

SUBSTATION CONSTRUCTION STANDARDS

August 25, 2022



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Standard books should only be used for reference. Appropriate standard revisions for each project should be listed in the Construction Release or the specific construction specification

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Consolidated – 8/25/22

Bold Titles indicate new or updated standards since last revision

Standard books should only be used for reference. Appropriate standard revisions for each project should be listed in the Construction Release or the specific construction specification.

SUBSTATION DESIGN

STANDARD NO. 02110

GENERAL REQUIREMENTS FOR SITE CLEARING



Rev. No.	Date	Revisions	By	Approvals		
0	09/26/05	Initial Issue	MJW	DCB	JLH	PJN
1	10/14/13	Major Revision	JHL	JEL	DWW	
2	08/06/18	Major Revision	JHL	GLC	FF	DES

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1.0 General

1.1 Work Included

1.1.1 Clear defined construction areas of plant life/grass

1.1.2 Remove trees and shrubs, including root system

1.1.3 Remove surface debris

1.2 Related Work

1.2.1 Section 02211 – Grading

1.2.2 Section 02222 – Excavation

1.3 Regulatory Requirements

1.3.1 Conform to all applicable Local, State and Federal laws, codes and ordinances for burning and disposal of debris.

2.0 Execution

2.1 Clearing

2.1.1 Discuss with Construction Supervisor and Ameren Environmental the method of disposal to be used in disposing of all brush. This includes but is not limited to burning, mulching, or hauling off site to an approved landfill. All burning (if permitted by Local and State laws, codes, and ordinances) must be done in an air-curtain burner.

2.1.2 In areas to be excavated, filled, or graded, and as required to access the site, clear all debris and vegetable matter and dispose of as instructed by Construction Supervisor.

2.1.3 Grub out all tree roots and stumps within the areas to be graded.

2.1.4 Remove all miscellaneous surface debris in areas to be graded. This shall include any rubble or stones larger than three inches in diameter.

2.1.5 Remove and stockpile topsoil in accordance with Section 02211.

2.1.6 Should any unidentified underground utilities be encountered, immediately take all necessary precautions and notify the Construction Supervisor.

2.2 Protection

2.2.1 Protect plant growth and features remaining as final landscaping.

2.2.2 Protect benchmarks and existing work from damage or displacement.

2.2.3 Prior to commencing site clearing, request all local utilities to mark all known utilities in accordance with the Illinois One Call System (JULIE) or Missouri One Call System Requirements.

2.2.4 Protect all above or below ground features that are to remain including but not limited to: utilities, poles, and structures.

2.2.5 Maintain designated site access for vehicle and pedestrian traffic.

2.3 Disposal

2.3.1 After consulting with the Environmental Group, Construction Supervisor will instruct how to remove all debris from the work site and properly dispose.

3.0 Revisions

<u>Date</u>	<u>Description</u>
9-26-05	Initial Issue
10-14-13	Major Revision
5-21-18	Updated Formatting, Corrected Section Number, Added Mulching as an option for the disposal of vegetation

SUBSTATION DESIGN

STANDARD NO. 02202

GENERAL REQUIREMENTS FOR ROCK REMOVAL



Rev. No.	Date	Revisions	By	Approvals		
0	09/26/05	Initial Issue	DRR	DCB	JLH	PJN
1	10/14/13	Major Revision	JHL	JEL	DWW	
2	08/06/18	Major Revision	JHL	GLC	FF	DES

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1.0 General

1.1 Work Included

1.1.1 Removal of identified and discovered rock during excavation.

1.2 Related Work

1.2.1 Section 02222 - Excavation

1.2.2 Section 02371 - Cast-In Place Concrete Piers

1.2.3 Section 02223 - Backfilling

2.0 Products

2.1 Materials

2.1.1 Rock (Definition):

2.1.1.1 Material requiring continuous drilling and blasting for removal.

2.1.1.2 Layers of softer material not more than 12 inches thick when occurring between layers of material described in (1), above, of equal or greater thickness.

2.1.1.3 Boulders having a volume of one cubic yard or more.

2.1.1.4 Materials that cannot be removed by ripping with a Cat. D8L or equivalent machine with a single shank, hydraulic ripper.

3.0 Execution

3.1 Inspection

3.1.1 Verify site conditions and note irregularities affecting work of this Section.

3.1.2 Review soil borings (if available) for presence of rock.

3.1.3 Beginning work of this Section means acceptance of existing condition.

3.2 Rock Removal - Mechanical Method

3.2.1 Excavate for and remove rock by the mechanical method.

3.2.2 Cut away rock at excavation bottom to form level bearing.

3.2.3 Remove scaled layers to provide sound and unshattered base.

3.2.4 Construction Supervisor will instruct whether excavated material should be removed from site.

3.2.5 Correct excess rock removal in accordance with backfilling and compaction requirements of Standard No. 02223, or other approved method, under the oversight and direction on the Construction Supervisor.

3.3 Field Quality Control

3.3.1 Hold open areas of rock removal for visual inspection, by Construction Supervisor, of bearing surfaces and cavities formed by removed rock.

4.0 Revisions

<u>Date</u>	<u>Description</u>
9-26-05	Initial Issue
10-14-13	Major Revision
5-21-18	Updated Formatting, Removed Basis of Payment Section, Added Section 3.1.2

SUBSTATION DESIGN
STANDARD NO. – 02211
General Requirements for
Grading



Transmission & Distribution Design Department
ENERGY DELIVERY TECHNICAL SERVICES
AMEREN SERVICES COMPANY

Rev. No	Date	Revisions	By	Approvals		
0	9-26-05	Initial Issue	DRR	DCB	JLH	PJN
1	9-3-13	Issue For Use	DJG	JEL	DWW	
2	8-15-18	Major Revision	JLF	GLC/SM /SAL		

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SECTION 02211

GRADING

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Excavation and removal of all materials taken between the original surface and the top of suitable material for the construction of new site contours.
- B. Grade and contour site.

1.02 RELATED WORK

- A. Section 02210 - Site Clearing
- B. Section 02222 - Excavation
- C. Section 02223 - Backfilling: Fill and compaction requirements

1.03 PROJECT RECORD DOCUMENTS

- A. Submit as-built documents.
- B. Accurately record location of utilities remaining, rerouted, or new utilities (by horizontal dimensions), the elevations or inverts, and the slope gradients.

1.04 PROTECTION

- A. Protect features remaining as portion of final landscaping.
- B. Protect benchmarks, existing structures, fences, roads, and paving.
- C. Protect above or below grade utilities which are to remain.
- D. Repair damage resulting from construction activities.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Topsoil: Surface soil containing organic matter and microorganisms which provides a covering over slopes, supports vegetation, and protects a more erodible material. Do not assume the top of soil present at the construction site is always suitable for topsoil. Consult the Construction Supervisor and site plans to determine areas for topsoil removal.
- B. Cut Subsoil: Soil beneath topsoil (if present) which is to be excavated.
- C. Fill Subsoil: Subsoil suitable to be placed as fill beneath topsoil or other surfacing. Fill Subsoil may include Imported Fill and Cut Subsoil which has been approved by the Engineer or the Construction Supervisor. No Cut Subsoil shall be used as fill prior to approval by the Engineer or Construction Supervisor.
- D. Imported Fill: See common fill materials in Section 02223.

PART 3 EXECUTION

3.01 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Identify and mark all known above and below grade utilities.
- C. Maintain and protect existing utilities (remaining) which pass through work area.
- D. Notify the Construction Supervisor upon discovery of unknown utility or concealed conditions, and discontinue affected work.
- E. Provide and maintain ample means and devices to intercept and/or remove promptly and dispose of properly all water entering excavations.
- F. Erosion control is the responsibility of the Contractor.
- G. All excavation shall be completed in accordance with Section 02222.

3.02 TOPSOIL REMOVAL

- A. Excavate topsoil within the proposed construction limits to a minimum depth of 6 inches, but to a sufficient depth to remove excessive roots or unsuitable material, and as required to remove all soil containing organic material as specified by the site plans, Engineer and Construction Supervisor. All stripped topsoil deemed acceptable for use as topsoil for the proposed finished grade shall be stockpiled in a designated area. Engineer

and Construction Supervisor approval is required for any topsoil stripping beyond 6", unless noted otherwise on the project plans.

- B. Stripped topsoil shall be kept separate from excavated subsoil. Consult the Construction Supervisor for guidance on the location and depths of all stockpiles. Protect stockpiles from erosion by installing siltation control completely around all earthen stockpiles.
- C. Topsoil shall be free of roots, rocks larger than one inch, subsoil, debris, and weeds.

3.03 SUBSOIL EXCAVATION/GRADING

- A. The subgrade shall be prepared such that after compaction, it will be smooth and conform to the grades and sections shown in the plans.
- B. In cut sections, plan ditches should be cut to grade first to drain the area. When finished grades are reached, the section shall be proof rolled to detect soft spots.
- C. For fill sections, proof roll after topsoil removal to detect soft spots prior to the first lift.
- D. Proof rolling performed in accordance with the site Geotechnical Report recommendations and in the presence of the Geotechnical Engineer or qualified Geotechnical Representative using a fully loaded tandem axle dump truck or water truck with a minimum gross weight of 25 tons or a fully loaded belly dump with an equivalent axle loading. Proof-rolling acceptance standards include no rutting greater than 1.5" and no "pumping" of the soil behind the loaded truck.
- E. Soft spots shall be air dried including at least two 8 inch deep processing's utilizing disks or tillers for up to three consecutive good drying days to attempt to reduce the moisture content closer to optimum. Compact the processed layer to achieve the required density. When these steps have been performed and the required density and stability have not been reached, the Engineer shall determine whether additional drying and compacting will be needed or if the ground and soil conditions warrant more extensive treatment.
- F. The Engineer shall determine if the soft and unstable material that will not compact when rolled or tamped shall be removed and replaced with suitable fill.
- G. Any proposal for lime drying or soil modification shall be reviewed by Engineering and the Construction Supervisor.

- H. Cut subsoil approved for reuse as fill shall be stockpiled separately from unsuitable fill material. Consult the Construction Supervisor for guidance on the location and depths of all stockpiles. Protect stockpiles from erosion by installing siltation control completely around all earthen stockpiles.
- I. Unless otherwise specified by the Engineer, all compaction of subsoils shall be performed in accordance with Section 02223. This includes but is not limited to the level of compaction to achieve, the method of compaction, and the thickness of lifts to be used during compaction.

3.04 SUBSOIL PREPARATION FOR TOPSOIL

- A. Verify that the subsoil is at the required grades and elevations, completely compacted (to required effort), accepted by the Construction Supervisor, and ready to receive topsoil.
- B. Prepare subsoil to eliminate uneven areas and low spots. Maintain lines, levels, profiles, and contours. Make changes in grade gradual. Blend slopes into level areas.
- C. Remove debris, roots, branches, stones, and foreign material larger than 1 inch. Remove weeds and plants, including their roots. If contaminated soils are present, remove and replace according to direction given by Environmental Service Department and/or Construction Supervisor.
- D. Scarify subsoil to a depth of 3 inches where topsoil is to be placed. Repeat scarification operations in areas where equipment used for hauling and spreading has compacted the soil.

3.05 PLACING TOPSOIL

- A. Spread topsoil to a minimum depth of 6 inches over all disturbed areas that do not receive rock surfacing and are to be seeded or sodded. Work until smooth.
- B. Use topsoil in a relatively dry state. Place topsoil during dry weather on unfrozen subgrade.
- C. Place the topsoil as close to the time of seeding operations as possible.
- D. Remove all existing vegetable matter and foreign (non-organic) material while spreading topsoil.
- E. Grade to eliminate rough, low, or soft areas, and to ensure positive drainage. The spreading of subsoil and topsoil shall not modify the proposed drainage path(s) of the site.

- F. Lightly roll placed topsoil.
- H. Leave stockpile area and site clean and raked with a smooth surface without imperfections—ready to receive seed, sod, or landscaping materials.

3.06 TOLERANCES

- A. Top Surfaces of Subgrade and Topsoil: Plus or minus one inch.

SUBSTATION DESIGN

STANDARD NO. 02222

GENERAL REQUIREMENTS FOR EXCAVATION AND SPOILS MANAGEMENT



Rev. No.	Date	Revisions	By	Approvals		
0	09-26-05	Initial Issue	DRR	DCB	JLH	PJN
1	09-03-13	Issued For Use	DJG	JEL	DWW	
2	01-22-19	Major Revision	DJG	GLC	FF	DES
3	12-20-19	Absorbed Trenching Specification No. 02225	DJG	GLC	FF	DES

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1.0 General

1.1 Work Included

- 1.1.1 Excavation for structures and foundations.
- 1.1.2 Excavation of trench for underground utility work or installations.
- 1.1.3 Excavation to working elevation only for drilled pier work. Drilling work is covered under Section 02371 – Cast-in-Place Concrete Piers.

1.2 Related Work

- 1.2.1 Section 02110 – Site Clearing
- 1.2.2 Section 02202 – Rock Removal
- 1.2.3 Section 02211 – Grading
- 1.2.4 Section 02223 – Backfilling
- 1.2.5 Section 16C – General Requirements for Grounding Installation
- 1.2.6 Section 16M – Underground Power Ducts and Manholes
- 1.2.7 Section 02371 – Cast-in-Place Concrete Piers

1.3 References

- 1.3.1 IDOT Standard Specification for Road and Bridge Construction
- 1.3.2 MoDOT Standard Specification for Highway Construction
- 1.3.3 OSHA 1926 Subpart P – Excavations

1.4 Regulatory Requirements

- 1.4.1 Conform to all applicable Local, State and Federal laws, codes and ordinances for safety during excavation and for management of spoils.

2.0 Execution

2.1 Protection

- 2.1.1 Protect bench marks, existing structures, and paving from equipment and vehicular traffic.
- 2.1.2 Protect above and below grade utilities which are to remain or are currently in-service.
- 2.1.3 Prevent cave-in or loose soil falling into excavations by shoring, bracing, sheet piling, underpinning, or other methods as required.
- 2.1.4 Underpin adjacent structures which may be damaged by excavation work, including service utilities and pipe chases.
- 2.1.5 Notify Construction Supervisor of unexpected subsurface conditions including unusual odors or stains and discontinue affected work in area until notified to resume work.
- 2.1.6 Protect bottom of excavations, and soil adjacent to and/or beneath foundations, from frost.

- 2.1.6.1 *EXCEPTION: For non-structural excavations only, ground grid wires and electrical conduit may be placed on frozen ground. This exception does not apply to riser pads or other structural excavations related to ground grid or conduit work.*
- 2.1.7 Prevent surface water run-off into excavation. In excavations where water may collect, the Construction Crew shall establish and maintain pumping capabilities to keep the excavation free of water. This includes a layer (+/- 4" thick) of oversized rock (3" or larger) covered by a layer (+/- 2" thick) of crushed stone (CA-6 or CA-10) or a mud mat to allow work to proceed in the excavation without contamination by mud or water.
- 2.1.8 Pumped water must be free of contaminants and cannot be directed to a drainage ditch, sewer or storm water drain, or any surface body of water. Dispose of all pumped water in such a way that it does not cause excessive interference to other work or cause damage to the ground surface or property. Water from an excavation shall be land applied in such a manner as to ensure that it percolates into the ground and does not run off the site.

2.2 Preparation

- 2.2.1 Identify required lines, levels, contours, and datum.
- 2.2.2 Identify and mark all known above and below grade utilities.
- 2.2.3 For all excavations located outside of an existing substation fence, the 811 One-Call-System shall be contacted prior to excavation.
 - 2.2.3.1 For IL, the One-Call website is: <https://illinois1call.com/>.
 - 2.2.3.2 For MO, the One-Call website is: <https://www.mo1call.com/>.
- 2.2.4 Coordinate with utility companies to remove and/or relocate utilities when required. Contact Construction Supervisor and Project Engineer for guidance if any utility conflicts are discovered which are not addressed by the issued drawings.
- 2.2.5 Maintain and protect existing utilities (remaining) which pass through work area in accordance with section 2.1 of this specification.

2.3 Spoils Management

- 2.3.1 Excavated spoil materials, soil, gravel, concrete, or asphalt, must be managed on the Ameren property from which it was excavated or it must go to a permitted, Ameren-approved commercial landfill, unless an exception is approved by the Ameren Environmental Support & Waste Management group. If managed on-site, both the excavated spoils management area and the construction area must be included in the calculation to determine if a land disturbance permit is required.
- 2.3.2 Ameren, not the excavation contractor, shall determine the proper management of spoils excavated from Ameren projects.
- 2.3.3 All excavation sites are to be evaluated by the Ameren Environmental Support & Waste Management group to determine if any spoils will require special handling and disposal. This includes, but is not limited to, testing the soil and concrete for PCBs. Notification of an impending excavation project should be provided to the Ameren Environmental Support & Waste Management group in a timely manner so as to allow a sufficient review period. Prior to beginning any excavation, the Contractor shall contact the Construction Supervisor for the results of these evaluations and for any special handling or disposal requirements.

- 2.3.4 Any excavated spoils from an area not yet evaluated by Ameren Environmental Support & Waste Management must be stored on-site in an area approved by the Construction Supervisor. The excavated spoil material must be placed on and covered with plastic to prevent any potential cross contamination and minimize water contact. The Construction Supervisor will contact the Ameren Environmental Support & Waste Management group to evaluate the spoils.
 - 2.3.5 Hydro-excavated spoil materials which are to remain on-site will be stored in a location approved by the Construction Supervisor. The wet materials shall be maintained in a manner that prevents runoff until the material is dry. Once the material is dry the area will be graded and rocked or seeded to prevent runoff and erosion as approved by the Construction Supervisor
 - 2.3.6 Excavated spoils taken off-site must be dry to meet landfill requirements.
 - 2.3.7 For spoils designated by Ameren Environmental Support & Waste Management as requiring disposal at an Ameren designated disposal facility, excavation by a dry method is preferred. Hydro-excavated material must be solidified before transport to a commercial landfill using a method of solidification accepted by that landfill.
 - 2.3.8 Designated spoils must be transported by a licensed special waste hauler with completed manifest. The Ameren Environmental Support & Waste Management group may waive the licensed special waste and manifest requirements for materials that can be certified as non-special waste.
 - 2.3.9 Designated spoils that cannot be transported to the disposal facility within 24 hours of excavation must be covered during storage.
- 2.4 Excavation
- 2.4.1 Soft-dig techniques are non-mechanical excavation techniques such as air-knifing or hydro-excavation.
 - 2.4.2 Hand-dig and/or soft-dig techniques shall be utilized for at least the first four feet of depth for any excavation within the fence line of any existing Ameren substation.
 - 2.4.2.1 *With the Construction Supervisor's approval, any excavation required below the initial four foot depth may then be completed by conventional mechanical methods of excavation.*
 - 2.4.2.2 *With the Construction Supervisor's approval, when excavating a large area, it may be sufficient to soft-dig the perimeter of the area and along any obstacles crossing the area. The Construction Supervisor shall have final say on when and where this method is acceptable.*
 - 2.4.2.3 *Engineering should provide guidance in the construction documents on any known below grade obstructions or hazards.*
 - 2.4.2.4 *Any deviations from the original cost estimate or contract bid due to changing the chosen excavation techniques must be elevated per the AIC Quality Management Plan guidance.*
 - 2.4.3 Excavate subsoil required for foundations, structures, trenches, and/or other work.
 - 2.4.3.1 *Cut trenches sufficiently wide to enable installation of utilities and allow for inspection.*
 - 2.4.4 Hand trim excavation, where required, and leave free of loose matter.
 - 2.4.5 Remove lumped subsoil, roots, any other foreign material, boulders, and rock, as required, to obtain specified elevation and grade.

- 2.4.6 Excavated material shall be deposited a proper distance from the edge of all excavations per OSHA regulations. It is the responsibility of the Construction Crew to ensure that the excavation site meets OSHA safety standards.
 - 2.4.7 Contact the Construction Supervisor for guidance in the case of unauthorized excavations. This includes, but is not limited to, excavations in locations not marked on the construction plans and over-excavations. Correct unauthorized excavation at no cost to Owner.
 - 2.4.8 Contact the Construction Supervisor for guidance if soft, unsuitable, and/or unstable soil is discovered under structure or utility bearing surfaces.
 - 2.4.9 Contact the Construction Supervisor to determine acceptable locations and heights of all stockpiled excavated material.
 - 2.4.10 Contact Construction Supervisor for guidance concerning excess subsoil not to be reused. Do not remove any material from the substation prior to consulting the Construction Supervisor.
- 2.5 Field Quality Control
- 2.5.1 Contractor shall provide the opportunity for visual inspection of bearing surfaces as requested by Construction Supervisor and/or Civil Engineer.

3.0 Revisions

<u>Date</u>	<u>Description</u>
09-26-05	Initial Issue
09-03-13	Issued for Use
01-22-19	Updated formatting. Clarified existing wording. Added paragraphs addressing regulatory requirements, bulk excavation, and spoils management. Moved protection tasks and requirements from "1.0 General" to "2.0 Execution". Renamed standard from "General Requirements for Excavation" to "General Requirements for Excavation and Spoils Management".
12-20-19	During revision of Trenching Specification No. 02225, it was determined that having separate specifications for trenching and structural excavations was redundant. Minor revisions were made to this specification to allow trenching work to be covered herein.

SUBSTATION DESIGN

STANDARD NO. 02223

GENERAL REQUIREMENTS FOR BACKFILLING



Rev. No.	Date	Revisions	By	Approvals		
0	09-26-05	Initial Issue	DRR	DCB	JLH	PJN
1	09-30-13	Issued For Use	SES	JEL	DWW	
2	01-22-19	Major Revision	DJG	GLC	FF	DES
3	11-03-20	Minor Revision	GLC	GLC	FF	RKD

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1.0 General

1.1 Work Included

- 1.1.1 Structure backfilling
- 1.1.2 Compaction requirements

1.2 Related Work

- 1.2.1 Section 02211 – Grading
- 1.2.2 Section 02222 – Excavation and Spoils Management
- 1.2.3 16C – Grounding Installation

1.3 References

- 1.3.1 ANSI/ASTM D75 – Standard Practice for Sampling Aggregates.
- 1.3.2 ANSI /ASTM C136 - Sieve Analysis of Fine and Coarse Aggregates.
- 1.3.3 ANSI /ASTM D698 - Moisture-Density Relations of Soils and Soil-Aggregate Mixture Using 5.5 lb (2.49 kg) Hammer and 12 inch (305 mm) Drop.
- 1.3.4 ANSI /ASTM D1557 – Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2,700 kN-Nm/m³)
- 1.3.5 ANSI/ASTM D2487-11 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
- 1.3.6 ANSI /ASTM D6938-10 Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- 1.3.7 IDOT Standard Specification for Road and Bridge Construction
- 1.3.8 MoDOT Standard Specification for Highway Construction

1.4 Tests

- 1.4.1 Tests and analysis of fill materials will be performed in accordance with the above references. Unless specified otherwise, Ameren shall specify the Testing Company to be used. The Contractor shall be responsible for coordinating work with the Testing Company.

1.5 Samples

- 1.5.1 Contractor shall coordinate with Testing Company to ensure samples of each type of fill are obtained by Testing Company. Sample sizes shall be determined by the Testing Company.

2.0 Products

2.1 Select Fill Materials

2.1.1 Illinois

2.1.1.1 Illinois - IDOT CA6, Crushed Stone

<u>Sieve Size</u>	<u>Percent Passing</u>
1 ½ in.	100
1 in.	95 ± 5
½ in.	75 ± 15
No. 4	43 ± 13
No. 16	25 ± 15
No. 200	8 ± 4

2.1.1.2 Illinois – IDOT FA6, Sand

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 4	92 ± 8
No. 100	20 ± 20
No. 200	6 ± 6

2.1.1.3 Flowable Fill

With Civil Engineer's approval, flowable fill may be used. Flowable fill shall be in accordance with IDOT Standard Specification for Road and Bridge Construction (latest edition) section 1019, mix 2 for CLSM.

<u>Mix 2</u>	
Portland Cement	125 lb
Fine Aggregate – Saturated Surface Dry	2500 lb
Water	35 – 50 gal.
Air Content	15 – 25%

2.1.2 Missouri

2.1.2.1 Missouri - MoDOT Type 5 Aggregate

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
1/2 in.	60 – 90
No. 4	35-60
No. 10	10 – 35
No. 200	0 – 15

2.1.2.2 Missouri – MoDOT Gradation D

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
3/4 in.	85 - 100

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 in.	15 - 55
No. 4	0 - 10

2.1.2.3 *Missouri – MoDOT Grade 1*

<u>Sieve Size</u>	<u>Percent Passing</u>
3/8 in.	100
No. 4	95 - 100
No. 8	70 - 100
No. 16	45 - 90
No. 30	15 - 65
No. 50	5 - 30
No. 100	0 - 10

2.2 Common Fill Materials

- 2.2.1 The source location shall not be from any known environmental remediation site under any local, state, or federal agency. The source location shall be free of ash, cinders, glass, garbage, or industrial wastes.
- 2.2.2 Subsoil: Reused and/or imported subsoils shall be lean clay (preferred) or silty clay with the unified soil classification of CL as per ANSI/ASTM D2487; shall have a Liquid Limit (LL) less than 50 and a Plasticity Index (PI) less than 25; shall be free of gravel larger than 3 inch size, debris, vegetation, frost, and/or mulch.
- 2.2.3 Backfill material for ground grid or ground wire trenches shall be clean and compactable earth material only. Rock and/or sand are not acceptable as backfill material for ground grid or ground wire trenches. Backfill material shall be compacted by plate compactor or another approved mechanical means in lifts not exceed 6 inches. Reference Ameren Substation Design Standard 16C – General Requirements for Grounding Installation.
- 2.2.4 Backfill material for direct bury control or power cables shall be clean and compactable earth material only (rock or sand are not acceptable), unless alternative is approved by the Construction Supervisor and the Civil Engineer.
- 2.2.5 The source of all imported fill shall be identified and approved prior to commencement of filling operations. Fill materials must not have an unusual appearance or odor. Testing and approval of fill materials is required (by Ameren) prior to acceptance of the fill material and/or fill source unless stated otherwise.

3.0 Execution

3.1 Verifications Prior to Beginning Work

- 3.1.1 Verify stockpiled fill conforms to material specified for the intended use.
- 3.1.2 Verify piping and in-ground structures have been inspected.
- 3.1.3 Verify walls are braced to support surcharge forces imposed by backfilling operations.

3.1.4 Verify areas to be backfilled are free of debris, snow, ice, or water, and ground surfaces are not frozen.

3.2 Preparation

3.2.1 Fill material shall be compacted to 95% or greater and within $\pm 2\%$ of the optimum moisture content per ANSI/ ASTM D698.

3.2.2 When necessary, compact subgrade surfaces to density requirements for backfill material.

3.2.3 Cut out soft areas of subgrade not readily capable of in-situ compaction. Backfill with Engineer-approved subsoil materials and compact to density equal to requirements for subsequent backfill material.

3.3 Backfilling

3.3.1 Backfill areas to the specified contours and elevations. Make changes in grade gradual. Blend slopes into level areas.

3.3.2 Backfill systematically, as early as possible, to allow maximum time for natural settlement. Do not backfill over porous, wet, or spongy subgrade surfaces.

3.3.3 Maintain optimum moisture content of backfill materials to attain required compaction density. Use unfrozen materials.

3.3.4 Fill materials shall be placed in such a manner as not to disturb or damage the structures, piping, foundations, and/or utilities within or adjacent to the space being filled. Backfill simultaneously on each side of unsupported walls until supports are in place.

3.3.5 If using Select Fill Materials (per section 2.1):

3.3.5.1 *Place and compact Select granular fill materials in continuous layers not exceeding 6 inches loose depth. Granular fill materials shall be compacted by vibratory compaction equipment (preferred) and/or the use of water jetting.*

3.3.5.2 *Place Select flowable fill materials directly from the chute into the space to be filled. The Contractor may submit other placement methods for approval to the Construction Supervisor and the Civil Engineer.*

3.3.6 If using Common Fill Materials (per section 2.2):

3.3.6.1 *Place and compact Common Fill Materials in continuous layers not exceeding 8 inches loose depth.*

3.3.7 Exact locations of surplus backfill and stockpile areas shall be coordinated with the Ameren Construction Supervisor.

3.3.8 See Section 02222 – General Requirements for Excavation and Spoils Management for requirements for testing and disposal of excavated spoils.

3.4 Tolerances

3.4.1 Top Surface of Backfilling: Plus or minus one inch.

3.5 Field Quality Control

3.5.1 Compaction testing will be performed in accordance with ANSI/ASTM D698, and D6938-10.

3.5.2 Where deemed appropriate, Ameren will obtain the services of a commercial Testing Company to perform all testing.

- 3.5.3 The exact schedule of locations and testing will be determined on a project by project basis.
- 3.5.4 Any backfill not meeting the requirements of this section (as determined by testing) shall be removed or reworked and retested.
- 3.5.5 Fill material shall be compacted to 95% or greater and within $\pm 2\%$ of the optimum moisture content per ANSI/ ASTM D698.

4.0 Revisions

<u>Date</u>	<u>Description</u>
09-26-05	Initial Issue
09-30-13	Issue For Use
01-22-19	Updated formatting. Clarified testing coordination requirements and definitions for "Common Fill" and "Select Fill" terms. Included flowable fill to IL Select Fills.
11-05-20	Out-Of-Cycle Specification Update. Update Missouri Materials

SUBSTATION DESIGN

STANDARD NO. 02224

**SPECIFICATION FOR
SOIL STABILIZATION AND MODIFICATION**



Rev. No.	Date	Revisions	By	Approvals		
0	02-13-2020	Initial Issue	RGV	RGV	SM	-

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1.0 General

- 1.1 Soil modification is the process of mixing soil additives into the natural soil to provide adequate working surfaces for equipment and personnel for a temporary timeframe. Modification is intended to provide a suitable working platform to expedite construction.
- 1.2 Soil stabilization is the process of mixing soil additives into the natural soil to improve the engineering properties, such as density, water content, plasticity, shrink/swell potential, permeability and strength of the soil-additive mixture to minimum specified design values. Stabilization is intended to permanently improve the long-term engineering performance and structure of the soil.
- 1.3 When the above treatments are not practical, removal and replacement of the unsuitable soil and replacement with a select material shall be considered by Ameren, either a select soil or often granular backfill depending upon the time of year.
- 1.4 Related Work
 - 1.4.1 Section 02210 – Site Clearing
 - 1.4.2 Section 02211 – Grading
 - 1.4.3 Section 02222 – Excavation
 - 1.4.4 Section 02223 – Backfilling
- 1.5 References
 - 1.5.1 Federal Highway Administration, “Soil and Base Stabilization and Associated Drainage Considerations; Vol. I and II”, FHWA-SA-93-005, December 1992.
 - 1.5.2 Illinois DOT, “Standard Specifications for Road and Bridge Construction”, April 2016.
 - 1.5.3 Indiana DOT, “Design Procedures for Soil Modification or Stabilization”, January 2008.
 - 1.5.4 Iowa State University, “Fly Ash Soil Stabilization for Non-Uniform Subgrade Soils, Vol. I: Engineering Properties and Construction Guidelines”, April 2005.
 - 1.5.5 Iowa State University, “Soil Stabilization with Lime”, 1962.
 - 1.5.6 Missouri DOT “Missouri Standard Specification for Highway Construction”, 2018.
 - 1.5.7 National Lime Association, “Lime-Treated Soil Construction Manual: Lime Stabilization & Lime Modification”, January 2004.
 - 1.5.8 Pourbaix, Marcel, “Atlas of Electrochemical Equilibria in Aqueous Solutions”, 1974.
 - 1.5.9 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort, ASTM D698.
 - 1.5.10 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM D4318.
 - 1.5.11 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing, ASTM G51.
 - 1.5.12 Standard Test Method for Particle-Size Analysis of Soils, ASTM D422.

