet of sheets

file MRKTGCS001.DWG

Millimeters
Inches
Scale For Microfilming



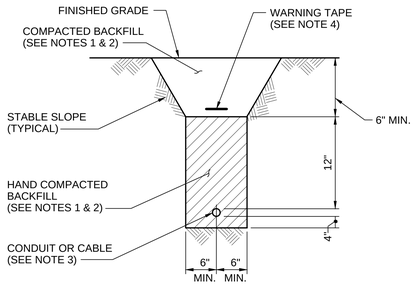
EQUIPMENT PAD DETAIL 1
NOT TO SCALE

GROUNDING NOTES:

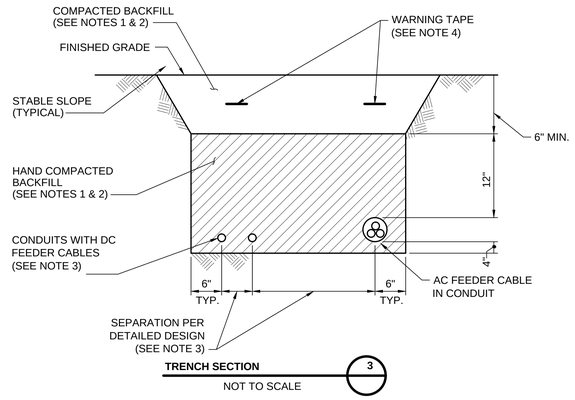
1. BOND PV MODULES TO RACK WITH WEEB CLIP OR EQUIVALENT.
2. BOND EACH RACK TO ADJACENT RACK WITH #10 AWG BARE CU EQUIPMENT GROUNDING CONDUCTOR (EGC) AND ILSCO GBL4-DBT OR EQUIVALENT TIN PLATED COPPER LAY IN LUG.
3. TERMINATE #10 AWG EGC IN COMBINER BOX AT END OF EACH ROW OF RACKS.
4. RUN #2 AWG Al EGC FROM COMBINER BOXES TO INVERTER WITH FEEDER CIRCUITS IN CONDUIT.

LEGEND

UG — UNDERGROUND CABLES
GROUNDING ELECTRODE CONDUCTOR
GROUND ROD



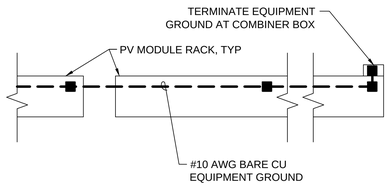
TRENCH SECTION 2
NOT TO SCALE



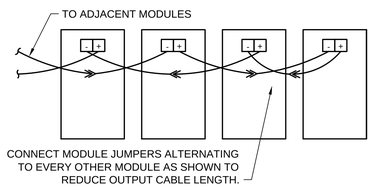
TRENCH SECTION 3
NOT TO SCALE

TRENCHING NOTES:

1. BACKFILL-
   A. OBTAIN BACKFILL MATERIALS FROM TRENCHES AND OTHER EXCAVATION IN THIS CONTRACT AND/OR FROM THE ON SITE BORROW AREAS AS DESIGNATED BY THE RESIDENT PROJECT REPRESENTATIVE.
   B. BACKFILL MATERIALS INCLUDE MATERIAL THAT IS FREE OF DEBRIS, ROOTS, ORGANIC MATTER, REFUSE, CINDERS, FROZEN MATTER AND ALSO FREE OF ROCK WITH A DIMENSION GREATER THAN 2 INCHES.
2. COMPACTION-
   A. PLACE BACKFILL MATERIAL IN LEVEL LAYERS NOT EXCEEDING 4 TO 8 INCHES.
   B. USE HAND METHODS TO A HORIZONTAL PLANE 12 INCHES ABOVE TOP OF CONDUIT.
   C. USE APPROVED MECHANICAL METHODS WHERE HAND BACKFILL IS NOT REQUIRED.
   D. FOR BACKFILL COMPACTION AND MOISTURE CONTENT REQUIREMENTS, SEE SITE WORK PREPARATION AND EARTHWORK SPECIFICATIONS.
3. DETAIL ALSO APPLIES TO MULTIPLE CONDUIT INSTALLATION AND DIRECT BURIED CABLE. MAINTAIN CONSISTENT SPACING BETWEEN PARALLEL ADJACENT CABLES AND CONDUITS. MULTIPLE TRENCHES MAY BE USED WHERE APPLICABLE. EXCEPTIONS SHALL BE APPROVED BY PROJECT ENGINEER.
4. PROVIDE METALLIC WARNING TAPE ABOVE BURIED CONDUIT AND DIRECT BURIED CABLE AS A CAUTIONARY MARKING.