- 1.5.13 Standard Test Method for Unconfined Compressive Strength of Cohesive Soil, ASTM D2166/D2166M.
- 1.5.14 Transportation Research Board, "State of the Art Report: Reactions, Properties, Design and Construction", 1987.

1.6 Definitions

- 1.6.1 Owner's Representative: Person employed by Ameren or hired by Ameren, authorized to make construction decisions on behalf of Ameren. Project civil/structural engineer and Construction Supervisor both qualify as Owner's Representative.
- 1.6.2 Owner's Representative – Geotechnical Engineer: Geotechnical engineer, or a qualified NICET-certified technician working under supervision of a geotechnical engineer, specifically authorized to carry out the responsibilities of this specification. The Owner's Representative – Geotechnical Engineer shall have acceptable experience in the inspection of modified or stabilized soils.
- 1.6.3 Testing Agency: Person, firm, or corporation hired by Ameren to complete concrete tests as outlined in Contract Documents.

2.0 Soil Additives

2.1 Brief Additive Descriptions

- 2.1.1 Soil stabilization or modification additives may include lime, fly ash, Portland cement or limestone screenings. The additives may be used independently or in combination depending upon site conditions and project objectives. All will act as a waterproofing/drying agent, but the lime products will chemically alter the soil while fly ash & cement will cause a pozzolanic/self-cementing reaction. Numerous variables shall be considered when choosing the optimal additive, including:
 - 2.1.1.1 *Soil properties: plasticity, workability, shrink-swell potential, strength, etc.*
 - 2.1.1.2 *Purpose: temporary or permanent improvement*
 - 2.1.1.3 *Cost: generally lime is cheaper than fly ash or Portland cement,*
 - 2.1.1.4 *Availability: proximity of nearest product to project site, and;*
 - 2.1.1.5 *Construction season.*
- 2.1.2 Lime includes all classes of quicklime and hydrated lime, both calcitic and dolomitic, and non-hydrated lime kiln dust (aka Code-L).
 - 2.1.2.1 *Code-L is a commercial by-product of Mississippi Lime. If it is "fresh" then it will act like a weak lime. If it is from a stockpile that has been wetted, then it is non-reactive and is only adding a semi-dry bulk to the soil mass.*
- 2.1.3 Fly ash includes class "C" and "F" types. Dry or conditioned state fly ash may be used as a soil additive. Conditioned fly ash may need to be crushed to a reasonably fine state prior to mixing. Sluice pond fly ash should not be used as a soil additive.
- 2.1.4 Portland cement primarily consists of various amounts of calcium based compounds.

- 2.1.5 Limestone screenings are small limestone fragments remaining after limestone has been crushed and ran over a screener. Limestone screenings act as a bulking or drying agent and tend to have little to no chemical reaction with the natural soil.
- 2.1.6 Soil Cement is a manufactured mixture of soil and cement similar to a weak concrete and is beyond the scope of this specification.

2.2 Soil-Additive Sampling and Laboratory Testing

2.2.1 Representative samples of the natural soil requiring modification or stabilization shall be collected for laboratory testing to determine the optimal additive type(s).

2.2.1.1 *Minimum laboratory testing includes Atterberg Limits (ASTM D4318) and grain size analyses (ASTM D422).*

2.2.2 Applicable laboratory testing to determine soil additive quantities for soil modification or stabilization to meet project objectives shall be completed prior to construction. The contractor shall supply necessary soil and additive samples to the Testing Agency.

2.2.2.1 *For soil modification, determine the amount of additive(s) required to temporarily improve soil performance to expedite construction, as determined by the Owner's Representative - Geotechnical Engineer, through laboratory testing.*

2.2.2.2 *For soil stabilization, in addition to the minimum laboratory testing, Standard Proctor (ASTM D698) and unconfined compression testing (ASTM D2166/D2166M) on soil-additive mixture should be completed to determine additive quantities. Maximum dry unit weight and optimum moisture content of the soil-additive mixture will be provided following laboratory testing for field verification.*

2.2.2.3 *The pH of the soil-additive mixture should be determined for corrosion potential considerations for copper grounding grids (ASTM G51).*

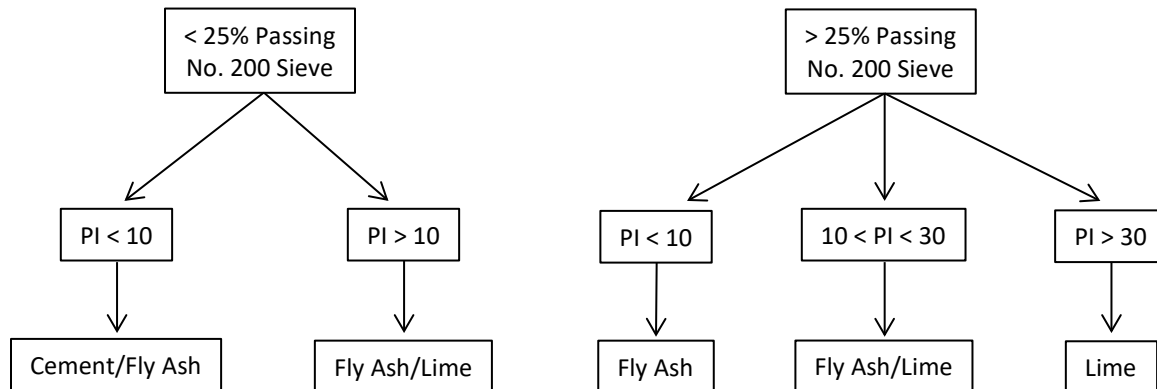
2.2.3 Sulphate and organic content levels should be determined to assess potential impact on soil-additive mixture.

2.2.3.1 *Sulphate heave potential testing may be required based on sulphate levels.*

2.2.3.2 *Organic content shall be less than 10% by weight.*

2.3 General Additive Selection

2.3.1 The natural soil gradation and plasticity are two of the primary factors used to select the optimal additive type to use for modification and stabilization. The time of year for application is also a factor in determining the additive(s). The diagram below provides general guidance for additive selection.



- 2.3.2 For lime additives the natural soil needs to have a clay content greater than 15% by weight.
 - 2.3.3 For fly ash and cement additives, a pozzolanic bond forms among the particles of silts, sands and gravels.
 - 2.3.4 For stabilization, the soil-additive mixture shall be covered within the same construction season. If uncovered, freeze/thaw cycles will negatively impact the treated soil's resistance to moisture absorption, reduce bearing capacity and alter the chemical structure.
 - 2.3.5 For stabilization of high plastic clay to reduce the swell/shrinkage potential, sufficient active lime must be added to temporarily increase the pH of the soil/lime mixture to 12 or more. This causes a permanent change in the swell/shrinkage properties of the clay.
 - 2.3.6 Soil modification performance is not as impacted by seasonal conditions due to the temporal objective of the soil-additive mixture. Modified soils should be covered with subsequent lift(s) to reduce potential performance loss.
- 2.4 General Additive Quantities and Application Depth
- 2.4.1 Per Section 2.2, the Owner's Representative - Geotechnical Engineer shall confirm the quantities to be applied. Numerous variables regarding the additive source and properties, and site soils will affect the quantity of additive(s) needed to meet project objectives. The table below provides general additive type quantities as a percent by weight.

Additive Type	General Percent by Weight
Lime	3-7%
Fresh Code-L	8-12%
Fly Ash	10-30%
Cement	2-11%

- 2.4.2 Higher quantities of additive(s) are generally necessary for soil stabilization compared to modification.
- 2.4.3 Additive depths, application methods and compaction means should be approved by the Geotechnical Engineer prior to construction. In no case shall the treated depth be less than 6 inches.
- 2.4.4 Additive overuse can have a negative impact on construction conditions and/or engineering properties of the soil-additive mixture.

3.0 General Construction Practices

- 3.1 Soil stabilization will not be permitted when the temperature of the soil, measured 6 inches below the surface, is below 50°F and the ambient air temperature is below 45°F. Additionally, these activities will not be permitted if forecasted temperatures within the next 3 days are below 45°F.
- 3.2 Per Ameren's request, the Owner's Representative – Geotechnical Engineer shall observe and/or verify through select laboratory and/or field testing procedures that soil modification or stabilization results are satisfactory based upon project goals or design engineering property standards.

- 3.3 Provide protective equipment, apparel, and barriers to protect the eyes, respiratory system, and the skin of workers exposed to contact with lime dust or slurry.
- 3.4 Caution shall be taken when mixing dry additives in urban areas or near residences/businesses, as these options present dust and environmental concerns. Removal and replacement or slurry application techniques should be considered in these areas.
- 3.5 Initial Soil Preparation and Additive Application
 - 3.5.1 All deleterious materials and vegetation such as stumps, roots and rocks greater than 3 inches should be removed when encountered during soil-additive conditioning.
 - 3.5.2 When site conditions permit, scarification and pulverization of natural soil will facilitate uniform application of additive(s).
 - 3.5.3 Soil moisture content may need to be adjusted to provide satisfactory pulverization. All water used shall be potable.
 - 3.5.4 For stabilization of the final lift, soil shall be shaped to the grades and elevations shown on the drawings prior to mixing.
 - 3.5.5 Soil additive(s) should be spread using methods and techniques to uniformly distribute the additive(s). Methods & techniques must be approved by Owner's Representative - Geotechnical Engineer.
 - 3.5.6 High plastic natural soils may require multiple applications of additives.
- 3.6 Mixing and Compaction
 - 3.6.1 Equipment with adequate mixing capabilities shall be utilized to uniformly distribute the soil additive(s) to sufficient soil layer thicknesses.
 - 3.6.1.1 *Disking and light compaction equipment are typically suitable for loose soil-additive layers or thicknesses generally less than 12 inches. These techniques are generally suitable for modification.*
 - 3.6.1.2 *Rotary mixing, a special soil-stabilization apparatus such as a CAT 250, and heavy compaction equipment are necessary for loose soil-additive layers or thicknesses generally 12 inches or greater. These techniques are generally necessary for stabilization.*
 - 3.6.2 Typically high plastic soil will require increased mixing effort.
 - 3.6.3 Soil-additive mixture material should be mixed until all the admixture is less than 1-inch in size prior to compaction.
 - 3.6.4 The application of the additive shall be limited to that amount which can be mixed with the soil within the same working day.
 - 3.6.5 Compaction should commence as soon as possible following mixing and watering. More compaction effort may be necessary, the more time passes following mixing. Compaction of soil-lime mixture should begin within the same construction day and soil-fly ash or -cement mixture should begin within 1 hour of mixing/watering.
 - 3.6.6 The compacted, stabilized soil-additive mixture shall have a minimum dry unit weight of 95% of the maximum dry unit weight and 2% above the optimum moisture content, according to Section 2.2. See Section 02223 – Backfilling.

3.6.6.1 *As a general rule for typical additive quantities, the expectation is for the dry unit weight to decrease 3-5 pcf, while the optimum moisture content will increase 2-4%. Further reductions in dry unit weight and increases in optimum moisture content can be expected the longer the soil-additive mixture cures.*

3.6.6.2 *In the absence of laboratory testing for stabilized soil-additive mixtures, a minimum unit weight of 95% of maximum natural soil dry unit weight should be used to verify compaction.*

3.7 Curing

3.7.1 Curing time will be dependent upon project goals. Soils modified may be ready for continued work within 24 hours following compaction. Soils stabilized will likely require additional curing time. Generally 48 hours or longer is necessary to allow sufficient curing of stabilized soil-additive mixture prior to loading.

3.7.2 Maintaining the optimum moisture content determined in Section 2.2 is beneficial during the curing process for stabilization. Maintain optimum moisture content by moist curing (potable water only) or by another method approved by Owner's Representative - Geotechnical Engineer. Keep surface damp by sprinkling and use of light rollers to keep surface knitted together.

3.7.3 Temperatures less than about 60° F will retard the curing process of the soil-additive mixture.

4.0 Additional Considerations

4.1.1 Construction team shall notify Substation Electrical Engineer about need for additional Resistivity Testing at locations of all modified/stabilized soils.

4.1.2 Calcium based additives will tend to increase the pH of the natural soil. Stabilized soil-additive mixtures will tend to have higher pH levels than modified soil-additive mixtures. A soil-additive pH level of above 12 will tend to increase the corrosion potential of copper.

SUBSTATION DESIGN
STANDARD NO. – 02371

General Requirements for
Cast-In-Place Concrete Piers



JOINT SUBSTATION STANDARD
AMEREN TRANSMISSION
AMEREN MISSOURI
AMEREN ILLINOIS

Rev. No	Date	Revisions	By	Approvals		
0	09/26/2005	Initial Issue	MJW	DCB	JLH	PJN
1	09/04/2012	Added ACI 336.1 reference and Special Inspector requirement	JAB/ SM	DCB	WJH	RQR
2	12/18/2018	Major Revision	JLF	SM	BLC	-
3	04/01/2019	Added Attachment 3	GAP	SM	BLC	-

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SECTION 02371

CAST-IN-PLACE CONCRETE PIERS

PART 1 GENERAL

1.01 This standard is applicable to cast-in-place concrete pier foundations constructed throughout the Ameren service territories.

1.02 All Work shall conform to all requirements of ACI 336.1 and ACI 336.3R except as modified by the Contract Documents or this standard.

1.03 RELATED WORK

- A. Section 02202 – General Requirements for Rock Removal
- B. Section 02222 – General Requirements for Excavation
- C. Section 03001 – General Requirements for Concrete
- D. Geotechnical Data: Soils Reports

1.04 REFERENCES

- A. References per Ameren Section 03001.
- B. References per ACI 336.1.
- C. ACI 336.3R-14 – Report on Design and Construction of Drilled Piers

1.05 DEFINITIONS

- A. Project Civil/Structural Engineer: Person employed by Ameren or hired by Ameren, responsible for the civil and structural design of the project, and authorized to make construction decisions on Ameren's behalf.
- B. Construction Supervisor: Person employed by Ameren or hired by Ameren, responsible for the construction oversight of the project, and authorized to make construction decisions on behalf of Ameren.
- C. Owner's Representative – Geotechnical Engineer: Geotechnical engineer, or a qualified technician working under supervision of a geotechnical engineer, specifically authorized to carry out the responsibilities of this

specification. Employed by Ameren or hired by Ameren, and reports to the Project Civil/Structural Engineer.

- D. Testing Agency: Person, firm, or corporation hired by Ameren to complete concrete tests as outlined in Contract Documents.

1.06

QUALITY ASSURANCE

- A. Owner's Representative – Geotechnical Engineer is authorized to stop construction practices not in compliance with Contract Documents. In the event a practice is stopped, contractor is responsible for proposing alternate construction procedure and shall obtain approval from Owner's Representative – Geotechnical Engineer and Project Civil/Structural Engineer prior to continuing work. Written documentation of practice stopped and approved alternate procedure shall be recorded through the RFI and NCR process as required in the contract documents.
- B. Complete all excavation or concrete work in the presence of the Owner's Representative – Geotechnical Engineer. Requirement for full time excavation inspection may be waived by Project Civil/Structural engineer. The full time presence of the Owner's Representative – Geotechnical Engineer is required during concrete placement.
- C. Concrete shall be tested by Testing Agency in accordance with Section 03001.
- D. Drilling contractor shall submit a pier drilling plan with the project bid documents including project specific construction methods such as the need for slurry holes, temporary casing and their depths, permanently installed corrugated metal pipe or other alternative construction methods for transmission line foundations and substation piers larger than 4' in diameter. Due to the fact that site geotechnical information is not always available prior to bidding, a preliminary drilling plan is acceptable with the bid documents, given that a complete drilling plan is submitted at least 2 weeks prior to construction.

1.07

SUBMITTALS BY CONTRACTOR

- A. Submittals per Section 03001.
- B. Contractor and Owner's Representative – Geotechnical Engineer shall each complete the Cast-in-Place Concrete Pier Record, Attachment 1 (or approved equal pour report), included in this document and submit

electronically within 7 days of pier completion to the Project Civil/Structural engineer, Construction Supervisor and/or Project Manager. Each pier constructed should be documented. Reporting requirements for substation piers may be waived by Project Civil/Structural engineer.

- C. Pier reinforcement splices are not permitted unless explicitly approved by the Project Civil/Structural engineer and documented through the contract RFI process. Reinforcement splice location shall not vary from approved location.
- D. Owner's Representative – Geotechnical Engineer shall complete concrete placement curves of theoretical and actual volume of concrete placed versus depth for piers constructed using wet concreting methods and cased holes. Curves shall be submitted electronically within 7 days of pier completion or upon request to the Project Civil/Structural Engineer, Construction Supervisor and/or Project Manager. Concrete Placement Curves template is included as Attachment 2, or an alternative template can be submitted for approval to Project Civil/Structural Engineer.
- E. Contractor shall submit concrete placement curves upon request of Project Civil/Structural Engineer.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Concrete Materials and Mix: Specified in Section 03001
- B. Reinforcing: Specified in Section 03001.
- C. Other Concrete Related Materials: Specified in Section 03001.
- D. Slurry: As specified in ACI 336.3R, or per Engineer's approval.

PART 3 EXECUTION

3.01 PREPARATION

- A. See Contract Documents for the pier design depth and required bearing materials.
- B. See Specification 03001 for cold and hot weather concrete requirements.

- C. Provide and install casing where required. If permanent casing is not shown on Project Drawings, approval to use permanent casing or corrugated metal pipe must be explicitly given by Project Civil/Structural Engineer and documented through the contract RFI process.

3.02

TOLERANCES

- A. For substation piers, top concrete elevation of pier shall be within $\frac{1}{2}$ " of top of concrete elevation as noted on Project Drawings. Drilled piers shall have a smooth outer surface for a minimum depth of 1.5' below finished subgrade and shall have roundness tolerance not to exceed $\frac{1}{2}$ " in any direction.

For transmission line piers, top of concrete elevation of pier shall be within 0.1' of top of concrete elevation as noted on Project Drawings. Contractor shall notify Owner's Representative if there is a discrepancy between top of concrete and pier projection, as called out on the Project Drawings.

- B. For substation piers, anchor bolt horizontal placement deviation shall not be more than $\pm \frac{1}{4}$ " nor vertical placement deviation more than $\pm \frac{1}{2}$ " from location specified on Project Drawings.

For transmission line piers, anchor bolt horizontal and vertical placement deviation shall not be more than $\pm \frac{1}{2}$ " from location specified on Project Drawings.

- C. Anchor bolts shall be plumb.
- D. If a rock socket is identified in the foundation drawings, the length of the rock socket shall be met. If rock is encountered at a different elevation ($\pm 1'$) than noted in the geotechnical report, then the Project Civil/Structural Engineer shall be contacted to give further direction.

PART 4 DELIVERABLES

Responsible Party	Deliverables	Submitted To	Time Frame
Contractor	Drilling Plan	Project Civil/Structural Engineer	Included with bid documents
	Cast-in-place concrete pier record		Within 7 days after pier completion
Owner's Representative – Geotechnical Engineer	Cast-in-place concrete pier record	Project Civil/Structural Engineer	Within 7 days after pier completion
	Concrete placement curve		Within 7 days after pier completion
	Final Inspection Report		At project completion

PART 5 REVISION SUMMARY

<u>Date</u>	<u>Description</u>
09/26/2005	Initial Issue
09/04/2012	Added ACI 336.1 reference and Special Inspector requirement.
11/14/2018	Major revision, addition of ACI 336.3R reference, addition of deliverables section. Removed content available in specification 03001 Concrete, revised concrete and anchor bolt tolerances.
04/01/2019	Clarified Drilling Plan submittal requirements, reformatted Attachment 1 heading and Attachment 2, Added Attachment 3 – "Construction Quality Assurance Checklist for Drilled Pier Construction"

**ATTACHMENT 1
CAST-IN-PLACE CONCRETE PIER RECORD**

This form to be completed and submitted by BOTH the Contractor and the Owner's Representative – Geotechnical Engineer or Testing Agency, depending on division of responsibility for the particular project (hereafter referred to as "CQA Contractor").

Project: _____
 Structure/Foundation Number: _____
 Civil Contractor: _____
 CQA Contractor: _____
 CQA Contractor Inspector: _____
 Date: _____

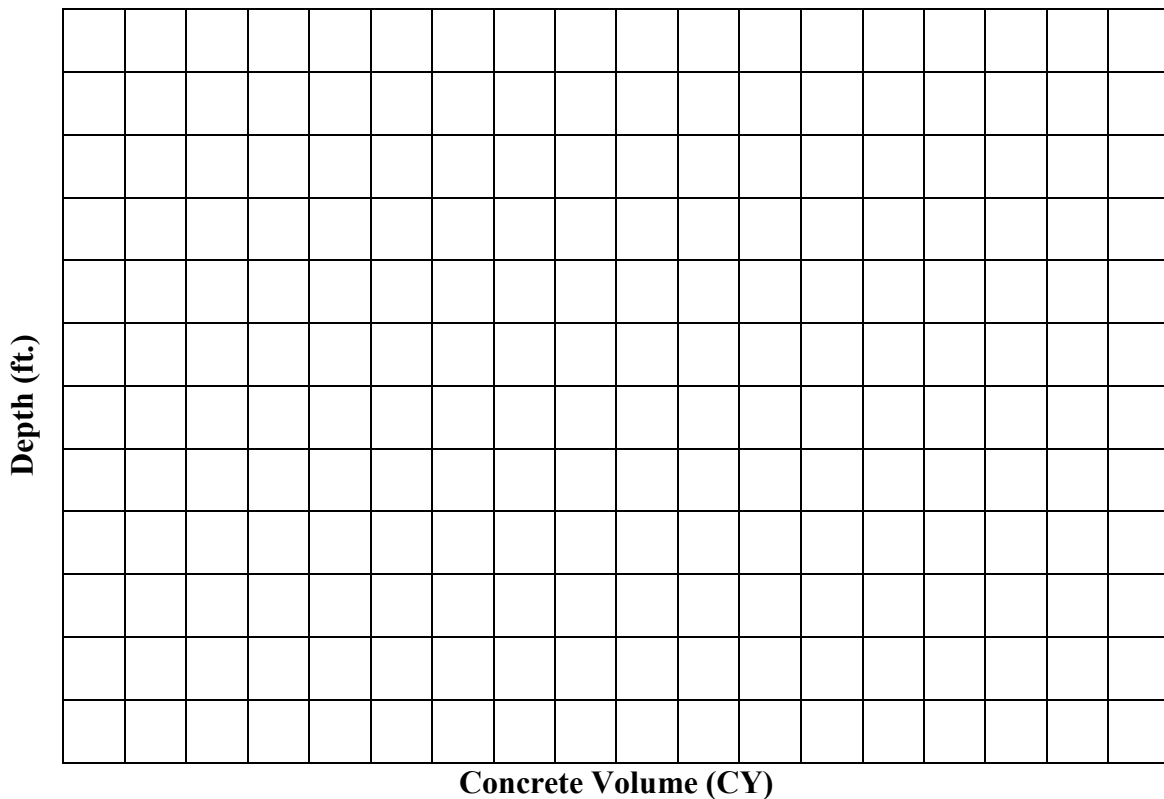
Foundation Number	Date Drilled/Date Poured	Shear Key Installed (Y or N) If Y, Elev.	Batch Ticket #	Concrete Batch Plant Identifier	Design Pier Dia./ Constr. Pier Dia. *	Theoretical Concrete Volume (Yd³)	Actual Concrete Volume (Yd³)**	Length Drilled Soil (Ft)	Length Drilled Rock (Ft)	Cuttings Match Soils Boring Log (Y or N) ***	Anchor Bolt Diameter, Length, Spacing & Orientation Confirmed w/ plans (Y or N)	TOC Elev.	Earth Grade Elev.	Total Pier Length (Ft)	Casing Temp. Perm. (LF)	Reinforcing			Field Added Admixtures – Type & Qty.	Method of Construction (wet/dry, dewatering req'd, slurry type, etc.)	Owner's Representative – Geotechnical Engineer Approval (Initials)		
																Vertical # @ _	Splice Installed (Y or N) If Y, Elev.	Ties # @ _					
																		T1				T2	T3

*If more than (1) diameter used, Contractor to submit sketch
 ** Required only for piers constructed using the slurry method and cased holes.
 *** If N, note differences: _____

ATTACHMENT 2
CONCRETE PLACEMENT CURVES

This form to be submitted by the Owner's Representative – Geotechnical Engineer or Testing Agency, depending on division of responsibility for the particular project (hereafter referred to as "CQA Contractor").

Project: _____
Structure/Foundation Number: _____
Civil Contractor: _____
CQA Contractor: _____
CQA Contractor Inspector: _____
Date: _____



Instructions for Use:

1. Plot both the theoretical concrete volume vs. pier depth and actual concrete volume vs. pier depth on the graph above.
2. Plot volume at elevation intervals not exceeding the shaft diameter.
3. It is permissible for the Contractor/CQA Contractor to submit this graph on a different form, given that all required information is shown on the form.

ATTACHMENT 3

CONSTRUCTION QUALITY ASSURANCE CHECKLIST FOR DRILLED PIER CONSTRUCTION

All items below are to be performed by the Owner's Representative – Geotechnical Engineer or Testing Agency, depending on division of responsibility for the particular project (hereafter referred to as "CQA Contractor"). This is a list of minimum requirements and is not meant to be comprehensive. Verification of these items does not release the Contractor from the responsibility of constructing per the project plans and specifications.

Project: _____
Structure/Foundation Number: _____
Civil Contractor: _____
CQA Contractor: _____
CQA Contractor Inspector: _____
Date: _____

1. Drilled Pier Excavation

- Check that the excavation reasonably matches the soils types and depths from the associated geotechnical report.
- Record the diameter and depth of the drilled pier excavation vs. the specified diameter and depth from the construction drawings. (Note that contractors sometimes over-excavate in order to set casing.)
- Record type of excavation technique used by contractor (standard/dry, temporary casing, permanent casing, slurry method, rock coring, etc.).
- Record the diameter, length, and wall thickness of each steel casing used.
- Record any sloughing or groundwater infiltration (including approximate location and rate of infiltration) into the pier excavation and the Contractor's actions to address. Record any potential contamination of concrete by soil/groundwater infiltration.
- If necessary to backfill and re-excavate a drilled pier excavation (after approval by Ameren Construction Supervisor **AND** Ameren Civil Engineer), record the method of backfill used by the Contractor. Included photos of backfill method and material in report. (NOTE: If flowable fill is used as a backfill material, it may be necessary to obtain cylinders for strength testing – verify with Ameren Civil Engineer prior to flowable fill placement.)
- Include written (typed) summary of excavation series of events in report.
- Include a sketch of the drilled pier excavation (side profile) in report.
- Include several photos of drilled pier excavation in report.
- If permanent steel casing installed, verify that backfill material properly placed in void around outside of casing.
- Contractor **AND** CQA Contractor to complete Attachment 1 – Cast-in-Place Concrete Pier Record and submit to Ameren Civil Engineer.

2. Drilled Pier Reinforcement

- Check that the reinforcing cage matches the construction drawings and/or approved shop drawings. Record the length, size, spacing, and alignment of vertical bars and ties (include photos in report). If splices are used, check that the splice locations match those on the approved shop drawings.
- If measured away from the pier location, check that the correct reinforcing cage is used for the pier being constructed.
- Check that the reinforcing cage is centrally placed in the pier excavation and that the specified concrete cover over the reinforcing steel is achieved (include photos of reinforcing cage placement in report). Record the type of spacers used by the Contractor to maintain concrete cover (include photos of spacers in report).

3. Drilled Pier Anchor Bolts

- Check that the anchor bolt cage matches the construction drawings. Note the diameter, length, spacing (center-to-center), and thread lengths of bolts. Also note the length, width, and thickness of both the top and bottom templates.
- Verify that the stamped structure number on the anchor bolt cage (usually on the top template) matches the structure/foundation number of the pier being constructed. This check should be performed immediately prior to anchor bolt placement in the pier excavation.
- Verify that orientation notches match those shown on anchor bolt drawing (if applicable).
- Include photos of anchor bolt cage in report.

4. Drilled Pier Concrete

- Collect concrete batch tickets and include copies in the report. Verify that the slump, percent air, temperature, and any admixtures match the approved concrete mix design.
- Verify that the Testing Agency is relaying on-site concrete quality test results of each load of concrete immediately to both the Contractor and Ameren Construction Supervisor.
- If free-fall concrete placement is used, verify that the concrete does not impact the reinforcing cage.
- Record type of concrete placement used by Contractor and include in report.
- Verify that the pier is poured as a single monolithic structure. If a construction joint is requested by the Contractor, approval from the Ameren Construction Supervisor **AND** Ameren Civil Engineer must first be obtained. If a construction joint is approved, verify that the dimensions are in accordance with construction drawings. (Include photos of construction joint in report.)
- If concrete is placed during cold/hot weather conditions (as defined in Ameren Standard 03001), assure that the Contractor is following the cold/hot weather concreting plan. Record what protection measures are taken by Contractor. (Include photos of protection measures taken by Contractor in report.)
- Verify that concrete is vibrated from 3'-0" below the bottom of the anchor bolt cage to TOC.
- Check that surface finishing is a light broom finish, the top of the pier will not hold water, and has a ¾" bevel/radius around the edge. (Include photos of finished top of pier in report.)
- Include written (typed) summary of concrete placement series of events in report.
- CQA Contractor to complete Attachment 2 – Concrete Placement Curves and submit to Ameren Civil Engineer.

- Verify that all drilling slurry has been removed from the pier at the conclusion of concrete placement.

5. Drilled Pier Form

- Verify that pier is formed to the specified depth shown on construction drawings or in construction specification.
- Record the diameter and length of the above-ground form. (Include photos of form in report.) Note that the construction drawings and/or specification may allow oversized pier projections – verify for each project.

6. Anchor Bolt Placement

- Verify that the Contractor is using string lines, levels, and other survey equipment to properly orient the anchor bolt cage, both vertically and horizontally.
- Record method of anchor bolt placement (cast-in, "wet-set", etc.). (Include photos of anchor bolt placement in report.)
- Check plumbness of anchor bolts prior to concrete placement.
- Verify that the Contractor is placing concrete to the specified TOC elevation. Record final TOC elevation and include in report.
- Verify that the anchor bolt projection above TOC matches the construction drawings. Record projection and include in report.
- Verify that anchor bolt projections are clean and free of mud, concrete, etc.
- For control enclosure piers with embedded plates, verify that plates are placed flush with TOC. (Include photos of embedded plates in report.)

Note: The responsibilities and authority of Inspecting Field Personnel include neither the responsibilities nor the authority of the "Competent Person" for the Project Site as defined by OSHA Regulations: 29 CFR1926 Subpart P.

SUBSTATION DESIGN

STANDARD NO. 02508

GENERAL REQUIREMENTS FOR CRUSHED STONE SURFACING



Rev. No.	Date	Revisions	By	Approvals		
0	12/15/10	Initial Issue	DRR	DCB	WJH	KDA
1	03/01/11	Changed Rock Type	DRR	DCB	WJH	RQR
2	11/14/17	Major Revision	JHL	GLC	FF	DES
3	11/03/20	Minor Revision	GLC	GLC	FF	RKD
4	11/05/21	Minor Revision	JHL	GLC	FF	REW

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1.0 General

1.1 Work Included

1.1.1 Yards located in Missouri; 3 inch thick bottom layer of Commercial 3 or 2-inch Clean Limestone covered with 3 inches of MoDOT Gradation D Limestone.

1.1.2 Yards located in Illinois; 3 inch thick bottom layer of IDOT CA3 covered with 3 inches of IDOT CA11.

1.2 Related Work

1.2.1 Section 02211 – Grading

1.2.2 Section 02223 - Backfilling

1.3 References

1.3.1 ASTM C136 – Sieve Analysis of Fine and Coarse Aggregates

1.3.2 Missouri Standard Specifications for Highway Construction

1.3.3 IDOT Standard Specifications for Road and Bridge Construction

1.3.4 American Association of State Highway and Transportation Officials T27

1.4 Tests

1.4.1 Gradation of stone material will be performed in accordance with ASTM C136.

1.4.2 Gradations of stone material will be performed in accordance with AASHTO No. T27.

2.0 Products

2.1 Materials

2.1.1 Illinois - IDOT CA11, Crushed Stone

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
¾ in.	92 ± 8
½ in.	45 ± 15
No. 4	6 ± 6
No. 16	3 ± 3

2.1.2 Illinois – IDOT CA3, Crushed Stone

<u>Sieve Size</u>	<u>Percent Passing</u>
2 ½ in.	100
2 in.	93 ± 7
1 ½ in.	55 ± 20
1 in.	8 ± 8
½ in.	3 ± 3

2.1.3 Missouri - MoDOT Gradation D, Limestone

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
¾ in.	85 – 100

3/8 in.	15 – 55
No. 4	0 – 10

2.1.4 Missouri - Commercial 3 or 2-inch Clean Limestone meeting the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing</u>
3 in.	100
2 ½ in.	90 – 100
1 ½ in.	25 – 70
¾ in.	0 – 10
½ in.	0 – 5

3.0 Execution

3.1 Inspection

3.1.1 Verify compacted subgrade is dry and ready to receive the work of this Section. Remove and replace or repair all soft or unstable areas to the satisfaction of the Construction Supervisor.

3.1.2 Verify gradients and elevations of sub-base are correct.

3.1.3 Beginning of installation means acceptance of existing conditions.

3.2 Preparation

3.2.1 After completion of foundations, grounding, conduits, fencing and road work, clean up yard area.

3.2.2 Complete all grading and compaction of yard area.

3.3 Surfacing

3.3.1 Spread yard rock uniformly in areas shown on the plans. The rolled thickness shall be as shown on the plans; compaction testing shall not be required for Yard Surfacing. However, two passes on each layer with a steel wheel, static smooth drum roller is required to interlock the aggregate. Vibratory rolling is not required.

3.3.2 Where access restraints do not permit the use of the rolling equipment specified above, roll to levels specified above using appropriately sized mechanical rolling equipment.

3.4 Tolerances

3.4.1 Top surface of yard rock: The finished surface shall not vary from the lines, grades and cross sections shown on the plans by more than 1 inch.

3.4.2 Thickness of each rock layer: The thickness of each layer shall not deviate by more than 1 inch from the cross sections shown on the plans.

3.4.3 Thickness determinations will be made at such points as the Engineer or Construction Supervisor may select. When the constructed thickness is less than 90 percent of the thickness shown on the plans, aggregate shall be added to obtain the required thickness.

4.0 Cross Section Examples

4.1 Yard rock used in Missouri Substations

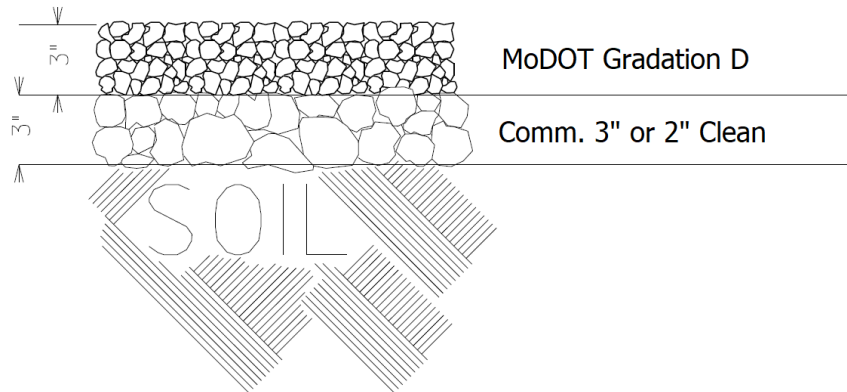


Figure 1 – Yard Rock Cross Section (Missouri Substations)

4.2 Yard rock used in Illinois Substations

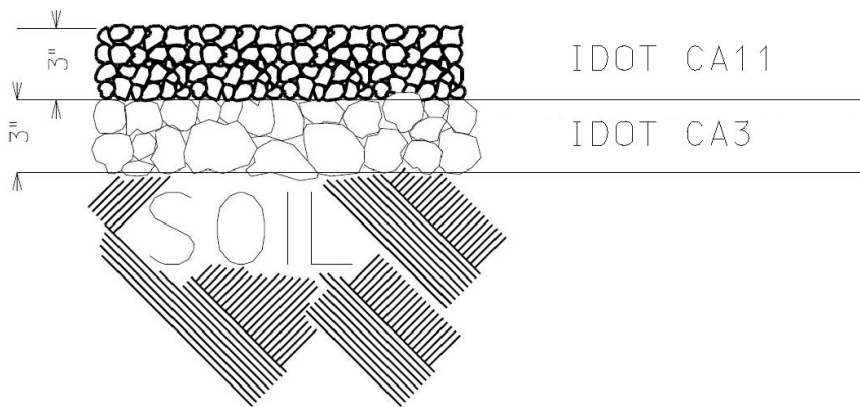


Figure 2 – Yard Rock Cross Section (Illinois Substations)

5.0 Revisions

<u>Date</u>	<u>Description</u>
12-15-10	Initial Issue
3-1-11	Changed Rock Type
11-14-17	Updated Formatting, Changed IL Base Rock to IDOT CA3, Added Tolerances in Section 3.3.1
11-05-20	Out-Of-Cycle Specification Update. Update Missouri Materials
11-05-21	Out-Of-Cycle Specification Update. Update rolling requirements.

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SUBSTATION DESIGN

STANDARD NO. 02511

GENERAL REQUIREMENTS FOR CRUSHED STONE PAVING



Rev. No.	Date	Revisions	By	Approvals		
0	9/26/05	Initial Issue	RO	DCB	JLH	PJN
1	2/7/11	Major Revision	DRR	DCB	WJH	RQR
2	11/14/17	Major Revision	JHL	GLC	FF	DES
3	11/03/20	Minor Revision	GLC	GLC	FF	RKD
4	11/05/21	Minor Revision	JHL	GLC	FF	REW

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1.0 General

1.1 Work Included

- 1.1.1 Roadways and drives located in Missouri; 3 inch thick layer of Commercial 3 or 2-inch Clean Limestone covered with 3 inches of MoDOT Type 1 or MoDOT Type 5 limestone.
- 1.1.2 Roadways and drives located in Illinois; 3 inch thick layer of IDOT CA3 covered with 3 inches of IDOT CA6.

1.2 Related Work

- 1.2.1 Section 02211 - Grading
- 1.2.2 Section 02223 - Backfilling

1.3 References

- 1.3.1 ASTM C136 – Sieve Analysis of Fine and Coarse Aggregates
- 1.3.2 Missouri Standard Specifications for Highway Construction
- 1.3.3 IDOT Standard Specifications for Road and Bridge Construction
- 1.3.4 American Association of State Highway and Transportation Officials T27

1.4 Tests

- 1.4.1 Gradation of stone material will be performed in accordance with ASTM C136.
- 1.4.2 Gradation of stone material will be performed in accordance with AASHTO No. T27.

2.0 Products

2.1 Materials

2.1.1 Illinois - IDOT CA6, Crushed Stone

<u>Sieve Size</u>	<u>Percent Passing</u>
1 ½ in.	100
1 in.	95 ± 5
½ in.	75 ± 15
No. 4	43 ± 13
No. 16	25 ± 15
No. 200	8 ± 4

2.1.2 Illinois – IDOT CA3, Crushed Stone

<u>Sieve Size</u>	<u>Percent Passing</u>
2 ½ in.	100
2 in.	93 ± 7
1 ½ in.	55 ± 20
1 in.	8 ± 8
½ in.	3 ± 3

2.1.3 Missouri - MoDOT Type 1, Limestone

<u>Sieve Size</u>	<u>Percent Passing</u>
-------------------	------------------------

1 in.	100
1/2 in.	60 – 90
No. 4	35 – 60
No. 30	10 – 35

2.1.4 Missouri – MoDOT Type 5, Crushed Stone

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
1/2 in.	60 – 90
No. 4	35 – 60
No. 30	10 – 35
No. 200	0 – 15

2.1.5 Missouri - Commercial 3 or 2-inch Clean, Limestone meeting the following gradation requirements.

<u>Sieve Size</u>	<u>Percent Passing</u>
3 in.	100
2 1/2 in.	90 – 100
1 1/2 in.	25 – 70
3/4 in.	0 – 10
1/2 in.	0 – 5

2.1.6 Water: Clean and free of injurious amounts of oil, acid, alkali, salt, organic matter, vegetable matter, or other deleterious substances.

3.0 Execution

3.1 Inspection

- 3.1.1 Verify compacted subgrade is dry and ready to receive the work of this Section. Remove and replace or repair all soft or unstable areas to the satisfaction of the Construction Supervisor.
- 3.1.2 Verify gradients and elevations of sub-base are correct.
- 3.1.3 Beginning of installation means acceptance of existing conditions.

3.2 Placing Bottom Layer of Rock

- 3.2.1 Spread bottom layer of stone evenly over area to be paved; rolled thickness shall be 3 inches unless shown otherwise on the plans.
- 3.2.2 Rolling shall be performed utilizing a self-propelled steel wheel, static smooth drum roller. Steel wheel rollers shall weigh between 6 to 10 tons. Vibratory rolling is not required. Do not spread bottom layer of stone for more than one day's work ahead of the top layer of rock. Construction Supervisor or Civil Engineer can approve alternate rolling equipment.
- 3.2.3 Begin rolling at edges and progress gradually toward the center. Uniformly overlap each preceding track and thoroughly cover the entire surface. Do not roll/push the bottom layer into the subgrade (soil). Ensure the edges of the paved area are well aligned.

- 3.2.4 Check the stone for humps, hollows, or other irregularities. Loosen defective areas, remove surplus or add new material as required, re-roll, and treat as necessary to completely eliminate the defects.
- 3.2.5 Where access restraints do not permit the use of the rolling equipment specified above, roll to levels specified above using appropriately sized mechanical rolling equipment.
- 3.3 Placing Top Layer of Rock
 - 3.3.1 Spread the top layer of stone directly from trucks equipped with hydraulic hoists and adjustable tailgates, or with mechanical spreaders, or with spreader boxes to achieve a compacted thickness of 3 inches unless otherwise shown on the plans. If a mechanical spreader is not used, blade the material a sufficient number of times to form the required gradation. Spread stone to a uniform distribution of sizes throughout, remove any segregated areas, and replace with suitable materials.
 - 3.3.2 Rolling shall be performed utilizing a self-propelled steel wheel, vibratory smooth drum roller. Steel wheel rollers shall weigh between 6 to 10 tons, and shall provide a smooth operation when starting, stopping or reversing directions. The vibrating drum(s) amplitude and frequency shall be approximately the same in each direction.
 - 3.3.3 Begin rolling at edges and progress gradually toward the center. Uniformly overlap each preceding track and thoroughly cover the entire surface. A minimum of FOUR (4) complete passes with the roller is required in all areas accessible by the roller.
 - 3.3.4 Check the stone for humps, hollows, or other irregularities. Loosen defective areas, remove surplus or add new material as required, re-roll, and treat as necessary to completely eliminate the defects.
 - 3.3.5 Where access restraints do not permit the use of the rolling equipment specified above, roll to levels specified above using appropriately sized mechanical rolling/vibrating-plate equipment.
- 3.4 Coordination
 - 3.4.1 No paving work shall be done or paving materials placed until all excavation and backfill for all utilities and storm water drainage (under the roads and/or drives) is installed, inspected, and has been allowed to settle.
- 3.5 Tolerances
 - 3.5.1 Top surface of drive rock: The finished surface shall not vary from the lines, grades and cross sections shown on the plans by more than 1 inch.
 - 3.5.2 Thickness of each rock layer: The thickness of each layer shall not deviate by more than 1 inch from the cross sections shown on the plans.
 - 3.5.3 Thickness determinations will be made at such points as the Engineer or Construction Supervisor may select. When the constructed thickness is less than 90 percent of the thickness shown on the plans, aggregate shall be added to obtain the required thickness.

4.0 Basis of Measurement/Field Quality Control

4.1 Quantities

4.1.1 Before starting the paving work associated with each area of paving, the Contractor shall verify with the Construction Supervisor the total number of square yards of paving.

4.1.2 During the course of the paving operations, supply the Construction Supervisor with bonded load tickets for all materials supplied to and installed for each material type, quantity, and source.

5.0 Cross Section Examples

5.1 Roadway and drive rock used in Missouri Substations

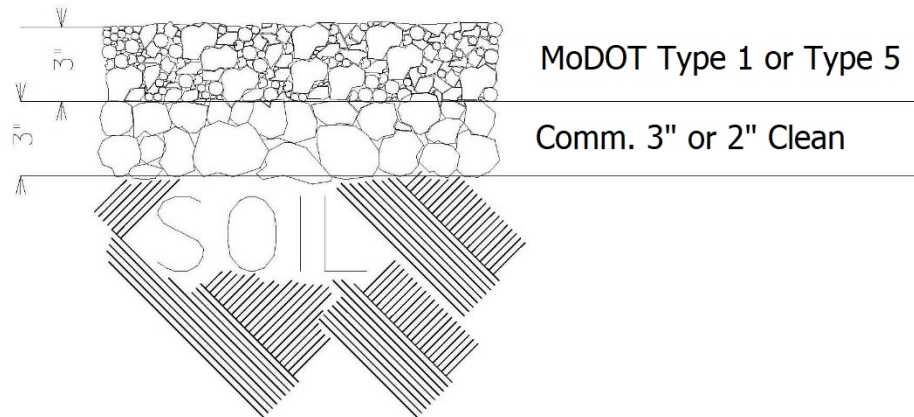


Figure 1 – Roadway and Drive Rock Cross Section (Missouri Substations)

5.2 Roadway and drive rock used in Illinois Substations

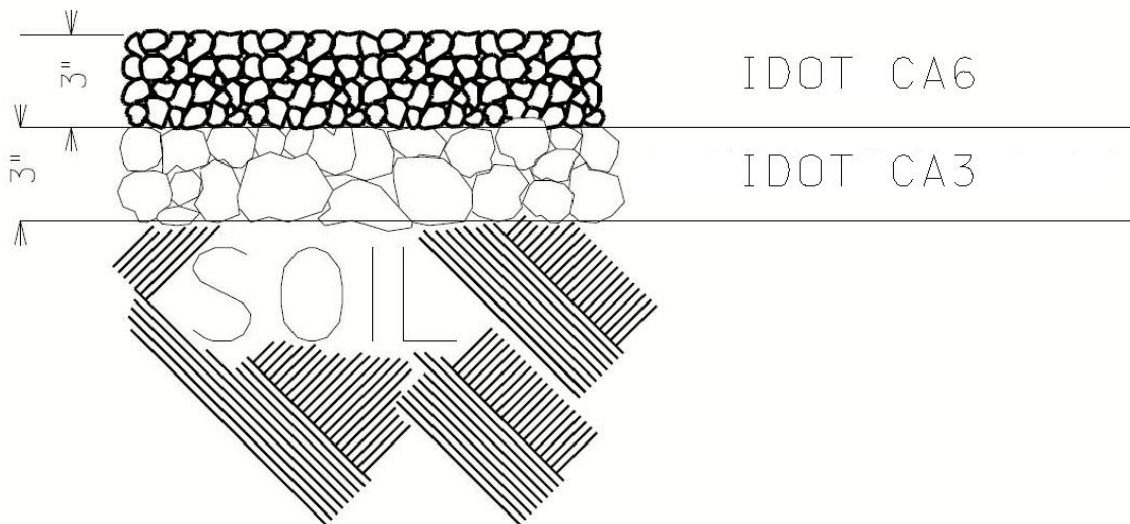


Figure 2 – Roadway and Drive Rock Cross Section (Illinois Substations)

6.0 Revisions

<u>Date</u>	<u>Description</u>
9/26/05	Initial Issue
2/7/11	Major Revision
11/14/17	Updated Formatting, Changed IL Base Rock to IDOT CA3
11/03/20	Out-Of-Cycle Specification Update. Update Missouri Materials
11/05/21	Out-Of-Cycle Specification Update. Update rolling requirements.

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SUBSTATION DESIGN

STANDARD NO. – 02513

General Requirements for Asphaltic Concrete Paving



JOINT SUBSTATION STANDARD AMEREN TRANSMISSION AMEREN MISSOURI AMEREN ILLINOIS

Rev. No	Date	Revisions	By	Approvals		
0	9-26-05	Original Issue	BLC	DCB	JLH	PJN
1	7-9-13	Rev 1 - Reissue	GAP	JEL	DWW	
2	10-03-19	Rev 2 - Issue for Use	GLC	JLF	MKF	

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SECTION 02513

ASPHALTIC CONCRETE PAVING

1.0 GENERAL

1.01 WORK INCLUDED

- A. Crushed stone base and base priming.
- B. Asphaltic concrete paving.
- C. Surface sealer.

1.02 RELATED WORK

- A. Section 02211 – Grading
- B. Section 02508 – Crushed Stone Surfacing
- C. Section 02511 – Crushed Stone Paving

1.03 REFERENCES

All publications below that do not have a year referenced shall be assumed to be the most current edition in publication.

- A. AASHTO T99 – Standard Method of Test for Moisture
- B. AASHTP T209 - Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA)
- C. AASHTO T 224 - Standard Method of Test for Correction for Coarse Particles in the Soil Compaction Test
- D. AASHTO M288 – Standard Specification for Geotextile Specification for Highway Applications
- E. AASHTO M 320 – Standard Specification for Performance-Graded Asphalt
- F. ASTM D977 – Standard Specification for Emulsified Asphalt
- G. ASTM D2027 – Standard Specification for Cutback Asphalt (Medium-Curing Type)
- H. ASTM D2397 – Standard Specification for Cationic Emulsified Asphalt

- I. Missouri Highways and Transportation Commission (MHTC) - Standard Specification for Highway Construction.
- J. Illinois Department of Transportation (IDOT) – Standard Specifications for Road and Bridge Construction

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated. Include technical data, tested physical and performance properties, and material certifications.
 - a. Geotextile Fabric (if applicable)
 - b. Aggregate Base Course
 - c. Prime Coat
 - d. Tack Coat
- B. Job-Mix Designs: For each job mix proposed for the Work and shall include the following:
 - a. All possible sources intended for use, and grade and specific gravity of asphalt binder.
 - b. Source, type (formation, etc.), ledge number(s) if applicable, gradation, and percent chert of each aggregate fraction.
 - c. Plasticity index of each aggregate fraction which has 10 percent or more passing the No. 30 sieve.
 - d. Bulk and apparent specific gravities and absorption of each aggregate fraction in accordance with AASHTO T85 for coarse aggregate and AASHTO T84 for fine aggregate, including all raw data, or in accordance with TM 81.
 - e. Specific gravity of hydrated lime, mineral filler or baghouse fines, if used, in accordance with AASHTO T100.
 - f. Percentage of each aggregate component.
 - g. Combined gradation of the job mix.
 - h. Percent of asphalt binder, by weight, based on the total mixture.
 - i. Bulk specific gravity (Gmb) by AASHTO T166, Method A of a laboratory compacted mixture
 - j. (j) Percent air voids (Va) of the laboratory compacted specimen.

- k. Voids in the mineral aggregate (VMA) and voids in the mineral aggregate filled with asphalt binder (VFA).
 - l. Theoretical maximum specific gravity (Gmm) as determined by AASHTO T209 in accordance with Sec 403.19.3 after the sample has been short-term aged in accordance with AASHTO R30.
 - m. Mixing temperature and molding temperature.
 - n. Bulk specific gravity (Gmb) of the combined aggregate.
 - o. Percent deleterious content of the combine aggregate.
 - p. Baghouse fines added for design. Provide the combine gradation with and without the baghouse percentage.
- C. Test Results
- a. Base Course Density
 - b. Asphalt Density

2.0 PRODUCTS

2.01 Storage and Handling

- A. All materials used during the completion of this work shall be handled and stored in accordance with manufacturer's recommendations. Where no manufacturer's guidance is given, storage and handling requirements of MHTC Standard Specification for Highway Construction and IDOT Standard Specifications for Road and Bridge Construction shall apply.

2.02 Geotextile Fabric

- A. For use only where noted or shown on the Drawings: Geotextile fabric shall be in accordance with the physical and chemical requirements of AASTHO M 288 Class 1.

2.03 Aggregate Base Course

- A. For Missouri: Aggregate conforming to Section 1007 of the MHTC Standard Specification for Highway Construction - Type 1 Aggregate Base.

<u>Sieve Size</u>	<u>Percent Passing</u>
1 inch	100

1/2 inch	60 to 90
No. 4	35 to 60
No. 30	10 to 35

- B. For Illinois: Aggregate conforming to the IDOT Standard Specifications for Road and Bridge Construction – Article 1004.04 - Coarse Aggregate for Granular Embankment Special; Granular Subbase; Stabilized Subbase; and Aggregate Base, Surface, and Shoulder Courses. The aggregate shall be Type CA-6 or CA-10.

<u>CA-6</u>	
<u>Sieve Size</u>	<u>Percent Passing</u>
1 inch	95 to 100
1/2 inch	60 to 90
No. 4	30 to 56
No. 16	10 to 40
No. 200	4 to 12

<u>CA-10</u>	
<u>Sieve Size</u>	<u>Percent Passing</u>
1 inch	94 to 100
1/2 inch	45 to 75
No. 4	40 to 60
No. 16	15 to 45
No. 200	5 to 13

- 2.04 Prime Coat: Light grade cutback asphalt conforming to the requirements of ASTM D2027 designation MC-30 or MC-70 free of water and showing no separation or curdling prior to use. The use of MC-70 shall be limited to air temperatures less than 60°F.
- 2.05 Tack Coat: Liquid asphalt emulsion conforming to the requirements of ASTM D977 for SS-1, SS-1h, RS-1, RS-2 and ASTM D2397 for CSS-1, CSS-1h, CRS-1, CRS-2.
- 2.06 Hot-Mix Asphalt
- A. Aggregates, Mineral Filler, and Hydrated Lime
- a. Missouri: All course aggregate, fine aggregate, mineral filler and hydrated lime shall conform to applicable requirements outlined in Section 1002 of MHTC Standard Specification for Highway Construction.

- b. Illinois: All course aggregate, fine aggregate, mineral filler, and hydrated lime shall conform to applicable requirements outlined in Sections 1004.03, 1003.03, 1011, and 1012.1 of IDOT Standard Specifications for Road and Bridge Construction.

B. Asphalt Mixture

- a. Missouri: The total aggregate prior to mixing with asphalt binder shall be in accordance with the MHTC Standard Specification for Highway Construction BP-1 designation in Section 401. BP-1 mixtures shall have between 60 and 80 percent of the VMA filled with asphalt binder and dust to effective binder ratio of 0.8 to 1.6.

BP-1 MIXTURE COMPOSITION	
Sieve Size	Percent Passing
1 inch	100
3/4 inch	100
1/2 inch	85 to 100
No. 4	50 to 70
No. 8	30 to 55
No. 30	10 to 30
No. 200	5 to 12

- b. Illinois: Low ESAL Mixture – IL-19.0L Binder, IL-9.5L surface

Low ESAL, MIXTURE COMPOSITION (% PASSING)				
Sieve Size	IL-9.5L		IL-19.0L	
	Min.	Max.	Min.	Max.
1 in.	-	-	-	100
¾ in.	-	-	95	100
½ in.	-	100	-	-
3/8 in.	95	100	-	-
#4	52	80	38	65
#8	38	65	-	-
#30	-	< 50% of the percentage passing the #4	-	< 50% of the percentage passing the #4
#200	4.0	8.0	3.0	7.0
Asphalt Binder %	4.0	8.0	4.0	8.0
Ratio Dust/Asphalt Binder	-	1.0 @ design	-	1.0 @ design

- C. Performance Grade Asphalt Binder: Performance graded asphalt binder shall be an asphalt-based binder produced from petroleum residue either with or without the addition of non-particulate organic modifiers and shall be in accordance with AASHTO M320. Where performance grade of asphalt binder is not noted or shown on the Drawings, PG 64-22 shall be used.
- D. Water: potable

3.0 EXECUTION

3.01 GENERAL CONSTRUCTION

- A. Hauling Equipment: The aggregate base course shall be transported from the plant to the job site in hauling equipment having beds that are smooth, clean, and tight. Trucks that transport aggregate shall be legally licensed, in good working condition, free from hydraulic or transmission oil leaks, have beds that are free from detrimental foreign matter, and are equipped with the safety devices required by the United States Department of Transportation.

3.02 INSPECTION

- A. Verify that the subgrade and granular base are dry, stable, and ready to support paving and other imposed loads.
- B. Verify gradients and elevation of subgrade and base are correct.

3.03 WEATHER LIMITATIONS

- A. Aggregate base shall not be placed on frozen subgrade.
- B. Prime coats shall not be normally placed when:
 - a. When either the air temperature or the temperature of the surface on which the mixture is to be placed is below 40°F;
 - b. On any wet or frozen surface;
 - c. When weather conditions prevent the proper handling, curing, or finishing,
 - d. Unless authorized by the Construction Supervisor during critical temperature periods below 40°F.
- C. Asphalt Base Course: Minimum surface temperature of 40°F and rising at the time of placement

- D. Asphalt Surface Course: Minimum surface temperature of 60°F at time of placement.
- E. No work shall be started if local conditions indicate that rain is imminent.

3.04 AGGREGATE BASE COURSE

- A. Subgrade: All work on the portion of the subgrade on which the base course is to be construction shall be completed in accordance with the requirements of Section 02110, 02211, and 02222 prior to the placement of any base material on that portion.
- B. Geotextile Fabric: Where noted or outlined in the Drawings, a layer of geotextile fabric shall be placed over the original subgrade. Fabric shall cover the full width of the aggregate base, as shown in the plans. Fabric shall be installed and overlapped in accordance with the manufacturer's recommendations.
- C. Mixing: Unless otherwise specified, base material, any additional material required, and sufficient water to obtain the desired compaction shall be thoroughly mixed and delivered to the road as a combined product.
- D. Placement
 - a. Place aggregate base course to bring the base to the elevations specified less the asphaltic paving thickness.
 - b. Base shall be laid in lifts not to exceed 6" thick when compacted. Where the specified compacted depth of the base course exceeds 6-inches, the base shall be constructed in two or more layer of equal thickness.
- E. Shaping and Compacting
 - a. The mixture shall be uniformly spread in successive layers of such depth that when compacted, the base will have the approximate thickness specified. Each layer shall be compacted to the specified density before another layer is placed. Compact the stone base to not less than 100 percent of standard laboratory density, using appropriate equipment.
 - b. During shaping and compacting operations, the moisture content of the base shall be maintained at the level necessary for compaction, by wetting or drying as required.

- c. The finished aggregate base shall be checked for humps, hollows, or other irregularities. Loosen defective areas, remove surplus (or add new) material as required, recompact and treat as necessary to completely eliminate defect. Shaping and compacting shall be performed until a true, even, and uniform surface of proper grade, cross-section, and density is obtained.
- F. Density Determination: The standard laboratory density shall be the maximum dry density determined according to AASHTO T 99 (Method C). A coarse particle correction according to AASHTO T 224 shall be used.

3.05 PRIME COAT

- A. Preparation of Surface: The surface to be primed shall be shaped to the required grade and cross section, shall be free from all ruts, corrugations, segregated material, or other irregularities and shall be uniformly compacted. The surface shall be firm and slightly damp when primer is applied.
- B. Prime Coat Preparation: The temperature of the prime coat at the time of application shall be such that it will spray uniformly without clogging spray nozzles and shall be mixed and applied within the temperature outlined below or as recommended by the manufacturer:

Liquid Asphalt Grade	Temperature (°F)			
	Spraying		Mixing	
RC-30	70	150	50	110
RC-70	100	180	90	140

- C. Application:
 - a. The prime coat shall be applied to any completed portion of the aggregate base course as soon as practical.
 - b. The prime coat material shall be applied the full width of the base course by means of a calibrated pressure distributor in a uniform, continuous spread. When prime is to be placed by hand, a pressurized applicator system shall be used.
 - c. The application rate shall be 0.4 gallons per square yard unless otherwise approved by Construction Supervisor. The application rate at all times shall remain between 0.2 and 0.5 gallons per square yard.
 - d. There shall be no overlapping of primer coat. Pools of bituminous material occurring in the depressions shall be broomed or

squeegeed over the surrounding surface the same day the prime coat is applied.

D. Curing:

- a. The prime coat shall be permitted to cure until the penetration has been approved by the Construction Supervisor, but not less than 24 hours for MC-30.
- b. At locations where the prime coat has failed or is damaged, it shall be repaired in a manner satisfactory to the Construction Supervisor.
- c. The prime coat shall be maintained at all times until the cover coat is constructed. When required by the Construction Supervisor, the primed surface shall be swept prior to constructing the cover coat.

3.06 TACK COAT

- A. Tack coats shall be applied between all successive asphalt lifts where surface course does not immediately follow base course and at locations where existing asphalt shall abut new asphalt paving.
- B. Performance Graded (PG) Asphalt Binder: Hot applied PG graded asphalt binders may be used as tack coat in lieu of emulsified asphalt. The PG graded binders shall be applied uniformly with a pressure distributor to provide complete coverage of the preceding course or layer.
- C. Surface Preparation:
 - a. The existing surface shall be free of all dust, loose material, grease or other foreign material at the time the tack is applied.
 - b. Existing surfaces may be pre-wetted just prior to the tack coat application. Prewetting shall consist of misting the surface with controlled spraying equipment to achieve a damp condition with no standing water or shiny appearance.
- D. Dilution: Water may be added only by the tack coat manufacturer and shipped to the jobsite. No dilution shall be allowed in the field. When water is added to the asphalt emulsion, the resulting mixture shall contain no more than 20 percent of added water. The contractor shall notify the Construction Supervisor of the use of a diluted emulsion. The exact quantity of added water shall be indicated on the manufacturer's bill of lading, manifest or truck ticket.
- E. Tack Coat Preparation: The temperature of the tack coat at the time of application shall be such that it will spray uniformly without clogging

spray nozzles and shall be mixed and applied within the temperature outlined below or as recommended by the manufacturer:

Asphalt Emulsions	Temperature (°F)			
	Spraying		Mixing	
RS-1	120	140	-	-
RS-2	125	185	-	-
SS-1	120	160	70	160
SS-1h	120	160	70	160
CRS-1	125	185	-	-
CRS-2	125	185	-	-
CSS-1	120	160	70	160
CSS-2	120	160	70	160

F. Application:

- a. Emulsion shall be applied uniformly with a pressure distributor to achieve the residual rate of 0.03 to 0.04 gallons per square yard or as recommended by the manufacturer.
- b. Uniform application will not have streaks, bare spots, puddles, or other irregular patterns. Pools of bituminous material occurring in the depressions shall be broomed or squeegeed over the surrounding surface the same day the tack coat is applied.
- c. Longitudinal and transverse construction joints shall be treated using a rate that will thoroughly coat the vertical face without running off.