PV ARRAY GROUNDING DETAIL 4
NOT TO SCALE



PV MODULE WIRING DETAIL 5
NOT TO SCALE

PRELIMINARY - NOT FOR CONSTRUCTION

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date 29 AUGUST 2013	detailed M.GONZALEZ
designed M.GONZALEZ	checked K.EKSTROM

AMEREN COG BID
4.5 MWAC PV POWER PLANT
DETAILS

project 2270	contract 5.04.001

drawing **CS010** rev. **C**
sheet of sheets
file MRKTGEP010.DWG

Schedule C
Scale For Microfilming
Millimeters
Inches

Schedule C

NOTES:

1. EQUIPMENT SHALL BE INSTALLED IN ACCORDANCE WITH THE NEC WHERE APPLICABLE AND ALL APPLICABLE REQUIREMENTS OF THE SERVING ELECTRIC UTILITY COMPANY AND THE LOCAL AUTHORITY HAVING JURISDICTION.
2. FOLLOW MANUFACTURERS' SUGGESTED INSTALLATION PRACTICES AND WIRING SPECIFICATIONS.
3. ALL EQUIPMENT SHALL BE UL LISTED WHERE APPLICABLE.
4. GROUND ALL CONDUCTOR SHIELDS ON BOTH ENDS OF EACH MEDIUM VOLTAGE CABLE.
5. ALL BREAKER AND DISCONNECTS SHALL BE LABELED PER THE NEC.
6. ALL RATING SHOWN ARE PRELIMINARY AND ARE SUBJECT TO CHANGE DURING DETAIL DESIGN.

SYSTEM DESCRIPTION:

4.5 MWAC SOLAR PHOTOVOLTAIC POWER PLANT
5754.4 kW DC CAPACITY
(3) INVERTER SKID ASSEMBLIES
34.5 kVAC COLLECTION SYSTEM
1000 VDC SYSTEM USING 19 MODULES PER STRING
979 STRINGS AT 1000 VDC

INVERTERS:

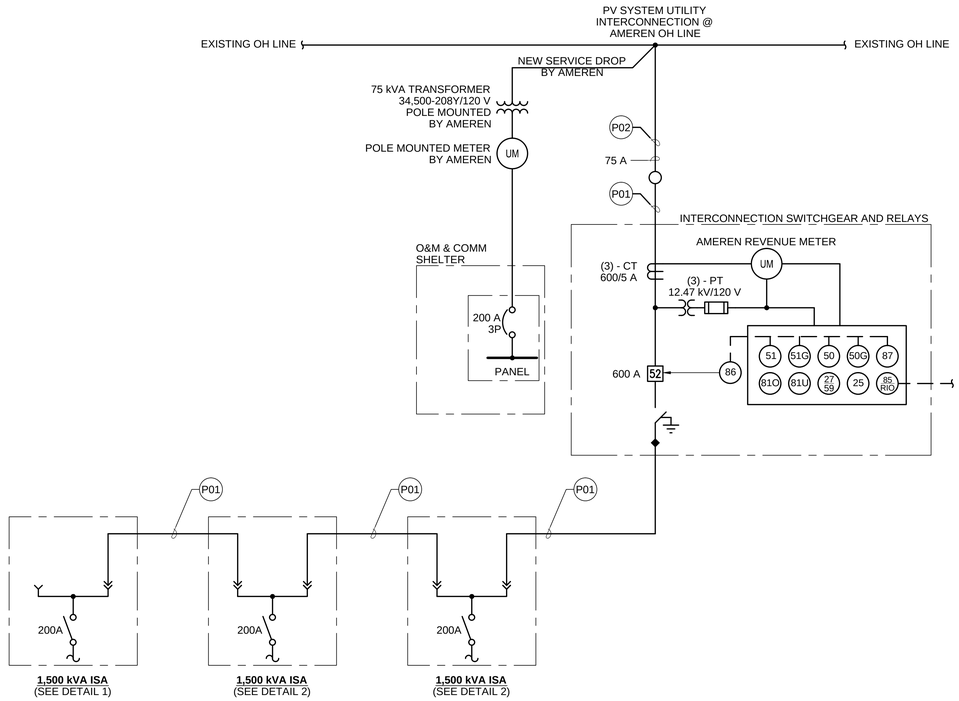
EATON
POWER XPERT SOLAR INVERTER
1500 kW, 480 VAC, 1000 VDC
CEC EFFICIENCY: 98.0%
MAX AC OUTPUT: 3000 A

PV MODULES:

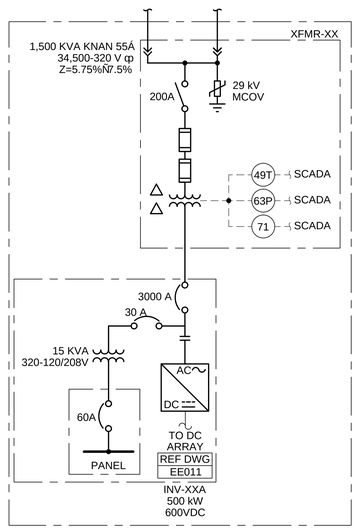
TRINA SOLAR
TSM-305PD14
P_{MAX}: 305 W @ STC
P_{MAX}: 221 W @ NOTC
Voc: 45.4 VDC Vmp:37.0 VDC
Isc: 8.75 A Imp: 8.25 A

LEGEND:

	POWER TRANSFORMER	50	INSTANTANEOUS OVER CURRENT RELAY
	FUSED DISCONNECT SWITCH	50G	INSTANTANEOUS OVER CURRENT RELAY (GROUND)
52	MEDIUM VOLTAGE CIRCUIT BREAKER	51	AC INVERSE TIME OVER CURRENT RELAY
	SURGE ARRESTER	51N	AC INVERSE TIME UNDER CURRENT RELAY (NEUTRAL)
	CURRENT TRANSFORMER (REVENUE)	81O	OVER FREQUENCY RELAY
	POTENTIAL TRANSFORMER (REVENUE)	81U	UNDER FREQUENCY RELAY
	OVERHEAD / UNDERGROUND TRANSITION	85 RIO	COMMUNICATION RELAY REMOTE INPUT / OUTPUT DEVICE
	MEDIUM VOLTAGE STRESS CONE	86	LOCKOUT RELAY
	FUSE	87	CURRENT DIFFERENTIAL RELAY
	FAULT INTERUPTER	27 59	UNDER VOLTAGE / OVER VOLTAGE RELAY
	DISCONNECT SWITCH	25	SYNCHRONIZING
	DISCONNECT SWITCH WITH GROUNDING OPTION	UM	REVENUE GRADE UTILITY METER
		49T	TRANSFORMER TEMPERATURE ALARM
ISA	INVERTER SKID ASSEMBLY	63P	TRANSFORMER PRESSURE ALARM
	MV CONNECTION	71	TRANSFORMER LOW OIL LEVEL ALARM