G. Curing: Allow tack coat to properly cure or break prior to applying successive lift. Traffic shall be kept off tack coat during curing period.

3.07 ASPHALT PAVEMENT

- A. Asphaltic concrete shall be mixed, transported, spread, rolled and finished in accordance with the Missouri State Highway Commission's (Missouri) or Illinois Department of Transportation's (Illinois) Standard Specification for asphalt concrete pavement.
- B. Handling and Transport
 - a. The prepared asphaltic mix shall be transported from the paving plant to the job in tight vehicles previously cleaned of all foreign materials. Each load shall be thoroughly protected from the weather.

- b. All surfaces which will be in contact with new asphalt mix shall be thoroughly cleaned of all dirt or other foreign material prior to spreading the asphaltic concrete.

C. Placing:

- a. Asphalt shall be spread only when the prepared grade or preceding course is dry.
- b. The paving mixture shall be spread by a mechanical spreading and finishing machine of a type that will uniformly spread the mixture to obtain the required compacted thickness. No segregation of the mixture during any of the operations will be permitted. The finished surface shall be smooth and true to cross section, free from all hollows and irregularities, and of uniform density throughout. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to achieve the required grade, cross section, and thickness when compacted.
- c. Paving that receives traffic between lifts shall be thoroughly cleaned, flushed and allowed to dry before receiving the next lift.
- d. Asphalt surface course shall be placed in a single lift.
- e. Spread mix at a minimum temperature of 250°F for Illinois sites and 260°F for Missouri sites.
- f. Begin applying mix along centerline of crown for crowned sections and on the high side of one-way slopes, unless otherwise indicated
- g. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess materials forming in high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

D. Rolling and Compaction:

- a. After the asphaltic mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. Rolling shall begin as soon after spreading the mixture as it will bear the weight of the roller without undue displacement. The number of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Compact mixture with vibratory-plate compactor in areas inaccessible to rollers.

- b. Rolling shall begin on the low and progress toward the high side of the spread. Each succeeding pass shall be offset by 1/2 the roller width from the previous pass.
- c. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Drive wheel and compaction roller shall be in direction of pavement.
- d. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while asphalt is still hot enough to achieve specified density. Continue rolling until asphalt has been uniformly compacted. Intermediate rolling shall be systematic to provide uniform complete coverage. Offset each pass one tire width (1/3 roller width for vibratory rollers) from succeeding pass. At least three complete coverages shall be made. The roller shall not be turned on the paving mix.
- e. Compaction shall be to 95% of reference laboratory density in accordance with AASHTO T209, but not less than 94% nor greater than 100%. Complete compaction before mix temperature cools to 185°F.
- f. In lieu of compaction testing, rolling shall be performed with a three wheel or tandem roller (10 tons Minimum) with a contact pressure of not less than 200 pounds per inch of roller width. A vibratory roller operated at as high a frequency as possible (as allowed by city/county ordinance) must be used for the initial rolling unless a pneumatic roller is used for the intermediate rolling. Rolling shall be systematic to provide complete coverage; minimum of three complete passes.
- g. Where spreading mix adjacent to previously compacted paving, the longitudinal joint shall be rolled immediately behind the paver. The new asphalt mix shall overlap the previously placed material by at least two inches. Before rolling, remove the coarse aggregate in the overlapping material with a broom or lute, leaving behind only the fine portion of the mix. The roller shall be operated on the previously placed material so that not more than six inches of the rear roller wheel rides on the edge of the fine material left by the brooming. The roller shall be shifted gradually across the joint until a thoroughly compacted, neat joint is obtained. Transverse joints shall be treated similarly to longitudinal joints except precautions shall be taken at the edge of pavement to provide for off-the-pavement movement of the roller in order to prevent damage to the edge. Edges of the pavement

shall be rolled concurrently with the longitudinal joint. The mix along the unsupported edges shall be slightly elevated with a tamping tool or lute before being compacted. Roller wheels shall extend two to four inches beyond the pavement edge.

- h. Finish Rolling: The finish rolling shall be performed while the mix is still workable enough for removal of roller marks. The finished surface shall be uniform, smooth, free of humps, laps, or other irregularities.

E. Tolerance and Repairs

- a. The finished surface shall correspond to the elevations shown. Divergence shall not exceed one-quarter (1/4) inch from a ten (10) foot straight edge.
- b. All weak and/or defective pavement shall be removed and replaced with fresh hot mixture; compacted to conform with the surrounding area; at the Contractor's expense.

3.08 SEAL COAT (Missouri Only)

- A. For use for asphalt maintenance activities only where noted or shown on the Drawings: The paving surface shall be swept and flushed clean, allowed to dry, and sealer shall be applied.
- B. The pavement surface shall be free of oil and grease spots, paint, clay, dust, rubber deposits, and other objectionable materials which might adversely affect bonding of the sealant to the asphalt.
- C. Solvents shall not be used for cleaning. Areas saturated with fuel or oil shall be burned out or replaced with new paving materials to match adjacent areas.
- D. The sealant shall be applied uniformly to the asphalt surface at a rate of 0.1 gallons per square yard.
- E. The first coat of sealant shall be allowed to dry (24 hours minimum). A second coat of sealant shall be applied at the rate of 0.1 gallons per square yard.
- F. All foot and vehicular traffic shall be excluded from the seal-coated area until sufficiently cured to completely resist damage from use, but not less than 24 hours.

3.09 ACCEPTANCE

- A. Before starting the work of this Section, verify with the Construction Supervisor the total square yards of paving to be provided. The Construction Supervisor shall be provided with signed and bound load tickets for materials delivered (aggregate, asphaltic concrete).
- B. Stone Base: Acceptable on the basis of 100 pounds aggregate being supplied per inch of thickness, per square yard of surfacing (1.8 tons/cu. yd.).
- C. Asphaltic Concrete: Acceptable on the basis of 112 pounds of material being supplied per square yard, per compacted inch of asphalt surfacing (2.016 tons/cu. yd.).

4.0 REVISIONS

DATE	DESCRIPTION
7/09/2013	Reissue
10/03/2019	Updated specification to reflect performance grade asphalt.

SUBSTATION DESIGN

STANDARD NO. – 02720

General Requirements for Storm Drainage Systems



Rev. No.	Date	Revisions	By	Approvals	
0	11-23-05	Initial Issue	RWD	DCB	JLH
1	11-15-17	Major Revision	RGV	DCB	SM
2	11-03-20	Minor Revision	GLC	RGV	SM

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SECTION 02720

STORM DRAINAGE SYSTEMS

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Storm drainage piping, fittings, and accessories.
- B. Catch basins, manhole access, and site surface & subsurface drainage.

1.02 RELATED WORK

- A. Section 02222 - Excavation: Short excavations, excavating subsoil for structures, foundations, sewer and drainage structures.
- B. Section 02223 - Backfilling: Structure backfilling, site fill including imported fill materials, backfill over pipes, and compaction requirements.
- C. Section 02730 - Sanitary Drainage System.

1.03 REFERENCES

- A. ANSI/ASTM C14 - Concrete Sewer Storm Drain, and Culvert Pipe.
- B. ANSI/ASTM C76 - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- C. ANSI/ASTM C443 - Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets
- D. AASHTO M36 - Standard Specification for Zinc-Coated (Galvanized) Corrugated Iron or Steel Culvert and Under-drains.
- E. ANSI/ASTM D1785; ANSI/ASTM D2665 – Standard Specification for PVC Poly (Vinyl Chloride) Plastic Pipe Schedules 40, 80, and 120.
- F. AASHTO M 252 (3”-10” Diameter) and M294 (12”-60” Diameter) – Standard Specification for Corrugated Polyethylene Drainage Pipe.
- G. Missouri Standard Specification for Highway Construction.

H. Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction.

I. IDOT Highway Standards.

1.04 REGULATORY REQUIREMENTS

A. Conform to all applicable Local, State and Federal laws, codes, specifications, and zoning ordinances for materials and installation of the work of this Section.

B. The requirements of any local Sewer District shall be followed for all storm sewage systems within its respective jurisdiction.

C. Culvert materials, accessories, and installation shall be in accordance with the Missouri Standard Specifications for Highway Construction or IDOT Standard Specifications for Road and Bridge Construction.

1.05 SUBMITTALS

A. Submit shop drawings as noted below and according to the project drawings and specifications.

B. Submit 1 pdf copy of shop drawings indicating dimensions, layout of piping, gradient of slope, fabrications, couplings, special sections, and accessories.

C. Submit 1 pdf copy of product data indicating pipe accessories and materials.

D. Submit 1 pdf copy of manufacturer's installation instructions.

E. Accurately record as-built location of pipe runs, connections, catch basins/area inlets, manholes, and invert locations.

PART 2 PRODUCTS

2.01 PIPES: SEWERS, CULVERTS AND SUBSURFACE DRAINS

A. Concrete Pipe: ANSI/ASTM C14, Class 3; un-reinforced; inside nominal diameter as shown on the drawings, cast using ASTM C150, Type II cement; bell and spigot or tongue and groove end joints.

B. Reinforced Concrete Pipe: ANSI/ASTM C76, Class IV (4) or greater; wall Type B with Circular Reinforcement in Circular Pipe; inside

nominal diameter as shown on the drawings, cast using ASTM C150, Type II cement; bell and spigot or tongue and groove end joints.

- C. Concrete Pipe Joint and Reinforced Concrete Pipe Joint (Device): Unless otherwise noted or required by the governing authority, joints shall be constructed with an approved compatible bituminous jointing material. For Missouri projects, the joints shall be in accordance with the requirements of the Metropolitan St. Louis Sewer District Standard Specifications for Sewers and Drainage Facilities, Type 'A' Joint designation, or other governing authority. For Illinois projects, the joints shall be in accordance with the requirements of Articles 1055 and 1056 of the IDOT Standard Specifications for Road and Bridge Construction.
- D. PVC Poly (Vinyl Chloride) Pipe: ANSI/ASTM D1785; ANSI/ASTM D2665, smooth-wall plastic pipe; inside nominal diameter as shown on the drawings.
- E. Corrugated Polyethylene Drainage Pipe: AASHTO M 252 (3"-10" diameter) and M294 (12"-60" diameter), heavy duty solid dual wall pipe; unless otherwise noted, pipe shall have a minimum stiffness of 46 psi; inside nominal diameter as shown on the drawings.
- F. Galvanized Steel Corrugated Metal Piping: Materials conforming to ASTM A444; helically corrugated, 2.67 X 0.5 corrugations; diameters as shown on the drawings.
- G. Fittings and Accessories: Materials and type same as pipes; manufactured by the pipe producer. Flared end sections (where shown) shall have dimensions as specified by the Missouri Standard Specifications for Highway Construction or the applicable IDOT Highway Standard (542301 for concrete; 542401 for metal).

2.03 BEDDING AND FILL MATERIALS

- A. For Missouri: Bedding, fill materials, and compaction shall be as specified in Section 02223, Type 5, Gradation D, or Grade 1, unless superseded by the requirements and specifications of the governing authority or shown on the project drawings. If no materials are indicated in specifications or project drawings, Gradation D shall be used.
- B. For Illinois: Bedding, fill materials, and compaction shall be as specified in Section 02223, unless superseded by the requirements and specifications of the governing authority or shown on the project drawings.

2.04 CATCH BASINS/AREA INLETS/MANHOLES

- A. New catch basins/area inlets/manholes shall conform to the project drawings and governing utility specifications/details in type, material, and dimension.
- B. Shaft Construction: Pre-cast concrete sections, diameters as shown on the drawings; 8 inch thick walls unless otherwise noted on the drawings; lipped male/ female section joints; cast iron shaft steps (16 inch centers) cast integral with the structure wall.
- C. Alternate brick construction meeting the requirements of the sewer authority may be substituted, subject to the approval of the Engineer.
- D. Lid Stone: If required and unless otherwise noted on the drawings; Reinforced pre-cast concrete section, 6 inches thick with 1 inch radius edges; cast with an opening of proper dimensions to receive and support standard cast iron inlet cover.

2.06 CONCRETE

- A. All concrete utilized in the construction or modification sewerage systems shall be per the requirements of the governing sewerage authority.
- B. Concrete (Unless otherwise required by Subsection A above): Class A concrete; 3500 psi ultimate strength at 28 days; 6 sacks (minimum) of Type II cement per cubic yard of concrete; 6.5 gallons (maximum) water per sack of cement; 3/4 inch maximum size aggregate; 3 inch slump (± 0.5 inch); 7.5 percent air by volume (± 1 %); with broomed finish.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that the trench cut and base excavation are ready to receive work and that excavation dimensions, and elevations are as shown on the drawings.

3.02 PREPARATION

- A. Remove large stones or other hard matter which could damage piping or impede consistent backfilling.

- B. Hand trim excavations to required elevations. Correct over excavation with fill materials as specified in Section 02223.

3.03 INSTALLATION OF PIPES

- A. Install pipes in accordance with the Missouri Standard Specification of Highway Construction, the IDOT Standard Specifications for Road and Bridge Construction (Article 542) and/or the governing sewer authority.
- B. Install pipe, fittings, and accessories in accordance with the manufacturer's instructions and the requirements of the governing sewer authority. Seal joints watertight.
- C. Lay pipes to slope gradient noted on the drawings, with maximum variation from true slope of 1/8 inch in ten feet.
- D. For Missouri: Install Type 5, Gradation D, or Grade 1 (or as required by the governing sewer authority) select fill as bedding, at sides, and over top of pipe. See Section 02223 for specific materials, order, and compaction level.

For Illinois: Unless superseded by the governing sewer authority, install select fill as bedding, at sides, and over top of pipe. See Section 02223 for specific materials, order, and compaction level.

- E. Increase compaction of each successive lift. Do not damage or displace piping when compacting.

3.04 INSTALLATION OF CATCH BASINS/AREA INLETS/ MANHOLES

- A. Install basins/inlets/manholes in accordance with the Missouri Standard Specification of Highway Construction, the IDOT Standard Specifications for Road and Bridge Construction (Article 602) and/or the governing sewer authority.
- B. Form bottom of excavation clean and smooth to correct elevation.
- C. Establish elevations and pipe inverts for inlets and outlets as indicated.
- D. Install pre-cast sections. Ensure all joints are proper and tight.
- E. Install pipes at specified invert elevations. Grout pipes in place to form watertight seal. Grout floor to provide consistent flowline from upstream to downstream pipe(s).

- F. Mount lid (if required) and frame, secured to top section at elevation indicated.

3.05 FIELD QUALITY CONTROL

- A. Request inspection by Construction Supervisor and governing authorities prior to commencing backfilling operations and as required by the governing authority.

3.06 PROTECTION

- A. Protect pipe and bedding from damage or displacement until backfilling operations begin.
- B. Protect finished installation from damage by other construction operations.
- C. Finished installation shall be cleaned of any accumulation of silt, debris, or foreign matter of any kind at time of final inspection.

PART 4 REVISIONS

Date Description

11-23-05 Initial Issue

11-15-17 Major Revision

11-03-20 Out-Of-Cycle Specification Update. Update Missouri Materials

SUBSTATION DESIGN

STANDARD NO. – 02730

General Requirements for

Sanitary Sewage Systems



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Rev. No	Date	Revisions	By	Approvals		
0	11-23-05	Initial Issue	RWD	DCB	JLH	PJN
1	09-01-17	Standard Update Review	CJS	SAL	MJN	
2	11-03-20	Minor Revision	GLC	JLF	MKF	

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SECTION 02730

SANITARY SEWAGE SYSTEMS

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Sanitary and combined drainage piping, fittings, and accessories.
- B. Connection of new and relocated sanitary/combined sewer system into existing municipal sewers.
- C. Manhole access.

1.02 RELATED WORK

- A. Section 02222 - Excavation: Short excavation and excavating for structures and foundations, sewer and drainage structures.
- B. Section 02223 - Backfilling: Structure backfilling, site fill including imported fill materials, backfill over pipes, and compaction requirements.
- C. Section 02720 - Storm Drainage System.

1.03 REFERENCES

- A. ANSI/ASTM C14 - Concrete Sewer Storm Drain, and Culvert Pipe.
- B. ANSI/ASTM C76 - Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- C. ANSI/ASTM C443 - Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
- D. ANSI/ASTM D2680 - Acrylonitrile-Butadiene-Styrene (ABS) and Poly(Vinyl Chloride) (PVC) Composite Sewer Piping.
- E. ANSI/ASTM D3034 - PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- F. ANSI/ASTM D3212 - Joints for Drains and Sewer Plastic Pipe Using Flexible Elastomeric Seals.

- G. ANSI/ASTM F679 – Poly(Vinyl Chloride) (PVC) Large Diameter Plastic Gravity Sewer Pipe and Fittings.

1.04 REGULATORY REQUIREMENTS

- A. Conform to all applicable Local, State and Federal laws, codes, specifications, and ordinances for materials and installation of the Work of this Section.
- B. The requirements of any local Sewer District shall be followed for all sewage/combined systems within its respective jurisdiction.

1.05 SUBMITTALS

- A. Submit shop drawings as noted below and according to the project drawings and specifications
- B. Submit 1 copies of shop drawings indicating dimensions, layout of piping, gradient of slope, fabrications, couplings, special sections, and accessories.
- C. Submit 1 copies of product data indicating pipe accessories and materials.
- D. Submit 1 copies of manufacturer's installation instructions.
- E. Accurately record location of pipe runs, connections, manholes, and invert locations.

PART 2 PRODUCTS

2.01 SEWER PIPES

- A. Reinforced Concrete Pipe: ANSI/ASTM C76, Class IV (4) or greater; wall Type B with Circular Reinforcement in Circular Pipe; inside nominal diameter as shown on the drawings, cast using ASTM C150, Type II cement; bell and spigot or tongue and groove end joints.
- B. Reinforced Concrete Pipe Joint (Device): Compression- type joints conforming to the requirements of ASTM C443. Band type gaskets depending entirely on cement for adhesion and resistance to displacement during jointing shall not be used.

- C. Polyvinyl Chloride (PVC): ANSI/ASTM D3034 or F679, Type PSM, polyvinyl Chloride (PVC) material; inside diameter as shown on the drawings.
- D. Polyvinyl Chloride (PCV) Joint (Device): Elastomeric gasket joints providing a water tight seal, conforming to the requirements of ASTM C3212.
- E. Composite Pipe: Acrylonitrile-Butadiene-Styrene (ABS) Composite material; inside nominal diameter as shown on the drawings.
- F. ABS Composite Joint (Device): Solvent cemented to provide a water tight seal; conforming to the Specification for Joints under ASTM D2680.

2.02 BEDDING AND FILL MATERIALS

- A. For Missouri: Bedding, fill materials, and compaction shall be as specified in Section 02223, Type 5, Gradation D or Grade 1, unless superseded by the requirements and specifications of the governing authority. If no materials are indicated in specifications or project drawings, Gradation D shall be used.
- B. For Illinois: Bedding, fill materials, and compaction shall be as specified in Section 02223, unless superseded by the requirements and specifications of the governing authority or shown on the project drawings.

2.03 MANHOLES

- A. New manholes shall conform to the governing utility specifications and details in type, material, and dimension.
- B. Shaft Construction and Concentric Cone Top Section: Pre-cast concrete sections conforming to ASTM C478, using Type II cement; nominal 42 inch diameter (inner) shaft section; 8 inch thick walls; watertight lipped male/female section joints; cast iron steps (16 inch centers) cast integral with the structure wall; connections of an approved patented compression type. Top cone section shall have a minimum top opening of 26.5 inches to accept standard lid and frame. Base riser section shall be integral with the floor.
- C. Alternate brick construction meeting the requirements of the governing sewer authority may be substituted, subject to the approval of the Engineer.

- D. Frame and Lid: Cast iron construction; lid per Subsection 2.04 above; 37.5 inch outer frame diameter, nominally 5/8 inch thick, with 6 ribs and centering lugs (bottom edge). Contact surface of the frame (supporting the lid) shall be machined. Prepare and coat by dipping in an asphalt emulsion; 10 mil dry film thickness.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that the trench cut and base excavation are ready to receive work and that excavation dimensions and elevations are as shown on the drawings.

3.02 PREPARATION

- A. Remove large stones or other hard matter which could damage piping or impede consistent backfilling.
- B. Hand trim excavations to required elevations. Correct over excavation with fill materials as specified in Section 02223.

3.03 INSTALLATION OF PIPE

- A. Install pipe, fittings, and accessories in accordance with the manufacturer's instructions and the requirements of the governing sewer authority. Seal joints watertight.
- B. Lay pipes to slope gradient noted on the drawings, with maximum variation from true slope of 1/8 inch in ten feet.
- C. For Missouri: Install Type 5, Gradation D or Grade 1 (or as required by the governing sewer authority) select fill as bedding, at sides, and over top of pipe. See section 02223 for specific materials, order, and compaction level.

For Illinois: Unless superseded by the governing sewer authority, install select fill as bedding, at sides, and over top of pipe. See Section 02223 for specific materials, order, and compaction level.

- D. Increase compaction of each successive lift. Do not damage or displace piping when compacting.
- E. Connection of the new or relocated sewer line shall be within a new manhole or a modified existing manhole. Details of connection to

municipal sewer shall be in accordance with the requirements of the governing sewer authority.

- F. All abandoned-in-place sewer piping shall be sealed at each end of the pipeline with a minimum of three feet of concrete or as required to form a watertight seal.

3.04 INSTALLATION OF MANHOLES

- A. Form bottom of excavation clean and smooth to correct elevation.
- B. Establish elevations and pipe inverts for inlets and outlets as indicated.
- C. Install pre-cast sections. Insure all joints are proper and tight.
- D. Mount lid and frame in grout, secured to top cone section at elevation indicated.

3.05 FIELD QUALITY CONTROL

- A. Request inspection by Construction Supervisor and governing authorities prior to commencing backfilling operations and as required by the governing authority.

3.06 PROTECTION

- A. Protect pipe, structures, and bedding from damage or displacement until backfilling operations begin.
- B. Protect finished installation from damage by other construction operations.

PART 4 Revisions

<u>Date</u>	<u>Description</u>
11-23-05	Initial Issue
09-01-17	Standard Update Review
11-03-20	Out-Of-Cycle Specification Update. Update Missouri Materials

SUBSTATION DESIGN

STANDARD NO. 02831

GENERAL REQUIREMENTS FOR SUBSTATION FENCES AND GATES



JOINT SUBSTATION STANDARD AMEREN TRANSMISSION AMEREN MISSOURI AMEREN ILLINOIS

Rev. No.	Date	Revisions	By	Approvals		
0	08/08/05	Original Issue	JWL	CJB 8/26/05	WJH 9/7/05	PJN 10/12/05
1	6/13/06	Revised Section 3.4 post sizes, 3.5, & 3.7 and Exhibits	JWL	CJB 8/9/06	WJH 8/9/06	PJN 8/14/06
2	9/15/11	Reordered sections, revised fence post, added Ameristar Fence	MK H	CJB 11/17/11	WJH 11/18/11	RQR 11/29/11
3	2/13/2020	Updated Title Sheet, Revised Chain Link and Ameristar Sections, Added Vanquish and Isolation Fence Sections. Removed Exhibits.	DRS	JHL 2/13/2020	JLC 2/13/2020	JLF 2/13/2020

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1.0 General Requirements

This specification sets forth all general requirements pertaining to Chain Link fence, Ameristar Impasse II fence, Vanquish fence, Isolation fence, Impenetrable fence, and gates to be supplied for Ameren Substation perimeter security. This will include fence framework, fabric, accessories, gates, and fence post foundations.

2.0 Standards

Unless otherwise stated herein, this material 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 or Zinc-Alloy Coatings
- ASTM Standard F626 Standard Specification for Fence Fittings
- ASTM Standard C94/C94M Standard Specification for Ready-Mixed Concrete

Concrete associated with this standard must conform to Ameren Standard Construction Specification Division 2 Section 03001 General Requirements for Concrete, unless otherwise stated herein.

3.0 Drawings and Documentation

The fence shall be constructed in accordance with the Project Drawings. For discrepancies between this Design Standard and the Project Drawings, the Project Drawings control.

The following Ameren drawings are available for Project Engineer reference only as a template for developing the Project Drawings. All construction shall be in accordance to the Project Drawings.

STND-C-000004-001	PROPERTY FENCE DETAILS
STND-C-000005-001	PROPERTY FENCE FOUNDATIONS
STND-C-000006-001	PROPERTY FENCE DETAILS AMERISTAR IMPASSE II

4.0 Materials and Requirements

4.1 Chain Link

In addition to this specification, chain link fence shall be constructed in accordance with the approved Project Drawings.

4.1.1 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" mesh and coated with an aluminum coating of 0.4 oz/sf. Top and bottom selvages shall have a twisted and barbed finish.

4.1.2 Chain Link Fabric (Alternate)

When required, fabric shall be, Privacy Master™, as specified in section 3.1 except with a 2-inch mesh with colored slats already in the wire as made by Privacy Link™ or approved equal. 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 Ameren.

4.1.3 Chain Link Fence Installation

The fence shall follow the final 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 ensure that bottom closure shall be within one inch of the final earth grade surface elevation before substation rock is added. Typically, the bottom 6" of the chain link fabric is buried in the rock.

4.1.4 Fabric Ties

Fabric shall be fastened to the line posts and top rail with 9 gauge steel tie wires, coated with an aluminum coating of 0.4 oz/sf. spaced no more than 24 inches apart. Aluminum ties are not permitted. Standard fabric stretcher bars and stretcher bar bands shall be furnished where required.

4.1.5 Tension Bar

The tension bar for fabric shall be in accordance with ASTM F1043 Class IC, latest revision. The tension bar for gate posts shall be a minimum 1/4" dia. galvanized steel bar and shall conform to ASTM F1043 Class IC, latest revision. (Heavy gauge wire is not acceptable.)

4.1.6 Posts

Posts shall be Allied SS-40 or Wheatland WT-40 pipe, or in accordance with ASTM F1043 Class IC, sized as follows:

Line	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' incl. or	
double over 12' to 26' include.....	6.625" OD (18.99 lb/ft)

<u>Length</u>	<u>For 7'-0" Fabric</u>
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 fabric or for Privacy Master™, or approved equal, chain link fabric.

Terminal Posts (end, corner, gate, pull) shall be set at the beginning and end of each continuous length of fence and at abrupt changes in vertical and/or horizontal alignments. Terminal posts shall be set at a maximum spacing of 500' when the fence continues in a long straight line.

4.1.7 Gates

Gates shall be constructed of SS-40/WT-40 (or ASTM F1043 Class IC approved equal) 1.875" O.D. pipe (2.28 lb/ft). The top of gate shall be at least 8' above final rock grade and match the elevation of the attached fence.

4.1.8 Gate Hardware

All gate hardware shall be in accordance with ASTM A153, latest revision.

For man gates:

Latch – gate, with 2" O.D. collar for gate frame and fork for 4" O.D. gate post. 59030413 – 4" x 2" Industrial Pioneer PS as manufactured by Merchants Metals, Minneapolis, MN. or an approved equal.

Hinges – Hot dipped galvanized box-type. 59050623 - 4" x 2" Industrial Hinge Bulldog as Manufactured by Merchants Metals, Minneapolis, MN or an approved equal.

For drive gates:

Latch – drive gate for 2" O.D. gate frames. 59030411 - 2"x 2" Industrial Pioneer 10" PS as manufactured by Merchant Metals, Minneapolis, MN. or an approved equal.

Hinges – Hot dipped galvanized box-type. 59050617 - 6 5/8" x 2" Industrial Hinge Bulldog or an approved equal.

4.1.9 Removable Panels

Removable panels shall be of standard construction, framed with SS-40/WT-40 (or ASTM F1043 Class IC approved equal) 1.625" OD (1.84 lb/ft).

4.1.10 Braces

Braces shall be made of SS-40/WT-40 (or ASTM F1043 Class IC approved equal) 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.

4.1.11 Top Rails

The top rail shall be made of SS-40/WT-40 (or ASTM F1043 Class IC approved equal) 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.

4.1.12 Barbed Wire

Barbed wire shall be Four Point Type Light Weight (two 0.080" diameter strands): two 12.5 gauge strands, with an aluminum coating equal to that specified per the fence fabric and shall conform to ASTM F626.

4.1.13 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.

4.1.14 Galvanizing and Steel Pipe

Galvanized steel pipe for posts, gates, top rail and removable panels shall be in accordance with ASTM standard F1043 Class IC, 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.

4.1.15 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 at the elevation of final rock grade. Tension wire shall be attached to the fence fabric with steel hog rings (aluminum hog rings are not permitted) every 24 inches.

4.1.16 Painting

When required fence shall be painted using the following process:

The fence fabric, posts, gates, and hardware shall be cleaned with PORTERPREP™ Heavy Duty Cleaner or approved equal per the manufacturer's recommendations and then power washed with clean water.

The fence fabric, posts, gates, and hardware shall then be sprayed with Henkel METALPREP® 79 or approved equal per the manufacturer's recommendations.

The fence fabric, posts, gates, and hardware shall be painted with PORTER GUARD® DTM Acrylic Primer/Finish or approved equal per the manufacturer's recommendations.

The fence fabric, posts, gates, and hardware shall be painted with one coat of PORTER GUARD® DTM Acrylic Gloss Enamel or approved equal per the manufacturer's recommendations.

4.1.17 Fence Security Cables (Optional)

Fence security cable shall only be installed when specified on the Project Drawings. The size/type of cable shall be as shown on the Project Drawings, which is either ½" diameter 6x19 IWRC EIPS/XIP galvanized wire rope with a breaking strength of 26,600 lbs. or ¾" diameter 6x19 IWRC EIPS/XIP galvanized wire rope with a breaking strength of 58,800 lbs. The wire rope galvanizing shall be in accordance with ASTM A1023 and approved by Ameren Engineering. There shall be 5 rows of cables clamped to the inside of the chain link fence fabric with wire rope clips with the nuts on the substation side of the chain link fence fabric. The wire rope clips shall be forged hot-dipped galvanized Crosby G-450, or an approved equal, in a size that matches the size of the fence security cables. The wire rope clips shall be installed per the manufacturer's instructions. The nuts on the wire rope clips shall be fully tightened so the wire rope clips are securely fastened to the fence fabric. The spacing of the cable and wire rope clips shall be as shown on the Project Drawings. The galvanizing on the cables and wire rope clips shall not be damaged during installation. Installation practices that could damage the galvanizing on the cables, such as dragging the cables on the rock, etc., shall not be used. Cables and wire rope clips with damaged galvanizing shall not be used. Specifications for the cables and wire rope clips shall be submitted to Ameren for review, prior to construction.

Fence security cables shall be attached to each terminal post (end/corner/gate/pull) and lapped spliced where needed using forged hot-dipped galvanized Crosby G-450 cable clips, or an approved equal, as shown in the details in the Project Drawings, unless noted or shown otherwise. The wire rope clips shall be installed per the manufacturer's instructions and the Project Drawings. The cables shall be installed taut, but shall not be tensioned.

4.2 Ameristar Impasse II Fence

In addition to this specification, Ameristar Impasse II fence shall be constructed in accordance with the Project Drawings and manufacturer instructions.

4.2.1 Ameristar (Alternate)

When required, Ameristar Impasse Anti-Scale Gauntlet fence may be used. The Impasse Anti-Scale pale spacing is 1.5 inches of airspace.

Posts shall be evenly spaced, but in no instance should spacing greater than 8 feet be used.

4.2.2 Gate Hardware

As Follows:

For man gates: Latch – Ameristar DSB300

For drive gates: Latch – Ameristar DDB200

4.3 Vanquish Animal Deterrent Fence System

Vanquish fence systems shall be designed by the manufacturer.

Vanquish fence systems shall be installed in accordance with Manufacturer instructions.

4.4 Isolation Fence

Isolation fence shall not be used for Ameren Substation perimeter fencing, unless it is approved by Ameren Engineering and it provides substation security equivalent to that provided by the chain link fence in this Standard. The Isolation Fence shall be a Shakespeare SafeFence Non-Conductive Barrier or approved equal. The color of the fence shall be as specified by Ameren. The height and length of the isolation fence shall

be constructed per the Project Drawings. Drilled footings shall be as specified in the Project Drawings.

4.5 Impenetrable Fence

Impenetrable Fence shall be used when NEC required clearances from Ameren Substation perimeter fencing cannot be met. The NEC required clearance from energized equipment live parts to substation perimeter fence is specified in Ameren Standard No. 7G - Design Guide for Substation Electrical Clearances. Fence height, supporting post spacing, and foundation for meeting the Safety Clearance requirement shall be constructed per the Project Drawings. Shakespeare SafeFence Safety Barrier or precast walls with no openings may be used to meet this requirement.

4.6 Support Footings

4.6.1 Chain Link Footings

Post shall be set in the center of concrete footings and extend 34" 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 the rock is placed.

4.6.2 Chain Link Footing Size

Footings shall be 10" or greater in diameter for Line Posts; 16" or greater in diameter for Terminal Posts and Gate Posts with leaves less than or equal to 6' wide; and 20" or greater in diameter for Gate Posts with leaves greater than 6' wide and up to and including 13' wide. Footings shall be set 1" above and extended 36" below the finished earth grade.

4.6.3 Ameristar Impasse II Footings

Post shall be set in the center of concrete footings 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 the rock is placed.

4.6.4 Ameristar Impasse II Footing Size

Footing shall be 18" in diameter for Line Post and 24" for Gate Posts. Footings shall be set 1" above and extend 48" below finished earth grade.

4.6.5 Isolation Fence Footing

The Isolation fence post and chain link fence post shall be set in reinforced concrete foundation and extended below top of the foundation, as shown on the Project Drawings. Foundation shall be set 1" above and extend below the finished earth grade as shown in the Project Drawings. The top of the foundation shall be sloped away from the posts to drain moisture. In most instances, fence posts are installed before yard rock is placed. The installer shall make sure that the concrete foundation extends one inch above earth subgrade but a minimum of 4 inches below finished rock surface after the rock is placed. Steel reinforcement shall be placed in the foundation as shown on the Project Drawings.

4.6.6 Isolation Fence Footing Size

Foundation diameter shall be constructed per the Project Drawings.

4.6.7 Footing Concrete

See Ameren Standard No. 03001 for concrete mix requirements.

4.7 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 3" and must be uniform. Substation perimeter fence shall be whole and separate from any and all substation equipment, structures, and control houses.

4.8 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 3 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 3 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.

4.9 Gate Catches

All double gates shall be provided with semi-automatic outer catches to secure gate in the open position.

4.10 Alvarado Man Gate with Card Readers

This gate is only used when shown on the Project Drawings and it is typically provided by the Security Contractor for warranty/maintenance reasons. The model number and special features of this gate shall be determined by Ameren Security Department. See Project Drawings for foundation and other details.

4.11 Security

(Applies only to modification work) If a section of fence is to be removed, the Contractor is responsible for maintaining the facility security. Substation security requires that the facility be either attended at all times or have a complete perimeter fence. A substation shall be considered completely fenced when a temporary fence is installed to replace the removed section. A substation shall be considered attended when the contractor has personnel at the facility and/or within line of sight of the removed fence section. Temporary fence shall be similar in height, material, etc. to the section of fence removed. Under no circumstances shall a substation facility be left either unattended or left overnight without properly installed temporary or permanent fence.

5.0 Revisions

<u>Date</u>	<u>Description</u>
8/8/05	Re-write entire standard with new exhibits. Supersedes Electrical Engineering Standard No. 2 dated 9/01, Illinois Power Company Electric Substation Design Specification for the Installation of Substation Perimeter Fence 16-103.1 dated 10/29/99, and Central Illinois Public Service Company Ordering Specification for Chain Link Fence TSS 6.3.1 dated 6/26/95. Latest standards at time of issue were ASTM Standards A491, A153/A153M, A53/A53M, A1011/A1011M, A90/A90M, F626, and C94/C94M. Re-write of entire standard with new exhibits. Supersedes Electrical Engineering Standard No. 1G dated 5/88.
6/13/06	Disallowed heavy gauge wire for tension bar use. Increased Terminal (end/corner/pull) Posts and Smaller Gate opening posts to 4" O.D. to match sizes provided by manufactures. Revised top of gate and top of fence lines to align in section 3.5. Revised bracing for terminal and gate posts in section 3.7. Added additional bracing detail to Exhibit 1 sheet 2.
8/4/11	Reordered sections, revised fence post, added Ameristar Fence Revised section numbering to add the Ameristar Impasse Gauntlet Fence. Revised the drive gate post size to 6" from 4" for chain link. Reduced post spacing from 10' to 8' for chain link. Updated concrete strength to 4000 psi from 3000 psi. Revised Exhibits to show new post sizes and concrete as 4000 psi. Added sections regarding Ameristar fence including sample drawings and footing details.
12/30/19	Updated Title Sheet, Revised Chain Link and Ameristar Sections, Added Vanquish, Isolation, and Impenetrable Fence Sections, Removed Exhibits (Project Drawings must include appropriate constructible fencing details). Modified the document to represent the most up to date 1G Standard. Revised section numbering to add Vanquish fence, Isolation fence, and Impenetrable fence. Changed spacing between posts in double leaf drive gates from 4" to 3". Updated concrete strength to 4500 psi from 4000 psi. Modified chain link material callouts with ASTM specification references.

SUBSTATION DESIGN

STANDARD NO. – 02936

General Requirements for

SEEDING



JOINT SUBSTATION STANDARD
AMEREN TRANSMISSION
AMEREN MISSOURI
AMEREN ILLINOIS

Rev. No	Date	Revisions	By	Approvals		
0	12-19-05	Initial Issue	BLC	WJH	JLH	PJN
1	12-29-17	General / update revision	EAS	SAL	MJN	

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SECTION 02936
SEEDING

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Fertilizing.
- B. Seeding and Hydroseeding.
- C. Mulching.
- D. Maintenance.

1.02 RELATED WORK

- A. Section 02211 - Grading: Grading of site.

1.03 DEFINITIONS

- A. Weeds: Includes Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.04 QUALITY ASSURANCE

- A. If Requested, Contractor to provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, percent purity and germination, and location of packaging.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to site; store and protect products from weather.
- B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.
- C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer. Bulk fertilizer may be substituted, provided that delivery tickets provide the same information required for bagged fertilizer.

1.06 COORDINATION

- A. Coordinate the work of this Section with installation of underground piping for sewer, water, and drainage.

PART 2 PRODUCTS

2.01 SEED MIXTURE

- A. Seed mixtures shall be fresh, clean, new seed. If requested, the Contractor shall furnish Ameren with the dealer's guaranteed statement of the composition of the mixture and the percentage of purity and germination of each variety.
- B. Seed Mixture: (98% pure, 85% germination, minimum)
 - 1. KY-31 Fescue: 60 percent.
 - 2. Perennial Rye: 40 percent.

2.02 ACCESSORIES

- A. Peat Moss: Michigan peat moss finely shredded; not less than 90% organic material (by weight); Ph between 4 and 5. Moisture shall be between 35 to 66% moisture by weight, but shall have a water holding capacity of 150 to 200%.
- B. Mulching Material (Alternate): Oat, wheat, rye, or barley straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are not acceptable. Applied at 1 ½ inch loose measure, approximately 3 ½ tons per acre.
- C. Hydroseeding Mulch: Mulch shall be a specially processed cellulose (or cellulose-wood) fiber containing no growth or germination-inhibiting factors. It shall be manufactured in such a manner that after addition and agitation in slurry tanks with water, the fibers in the material become uniformly suspended to form a homogeneous slurry. When sprayed on the ground the material shall allow absorption and percolation of moisture. Each package of cellulose fiber shall be marked by the manufacturer to show the air dry weight. Mulch shall be applied at the rate specified by the manufacturer for the slopes and soil types to which it is applied.
- D. Tackifier: Product shall be chemically inert and nontoxic to plants, humans, and animals.

- E. Dye: Colorant designed specifically for use with hydroseeding materials and equipment which will aid the operator in applying a uniform slurry. Dye shall be chemically inert, nontoxic to plants, humans, and animals.
- F. Fertilizer: Commercial fertilizer of the following proportions: Nitrogen 12 percent, phosphoric acid 12 percent, soluble potash 12 percent.
- G. Water: Clean, fresh and free of substances or matter which could inhibit vigorous growth of grass.
- H. Erosion Fabric: Bio-degradable, open weave matting.
- I. Stakes: Biodegradable plastic or softwood lumber, chisel pointed. Note: metal anchoring devices (staples) are not acceptable.

PART 3 EXECUTION

3.01 INSPECTION

- A. Verify that prepared soil base is ready to receive the work of this Section. Seedbed preparation per Ameren Design Standard 02211.
- B. Beginning of installation means acceptance of existing site conditions by Ameren Construction Supervision, Substation or Vegetation Maintenance.

3.02 FERTILIZING

- A. Apply fertilizer in accordance with manufacturer's instructions at a rate of seven pounds per 1000 square feet.
- B. Apply after smooth raking of topsoil.
- C. Do not apply fertilizer at same time or with same machine as will be used to apply seed.
- D. Mix thoroughly into upper 2 inches of topsoil.
- E. Lightly water to aid the dissipation of fertilizer.

3.03 HYDROSEEDING (PREFERRED SEEDING METHOD)

- A. Seeding shall be done within 2 days following soil preparation in the area to be seeded.

- B. Seed, fertilizer, mulch, dye, and tackifier shall be mixed in equipment designed to provide constant agitation and which will produce a uniform slurry for application to the prepared seedbed.
- C. The mixed slurry shall be applied using spray/spreading equipment specifically designed for this purpose, and which will result in a uniform application.
- D. Proceed with seeding operation on moist soil, but only after free surface water has drained away.
- E. Exercise due care to prevent drift and displacement of mixture into other areas and on adjacent structures.

3.04 MECHANICALLY BROADCAST SEEDING (ALTERNATE METHOD)

- A. Apply seed in accordance with manufacturer's instruction using an approved mechanical seeder. Culti-packer or approved similar equipment may be used to cover the seed and to form the seed bed in one operation. In areas inaccessible to culti-packer, the seeded ground shall be lightly raked with flexible rakes and rolled with a water ballasted roller. After rolling, seeded areas are to be mulched using peat moss at a thickness of not more than $\frac{1}{4}$ inch. Straw mulch may be permitted by the Engineer. Do not seed area in excess of that which can be mulched on same day.
- B. Do not sow immediately following rain, when ground is too dry, or during windy periods.
- C. Apply water with a fine spray immediately after each area has been mulched. Saturate top 4 inches of soil.

3.05 SEED PROTECTION

- A. Only cover seeded slopes (Not Hydroseeded) with erosion protection fabric wherever grade is 4 inches (vertical) per foot (horizontal) (1:3) or greater, and 3"1'H (1:4) or greater for Transmission sites only. All swale bottoms shall be covered with erosion protection fabric regardless of seeding method. Roll fabric onto slopes without stretching or pulling. No fabric shall be placed over existing established groundcover.
- B. For slopes, lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Provide 6 inch minimum overlap of adjacent rolls, and 4 inch overlap for Transmission sites only. Backfill trench and rake smooth, level with adjacent soil.

- C. At sides of ditches, lay fabric laps in direction of water flow with longitudinal seams no closer than 2 feet from the centerline of the ditch. Lap ends and edges a minimum of 6 inches.
- D. Secure outside edges and overlaps at 36 inch intervals with stakes.
- E. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

3.06 MAINTENANCE

- A. Maintain and water seeded areas as requested. Reimbursement will be in accordance with the contract documents.
- B. Mow grass at regular intervals to maintain at a maximum height of 2 1/2 inches. Do not cut more than 1/3 of grass blade at any one mowing.
- C. Water to prevent grass and soil from drying out.
- D. Roll surface to remove minor depressions or irregularities.
- E. Control growth of weeds. Apply herbicides in accordance with manufacturer's instructions. Remedy damage resulting from improper use of herbicides.
- F. Immediately reseed areas which show bare spots.
- G. Protect seeded areas with warning signs during maintenance period.
- H. Seeded areas may be turned over to Ameren for maintenance after a minimum of three mowings and the inspection and acceptance by Ameren Construction Supervision, Substation or Vegetation Maintenance.

PART 4 REVISIONS

<u>Date</u>	<u>Description</u>
12/29/17	Included specific requirements for contractors to maintain turf until established prior to turning responsibility back over to Ameren for maintenance. Included reference to Ameren Standard 02211 – Grading. Updated requirements for seed protection on slopes and ditches.

SUBSTATION DESIGN
STANDARD NO. – 03001

General Requirements for
Concrete



JOINT SUBSTATION STANDARD
AMEREN TRANSMISSION
AMEREN MISSOURI
AMEREN ILLINOIS

Rev. No.	Date	Revisions	By	Approvals			
0	10/12/2005	First Issue	MJW	DCB	JLH	PJN	
1	04/22/2013	Issue for Use	JAB	DCB	-	RQR	
2	12/13/2018	Major Revision	GAP	SM	BLC	-	
3	04/01/2019	Reformat Document & Update Section 1.07	GAP	SM	BLC	-	
4	01/05/2021	Minor Revision	GAP	GLC	JLF	RGV	BLC

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SECTION 03001

CONCRETE

PART 1 - GENERAL

- 1.01 The purpose of this specification is to cover materials, installation, and quality control of cast in place concrete for substation and transmission line foundations, retaining walls, cable pits, and stairs. This specification is intended for exclusive use throughout Ameren Missouri and Ameren Illinois service territories for concrete used on all substations and transmission lines. The only exceptions to this specification are concrete for chain link fence post foundations and concrete surrounding power conduit.
- 1.02 If independent inspection requirements are waived by the Contract Documents, general contractor shall complete all duties assigned to the Owner's Representative – Geotechnical Engineer.
- 1.03 Related Sections
- A. Section 02222 – Excavation
 - B. Section 02223 – Backfilling
 - C. Section 02371 – Cast-In-Place Concrete Piers
 - D. Section 02831 – Chain Link Fence and Gates
 - E. Section 16420 – Power Conduits

1.04 References

The requirements in the most recent edition of the following references are to be included in this specification.

- A. ACI 117 – Tolerances for Concrete Construction and Materials
- B. ACI 207.1R – Guide to Mass Concrete
- C. ACI 211.4R – Guide for Selecting Proportions for High-Strength Concrete Using Portland Cement and Other Cementitious Materials
- D. ACI 301 – Specifications for Structural Concrete for Buildings
- E. ACI 305 – Hot Weather Concreting
- F. ACI 306 – Cold Weather Concreting
- G. ACI 308 – Standard Practice for Curing
- H. ACI 309 – Guide for Consolidation of Concrete
- I. ACI 318 – Building Code Requirements for Structural Concrete
- J. ACI 336.1 – Specification for the Construction of Drilled Piers
- K. ACI 347 – Guide to Formwork for Concrete
- L. IBC – International Building Code
- M. ASTM C31 – Making and Curing Test Specimens in the Field
- N. ASTM C33 – Concrete Aggregates
- O. ASTM C39 – Compressive Strength of Cylindrical Concrete Specimens

- P. ASTM C42 – Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
- Q. ASTM C94 – Ready-Mixed Concrete
- R. ASTM C138 – Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- S. ASTM C143 – Slump of Hydraulic Cement Concrete
- T. ASTM C150 – Portland Cement
- U. ASTM C172 – Sampling Freshly Mixed Concrete
- V. ASTM C173 – Air Content of Freshly Mixed Concrete by the Volumetric Method
- W. ASTM A185 – Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
- X. ASTM C231 – Air Content of Freshly Mixed Concrete by the Pressure Method
- Y. ASTM C260 – Air Entraining Admixtures for Concrete
- Z. ASTM C309 – Liquid Membrane-Forming Compounds for Curing Concrete
- AA. ASTM C470 – Molds for Forming Concrete Test Cylinders Vertically
- BB. ASTM C494 – Chemical Admixtures for Concrete
- CC. ASTM C511 – Moist Cabinets, Moist Rooms, & Water Storage Tanks for Testing Concrete
- DD. ASTM C595 – Blended Hydraulic Cements
- EE. ASTM A615 – Deformed and Plain Billet-Steel Bars for Concrete
- FF. ASTM C618 – Coal Fly Ash and Raw of Calcined Natural Pozzolan for Use in Concrete
- GG. ASTM C989 – Slag Cement for Use in Concrete and Mortars
- HH. ASTM C1017 – Chemical Admixtures for Use in Producing Flowing Concrete
- II. ASTM C1064 – Temperature of Freshly Mixed Hydraulic Cement Concrete
- JJ. ASTM C1240 – Silica Fume Used in Cementitious Mixtures
- KK. ASTM A1064 – Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete

1.05 Definitions

- A. Project Civil/Structural Engineer: Person employed by Ameren or hired by Ameren, responsible for the civil and structural design of the project, and authorized to make construction decisions on Ameren's behalf.
- B. Construction Supervisor: Person employed by Ameren or hired by Ameren, responsible for the construction oversight of the project, and authorized to make construction decisions on behalf of Ameren.
- C. Owner's Representative – Geotechnical Engineer: Geotechnical engineer, or a qualified technician working under supervision of a geotechnical engineer, specifically authorized to carry out the responsibilities of this specification. Employed by Ameren or hired by Ameren, and reports to the Project Civil/Structural Engineer.
- D. Testing Agency: Person, firm, or corporation hired by Ameren to complete concrete tests as outlined in Contract Documents.

1.06 Submittals

A. Approval of Submittals

Contractor submittals shall be considered to be approved ONLY after receipt of approval from the Project Civil/Structural Engineer via Ameren approval stamp.

B. Concrete Mix Design

Contractor shall submit all concrete mix designs for use on project to verify that the materials and quality of ready-mixed concrete meet the requirements of this specification. Mix designs must be submitted to the Project Civil/Structural Engineer a minimum of two weeks prior to placement of the initial concrete for all projects. Proceeding with concrete placement prior to approval of the mix design shall be done so at the contractor's risk and expense. The concrete mix designs must have a name or number that can be easily verified on the batch ticket.

Concrete mix design shall include the following, at a minimum:

- Name and location of ready-mix batch plant
- Name or number of specific concrete mix design
- Design 28-day compressive strength of mix
- Cement type
- Fine aggregate type (including gradation report and letter of certification)
- Coarse aggregate type (including gradation report and letter of certification)
- Fly ash type (including letter of certification)
- All admixture types (including product data sheets)
- Weight of cement in mix
- Weight of fine aggregate in mix
- Weight of coarse aggregate in mix
- Weight of fly ash in mix
- Weight of silica fume in mix
- Weight of blast furnace slag in mix
- Weight of water in mix
- Design slump
- Design air content
- Compressive strength data from past use or trial batch

NOTE: If a hydration stabilizer admixture is to be used, a separate mix design including that admixture shall be submitted to the Project Civil/Structural Engineer for approval prior to use.

C. Reinforcing Steel Shop Drawings

Submit rebar shop drawings to Project Civil/Structural Engineer for review and approval. Drawings must be submitted a minimum of five working days prior to fabrication of the reinforcing steel. If the shop drawings do not comply with project drawings and specifications, the contractor will be required to make changes prior to commencement of fabrication.

Reinforcing Steel Shop Drawings shall include the following, at a minimum:

- Specific designation for each foundation type, per project drawings
- Size, quantity, and length of all bar types to be utilized in each foundation type
- Spacing of tie bars
- Dimensions of all bar hooks and bends
- Dimensions of all bar laps
- Details of all proposed bar splices
- Concrete cover dimension on all surfaces

D. Embedded Steel

Shop drawings for all embedded steel supplied by the contractor must be submitted a minimum of five working days prior to fabrication.

1.07 Quality Control

A. Construction Verification

The Contractor shall verify that the following conditions are per the project construction drawings and specifications (minimum):

- Anchor bolt diameter, length, arrangement, thread length, embedment, and projection
- Foundation and anchor bolt centerline locations and orientation
- Foundation dimensions (length, width, depth, diameter, embedment)
- Reinforcing steel size, length, arrangement, and concrete cover
- Top of concrete elevation

B. Batch Ticket Information

Concrete mixed in a batch plant and delivered to the job site via truck must be accompanied with a batch ticket. Concrete must be in accordance with ASTM C94 for Ready-Mixed Concrete. Before concrete can be placed the contractor shall verify that the following information is present on the ticket:

- Name and location of ready-mix batch plant – Ameren or its assigned representative shall be provided with full access to the batch facilities during normal working hours for the purpose of inspecting materials and processes used in the manufacture and delivery of the concrete.
- Serial number of ticket
- Date
- Truck number
- Name of purchaser
- Specific job name
- Specific concrete mix name or number, which must match the submitted mix design name or number
- Volume of concrete
- Time loaded or first mixing of cement
- Maximum amount of water per cubic yard of concrete that can be added in the field per the concrete supplier (if any) and revolutions of mixing drum or mixing time required at maximum rpm required after addition
- Maximum amount of admixtures per cubic yard of concrete that can be added in the field per the concrete supplier (if any) and revolutions of mixing drum or mixing time required at maximum rpm required after addition

Any concrete placed without the Testing Agency or Owner's Representative – Geotechnical Engineer present or without prior consent shall be done so at the contractor's risk and expense. Original copies of all batch tickets shall be submitted by the Contractor to the Testing Agency on a weekly basis. The Testing Agency shall compile all batch tickets into a single pdf file and email to Project Civil/Structural Engineer.

C. Time Limits

Concrete shall be placed within 90 minutes of batching. This time limit may be extended via use of admixture(s) added at the batch plant, but only with prior approval from the Project Civil/Structural Engineer. A letter of approval from the concrete supplier, the proposed set time extension, and the cure-delaying admixture dosage (per CY) shall be required in order to receive Engineer approval. **Field addition of cure-delaying admixtures is not permitted.** Cold joints shall not be allowed to form within a foundation without prior approval from Ameren Construction Supervisor and Ameren Civil Engineer. In the case of a delay between trucks to be placed in the same foundation, workability of the concrete at the interface shall be maintained until the next truck can be placed.

D. Concrete Testing

If required by the Project Civil/Structural Engineer, a Testing Agency will be provided at Ameren's expense* to perform quality control of concrete including testing, cylinder casting, and cylinder pick up. The contractor is responsible for all coordination with the Owner's Representative – Geotechnical Engineer and the Testing Agency. The Contractor shall notify the Testing Agency a minimum of 24 hours prior to placement of concrete.

*Exception: For Customer substations, the Testing Agency may be provided at the Customer's expense per project specification.

In order to verify that concrete meets slump and air requirements prior to placement, Testing Agency shall take preliminary slump and air tests on the first truck to arrive at the site. Additionally, concrete tests must be performed for every 50 cubic yards of concrete placed for substation foundations. For transmission line structure foundations, concrete tests must be performed for every 50 cubic yards of concrete placed but not less than one test per foundation. A minimum of one set of concrete tests must be performed for every day's work. In addition, one set of concrete tests must be performed on the first truck dispatched to a project from each batch plant and on the first load of each new mix design. If required by the Project Civil/Structural Engineer, while the Testing Agency is on site each truck of concrete shall be tested for slump, air and temperature. All test results shall be communicated immediately from the Testing Agency to the Owner's Representative – Geotechnical Engineer. Any results that violate this standard shall be immediately reported to the Ameren Construction Supervisor. The contractor shall attempt to group concrete pours so the amount of travel by the Testing Agency is minimized.

E. Sampling

- Concrete sampling for testing purposes must be in accordance with ASTM C172.
- The elapsed time shall not exceed 15 minutes between obtaining the first and last portion of the composite sample.
- Start tests for slump, temperature, and air content within 5 minutes after obtaining the final portion of the composite sample. Expediently obtain and use the sample and protect the sample from the sun, wind, and other sources of rapid evaporation, and from contamination.
- The procedures used in sampling shall include the use of every precaution that will assist in obtaining samples that are truly representative of the nature and condition of concrete sampled as follows.
- Samples for slump and air testing shall not be taken until after all of the water and any admixtures have been added to the mixer; also do not obtain samples from the very first or last portions of the batch discharge. (NOTE: No samples shall be taken before 10% or after 90% of the batch has been discharged.)
- Samples for test cylinders shall not be taken until all water and admixtures have been added in the field. Field addition of water or admixtures shall be noted on batch ticket and cylinder break reports.
- Samples for test cylinders shall be taken at the truck discharge, which could be different from the point of placement in the case of pumped or other mechanically transported concrete.

F. Testing

- All tests must be performed and cylinders cast by a field technician certified by ACI Field Testing Technicians, Grade I or equivalent. Equivalence must be submitted and approved by the Project Civil/Structural Engineer prior to performing tests.
- Temperature testing must be performed in accordance with ASTM C1064 within five minutes of obtaining the sample.
- Slump test must be performed in accordance with ASTM C143.
- Air content must be tested in accordance with ASTM C173 or ASTM C231.
- All tests must be performed and all cylinders cast from the same sample of concrete.
- Results of all on-site testing shall be reported immediately to the Owner's Representative – Geotechnical Engineer and Contractor.
- If testing shows concrete in violation of this standard, Contractor shall contact concrete supplier for recommendations to bring concrete into spec. If recommendations are not given or recommendations are not successful at bringing concrete within spec, the Contractor shall reject the concrete load or contact the Project Civil/Structural Engineer for recommendations on where or if it can still be used.
- Concrete that does not match the approved mix design shall be rejected, unless approved by Project Civil/Structural Engineer prior to use.

G. Concrete Cylinders

- A minimum of (8) cylinders shall be taken for 6" diameter cylinders. A minimum of (12) cylinders shall be taken for 4" diameter cylinders.
- Cylinders shall be taken in accordance with ASTM C31. All molds for forming cylinders must meet ASTM C470.
- Mold specimens promptly on a level, rigid surface, free of vibration and other disturbances, at a place as near as practicable to the location where they are to be stored.
- Concrete for casting cylinders shall be consolidated via tamping or vibration, per ASTM C31 requirements.
- If specimens cannot be molded at the place where they will receive initial curing, immediately after finishing, move the specimens to an initial curing place for storage.
- Initial Curing: Immediately after molding and finishing, the specimens shall be stored for a period up to 48 hours in a temperature range from 60° to 80° F and in an environment preventing moisture loss from the specimens. Various procedures may be used during the initial curing period to maintain the specified moisture and temperature conditions. An appropriate procedure or combination of procedures shall be used. Shield all specimens from the direct sunlight and, if used, radiant heating devices. The storage temperature shall be controlled by use of heating and cooling devices, as necessary. Record the temperature using a maximum-minimum thermometer.
- Final Curing: Upon completion of initial curing and within 30 minutes after removing the molds, cure specimens with free water maintained on their surfaces at all times at a temperature of $73.5^{\circ} \pm 3.5^{\circ}$ F using water storage tanks or moist rooms, except when capping with sulfur mortar capping compound and immediately prior to testing. When capping with sulfur mortar capping compound, the ends of the cylinder shall be dry enough to preclude the formation of steam or foam pockets under or in the cap larger than 1/4". For a period not to exceed 3 hours immediately prior to test, standard curing temperature is not required, provided free moisture is maintained on the cylinders and ambient temperature is between 68° and 86° F.
- Prior to transporting, cure and protect specimens as required. Specimens shall not be transported until at least 8 hours after initial set.
- Testing Agency shall communicate with contractor to determine an acceptable location for storing cylinders. The contractor is responsible for providing a secured space, electrical power, and access for initial curing of test specimens. The Testing Agency is responsible for providing the on-site curing facility (container) and ensuring that the test specimens are stored at temperatures conforming to ASTM C31.
- A pre-placement meeting between the Construction Supervisor, Testing Agency, and contractor is recommended so that on-site curing of test specimens can be coordinated between all parties.

- If cylinders are moved prior to completion of initial curing, both the field report and the test report must note that cylinders were moved.
- The timing of cylinder breaks shall be as directed by the Project Civil/Structural Engineer for each project. If no direction is given, (2) 6" diameter or (3) 4" diameter cylinders shall be broken at 7 days, 14 days and 28 days. Any remaining cylinders shall be kept at the Testing Agency and broken at 56 days, unless requested otherwise. All cylinders shall be broken in accordance with ASTM C39.
- A strength test shall be the arithmetic average of the strengths of at least two 6"x12" cylinders or at least three 4"x8" cylinders made from the same sample of concrete.
- Strength level of concrete shall be considered acceptable if both of the following criteria are satisfied:
 - Every arithmetic average of any two/three (depending on cylinder diameter) consecutive strength tests equals or exceeds the specified compressive strength.
 - No strength test falls below the specified compressive strength (f_c') by more than 500 psi if the f_c' is ≤ 5000 psi, or by more than $0.10f_c'$ if $f_c' > 5000$ psi.
- If any strength test of standard-cured cylinders falls below f_c' by more than the limit allowed for acceptance, or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to ensure that structural adequacy of the structure is not jeopardized.
- If the likelihood of low-strength concrete is confirmed, tests of cores drilled from the structure(s) in question in accordance with ASTM C42 shall be performed. In such cases, three cores shall be taken for each strength test that falls below f_c' by more than the limit allowed for acceptance.
- Concrete in structure(s) represented by core tests shall be considered adequate if the average of three results is $\geq 0.85f_c'$, and no single result is $< 0.75f_c'$.

H. Testing Agency Submittals

- Field Report: Testing Agency shall produce a field report for each sampling completed. Field reports shall be forwarded to the Project Civil/Structural Engineer at least once per week throughout foundation construction. The field report shall include the following information:
 - Client
 - Report Number
 - Project
 - Date
 - Sketch of general location of test or reference to structure name
 - Concrete supplier
 - Mix design number
 - Design strength
 - Admixtures added in field, name and amount (per concrete supplier's direction)
 - Amount of water added in field (per concrete supplier's direction)
 - Batch ticket number
 - Set Number (Number of sets of cylinders made for a given foundation)
 - Number of cylinders made
 - Time loaded or first mixing of cement (from Batch Ticket)
 - Time cylinders were made
 - Time truck completed discharge
 - Cubic yards of concrete placed at time of tests and total placed for the structure
 - Concrete slump, inches (initial and final)
 - Concrete air content, %
 - Air temperature, °F
 - Concrete temperature, °F
 - Comments regarding deviations from spec
 - Notes regarding special handling (curing, transport, etc.)

- Laboratory Test Report: All concrete strength test results shall be submitted electronically from the Testing Agency to the Project Civil/Structural Engineer, Construction Supervisor, contractor and concrete supplier within 24 hours after breaking the cylinder. If an Excel spreadsheet is the required method of reporting, all cylinders broken for a given project should be included on the same Excel spreadsheet. The reports should be cumulative; the results for 7-day breaks should also be shown on the report submitted for 14-day breaks. The test report submitted must include the following information:
 - Job Name
 - Identification number
 - Location of concrete associated with cylinder (i.e. foundation number or sketch)
 - Summary of initial curing conditions, such as location of curing, type of container utilized, any protection used, maximum and minimum temperatures of the medium surrounding the specimens
 - Date transferred from job site to lab
 - Diameter and length
 - Cross sectional area
 - Air content
 - Slump
 - Maximum load
 - Compressive strength calculated to the nearest 10 psi
 - Type of fracture
 - Defects in either specimen or caps
 - Age of specimen
 - Truck number
 - Batch Ticket number
 - Notes regarding special handling (curing, transport, etc.)