AC 1-LINE DIAGRAM



INVERTER SKID ASSEMBLY XX

TYPICAL 1,500 kVA INVERTER SKID ASSEMBLY DETAIL
NOT TO SCALE
1

MEDIUM VOLTAGE AC CABLE SCHEDULE	
CABLE NO.	MIN. CONDUCTOR SIZE AND TYPE
P01	1-3/C, #4/0 AWG, AL, 34.5kV, MV-105 + 1-#6 AWG CU GND, ARMORED DIRECT BURIAL CABLE
P02	3-1/C #4/0 AWG ACSR (OVERHEAD)

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date 29 AUGUST 2013	detailed M.GONZALEZ
designed M.GONZALEZ	checked K.EKSTROM

AMEREN COG BID
4.5 MWAC PV POWER PLANT
ELECTRICAL AC 1-LINE

project 2270	contract 5.04.001
drawing **EE001**	rev. **C**
sheet	of sheets
file MRKTGEE001.DWG	

Millimeters
Inches
Scale For Microfilming

Schedule C

no.	date	by	ckd	description
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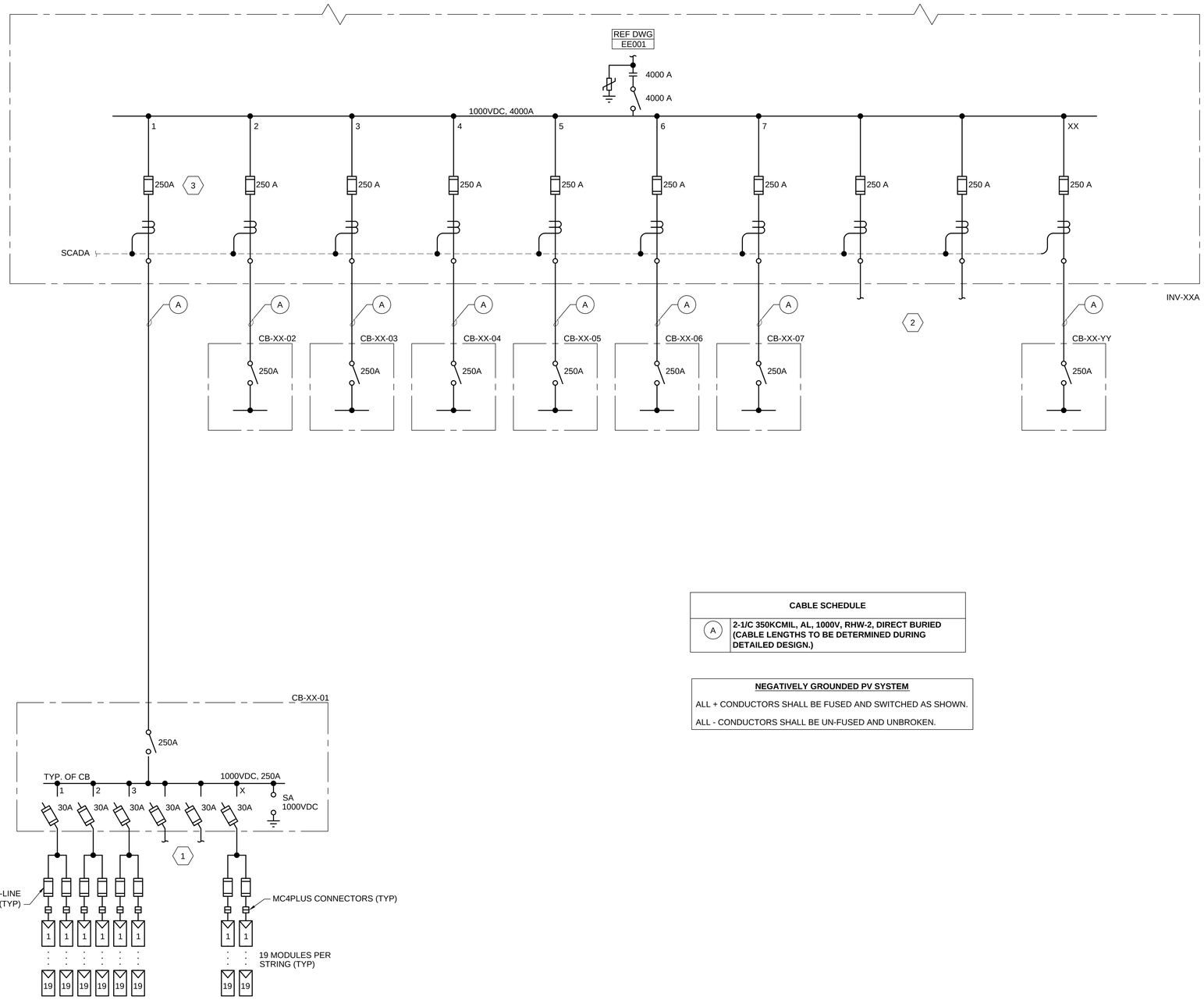
4. SCADA POINT FROM EACH ISA, INCLUDING INVERTER, TRANSFORMER AND WEATHER STATION (IF APPLICABLE) MUST BE SENT TO THE PLANT COMM BUILDING.
5. ALL SOURCE AND OUTPUT CIRCUITS SHALL BE PROVIDED WITH A GFP DEVICE.
6. TRANSFORMER SHALL MEET THE INVERTER MANUFACTURER'S SPECIFICATION FOR MEDIUM-VOLTAGE TRANSFORMERS.