PART 2 - MATERIALS

2.01 Reinforcing Steel

- A. Reinforcing bars shall be deformed bars with yield strength of 60 ksi, in accordance with ASTM A615. Bars shall be marked as follows:
- Point of origin – letter or symbol established as the producer’s mill designation.
 - Size designation – Arabic number corresponding to bar designation number.
 - Type of steel – Letter S indicating that the bar was produced to ASTM Specification A615.
 - Minimum yield designation – For Grade 60 either the number 60 or a single continuous longitudinal line through at least 5 spaces offset from the center of the bar.
- B. Welded wire fabric shall be plain wire in flat sheets with an uncoated finish and in accordance with ASTM A1064.

2.02 Concrete Materials

- A. Cement – Portland Cement Type I or Type II, in accordance with ASTM C150.
- B. Fine Aggregate – In accordance with ASTM C33.

- Gradation:

<u>Sieve Size</u>	<u>Total % Passing, by Weight</u>
3/8"	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 20	40-75
No. 50	5-30
No. 100	0-10

- Fine aggregate shall not have >45% passing any sieve and retained on the next consecutive sieve.
- Matching IDOT aggregate: FA 1 or FA 2.
- Matching MODOT aggregate: Per Specification section 1005, item 1005.2.4.1

C. Coarse Aggregate – In accordance with ASTM C33, size no. 67.

- Gradation:

<u>Sieve Size</u>	<u>Total % Passing, by Weight</u>
1"	100
3/4"	90-100
3/8"	15-45
No. 4	0-10

- Matching IDOT aggregate: CA 11
- Matching MODOT aggregate: Gradation D

D. Mineral Admixtures

- Fly Ash – Shall be class C in accordance with ASTM C618. Class C fly ash may be used up to 35% by weight of cement.
- Silica Fume – Shall be in accordance with ASTM C618. May be used up to 10% by weight of cement.
- Blast Furnace Slag – Shall be in accordance with ASTM C989. May be used up to 50% by weight of cement.
- Mineral admixtures shall not be used in combination unless specifically approved by the Project Civil/Structural Engineer.

E. Water – Must be drinkable and free of any pronounced taste or odor. Water shall not contain a deleterious amount of chloride ion.

F. Air Entrainment Admixture – Shall be in accordance with ASTM C260.

G. Chemical Admixtures – Shall be in accordance with ASTM C494 or ASTM C1017.

H. Hydration Stabilizer Admixture – Shall be in accordance with ASTM C494.

I. Calcium Chloride – SHALL NOT BE USED

J. Cure-Accelerating Admixtures – SHALL NOT BE USED without prior approval from Project Civil/Structural Engineer.

2.03 Concrete Mix

- A. Ready-mixed concrete must be produced in accordance with ASTM C94. Minimum 28-day compressive strength must be 4500 psi unless indicated otherwise on the design drawings.
- B. Water to cementitious material (w/cm) ratio shall not exceed 0.45 by weight. All mineral admixtures (fly ash, silica fume or blast furnace slag) shall be included in the calculation of w/cm ratio.
- C. Nominal maximum size of aggregate shall not exceed $\frac{3}{4}$ ".
- D. Air content shall be 6.50% with a tolerance of $\pm 1.50\%$.
- E. Slump for drilled piers shall be 5 to 9 inches. Slump for all other applications shall be 3 to 6 inches.
- F. Any slump over 6 inches shall be achieved using admixtures, not water.
- G. If air content or slump falls outside the tolerances defined in this specification, contractor shall contact concrete supplier for recommendations to bring concrete into compliance.
- H. Admixtures not listed on approved mix design shall not be added in field without consultation with the concrete supplier and Project Civil/Structural Engineer approval.

2.04 Concrete Forms

The contractor is responsible for the layout, design and construction of formwork. Drawings and calculations for the formwork are required only upon request from the Project Civil/Structural Engineer. Design and construction of formwork shall be in accordance with ACI 347 "Guide to Formwork for Concrete" and ACI 301. Acceptable material for formwork is per ACI 347.

2.05 Concrete Curing

- A. Normal Conditions: Shall be according to ACI 308. Normal conditions are those conditions that do not qualify for hot weather or cold weather, as defined in section 3.05.
- B. Curing material shall be placed immediately after concrete finishing.
- C. Polyethylene film must conform to ASTM C171 with a minimum 4 mil thickness. The film must be clear or white in the summer and black during cold weather to help warm the concrete. The film must be left in place a minimum of 7 days.
- D. Membrane curing compounds must conform to ASTM C309 and be clear or translucent. Curing compounds must be applied to exposed surfaces as soon as practical. However, all exposed surfaces must be treated on the day they were poured. Formed concrete surfaces must be treated when the formwork is removed. Follow all manufacturer's specifications and instructions.

2.06 Concrete Accessories

- A. Bonding agents shall be polymer resin emulsion, latex emulsion, or two component epoxy resin. No bonding agents shall be utilized without prior approval from Project Civil/Structural Engineer.
- B. Form release agents shall be colorless material, which will not stain concrete, absorb moisture or impair natural bonding or color characteristics of coating intended for use on concrete.

PART 3 - EXECUTION

3.01 Formwork Erection

- A. Prior to erection of forms, verify that structure of interest complies with the Project Drawings.
- B. After formwork erection, verify location, lines, levelness or plumbness, and all structure dimensions before proceeding with concrete placement.
- C. All earth formed sides of the structure shall be hand trimmed to prevent loose soil from falling into the excavation during concrete placement.
- D. All formwork shall be installed in accordance with ACI 347 “Guide to Formwork for Concrete”.
- E. Do not apply form release agent to concrete surfaces receiving concrete, special finishes or coatings that may be affected by the release agent.
- F. Coordinate work from all other Project Drawings and specifications to form and set openings, slots, recesses, chases, sleeves, bolts, anchors, conduit, and other inserts.

3.02 Anchor Bolts

- A. Anchor bolts provided by the structural steel vendor will be caged in top and bottom steel setting templates. The bottom template will be tack welded or bolted to the bolts and must remain in place. The top template will be secured between the nuts and should not be cast in the foundation.
- B. Top anchor bolt template shall remain installed on anchor bolts until placement of structure. It is permissible to remove the top template in order to complete surface finishing of the foundation, but the top template shall be immediately replaced and secured following surface finishing.
- C. All other anchor bolts are not typically caged with templates. The contractor is responsible for fabricating a top template out of wood or steel for use in setting the anchor bolts.
- D. All anchor bolts shall be plumbed and secured prior to placement of any concrete.

- E. In the case that the anchor bolts are damaged by the contractor or placed incorrectly during construction, the Construction Supervisor and the Project Civil/Structural Engineer shall be notified immediately. The Construction Supervisor will work with the Project Civil/Structural Engineer to develop an acceptable fix and the anchor bolts will be repaired or replaced at the contractor's expense.
- F. Unless otherwise specified by the Project Civil/Structural Engineer, anchor bolts shall be free of rust, weld slag, mud, oil or other materials that may adversely affect or reduce the bond. All anchor bolts shall be stored on dunnage or a paved surface prior to placement.
- G. Anchor bolt placement tolerances for drilled piers shall be per Ameren Standard No. 02371. All other anchor bolts shall be within 1/4" of the locations specified on Project Drawings.

3.03 Reinforcing Steel Placement

- A. Supplemental reinforcement shall be provided to maintain appropriate shape of rebar cages during transport and handling of rebar cages. Supplemental reinforcement shall not impede freefall or flow of concrete through reinforcing bars.
- B. All reinforcement shall be braced to prevent movement during placement of concrete.
- C. The required concrete cover over reinforcing bars shall be maintained for all structures through use of spacers, chairs, bolsters, etc.
- D. All reinforcement shall be free of mud, concrete splatter, oil or other materials that may adversely affect or reduce the bond. All reinforcement shall be stored on dunnage or a paved surface prior to placement.
- E. Rust, seams, surface irregularities, or mill scale is acceptable provided the weight, dimensions, cross-sectional area and tensile properties of a hand wire brushed test specimen are not less than the requirements of ASTM A615.
- F. Reinforcement shall not be heated for purpose of bending for any reason.
- G. All lap lengths, splices, and development lengths shall conform to ACI 318.

3.04 Existing Concrete

- A. When dowelling into existing concrete or installing adhesive anchors, holes should be drilled out and cleaned per the Project Drawings, adhesive manufacturer's instructions, and all applicable OSHA requirements.
- B. All existing concrete receiving new concrete shall be roughened and treated with a bonding agent prior to placement of new concrete.

3.05 Concrete Placement

- A. Concrete in any single structure shall come from a single batch plant.
- B. Water exceeding 2" in depth should be pumped out of excavation prior to placing concrete. If continuous water infiltration is encountered, Project Civil/Structural Engineer shall be contacted to instruct on the further course of action.
- C. Free fall of concrete is permitted in drilled pier foundations unless rebar or other obstacle impedes movement of the concrete to the bottom of the excavation.
- D. Cold Weather Concrete Placement: Shall be per ACI 306. Cold weather is when the air temperature has fallen to, or is expected to fall below, 40° F during the protection period. The protection period is defined as the amount of time recommended to prevent concrete from being adversely affected by the exposure to cold weather during construction. If these conditions are met or are expected to be met during concrete placement, the contractor shall submit a cold-weather concrete placement & curing plan for approval by the Project Civil/Structural Engineer. The plan shall include proposed methods for one or more of the following: temperature control of concrete prior to placement, use of admixtures to modify curing, protection after placement and during curing, heating of metal embedments (including rebar), as required.
- E. Hot Weather Concrete Placement: Shall be per ACI 305. Hot weather is any combination of high ambient temperature, high concrete temperature, low relative humidity, wind speed, and solar radiation that tends to impair the quality of freshly mixed or hardened concrete by accelerating the rate of moisture loss and rate of cement hydration, or otherwise causing detrimental results. In general, this is any combination of factors that results in an evaporation rate $>0.1 \text{ lb./ft}^2/\text{hr}$. If these conditions are met or are expected to be met during concrete placement, the contractor shall submit a hot-weather concrete placement & curing plan for approval by the Project Civil/Structural Engineer. The plan shall include proposed methods for one or more of the following (as required): temperature control of concrete prior to placement, use of cure-modifying admixtures, protection after placement and during curing.

- F. Concrete shall not be placed during rain, sleet or snow without approval of the Construction Supervisor.
- G. Dry concrete piers shall be vibrated from 3'-0" below the bottom of the anchor bolt cage to the top of concrete.
- H. All concrete placed for slabs, spread footings, retaining walls, cable pits, and cast-in-place stairs shall be vibrated.
- I. All vibration of concrete shall be internal vibration per ACI 309.
- J. Concrete placement must be continuous with no joints unless shown on Project Drawings. If extenuating construction circumstances are encountered, Construction Supervisor may allow construction keys on a case-by-case basis.

3.06 Surface Finishing

- A. Tops of exterior foundations shall have a light broom finish.
- B. All exposed concrete slab edges shall be chamfered $\frac{3}{4}$ " with a 45° bevel.
- C. All exposed concrete pier edges shall be chamfered $\frac{3}{4}$ " with a 45° bevel or finished with a $\frac{3}{4}$ " radius.
- D. Tops of all foundations shall be finished such that no water will be retained on the top surface.
- E. Tops of all foundations shall have a smooth transition to the sides, whether by chamfer or radius. No "lip" shall remain at bottom of chamfer/radius.
- F. Flatwork shall not be crowned.
- G. After forms are removed, any voids, blemishes, or "bug holes" $\frac{1}{2}$ " or larger in any direction shall be patched with an Engineer-approved patching mix. Any cracking of any size shall be reported to the Ameren Construction Supervisor and Project Civil/Structural Engineer immediately.

3.07 Inspection

- A. The Construction Supervisor and Owner's Representative – Geotechnical Engineer must be notified a minimum of 48 hours prior to the placement of concrete.
- B. The Owner's Representative – Geotechnical Engineer shall verify that the following conditions are per the project drawings and specification:
 - Anchor bolt diameter and length
 - Anchor bolt spacing
 - Anchor bolt thread length
 - Anchor bolt projection
 - Foundation and anchor bolt centerline locations
 - Anchor bolt orientation and elevation
 - Reinforcing steel size and spacing
 - Top of concrete elevation
- C. When requested, the contractor must provide one assistant and the necessary equipment for the Construction Supervisor and/or Owner's Representative – Geotechnical Engineer to verify the items listed above. Verification does not release contractor of liability.
- D. The contractor must notify the Testing Agency a minimum of 48 hours prior to placement of concrete.

PART 4 – REVISION SUMMARY

<u>Date</u>	<u>Description</u>
10/12/2005	First Issue
04/22/2013	Issue for Use
12/13/2018	Major revision: added submittal requirements, revised quality control requirements, revised concrete mix requirements (note fly ash, slump, and air), updated execution section, added requirements for hot and cold weather concrete placement, change vibration depth requirement, revised surface finishing requirements, added Appendix A - Schedule of Deliverables
04/01/2019	Reformat Document, Add Revision Summary, & Update Section 1.07
01/05/2021	Revise 1.04, Revise 1.07.C, Add exception to 1.07.D, Revise 3.02.F, Revise 3.03.D, Add 3.06.G

Appendix A

Schedule of Deliverables

Responsible Party	Deliverables	Submitted To	Time Frame
Contractor	Concrete Mix Design(s)	Project Civil/Structural Engineer	At least 2 weeks prior to initial concrete placement
	Reinforcing Steel Shop Drawing(s)		At least 5 working days prior to fabrication
	Embedded Steel Shop Drawing(s)		At least 5 working days prior to fabrication
	Cold-Weather Concreting Plan (as required)		At least 1 week prior to initial concrete placement
	Hot-Weather Concreting Plan (as required)		At least 1 week prior to initial concrete placement
	Batch Tickets	Testing Agency	Weekly during concrete placement
Owner's Representative – Geotechnical Engineer	Field Reports	Project Civil/Structural Engineer	Weekly during construction
	Final Report		At conclusion of construction
Testing Agency	Batch Tickets (pdf format)	Project Civil/Structural Engineer	At conclusion of concrete placement, or as requested
	Results of On-Site Testing	Owner's Representative – Geotechnical Engineer, Contractor	Immediately after performance of testing
	Field Reports	Project Civil/Structural Engineer, Owner's Representative – Geotechnical Engineer	Weekly during concrete placement
	Laboratory Testing Reports	Project Civil/Structural Engineer, Owner's Representative – Geotechnical Engineer, Construction Supervisor, Concrete Supplier	Within 24 hours of performance of concrete cylinder compressive strength tests

STANDARD NO. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE CONTRACTORS

DIVISION 9 – FINISHES

Section 9B – Galvanized Metal Repair



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Rev. No	Date	Revisions	By	Approvals		
0	6-18-15	Initial Issue	DAB	SM	DCB	

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1.0 Introduction

1.1 Purpose

- 1.1.1 The purpose of this document is to provide Ameren Employees and Contractors the requirements for field galvanizing repairs on galvanized steel structures only. This includes but not limited to baseplates, shafts, arms and appurtenances located within the transmission and distribution systems.
- 1.1.2 This procedure references the latest edition of ASTM A 780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.

1.2 Scope

- 1.2.1 ASTM A 780 describes the three acceptable repair procedures; however Ameren Engineering will only allow Ameren Employees and Contractors to use procedure A1. Repair using Zinc-Based Alloys and procedure A2. Repair using Paints Containing Zinc Dust. Ameren Engineering will not allow Ameren Employees and Contractors to use procedure A3. Repair Using Sprayed Zinc (Metallizing) for field repairs.
- 1.2.2 Suppliers performing field work on Ameren property shall use their own repair procedures that are in accordance with ASTM A 780 and that have been pre-approved by Ameren Engineering.

2.0 General Information

2.1 Definitions

- 2.1.1 **Cold Galvanized Repair** - the use of an aerosol or brush application of zinc rich coatings for touch up repair to steel poles.
- 2.1.2 **Hot Stick Repair** – the use of zinc based alloy solders, typically in rod form, for repair of zinc rich coatings in touch up repair to steel poles.

2.2 Acronyms

- 2.2.1 **DFT** – Dry Film Thickness
- 2.2.2 **MAD** – Minimum Approach Distance
- 2.2.3 **SSPC** – Steel Structures Painting Council

3 Safety

3.1 Requirements

- 3.1.1 All work is to be done in accordance with the latest OSHA worker safety requirements and the paint manufacturers or the hot stick manufacturer's instructions and specifications.
- 3.1.2 When working on or around energized equipment check with Ameren's Construction Supervisor to verify all work being done is in accordance with Ameren's Minimum Approach Distance (MAD) requirements.

4 Procedures

4.1 Galvanizing Repair Using Paints Containing Zinc Dust

Paints Containing Zinc Dusts – These are usually based on organic binders, pre-mixed and formulated specifically for use on steel surfaces. Paints containing zinc dust, with concentrations of zinc dust in the range of 65 to 69% or above 92% in the dry film, are considered equally effective for the repair of damaged galvanized coatings.

- 4.1.1 Surfaces to be reconditioned with paint containing zinc dust shall be clean, dry, and free of oil grease, preexisting paint, and corrosion by-products. Apply cold galvanize when the surface and ambient temperature is above 45°F (7°C). Under no circumstances is cold galvanize to be applied to wet or damp surfaces; poor adhesion and ultimate coating failure will result.
- 4.1.2 Clean the surface to bare metal in accordance with SSPC-SP11- Power tool to bare or other method pre-approved by Ameren Engineering. Where circumstances do not allow blast or power tool cleaning, it is permissible to hand tool areas in accordance with SSPC-SP2 hand tool cleaning. To ensure that a smooth reconditioned coating can be effected, surface preparation shall extend a minimum of 1 inch into the undamaged galvanized coating.
- 4.1.3 If the area to be conditioned includes welds, first remove all weld flux residue and weld spatter by mechanical means, such as chipping, grinding, or power scaling, etc.
- 4.1.4 Spray or brush-apply the paints containing zinc to the prepared area. Apply the paint as in accordance with the manufacturer's printed instructions in a single application employing multiple passes to achieve the desired dry film thickness (DFT). The application is to extend into the surrounding undamaged galvanized coatings. The recommended DFT for the sprayed zinc should not be less than 4 mils. Allow adequate curing time before

subjecting repaired items to service conditions in accordance with the manufacturer's printed instructions. Make final inspection to ensure uniform surface profile and dry film thicknesses are met.

- 4.1.5 Take thickness measurements with either a magnetic, electromagnetic, or eddy-current gage to ensure that the applied coating is as specified.
- 4.1.6 Ameren's approved aerosol spray is LPS Cold Galvanize, Ameren Stock Code 3051402. For brush paint use LPS Cold Galvanize and follow manufacture's recommendations. If this product is not available an alternative coating product must be submitted to Ameren Engineering for review and approval.
- 4.1.7 Clean up and disposal shall be per manufacturer's instructions and recommendations.
- 4.1.8 Galvanizing repairs for structural modifications should be documented or reported with a Non Conformance Report (NCR). Galvanizing repairs (touch ups) for any damages to the galvanized surfaces due to shipping, jacking, or erection do not need to be documented or reported.

4.2 Galvanizing Repair Using Zinc Based Solders (Alloys)

Zinc based solders (hot stick) are to be used for repairs. The most common type are zinc-cadmium and zinc-tin-copper alloys, no lead products shall be used. The solders can be used in rod form or as powders.

- 4.2.1 Clean the surface to be reconditioning using wire brush, a light grinding action, or mild blasting. To ensure that a smooth reconditioned coating can be affected, surface preparation shall extend a minimum of 1 inch into the surrounding, undamaged galvanized coating.
- 4.2.2 If the area to be conditioned includes welds, first remove all weld flux residue and weld spatter by mechanical means, such as chipping, grinding, or power scaling, etc.
- 4.2.3 Preheat the cleaned surface to be repaired to at least 600°F (315°C). Do not overheat the surface beyond 750°F (400°C) nor allow the surrounding galvanized coating to be burned.
- 4.2.4 Rub the cleaned, preheated area with the repair stick to deposit an evenly distributed layer of zinc alloy. The application is to extend into the surrounding undamaged galvanized coatings. When powdered zinc alloys are used, sprinkle the powder on the cleaned, preheated surface and spread out with spatula or similar tool.
- 4.2.5 When the repair is completed, remove flux residue by rinsing with water or wiping with a damp cloth.

- 4.2.6 Take thickness measurements with either a magnetic, electromagnetic, or eddy-current gage to ensure that the applied coating is as specified. The recommended DFT should not be less than 4 mils.
- 4.2.7 Galvanizing repairs for structural modifications should be documented or reported with a Non Conformance Report (NCR). Galvanizing repairs (touch ups) for any damages to the galvanized surfaces due to shipping, jacking, or erection do not need to be documented or reported.

SUBSTATION DESIGN

STANDARD No. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 – ELECTRICAL

Section 16B – Insulators & Hardware



JOINT SUBSTATION STANDARD AMEREN TRANSMISSION AMEREN MISSOURI AMEREN ILLINOIS

<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>			
<i>0</i>	<i>12/08/10</i>	<i>Initial Issue</i>	<i>BKS/DEG</i>	<i>FF</i> <i>1-24-11</i>	<i>DJP</i> <i>1-31-11</i>	<i>WJH</i> <i>1-31-11</i>	<i>KDA</i> <i>1-31-11</i>
<i>0</i>	<i>10/18/17</i>	<i>General Revisions</i>	<i>RSN/DAB/PW</i>	<i>RAK</i> <i>2/5/18</i>	<i>DES</i> <i>4/10/18</i>		

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SECTION 16B - INSULATORS AND HARDWARE1.0 WORKMANSHIP1.1 Strain Insulators

1.1.1 When the insulators are installed, the porcelain and metal portions shall be clean and free from dirt or corrosion. Only clean cotton rags shall be used for cleaning purposes. Cracked insulators or insulators with defective ball or socket shall not be installed.

1.1.2 Assemble the insulator strings using the number of bells specified on the construction drawings. If not specified, use the number of bells listed in the following table:

Nominal voltage	Number of bells
15 kV	2
34.5 kV	4
69 kV	6
138 kV	12
161 kV	13
230 kV	15
345 kV	20

1.1.3 Polymer suspension insulators listed in the table below can be substituted for porcelain insulators when specified on the construction drawings:

Nominal voltage	Ultimate Strength (lb)	Stock Code
15 kV	10000	25-06-052
34.5 kV	15000	25-06-053
69 kV	25000	25-06-113

1.1.4 When specified, strain springs for strain bus insulators shall be installed as shown on the construction drawings and per the manufacturer's instructions.

1.2 Bus Support and Switch Insulators

1.2.1 When the insulators are installed they shall be clean and free from dirt and corrosion. Only clean cotton rags shall be used for cleaning purposes. All connection bolts shall be drawn up so that full rated mechanical strength is secured.

1.2.2 Cracked insulators shall not be installed. Insulators found in this condition shall be assembled in a separate group as soon as they are discovered. Subject to the approval of the Engineer, chipped units may be used if the leakage distance, as measured across the chip, has not been reduced more than one inch. An Ameren furnished solution shall be applied to the chipped area of the porcelain. Use stock code #3057044 when ordering. The

Contractor shall be extremely careful in handling, assembling and installing these insulators to prevent damage.

1.3 Insulator Hardware

- 1.3.1 All insulator assemblies and hardware shall be installed as shown on construction or manufacturer drawings for the various conditions and combinations. Hardware shall be kept free from dirt and mud and shall be thoroughly cleaned before cable or tubing is clamped in place.

SUBSTATION DESIGN

STANDARD NO. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16C – General Requirements for Grounding Installation



JOINT SUBSTATION STANDARD AMEREN TRANSMISSION AMEREN MISSOURI AMEREN ILLINOIS

Rev#	Date	Revisions	By	Approvals				
0	2009-12-02	First Issue	AHS MMD	CJB 12/3/09	WJH 12/4/09	KDA 12/4/09		
1	2019-01-23	Added grid testing.	CWB DWD CDG	KSM RAK	FF	DES		

1.0 Purpose

- 1.1 This design guide sets forth all general requirements pertaining to the installation, testing, and commissioning of substation yard grounding associated with Ameren's transmission, bulk, and distribution substations.

2.0 References

- [1] Ameren, *Std 16U- Soil Resistivity Testing*, St. Louis, 2018.
- [2] IEEE, *IEEE Std 80- IEEE Guide for Safety in AC Substation Grounding*, New York, 2013.
- [3] IEEE, *IEEE Std 81- IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System*, New York, 2012.
- [4] IEEE, *National Electrical Safety Code*, 2017.
- [5] IEEE, *IEEE Std 837- IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding*, New York, 2017.
- [6] Ameren, *Std 9G Substation Ground Grids*, St Louis, 2018.

3.0 Definitions

- 3.1 Ground Electrode: A conductor embedded in the earth and used for collecting ground current from or dissipating ground current into the earth. At a substation, the combination of the ground grid conductor and ground rods would be an example of a ground electrode.
- 3.2 Ground Grid: A system of horizontal ground electrodes that consists of a number of interconnected bare conductors buried in the earth.
- 3.3 Ground Mat (Switch Mat): A solid metallic plate or a system of closely spaced bare conductors that are connected to the ground grid and placed at the earth's surface under the insulating rock layer.
- 3.4 Riser: An Ameren term, which the NESC calls the "grounding conductor". It is the conductor that connects equipment, steel structures, fences, etc. to the grounding grid.
- 3.5 Surface Material: A material installed over the soil consisting of, but not limited to rock, or crushed stone, asphalt, or man-made materials.

4.0 Materials

- 4.1 Cable - Bare copper, stranded, soft drawn, ASTM Designation B3, Class A or B stranding, unless otherwise noted on the drawings.
- 4.2 Ground Rods - Copper clad steel core, with copper applied by extrusion process as manufactured by Copperweld Co., copper plated rods as manufactured by ITT Blackburn Co., or equivalent approved by Project Engineer.
- 4.3 Welded Joints – Molds and powder charges for "self-welding" process as manufactured by Cadweld Division of Erico Products Co. or equivalent approved by Project Engineer. Erico's Cadweld Plus system or approved equal should be used. Heavy duty molds shall be used for all connections to the existing ground grid. Because of safety, cost, and installation ease; standard duty molds should be used on all new to new connections (cleaned).
- 4.4 Swage Underground Connectors - Tooling and connectors for "high compression" process as manufactured by DMC Power or equivalent approved by Project Engineer should be used. The process uses a hydraulic press to create a high compression connection, fusing the connector and cable together as a cold weld.

- 4.5 Bolted Connectors (For above grade use only) - Copper alloy connectors. Copper alloy bolts and nuts preferred. A 2-bolt ground connector shall be used for electrical connections to bond risers to structures or extend a riser that is too short to reach the intended equipment. A 1-bolt ground connector should be used as a mechanical connection for routing risers to equipment. All ground connectors must have passed tests per IEEE Std. 837 and installed per manufacturers' instructions.

5.0 Workmanship

5.1 General:

- 5.1.1 Grounding – See construction specification section Scope of Work and associated construction drawings for additional requirements.
- 5.1.2 Unload and install all sub-surface ground rods, ground grid, switch ground mats and risers as shown on the Grounding Plan and Grounding Details drawings. This includes connecting risers to steel, fence posts and equipment and drilling holes if required. Install all necessary ground risers to outdoor equipment including switches, breakers, power transformer/s, arresters, CCVT's, etc.
- 5.1.3 Bury ground wire directly in earth at depth specified on drawings. Typically 2 feet below bottom of the rock layer.
- 5.1.4 Ground rods are buried at a minimum 10 feet deep in earth with their highest point being 2 feet below bottom of the rock layer. Notify Company Construction Supervisor if obstructions are encountered that prevent full-depth penetration.

5.2 Ground Connections:

- 5.2.1 All ground connections shall be bonded to the grid using acceptable methods and pass the test outline herein.
- 5.2.2 Welded joints shall be installed in accordance with instructions of manufacturer of molds and welding charges. Joints must be capable of withstanding repeated blows (2-3) with a hammer without rupturing at the weld and pass continuity testing. Contact the Company Construction Supervisor before covering below grade joints with earth so that inspection may occur as desired by the Company Construction Supervisor.
- 5.2.3 Compression fittings shall be installed in accordance with instructions of manufacturer of Swage Tool and hydraulic pump. Joints must pass the inspection gauge test and continuity testing. Contact the Company Construction Supervisor before covering below grade joints with earth so that inspection may occur as desired by the Company Construction Supervisor.
- 5.3 A continuity test shall be performed anytime additions or work is being performed on the ground grid to establish grid integrity. Commissioning testing shall be performed following new grid installations and major grid additions, or removals to reestablish a grid mat resistance determination.

5.4 Trenching and Back-filling:

- 5.4.1 Associated with new switchyard/substation sites/areas, the installation of the grounding grid requires trenching over portions of the whole switchyard or substation. It is imperative that trenching be done using only trenchers or equipment of the appropriate width to minimize disruption to the existing grade. Backhoe equipment is not allowed for trenching unless specifically authorized by Company Construction Supervisor.
- 5.4.2 See Division 2, Standard 02225 for trenching requirements.

- 5.4.3 Associated with work within existing switchyards and existing substations, only “soft dig” or “hand dig” excavation techniques are allowed, unless specifically authorized by Company Construction Supervisor. Ground penetrating radar (GPR) or other sub-surface locating methods may be utilized, if approved by the Company Construction Supervisor, to reduce the amount of soft digging or hand digging.
- 5.4.4 See Division 2, Standard 02225 for excavation requirements.
- 5.4.5 To minimize rain damage to the yard, trenching shall be completed as expeditiously as possible. Trenches shall be back-filled as soon as the grounding conductor has been laid and testing has been documented. Rock and/or sand are not acceptable as backfill material. Back-filled trenches shall be compacted by mechanical means to prevent future settlement.
- 5.4.6 See Division 2, Standard 02223 for back-filling requirements.

6.0 Ground Continuity Test

- 6.1.1 Ground continuity measurement are preformed to verify the adequacy of a newly installed ground connections and to reconfirm its condition periodically. The purpose of this test is to verify that a proper ground connection has been installed and has been maintained throughout its service life.
- 6.1.2 All ground connections shall be tested and documented by the installer using continuity testing and have a resistance less than 1.000 ohm measured to the milliohm, before being covered. This applies to all new additions to the grounding system and older risers if grid is to be verified at the engineers request.
 - 6.1.2.1 Approved Testing equipment are the following:
 - SGM-** Advanced Grounding Concepts Smart Ground Meter
 - Amprobe MO-**100 Milliohm Meter
 - Fluke 1625**
 - 6.1.2.2 Equipment used in testing shall be calibrated within one (1) year prior to the test. Proof of calibration date is to be submitted with the report.
- 6.1.3 New connections that do not pass will be re-installed at the installer's expense.
- 6.1.4 Existing risers that do not pass shall be repaired. Notify the Project Engineer and Company Construction Supervisor for next steps.
- 6.1.5 A marked up ground layout drawing showing connection locations shall be included in the test report given to the Project Engineer and Company Construction Supervisor. See Figure 1
 - 6.1.5.1 A table showing joint locations and values achieved shall be included in the test report given to the Project Engineer and Company Construction Supervisor. See Table 1.

7.0 Ground Grid Commission Test

- 7.1 The Ground Grid Commissioning Test is done to provide an estimate of the ground potential rise of the ground electrode. This test data will be compared to modeled data to give the final assurance that the installed grid will limit the surface voltage gradients to tolerable values.
- 7.2 The ground grids shall be tested in accordance with IEEE standards 80 and 81 upon completion of below grade construction of new switchyard/substation sites/areas or as specified by construction specification. 05

7.2.1 All ground grids shall be tested using approved methods and equipment outlined by the company and construction supervision. Any deviations require written approval from the Project Engineer and shall be documented in the report.

7.2.1.1 Approved Testing Methods are the following:

Fall of potential
Computer Based Multi-meter (SGM)
Current Injection Method

All other methods require written approval from the Project Engineer and shall be documented in the report.

Note: If there is an existing ground grid, the baseline resistance must be established first by the above testing methods. Resistivity can then be back calculated by the Project Engineer to verify the design criteria has been met. See Ameren Standard 9G.

7.2.1.2 Approved Testing equipment are the following:

SGM- Advanced Grounding Concepts Smart Ground Meter
Aemec 3640 with frequency rejection
Fluke 1625-2 Ground Test Set

All other equipment require written approval from the Project Engineer and shall be documented in the report.

7.2.1.3 Equipment used in testing shall be calibrated within one (1) year prior to the test. Proof of calibration date is to be submitted with the report.

Note: The equipment to be used for commissioning the grid shall be of nature that rejects the harmonics and uses frequency between 12 and 30 Hz or out of the harmonics range to avoid noise in the results.

7.3 Testing should be completed after grid has been completed and back-filled.

7.4 Testing should be done out to a minimum of two times the longest diagonal of the substation, as can be seen in Figure 2.

7.4.1 If testing distances cannot be achieved Project Engineer shall be consulted on appropriate solutions.

7.5 If the test cannot be performed due to field conditions, the Company Construction Supervisor and Project Engineer shall be notified and testing rescheduled. Testing can be rescheduled due to the following field conditions or as determined by the Project Engineer or Inspector:

- Wet soil conditions-greater than or equal to 50% moisture content
- Field found soil impediments
- Previously unknown rocky soil or pavement in location
- Inclement weather

7.6 Maximum tested value for the grid shall not exceed 0.5 ohm or within 10% above the computed value by the project engineer. Consult the Project Engineer if test values are above these values.

7.7 Testing report similar to one shown in Figure 2 below must be submitted to and verified by the project engineer prior to demobilization.

7.7.1 Testing report shall include a .KMZ or .pdf of testing locations. See Figure 1.

8.0 Appendix

Table 1: Continuity Test Result Example

Continuity Test Results			
Joint Number	Value	Joint Number	Value
1	0.015	11	0.018
2	0.026	12	0.018
3	0.025	13	0.018
4	0.024	14	0.037
5	0.027	15	0.052
6	0.028	16	0.017
7	0.018	17	0.019
8	0.018	18	0.031
9	0.018	19	0.023
10	0.019	20	0.028

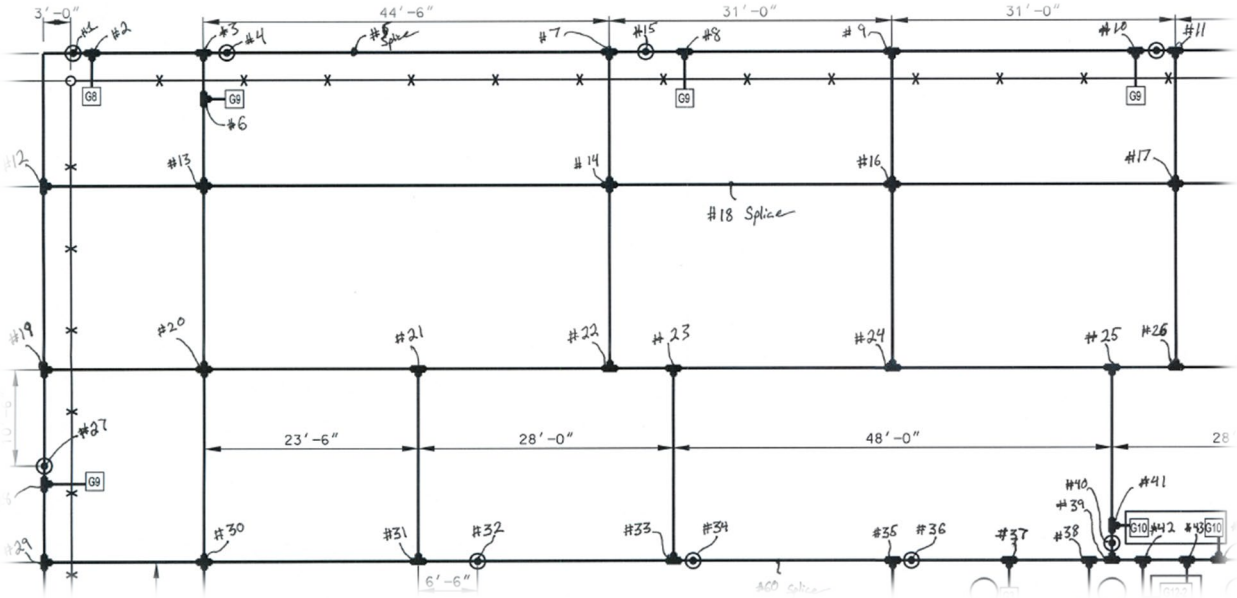


Figure 1: Example of Layout Mark Up

**Ameren Substations
 Final Ground Test**

Location: _____

Date: _____

<p>Substation Dimension: Long side = _____ Short side = _____ Area of Substation = _____ Diagonal Distance = _____</p> <p>Circle the row in the table below for the C2 and P2 distances used during the test.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="4">Guide to Approximate Location of Reference Probes</th> </tr> <tr> <th>Diagonal Distance (Feet)</th> <th>C2 Distance (Feet)</th> <th>P2 Starting Point from P1 (Feet)</th> <th>P2 Increment Distance (Feet)</th> </tr> </thead> <tbody> <tr><td>20</td><td>220</td><td>60</td><td>20</td></tr> <tr><td>40</td><td>320</td><td>80</td><td>30</td></tr> <tr><td>60</td><td>390</td><td>100</td><td>35</td></tr> <tr><td>80</td><td>450</td><td>120</td><td>40</td></tr> <tr><td>100</td><td>500</td><td>130</td><td>45</td></tr> <tr><td>120</td><td>550</td><td>140</td><td>50</td></tr> <tr><td>140</td><td>590</td><td>165</td><td>50</td></tr> <tr><td>160</td><td>640</td><td>180</td><td>55</td></tr> <tr><td>180</td><td>680</td><td>180</td><td>60</td></tr> <tr><td>200</td><td>710</td><td>200</td><td>60</td></tr> <tr><td>250</td><td>810</td><td>220</td><td>70</td></tr> <tr><td>300</td><td>900</td><td>240</td><td>80</td></tr> <tr><td>350</td><td>980</td><td>270</td><td>85</td></tr> </tbody> </table>	Guide to Approximate Location of Reference Probes				Diagonal Distance (Feet)	C2 Distance (Feet)	P2 Starting Point from P1 (Feet)	P2 Increment Distance (Feet)	20	220	60	20	40	320	80	30	60	390	100	35	80	450	120	40	100	500	130	45	120	550	140	50	140	590	165	50	160	640	180	55	180	680	180	60	200	710	200	60	250	810	220	70	300	900	240	80	350	980	270	85	<p align="center"><u>Formula for Area & Diagonal Distance</u></p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p>Area = Longside X Shortside</p> <p>Diagonal Distance = $\sqrt{(\text{Longside})^2 + (\text{Shortside})^2}$</p> </div> <div style="border: 1px solid black; height: 150px; margin: 5px 0;"> <p align="center">SKETCH</p> </div> <p>Example: St. Ann Substation measures 60' x 90'. The diagonal distance = 108'. Use 100' line on the chart, C2 = 500'. The first measurement for P2 is made 130' from P1. The second measurement is made 45' farther or 175' from P1. A total of 8 measurements are made. Record the results in the table below. Note: C2 = 1000' will be used whenever possible and P2 distances for a diagonal of 350' will be used per above chart.</p> <p>In general P2 and C2 should be placed in the same direction. If a stable reading cannot be obtained due to interference, then try selecting a direction for P2 such that the C2 to P2 angle is between 90 and 270 degrees and repeat the test.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>P2 Distance</th> <th>Interference Voltage U_{ST} (typ. > 1 V)</th> <th>Ground Resistance R_E</th> <th>Freq. of Volt. F_M</th> <th>Resistance of C2 Connection R_H (typ. 0.1 kΩ)</th> <th>Resistance of P2 Connection R_S (typ. 0.1 kΩ)</th> <th>Type of Soil Top Soil (T) Clay (C) Sand (S) Rock (R) Fill (F)</th> <th>Moisture Content Wet (W) Moist (M) Semi-dry (S) Dry (D)</th> <th>Soil Density Loose (L) Packed (P)</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td><td> </td></tr> </tbody> </table>	P2 Distance	Interference Voltage U_{ST} (typ. > 1 V)	Ground Resistance R_E	Freq. of Volt. F_M	Resistance of C2 Connection R_H (typ. 0.1 kΩ)	Resistance of P2 Connection R_S (typ. 0.1 kΩ)	Type of Soil Top Soil (T) Clay (C) Sand (S) Rock (R) Fill (F)	Moisture Content Wet (W) Moist (M) Semi-dry (S) Dry (D)	Soil Density Loose (L) Packed (P)																																																															
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Typical Ground Resistances should be <0.5Ω or +10% of Modeled Value

15-Jan

ATX - 22

Tester: _____

Supervisor: _____

Figure 2: Example of Ground Grid Commissioning Test Form

SUBSTATION DESIGN

STANDARD No. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 – ELECTRICAL

Section 16D – Control Conduit, Precast Cable Tray, and PVC Solid Wall Sewer Pipe



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>		
0	04/28/09	Original Issue	J. Williamson 4/28/09	CJB 4/28/09	WJH 5/5/09	KDA 5/13/09
1	11/02/17	2017 Update	N. Roach 11/02/17	RAK 1/9/18	DES 1/16/18	

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DIVISION 16 – ELECTRICAL**Section 16D – Control Conduit, Precast Cable Trench, and PVC Solid Wall Sewer Pipe****1.0 General**

1.1 Work Included – Furnish all material, tools, equipment, labor, and supervision to construct and install the underground and in ground facilities as specified and as shown on the construction drawings.

1.2 Related Work

1.2.1 Section 02222 – Excavation

1.2.2 Section 02223 – Backfilling

1.2.3 Section 02225 – Trenching

2.0 Materials

2.1 Control Conduit – PVC type DB, or better, with compatible fittings, accessories, and elbows. Any PVC conduit or PVC elbow that extends above the ground line shall be PCV Sch. 40 or better. Unless otherwise shown on the drawings, or approved by Ameren Construction Supervisor or Ameren Engineer, all vertical elbows shall be 24" radius minimum sweep bends, and all horizontal elbows shall be 36" radius minimum sweep bends as shown on the construction drawings. Detectable tape shall be installed on top of buried conduits to mark all locations of ducts before backfilling.

2.2 Precast cable trench shall be Trenwa, Concast, or Old Castle (Plastibeton) Incorporated modular trench, size as called out on the construction drawings. Lids shall be of lightweight construction HS20 road rated at a minimum.

2.3 PVC solid wall sewer pipe shall be North American Pipe Corporation ASTM D3034 gasketed gravity sewer pipe for sizes 4" through 15" and North American Pipe Corporation ASTM F679 gravity sewer pipe for sizes 18" and larger. Refer to the construction drawings for specific job requirements.

2.4 Pull boxes / junction boxes for PVC solid wall sewer pipe shall be precast concrete and be minimum HS20 road rated. Please reference construction drawings for specific job requirements.

3.0 Execution

3.1 Trenches

- 3.1.1 Trenches shall be 1-6" to 4' deep as required to approach the 90 degree, 24" radius bends along a straight and true line for conduit and to match the manufacturer's recommended exposure above finish grade for cable trench side walls and sewer pipe pull boxes.
- 3.1.2 Trenches shall slope away from the control house at a 0.5% slope; six inches in 100 feet.
- 3.1.3 Protect excavations by shoring, bracing, sheet piling, underpinning, sloping side walls, or other methods, as required, to prevent cave-ins and/or loose soil falling into the trench.
- 3.1.4 Grade the top perimeter of the excavation to prevent surface water run-off into the excavation. Trenches and excavations shall be kept free of water.
- 3.1.5 The trench floor shall be undisturbed or well compacted soil or approved backfill for leveling. The trench floor shall have a constant grade change or be level as applicable.
- 3.1.6 Excavation and backfilling shall conform to other requirements of Sections 02222 and 02223 respectively.

3.2 Control Conduit

- 3.2.1 All control conduits shall be direct buried. Conduit should be covered in sand and detectable tape shall be installed in the cable trench on top of the sand prior to back filling.
- 3.2.2 The conduit runs shall be installed as shown on the drawings. The conduits shall be laid straight and true. Obstructions shall be removed. The minimum cover to finished yard surface shall be no less than 1' - 6".
- 3.2.3 A conduit stubbed for further use shall be cleaned and capped and have a pulling tape installed per 3.2.7.
- 3.2.4 Conduit shall be joined with couplings and PVC cement.
- 3.2.5 Control and power conduits terminating in cabinets, junction boxes, or equipment enclosures shall have duct seal installed to seal conduits after cables are installed.

- 3.2.6 All power cable ducts shall be terminated with a coupling and a removable plug. Ducts which extend or will extend above grade shall be plumb and square and shall be terminated with the bottom of the coupling flush with the foundation's top of concrete.
- 3.2.7 All power cable ducts shall be swabbed clean, have a 2500 pound rated flat pulling tape installed, and be plugged with removable plugs or caps. Ten feet of pulling tape shall extend outside the plug.
- 3.2.8 Excavation, backfilling, and trenching shall conform to other requirements of Sections 02222, 02223, and 02225 respectively.

3.3 Precast Cable Trench

- 3.3.1 Install to the grades and lines as shown on the construction drawings.
- 3.3.2 Framing members shall be set only on firm, compacted earth, sand or gravel mix, at an elevation such that the top of bracket will be at the final grade (top of crushed rock) for the substation.
- 3.3.3 After setting frames and sides in place, place backfill along sides and place a minimum 4" bedding of sand in trench to form a level bottom, just covering the framing members or as recommended by manufacturer's instructions.
- 3.3.4 Protect trenches against entrance of construction debris, rock, and earth during the construction and after placing of the sand bedding. Clean out trenches of any such foreign material prior to placing cables and just before final placing of covers.
- 3.3.5 Excavation and backfilling shall conform to other requirements of Sections 02222 and 02223 respectively.
- 3.3.6 At entrances to hand holes, or buildings, set trench support frame members on brackets provided in foundation construction.
- 3.3.7 Install a 4/0 ground cable in the trench system over its entire length using manufacturer's non-corrosive metal cable clip supported on each framing member. The ground cable shall be periodically bonded to the ground grid where the trench system crosses ground grid runs through the bottom of the trench.

3.3.8 Conduits entering the precast trench system shall be installed as shown on the conduit detail drawing. Conduits should either be laid beneath the sides of the precast trench and enter through the trench floor opening, or should be laid through the side wall of the precast trench at a 90 degree angle at spacing in accordance with manufacturers requirements. Conduits shall be terminated with a bushing or end bell.

3.3.9 Place covers on trenches after installation of cables is completed.

3.4 PVC Solid Wall Sewer Pipe

3.4.1 Install to the grades and lines as shown on the construction drawings.

3.4.2 Maintain a minimum cover of 12" from finished grade over a 12" to 16" pipe. Maintain a minimum cover of 1'-6" from finished grade over 4" to 10" diameter pipe

3.4.3 Pipe shall be placed on a minimum 3" bed of Type A or Type C material or pea gravel to provide continuous support to the pipe.

3.4.4 Fill the trench to the top of the pipe with compacted Type A or Type C material.

3.4.5 For roadway areas where 10" and larger conduits cross the roadway, back fill around and 6" above the pipe with flowable fill.

3.4.6 Complete backfilling in 6" layers with excavated sub soil free of gravel, debris, and organic material. Compact per Backfilling Section 02223.

3.4.7 Cutting, smoothing cut edges, assembly, and joining of pipe sections shall be per the pipe manufacturer's recommendations.

3.4.8 Excavation, backfilling, and trenching shall conform to other requirements of Sections 02222, 02223, and 02225 respectively.

3.5 Pull boxes and Junction Boxes for PVC Solid Wall Sewer Pipe

3.5.1 Install at the locations shown on the construction drawing to the elevation and line shown on the construction drawings.

3.5.2 Compact and level the bottom of the excavation.

3.5.3 Place a 4" to 8" base of washed, compacted Type A material.

- 3.5.4 Place the pull/junction box on the prepared crushed rock base and verify correct elevation and level. Adjust as necessary.
- 3.5.5 Pull boxes shall be road rated with a HS20 minimum rating.
- 3.5.6 Pull boxes shall have venting holes installed in lids to allow trapped gasses to escape.
- 3.5.7 Install conduit and/or PVC sewer pipe at the desired locations. Fill the pull/junction box with Type C material to the bottom of the lowest conduit/pipe.
- 3.5.8 Fill all voids at the joints between the pull/junction box and pipe/conduit with spray foam or cement patching designed for this purpose and suitable for use below grade.
- 3.5.9 Backfill around the pull/junction box in horizontal, evenly distributed, compacted 6" layers covering the full circumference of the area to be filled before the next layer is placed.
- 3.5.10 Backfill with flowable fill, Type A material, or excavated sub soil free of gravel, rocks, debris, and organic material.
- 3.5.11 Excavation, backfilling, and trenching shall conform to other requirements of Sections 02222, 02223, and 02225 respectively.

SUBSTATION DESIGN

STANDARD No. 6-SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16-ELECTRICAL

Section 16E - Aluminum Tube Welding



<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>		
0	11/19/09	Original Issue	A. Newman	DJP 11/19/09	WJH 11/19/09	KDA 11/19/09
1	11/13/18	First rev	J.T. Scott	DJP 11/13/18	LNW 11/13/18	

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SECTION 16E - ALUMINUM TUBE WELDING

1.0 APPROVED WELDING METHODS

- 1.1 Alternating Current Gas Tungsten Arc Welding (GTAW) process (commonly referred to as TIG).
- 1.2 Gas Metal Arc Welding (GMAW) process (commonly referred to as MIG)

2.0 CONTRACTOR FURNISHED MATERIALS

- 2.1 Based on the welding method, equipment shall include necessary cooling water system, nozzles, appropriate electrodes, and high frequency control.
- 2.2 Contractor shall use thorium-free tungsten electrodes.
- 2.3 Filler rod shall be aluminum alloy 4043 unless specified otherwise by the connector or tubing supplier.
- 2.4 Refer to the attached tables for the recommended filler rod diameters when welding pipe to pipe unless otherwise directed by the connector supplier.
- 2.5 Shielding gas shall be welding grade Argon.

3.0 WORKMANSHIP

- 3.1 Welding Operator's Qualifications
The welding process and all welding operators shall be qualified in accordance with Structural Welding Code – Aluminum (AWS D1.2M:2014). Prior to start of any welding, at the Company's discretion, the Contractor shall submit for review and Company approval, Welding Procedure Qualification Records (PQR), Welding Procedure Specification (WPS), and Welder Performance Qualification Records (WPQR) with supporting continuity. (All documents shall conform to AWS D1.2/D1.2M:2014 and AWS B2.1/B2.1M:2014).
- 3.2 Protection from the Elements
Provide a portable enclosure to keep wind, rain and snow from the welding area, when applicable.
- 3.3 Preparation of Material
 - 3.3.1 Prior to assembling joints, remove all grease, dirt and any other foreign material from the mating surfaces using a suitable non-toxic and non-flammable solvent which will not evolve toxic fumes while welding. Solvent shall be applied using lint-free rags.
 - 3.3.2 Remove surface oxides from the joint area with a clean stainless

steel file or stainless steel bristled brush immediately prior to

assembling parts for welding. Iron or brass wire brushes, emery cloth, or other devices which might embed contaminants in the working surface will not be permitted. Do not wipe the weld area or filler rod with gloves, lint-emitting rags or other fibrous material.

- 3.3.3 Before welding, the welding machine settings should be tested by making a test bead on an aluminum test piece. Clamp the fitting in intimate contact with the conductor, tack weld in place and remove Clamps. Tack welds shall have complete root penetration and not exceed 1" in length.¹
- 3.3.4 When welding aluminum tube to aluminum tube the external edges of the tubing shall be beveled in order to obtain complete root penetration. Ameren typically uses pipe with wall thicknesses less than 3/4-in which requires a 37.5 degree bevel as shown in Tables 1-4.
- 3.3.5 All tube to tube butt splices shall be made using cast aluminum inserts such as Anderson Type WCI bus couplers (or equal).
- 3.3.6 Piping components to be joined by butt welding shall be aligned as accurately as practicable within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness. Alignment shall be preserved during welding. The radial off-set of abutting tube inside diameters, to be joined by girth welds shall not exceed 3/32".

3.4 Preheat and Weld

- 3.4.1 Minimum 50 (F) degree preheat is recommended. The maximum preheat and interpass temperature shall not exceed 250°F (120°C).² Most of the castings from connector suppliers are made of 356-T6 aluminum which can only withstand the maximum temperature for a short duration before the casting's mechanical properties are affected.
- 3.4.2 Preheat temperature shall be verified by using temperature sensitive crayons.
- 3.4.3 Weld the joint complete as soon as possible after cleaning and tack welding.
- 3.4.4 All welds shall be made with clean metal and clean filler rods and the finished weld shall be free of pores. The weld shall have complete joint penetration into backing of the joint.
- 3.4.5 When multiple passes are required, wire brush the original weld before proceeding to the next pass.
- 3.4.6 The area of fusion of the weld shall be at least 150% of the conductor cross section. The contour of all welds shall have a

smooth finish and shall indicate good fusion with the parent metal. Weld profiles shall conform to clause 4, Table 5.3, AWS D1.2/D1.2M. Welds shall be free of under-fill, course grooves and ripples, lack of fusion, cold roll, porosity and undercut. For EHV ($\geq 345\text{kV}$) applications, grind and clean the weld as needed to leave a smooth corona free finish.

- 3.4.7 At the discretion of the company, all welds shall be subject to pass a red visible liquid penetrant test (PT). PT shall be unacceptable if the inspection confirms the presence of cracks, lack of fusion, or porosity.

3.5 Repair of Weld Defects

- 3.5.1 Repair areas showing lack of fusion, undercutting, overlapping, cracks and porosity prior to proceeding with the weld. Remove the defective area to clean metal by rotary file or wire brush; plasma cutting will not be permitted. The width of metal removed must be adequate to permit a sound re-welding job.

- 3.5.2 Weld craters and poor blending of the ends of the welds are considered to be defects. Fill all craters, and blend weld terminations.

- 3.5.3 All welds shall have a smooth corona free finish; welds with splatter and craters will not be acceptable. Weld profiles shall conform to Clause 4, Table 5.3, AWS D1.2/D1.2M:2014. Welds shall be free of under fill, course grooves and ripples, lack of fusion, cold roll, porosities and undercut exceeding $1/32"$. All final welds must pass inspection of the Company Construction Supervisor or other Company approved inspector. Contractor shall correct, at its expense, any weld defects found by such inspection.

3.6 Cleaning After Welding

Wire brush and abrade all welded areas to remove any sharp surface irregularities, which may induce corona.

3.7 Control of Weld Quality

- 3.7.1 The Contractor is responsible to provide quality end product. At Company's discretion, Contractor may be required to provide a Certified Welding Inspector (CWI) or Company approved inspector on sight while fit-up and welding operations are in progress. The Contractor is responsible for tracking all welds on a weld joint record. This document shall have, but is not limited to:

A. The date of and results of the fit up inspection. (signed off by

- the Contractor foreman, and CWI if applicable).
- B. The date and results of in-process Visual Testing (VT). (signed off by the Contractor foreman, and CWI if applicable)
 - C. The date and results of a final VT. (signed off by the Contractor foreman, and CWI if applicable)
 - D. Copies of all records shall be available for review by Company at any time, and turned in to Company with as-built submittals.

3.7.2 At the discretion of Company Construction Supervisor, the qualified welding operator may be required to make a sample weld at the job site on a typical fitting connection before starting final welding of bus and fittings. Material for this sample will be furnished by the Company. The sample shall pass the inspection of the Company Construction Supervisor or other Company approved inspector.

3.7.3 Company reserves the right to have x-ray inspection performed by a testing laboratory at its own expense on any welds. Contractor shall correct, at its expense, any defects found by such inspection.

Footnotes

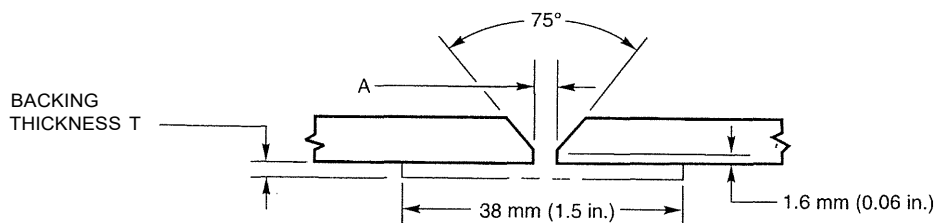
¹ . AWS D10.7M/D10.7:2008 pg. 22

² . AWS D 1.2/D1.2M:2014 Section 4.9

4.0 TABLES

The following tables show several values that should be controlled by the welder. The values shown in the tables provide a good starting point but they may be varied by an experienced welder to obtain the best quality weld. Please note that only schedule 40 pipe is shown on the tables. The contractor is required to adjust the rod diameter, current and number of passes accordingly for schedule 80 pipe.

TABLE 1
Gas Tungsten Arc Welding – Alternating Current in the Flat Position⁵



EDGE PREPARATION

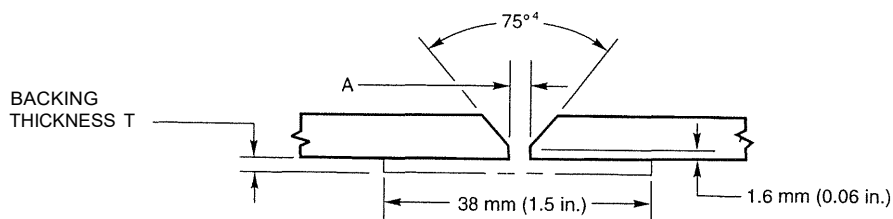
A = 0 FOR NO BACKING RING OR REMOVABLE BACKING RING
A = 6 mm (0.24 in.) MAXIMUM FOR INTEGRAL BACKING RING

Piping Dimensions						Welding Rod Diameter	Approximate Current A-C	Backing Thickness T		Number of Passes ⁴	
Nominal Pipe Diameter		Outside Diameter (OD)		Wall Thickness				amp	mm		(in.)
NPS	Sch.	mm	(in.)	mm	(in.)	mm	(in.)			A=0	
1	40	33.4	(1.31)	3.4	(0.13)	2.4-3.2	(0.094-0.125)	100-115	1.8	(0.07)	1-2
1-1/4	40	42.2	(1.66)	3.6	(0.14)	2.4-3.2	(0.094-0.125)	110-135	1.8	(0.07)	1-2
1-1/2	40	48.3	(1.90)	3.7	(0.14)	2.4-3.2	(0.094-0.125)	115-140	1.8	(0.07)	1-2
2	40	60.3	(2.37)	3.9	(0.15)	2.4-3.2	(0.094-0.125)	125-150	2.4	(0.09)	1-2
2-1/2	40	73.0	(2.87)	5.2	(0.20)	2.4-3.2	(0.094-0.125)	140-180	2.4	(0.09)	2
3	40	88.9	(3.50)	5.5	(0.22)	3.2-4.0	(0.125-0.156)	150-190	2.4	(0.09)	2
3-1/2	40	101.6	(4.00)	5.7	(0.23)	3.2-4.0	(0.125-0.156)	160-200	2.4	(0.09)	2
4	40	114.3	(4.50)	6.0	(0.24)	3.2-4.8	(0.125-0.188)	170-210	3.2	(0.13)	2
5	40	141.3	(5.56)	6.6	(0.26)	4.0-4.8	(0.156-0.188)	190-230	3.2	(0.13)	2
6	40	168.3	(6.63)	7.1	(0.28)	4.0-4.8	(0.156-0.188)	210-250	5.0	(0.20)	2
8	40	219.1	(8.63)	8.2	(0.32)	4.0-4.8	(0.156-0.188)	220-260	5.0	(0.20)	2-3
10	40	273.1	(10.75)	9.3	(0.37)	4.0-4.8	(0.156-0.188)	240-280	5.0	(0.20)	2-3
12	40	323.9	(12.75)	10.3	(0.41)	4.0-4.8	(0.156-0.188)	250-290	5.0	(0.20)	2-3

General Notes:

1. Tungsten electrode diameter is 0.125-in for NPS 1 through 3-1/2-in pipe size and 0.187-in for NPS 4 through 12-in.
2. Gas nozzle orifice diameter is 0.44-in for NPS 1 through 2-1/2-in pipe size and 0.5-in for NPS 2-1/2 through 12-in pipe size.
3. Argon flow rate is 25 to 42 ft³/h
4. More passes are required when A=0.24-in
5. Data in table from AWS D10.7M/D10.7:2000

TABLE 2
Gas Tungsten Arc Welding – Alternating Current in the Horizontal Position⁶



EDGE PREPARATION

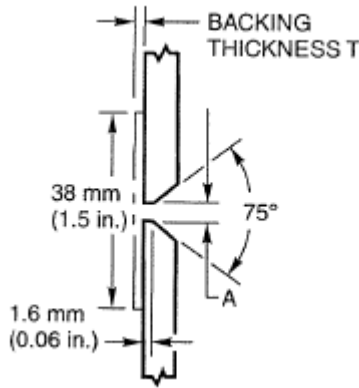
A = 0 FOR NO BACKING RING OR REMOVABLE BACKING RING
A = 6 mm (0.24 in.) MAXIMUM FOR INTEGRAL BACKING RING