KEYED NOTES: (XX)

1. NUMBER OF CB INPUTS AS DETERMINED BY NUMBER OF PV STRING INPUTS, TYP.
2. NUMBER OF INVERTER INPUTS AS DETERMINED BY NUMBER OF CBs.
3. FUSE SIZE AS DETERMINED BY NUMBER OF PV STRING INPUTS, TYP.



CABLE SCHEDULE	
A	**2-1/C 350KCMIL, AL, 1000V, RHW-2, DIRECT BURIED (CABLE LENGTHS TO BE DETERMINED DURING DETAILED DESIGN.)**

NEGATIVELY GROUNDED PV SYSTEM

ALL + CONDUCTORS SHALL BE FUSED AND SWITCHED AS SHOWN.

ALL - CONDUCTORS SHALL BE UN-FUSED AND UNBROKEN.

PRELIMINARY - NOT FOR CONSTRUCTION

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602-977-2623

date	detailed
29 AUGUST 2013	M.GONZALEZ
designed	checked
M.GONZALEZ	K.EKSTROM

AMEREN COG BID

4.5 MWAC PV POWER PLANT
ELECTRICAL DC 1-LINE

project	contract
2270	5.04.001

drawing **EE010** – rev. **B**

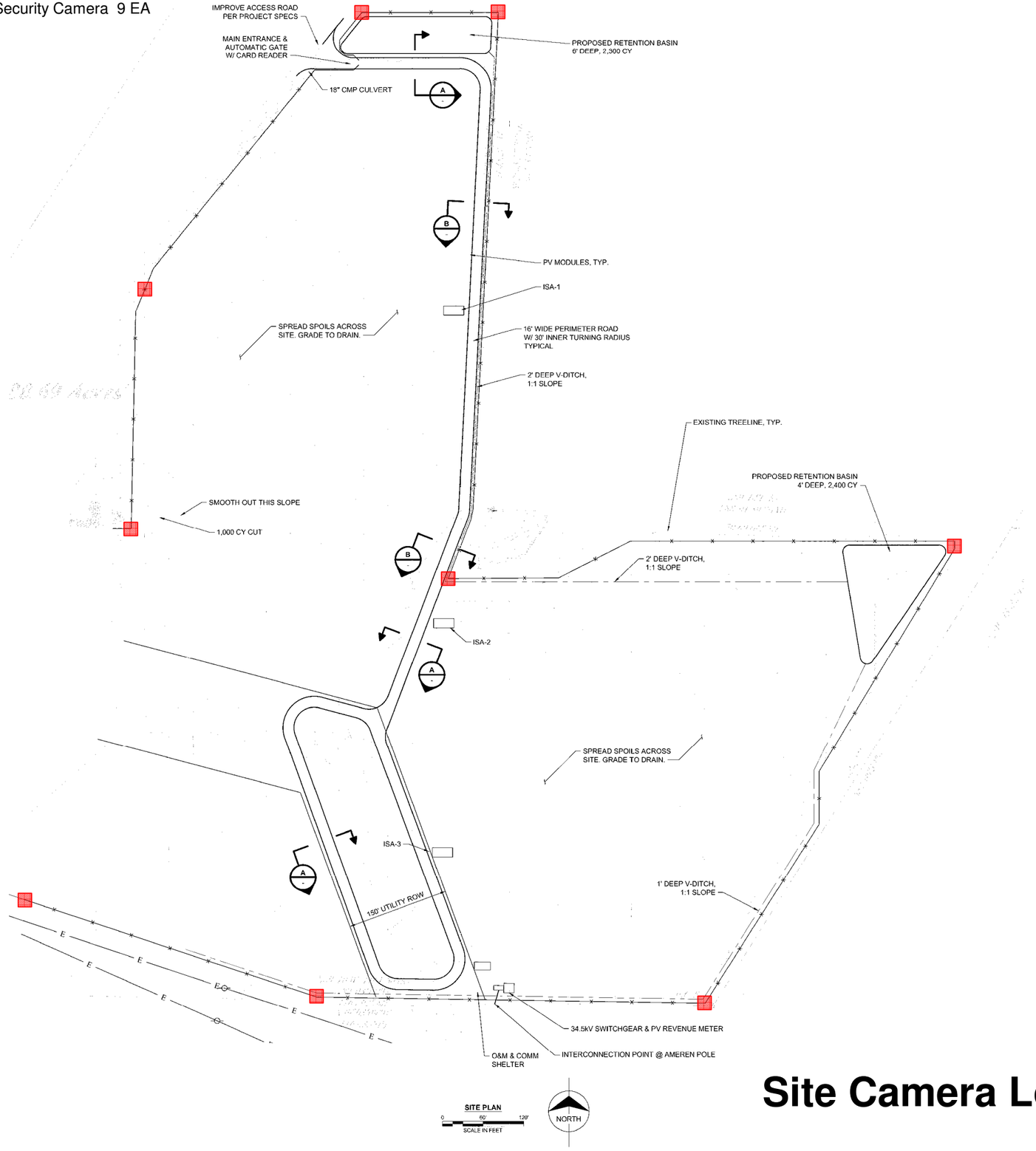
sheet of sheets

file MRKTGEE010.DWG

Scale For Microfilming
Millimeters
Inches

Schedule C

Security Camera 9 EA



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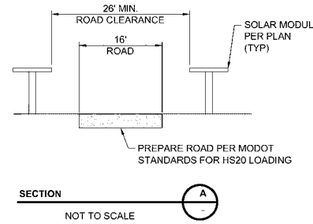
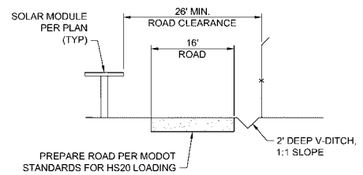


SECTION A
NOT TO SCALE



SECTION B
NOT TO SCALE

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Site Camera Locations

PRELIMINARY - NOT FOR CONSTRUCTION

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PHOENIX, AZ 85004
602-977-2623

date: 29 AUGUST 2013	detailed: M.GONZALEZ
designed: M.GONZALEZ	checked: T.DOWELL

AMEREN COG BID
4.5 MWAC PV POWER PLANT
SITE PLAN

project: 2270	contract: 5.04.001
drawing: CS001	rev.: F
sheet	of sheets
file: MRKTGCS001.DWG	

Scale For Microfilming: Millimeters 1 inches