Piping Dimensions						Welding Rod Diameter	Approx Current A-C	Argon Flow ⁵		Backing Thickness T	Number of Passes ³		
Nominal Pipe Diameter		Outside Diameter (OD)		Wall Thickness				L./min	(ft ³ /hr)		mm	(in.)	A = 0
NPS	Sch	mm	(in.)	mm	(in.)	mm	(in.)	amp			mm	(in.)	A = 0
1	40	33.4	(1.31)	3.4	(0.13)	2.4-3.2	(0.094-0.125)	90-110	14-40	(30-85)	1.8	(0.07)	1-2
1-1/4	40	42.2	(1.66)	3.6	(0.14)	3.2-4.0	(0.125-0.156)	100-120	14-40	(30-85)	1.8	(0.07)	1-2
1-1/2	40	48.3	(1.90)	3.7	(0.14)	3.2-4.0	(0.125-0.156)	110-130	14-40	(30-85)	1.8	(0.07)	1-2
2	40	60.3	(2.37)	3.9	(0.15)	3.2-4.0	(0.125-0.156)	120-140	14-40	(30-85)	2.4	(0.09)	1-2
2-1/2	40	73.0	(2.87)	5.2	(0.20)	3.2-4.0	(0.125-0.156)	130-150	14-40	(30-85)	2.4	(0.09)	2
3	40	88.9	(3.50)	5.5	(0.22)	3.2-4.0	(0.125-0.156)	145-165	14-40	(30-85)	2.4	(0.09)	2
3-1/2	40	101.6	(4.00)	5.7	(0.23)	3.2-4.8	(0.125-0.188)	150-170	14-40	(30-85)	2.4	(0.09)	2
4	40	114.3	(4.50)	6.0	(0.24)	3.2-4.8	(0.125-0.188)	160-180	15-40	(32-85)	3.2	(0.13)	2
5	40	141.3	(5.56)	6.6	(0.26)	4.0-4.8	(0.156-0.188)	180-190	15-40	(32-85)	3.2	(0.13)	2
6	40	168.3	(6.63)	7.1	(0.28)	4.0-4.8	(0.156-0.188)	195-205	25-40	(53-85)	5	(0.20)	2
8	40	219.1	(8.63)	8.2	(0.32)	4.0-4.8	(0.156-0.188)	210-220	25-40	(53-85)	5	(0.20)	2-3
10	40	273.1	(10.75)	9.3	(0.37)	4.0-4.8	(0.156-0.188)	230-240	25-40	(53-85)	5	(0.20)	2-3
12	40	323.9	(12.75)	10.3	(0.41)	4.0-4.8	(0.156-0.188)	245-255	25-40	(53-85)	5	(0.20)	2-3

General Notes:

1. Tungsten electrode diameter is 0.125-in for NPS 1 through 3-1/2-in pipe size, and 0.187-in for NPS 4 through 12-in pipe size.
2. Gas nozzle orifice diameter is 0.5-in
3. Greater number of passes for bottom 90 degrees of pipe when A=0.24-in
4. 100 degree angle required on bottom 90 degrees of pipe can be applied to full 360 degrees.
5. The higher flow rate is needed for the overhead quadrant
6. Data in table from AWS D10.7M/D10.7:2000

TABLE 3
Gas Tungsten Arc Welding - Alternating Current in the Vertical Position⁵



EDGE PREPARATION

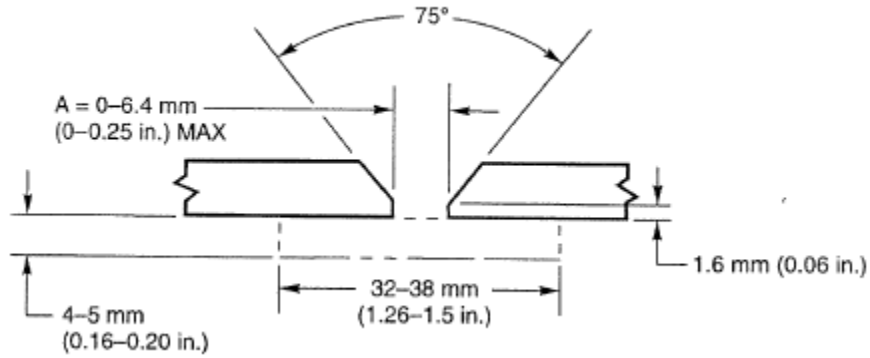
A = 0 FOR NO BACKING RING OR REMOVABLE BACKING RING
A = 6 mm (0.24 in.) MAXIMUM FOR INTEGRAL BACKING RING

Piping Dimensions						Welding Rod Diameter	Approx Current A-C	Argon Flow ⁴		Backing Thickness T	Number of Passes ³		
Nominal Pipe Diameter		Outside Diameter (OD)		Wall Thickness									
NPS	Sc h	mm	(in.)	mm	(in.)	mm	(in.)	amp	L./min	(ft ³ /hr)	mm	(in.)	A = O
1	40	33.4	(1.31)	3.4	(0.13)	2.4-3.2	(0.094-0.125)	95-115	12-40	(25-85)	1.8	(0.07)	1-2
1-1/4	40	42.2	(1.66)	3.6	(0.14)	3.2-4.0	(0.125-0.156)	105-125	12-40	(25-85)	1.8	(0.07)	1-2
1-1/2	40	48.3	(1.90)	3.7	(0.14)	3.2-4.0	(0.125-0.156)	115-135	12-40	(25-85)	1.8	(0.07)	1-2
2	40	60.3	(2.37)	3.9	(0.15)	3.2-4.0	(0.125-0.156)	125-145	15-40	(32-85)	2.4	(0.09)	1-2
2-1/2	40	73.0	(2.87)	5.2	(0.20)	3.2-4.0	(0.125-0.156)	135-155	15-40	(32-85)	2.4	(0.09)	2
3	40	88.9	(3.50)	5.5	(0.22)	3.2-4.0	(0.125-0.156)	150-170	20-40	(42-85)	2.4	(0.09)	2
3-1/2	40	101.6	(4.00)	5.7	(0.23)	3.2-4.8	(0.125-0.156)	155-175	20-40	(42-85)	2.4	(0.09)	2
4	40	114.3	(4.50)	6.0	(0.24)	3.2-4.8	(0.125-0.156)	165-185	20-40	(42-85)	3.2	(0.13)	2
5	40	141.3	(5.56)	6.6	(0.26)	4.0-4.8	(0.156-0.188)	185-195	25-40	(53-85)	3.2	(0.13)	2
6	40	168.3	(6.63)	7.1	(0.28)	4.0-4.8	(0.156-0.188)	200-222	25-40	(53-85)	5	(0.20)	2
8	40	219.1	(8.63)	8.2	(0.32)	4.0-4.8	(0.156-0.188)	215-235	30-40	(64-85)	5	(0.20)	2-3
10	40	273.1	(10.75)	9.3	(0.37)	4.0-4.8	(0.156-0.188)	235-255	30-40	(64-85)	5	(0.20)	2-3
12	40	323.9	(12.75)	10.3	(0.41)	4.0-4.8	(0.156-0.188)	250-270	35-40	(74-85)	5	(0.20)	2-3

General Notes:

1. Tungsten electrode diameter is 0.125-in for NPS 1 through 3-1/2-in pipe size, and 0.187-in for NPS 4 through 12-in pipe size.
2. Gas nozzle orifice diameter is 0.44-in for NPS 1 through 2-1/2-in pipe size and 0.5-in for NPS 3 through 12-in pipe size.
3. Greater number of passes for bottom 90 degrees of pipe when A=0.24-in
4. The higher flow rate is needed for the overhead quadrant
5. Data in table from AWS D10.7M/D10.7:2000

TABLE 4
Gas Metal Arc Welding – In the Horizontal Rolled Position⁴



EDGE PREPARATION

Piping Dimensions						Electrode Diameter	Current DCEP ³	Approximate Argon Flow		Number of Passes ²	
Nominal Pipe Diameter		Outside Diameter (OD)		Wall Thickness				L./min	(ft ³ /hr)		
NPS	Sch.	mm	(in.)	mm	(in.)	mm	(in.)	amp			A=0
4	40	114.3	(4.50)	6.0	(0.24)	1.2	(3/64)	190-210	20	(42)	2
5	40	141.3	(5.56)	6.6	(0.26)	1.2	(3/64)	205-225	20	(42)	2
6	40	168.3	(6.63)	7.1	(0.28)	1.2	(3/64)	215-235	20	(42)	2
8	40	219.1	(8.63)	8.2	(0.32)	1.6	(1/16)	215-235	25	(53)	3
10	40	273.1	(10.75)	9.3	(0.37)	1.6	(1/16)	215-235	25	(53)	3
12	40	323.9	(12.75)	10.3	(0.41)	1.6	(1/16)	240-260	25	(53)	3

General Notes:

1. Root opening=0 for no backing ring or removable backing ring and 0.24-in for permanent backing ring.
2. More passes required when A=0.24-in.
3. DCEP = Direct Current Electrode Positive.
4. Adjust settings accordingly for pipe sizes smaller than 4-inch.
5. Data in table from AWS D10.7M/D10.7:2000

Table 5.3 AWS D1.2/D1.2M

Table 5.3		
Visual Inspection Acceptance Criteria (see 5.14) (Dimensions in inches [mm])		
Issue	Statically Loaded Structures	Cyclically Loaded Structures
Cracks	None	None
Fusion between adjacent layers of weld metal and between weld metal and base metal	Required	Required
Fillet maximum convexity		
Width of Weld Face or Individual Surface Bead	Maximum Convexity	Maximum Convexity
$\leq 5/16$ [8]	$1/16$ [2]	$1/16$ [2]
$> 5/16$ [8] to < 1 [25]	$1/8$ [3]	$1/8$ [3]
≥ 1 [25]	$3/16$ [5]	$3/16$ [5]
Fillet maximum concavity	Throat shall not be underrsize	Throat shall not be underrsize
Craters	Underfilled craters in fillet welds are acceptable	Craters must be filled
Fillet weld maximum underrsize over no more than 10% of the weld length		
Specified Weld Size	Maximum Underrsize	Maximum Underrsize
$\leq 3/16$ [5]	$1/16$ [2]	$1/16$ [2]
$1/4$ [6]	$3/32$ [2.5]	$3/32$ [2.5]
$\geq 5/16$ [8]	$1/8$ [3]	$1/8$ [3]
Groove weld maximum reinforcement		
$t \leq 3/8$ [10]	$3/32$ [2]	$3/32$ [2.5]
$3/8$ [10] $< t \leq 3/4$ [20]	$1/8$ [3]	$1/8$ [3]
$t > 3/4$ [20]	$3/16$ [5]	$3/16$ [5]
Groove welds maximum underfill	None	None
Undercut limits	For material ≤ 1 [25] thick, undercut $< 1/32$ [1] except undercut $< 1/16$ [2] for any cumulative length up to 2 [50] in 12 [300]. For material > 1 [25] thick, undercut $< 1/16$ [2].	No more than 0.01 [0.25] for welds transverse to tensile stress; otherwise no more than 1/32 [1]
Scratch or arc strike maximum depth	Same as undercut	Same as undercut
Surface porosity	Shall not exceed limits given in 5.15.1	Shall not exceed limits given in 5.15.2

REFERENCES

1. Guide for the Gas Shielded Arc Welding of Aluminum and Aluminum Alloy Pipe
American Welding Society D10.7M/D10.7:2008.
2. Structural Welding Code – Aluminum
American Welding Society D1.2/D1.2M:2014.
3. Welding Aluminum Buses and Connectors
Hubbell/Anderson Reference Data- 1/07 (Section ST)
4. Aluminum Welded Connectors Installation Instructions
Sefcor Inc. Revised (2/19/07)

SUBSTATION DESIGN

STANDARD No. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 – ELECTRICAL

Section 16F – Compression, Bolted, and Flat Pad Connections



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>		
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DIVISION 16 - ELECTRICAL

Section 16F – COMPRESSION, BOLTED, and FLAT PAD CONNECTIONS

1.0 Compression Connectors

1.1 Materials and Tools

1.1.1 Joint Compounds:

All compression connector and compression dead end barrels are factory filled with the proper amount and proper type of electrical joint compound. Compound for coating conductors, etc. is normally provided by the connector supplier. Any additional compound required for proper installation shall be provided by the Contractor and shall be one of the following:

- **Alcoa Filler Compound (AFC) or equal:** Use to fill barrels of compression dead-ends, if necessary.
- **Alcoa Alnox or equal:** Use to coat P.G. clamps, terminal pad contact surfaces, and aluminum cables.
- **Alcoa CF-1 or equal:** Use to fill voids in barrels of compression terminal connectors after compression is made; applied through “Zerk” fittings. (Does not have aluminum particles suspended in compound.)

1.1.2 Compression Tools and Dies

1.1.2.1 Use the following table to select the proper and approved compression tools and dies:

COMPRESSION DIE REFERENCE CHART												
CONVENTIONAL COMPRESSION TOOL AND DIE INFORMATION (Information obtained from Anderson Catalog Section SA-33 - Dated 9/01)												
DIE REF.	BURNDY TOOLS & DIES						ANDERSON			ALCOA TOOLS & DIES		
	INDEX	Y34A	Y35	Y48B	Y486RB	Y60B	VC TOOLS	HC-12 (U-DIE)	EP-60S (L-DIE)	12A, 12HA	60A	100A
0.640	243	A243	U243	C243		L243	VC6	HT41DM		B73AH		
0.840	249	A249	U249	C249		L249	VC6	HT41DW		B74AH		
1.000	251	A251	U251	C251	F251	L251	VC6	HT41DY		B75AH		
1.125	316	A316	U316	C316	F316	L316	VC6	HT41FM		B76AH		
1.250	317		U317	C317	F317	L317	VC8	HT41FN	HT6020AH		6020AH	10020AH

COMPRESSION DIE REFERENCE CHART

CONVENTIONAL COMPRESSION TOOL AND DIE INFORMATION (Information obtained from Anderson Catalog Section SA-33 - Dated 9/01)

		BURNDY TOOLS & DIES					ANDERSON			ALCOA TOOLS & DIES		
1.468	261*		U261	C261	F261	L261	VC8	HT41EK	HT6024AH		6024AH	10024AH
1.625	301			C39AR	F39AR	L39ART	VC8	HT41EK	HT6027AH		6027AH	10027AH
1.844	302			C44AR	F44AR	L44ART	VC8		HT6030AH		6030AH	10030AH
2.062	479				F48AR	L48ART			HT6034AH		6034AH	10034AH
2.375	478				F46AR	L46ART			HT6038AH		6038AH	10038AH
2.625												10042AH
2.750												10044AH
2.937	740					L740						10048AH

*Same as 318

Notes:

1. It is recommended that a light coat of lubricant be applied to the crimping face of the dies.

1.1.2.2 Necessary “go-no go” gages and/or micrometers.

1.1.2.3 Stainless steel wire brush

1.2 Workmanship

1.2.1 Compression Connectors and Dead ends:

1.2.1.1 Compression connections to stranded aluminum cable may require either sixty or one hundred ton presses.

1.2.1.2 Unless otherwise advised by the Company in writing, all compression joints shall be made in the presence of the Construction Supervisor/Engineer or other designated Company Representatives; all completed joints shall pass his inspection.

1.2.1.3 The following sections detail the processes of making various types of compression joints; these processes are based on Alcoa’s instructions for their compression connectors. For other manufacturer’s connectors, follow the manufacturer’s instructions furnished with the connectors. The latest methods recommended by the manufacturer shall be used unless they conflict with the Company’s instructions below. Conflicts and/or lack of manufacturer’s instructions shall be referred to the Engineer who shall make the final decision.

1.2.1.3.1 Terminal Connector, Standard Compression:

- a) The cable area which is to be inserted into the connector shall be thoroughly coated with Alnox electrical joint compound and then thoroughly scratch brushed with a stiff, stainless steel, wire brush. Additional Alnox shall be added to re-coat the conductor and to fill all voids between external strands.
- b) The connector terminal barrel depth shall be measured and the conductor shall be marked with a tape collar to indicate the length to be inserted in the connector. This is necessary to insure that the cable has been inserted the full depth.
- c) The amount of compound in the barrel should be sufficient to insure that excess compound will be forced from the barrel after the compression is complete.
- d) Insert the clean, coated conductor until the conductor “bottoms out”. The mark on the conductor should be at the mouth end of the terminal. Entrapped air could indicate a false bottom - rotate terminal with lay of stranding while pushing terminal toward mark on conductor. Verify correct positioning of the terminal connector.
- e) Start compressing with initial compression at the mark indicated by arrow near the pad end of the terminal. Overlap each successive compression 1/3 width of die bite to avoid forming circumferential ridges. Compress to the end of the barrel keeping terminal in same position (do not rotate terminal). Remove flash at die parting line, if any, with file. Clean the excess compound from conductor and terminal
- f) Use the existing tapped hole for 1/8 inch N.P. threads and install pressure type (zerk) fitting at the base of the barrel. Using standard grease gun, pump CF-1 compound into the barrel until the compound is observed coming out between stranding at mouth of barrel. Remove zerk fitting and replace threaded plug which was furnished in the connector. On 345 kV and above file plug smooth.

1.2.1.3.2 Terminal Connector, Reverse Compression:

- a) Use this procedure for jumper terminal assemblies where conductor bird caging might be a problem. The first terminal shall be installed using the standard procedure and the second terminal shall be installed using this reverse compression procedure.

- b) If one terminal of a jumper is to be installed with its barrel pointing upward, this terminal should be the one installed in the standard manner.
- c) The cable area which is to be inserted into the connector shall be thoroughly coated with Alnox electrical joint compound and then thoroughly scratch brushed with a stiff, stainless steel, wire brush. Additional Alnox shall be added to re-coat the conductor and to fill all voids between external strands.
- d) The connector terminal barrel depth shall be measured and the conductor shall be marked with a tape collar to indicate the length to be inserted in the connector. This is necessary to insure that the cable has been inserted the full depth.
- e) The amount of compound in the barrel should be sufficient to insure that excess compound will be forced from the barrel after the compression is complete.
- f) Insert the clean, coated conductor until the conductor “bottoms out”. The mark on the conductor should be at the mouth end of the terminal. Entrapped air could indicate a false bottom - rotate terminal with lay of stranding while pushing terminal toward mark on conductor. Verify correct positioning of the terminal connector.
- g) Start compressing at the mouth or tapered end of the barrel using short bites of 1/3 to 1/2 die bites until the straight section of the barrel is reached. After reaching straight section, 2/3 die bites may be used overlapping the remainder 1/3 width of the bite. The marks indicating the compression area should be observed. Remove flash, if any, from die parting line and wipe away excess compound from conductor and terminal.
- h) Use the existing tapped hole for 1/8 inch N.P. threads and install pressure type (zerk) fitting at the base of the barrel. Using standard grease gun, pump CF-1 compound into the barrel until the compound is observed coming out between stranding at mouth of barrel. Remove zerk fitting and replace threaded plug which was furnished in the connector. On 345 kV and above file plug smooth.

1.2.1.3.3 Compression Dead Ends:

- a) The steel portion (eye or clevis) can be compressed to the aluminum body before compressing the conductor. Liberally coat the steel shank with Alcoa AFC filler compound and insert forging into the tongue

end of the aluminum dead-end body. Align eye or clevis to the desired position, in relation to the tongue, when the dead end is fastened to the insulator hardware. Make one initial compression over the steel forging starting at the mark indicated by the arrow near the tongue end. This initial compression will extrude the aluminum body against the non-metallic seal around the steel shank. This provides a seal between steel and aluminum portions. It also attaches the steel shank to the aluminum body.

- b) Measure the barrel depth and mark the conductor with a tape collar to indicate the length of conductor to be inserted into the barrel.
- c) The cable area which is to be inserted into the dead end barrel shall be thoroughly coated with Alnox electrical joint compound and then thoroughly scratch brushed with a stiff, stainless steel, wire brush. Additional Alnox shall be added to re-coat the conductor and to fill all voids between external strands.
- d) Insert the clean, coated conductor until the conductor “bottoms out”. The mark on the conductor should be at the mouth end of the terminal. Entrapped air could indicate a false bottom - rotate terminal with lay of stranding while pushing terminal toward mark on conductor. Verify correct positioning of the compression connector.
- e) Compressions shall begin at the closed end of the terminal barrel and proceed toward the “mouth” of the fitting. Compressions should be sufficiently overlapped to avoid the formation of ridges between adjacent compressions. Remove flash, if any, from die parting line and wipe away excess compound from conductor and terminal.
- f) OR Start compressing with initial compression at the mark indicated by arrow near the closed end of barrel. Overlap each successive compression 1/3 width of die bite to avoid forming circumferential ridges. Compress to the end of the barrel keeping the barrel in same position (do not rotate terminal). Remove flash at die parting line, if any, with file. Clean the excess compound from conductor and terminal
- g) For short span buses where conductor bird caging might be a problem, use the reverse compression procedure described in s 1.2.1.3.2. If one dead end is to be installed with its barrel pointing upward, this dead end should be the one installed in the standard manner.
- h) It is recommended that the outside dimensions of completed splices and dead ends be checked with a go/no-go gauge or micrometer to verify that the compression meets specifications. This check will also

confirm that the dies are not worn and that the dies have closed properly.

2.0 **Bolted Aluminum Bus Connections**

2.1 Materials and Tools

- 2.1.1 Alcoa Alnox or equal: Use to coat P.G. clamps, bolted aluminum connectors, and aluminum conductors.
- 2.1.2 Calibrated torque wrench
- 2.1.3 Stainless steel wire brush

2.2 Workmanship

- 2.2.1 Follow the manufacturer's instructions furnished with the connectors. Lacking manufacturer's instructions, contact the Engineer to confirm if the following instructions should be followed or if special instructions are needed.
- 2.2.2 The contact surface of the bus and the connector shall be thoroughly coated with Alnox then thoroughly scratch brushed with a stiff, stainless steel, wire brush. Additional compound shall then be added to re-coat the contact surfaces.
- 2.2.3 Position and align the connector on the bus as required. Avoid getting any Alnox on the clamping bolt threads because it affects proper nut/bolt torque values. Whenever possible, the bolt head should point downward with the connector in its final position.

SLOWLY TURN AND FINGER TIGHTEN THE NUTS TO PREVENT GALLING OF HARDWARE.

- 2.2.4 Using a torque wrench, alternately and evenly (using a crisscross pattern) tighten the clamping hardware **nuts** to the following values: values are for non-lubricated, aluminum, and stainless steel hardware.

2.2.5

Bolt Diameter	Recommended Torque for Aluminum Hardware (LB-IN)	Recommended Torque for SS Hardware (LB-IN)
3/8"	168	240
1/2"	300	480
5/8"	480	660
3/4"	720	840

- 2.2.6 Wipe away excess Alnox leaving a small bead at the bus - connector interface as a moisture seal.

3.0 Stranded Aluminum Wire to Aluminum Bolted Connectors

3.1 Materials and Tools

- 3.1.1 Alcoa Alnox or equal
- 3.1.2 Stainless steel wire brush
- 3.1.3 Calibrated torque wrench

3.2 Workmanship

- 3.2.1 Cut the conductor off beyond any damaged or missing strands.
- 3.2.2 The cable length which is to be inserted into the connector and the connector contact surface area shall be thoroughly coated with Alnox electrical joint compound and then thoroughly scratch brushed with a stiff, stainless steel, wire brush. Additional compound shall then be added to re-coat the connector and the conductor (fill all voids between external strands).
- 3.2.3 Assemble the connector being careful not to get any Alnox on the clamping hardware because it affects clamping hardware torque. Whenever possible, the bolt head should point downward with the connector in its final position.
- 3.2.4 Cable stranding shall be held tight with bands of tape (outside the conductor-connector contact area) while the connection is being made. Loose strands, if any, shall be worked down to the cable ends before inserting the cable in the connector.
- 3.2.5 Finger tighten the clamping hardware nuts. Turn the nuts slowly, **do not spin the nuts,** to avoid galling the stainless steel clamping hardware.
- 3.2.6 Using a torque wrench, alternately and evenly (using a crisscross pattern) tighten the clamping hardware **nuts** to the following values (values are for non-lubricated aluminum or stainless steel clamping hardware):

Bolt Diameter	Recommended Torque for Aluminum Hardware (LB-IN)	Recommended Torque for SS Hardware (LB-IN)
3/8"	168	240
1/2"	300	480
5/8"	480	660
3/4"	720	840

- 3.2.7 Wipe away excess Alnox leaving a bead at the connector-conductor interface as a moisture seal.

4.0 Stranded Copper Wire to Silicon Bronze Bolted Connectors

4.1 Materials and Tools

- 4.1.1 NO-OX-ID "A-Special" or equal
- 4.1.2 Stainless steel wire brush
- 4.1.3 Stainless steel, steel wool
- 4.1.4 Calibrated torque wrench

4.2 Workmanship

- 4.2.1 Cut the conductor off beyond any damaged or missing strands.
- 4.2.2 Clean the length of conductor to be inserted into the connector and the connector contact surface area with a stainless steel wire brush or stainless steel, steel wool to obtain perfectly bright, clean surfaces.
- 4.2.3 Apply a light coat of NO-OX-ID "A-Special" to the cleaned conductor and the connector.
- 4.2.4 Assemble the connector being careful not to get any NO-OX-ID "A-Special" on the clamping hardware because it affects clamping hardware torque. Whenever possible, the bolt head should point downward with the connector in its final position.
- 4.2.5 Cable stranding shall be held tight with bands of tape (outside the conductor-connector contact area) while the connection is being made. Loose strands, if any, shall be worked down to the cable ends before inserting the cable in the

connector.

- 4.2.6 Tighten the clamping hardware nuts with fingers.
- 4.2.7 Using a torque wrench, alternately and evenly (using a crisscross pattern) tighten the **nuts** to the following values:

Bolt Diameter	Recommended Torque for Silicon Bronze Hardware (LB-IN)
3/8"	240
1/2"	480
5/8"	660
3/4"	840

- 4.2.8 Wipe away excess NO-OX-ID "A-Special".

5.0 Flat Pad to Flat Pad Bolted Electrical Connections

5.1 Materials and Tools

- 5.1.1 Alcoa Alnox or equal
- 5.1.2 NO-OX-ID "A-Special" or equal
- 5.1.3 Stainless steel, steel wool
- 5.1.4 Stainless steel wire brush
- 5.1.5 Calibrated torque wrench

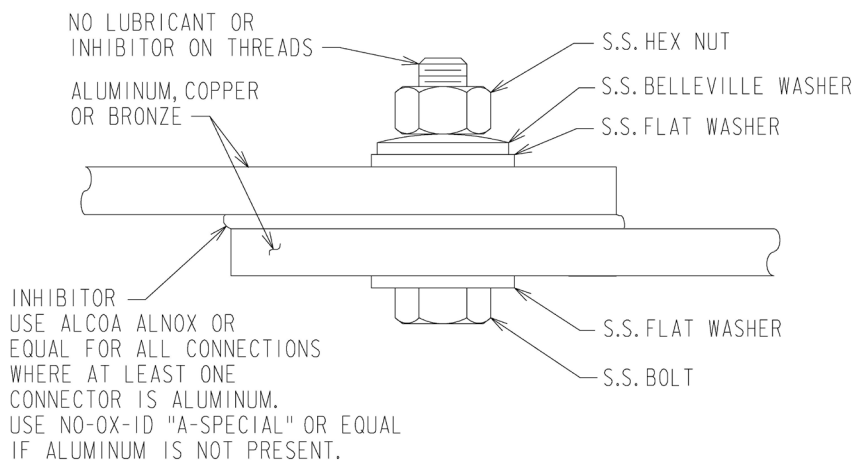
5.2 Workmanship

- 5.2.1 All flat pad to flat pad bolted electrical connections (aluminum to aluminum, aluminum to copper/bronze, aluminum to tinned copper/bronze, copper/bronze to copper/bronze, and copper/bronze to tinned copper/bronze) shall be made using the proper number of stainless steel bolts for the application. Each bolt assembly will consist of a stainless steel bolt, 2 stainless steel flat washers, one stainless steel Belleville washer, and one stainless steel nut. When required for 230 kV or 345 kV applications, hardware corona shields shall be installed. See Figure 1 and table A below for typical flat pad to flat pad bolted connections

FIG. 1.

TYPICAL FLAT PAD TO FLAT PAD BOLTED ELECTRICAL CONNECTIONS

HARDWARE: ALL STAINLESS STEEL (S.S.)



NOTE: FOR ALUMINUM TO COPPER/BRONZE OR TINNED COPPER/BRONZE CONNECTIONS, ALWAYS PLACE ALUMINUM PAD ON TOP TO PREVENT CORROSION OF ALUMINUM BY COPPER SALTS.

TABLE A

TORQUE VALUES FOR BOLTED FLAT PAD ELECTRICAL CONNECTIONS

BOLT DIAMETER	TORQUE	
	LB.-FT.	LB.-INCHES
$\frac{3}{8}$ "	20	240
$\frac{1}{2}$ "	40	480
$\frac{5}{8}$ "	55	660
$\frac{3}{4}$ "	70	840

TORQUE VALUES FOR NON-LUBRICATED S.S. HARDWARE.

5.2.2 Aluminum to Aluminum connections

5.2.2.1 Liberally apply Alnox inhibitor to all contact surfaces. Thoroughly abrade the surfaces through the inhibitor with a stainless steel wire brush. Apply additional inhibitor to all contact surfaces.

5.2.2.2 Assemble the connection being careful not to get any Alnox on the bolt threads because it affects bolt/nut torque. Whenever possible, the bolt head should point downward and the Belleville washer and nut should be on top of the connection with the connection in its final position.

5.2.2.3 Tighten the nuts with fingers. Turn the nuts slowly; to avoid galling the stainless steel hardware **do not spin the nuts.**

5.2.2.4 Using a torque wrench, alternately and evenly (using a crisscross pattern) tighten the **nuts** to the following values (values are for non-lubricated stainless steel hardware):

Bolt Diameter	Recommended Torque for Stainless Steel Hardware (LB-IN)
3/8"	240
1/2"	480
5/8"	660
3/4"	840

Make sure the Belleville washers do not flatten out

5.2.2.5 Wipe away excess Alnox leaving a bead at the connector interface as a moisture seal.

5.2.3 Aluminum to Copper/Bronze or Tinned Copper/Bronze Connections

NOTE: COPPER/BRONZE TERMINAL MUST BE ON THE BOTTOM TO AVOID ALUMINUM CORROSION BY COPPER SALTS

5.2.3.1 Liberally apply Alnox inhibitor to the aluminum contact surfaces. Thoroughly abrade the aluminum contact surfaces through the inhibitor with a stainless steel wire brush. Apply additional inhibitor to the aluminum contact surfaces.

5.2.3.2 Polish the copper/bronze, tinned or un-tinned, contact surfaces to a bright shine with stainless steel, steel wool and coat the surface with Alnox.

- 5.2.3.3 Assemble the connection being careful not to get any Alnox on the bolt threads because it affects bolt/nut torque. Whenever possible, the bolt head should point downward and the Belleville washer and nut should be on top with the connection in its final position.
- 5.2.3.4 Finger tighten the nuts. Turn the nuts slowly; to avoid galling the stainless steel hardware, **do not spin the nuts.**
- 5.2.3.5 Using a torque wrench, alternately and evenly (using a crisscross pattern) tighten the **nuts** to the following values (values are for non-lubricated stainless steel hardware):

Bolt Diameter	Recommended Torque for SS Hardware (LB-IN)
3/8"	240
1/2"	480
5/8"	660
3/4"	840

Make sure the Belleville washers do not flatten out

- 5.2.3.6 Wipe away excess Alnox leaving a bead at the connector interface as a moisture seal.
- 5.2.4 Copper/Bronze to Copper/Bronze, or Tinned Copper/Bronze Connections:
- 5.2.4.1 Polish copper/bronze contact surfaces to a bright shine with stainless steel, steel wool and coat the surface with NO-OX-ID "A-Special".
- OR
- **Very lightly** polish tinned contact surfaces with stainless steel, steel wool and coat the surfaces with NO-OX-ID "A-Special".
- 5.2.4.2 Assemble the connection being careful not to get any NO-OX-ID "A-Special" on the bolt threads because it affects bolt/nut torque. Whenever possible, the bolt head should point downward and the Belleville washer and nut should be on top with the connection in its final position.
- 5.2.4.3 Finger tighten the nuts. Turn the nuts slowly; to avoid galling the stainless steel hardware, do **not spin the nuts.**

- 5.2.4.4 Using a torque wrench, alternately and evenly (using a crisscross pattern) tighten the **nuts** to the following values (values are for non-lubricated silicon bronze hardware):

Bolt Diameter	Recommended Torque for Silicon Bronze Hardware (LB-IN)
3/8"	240
1/2"	480
5/8"	660
3/4"	840

- 5.2.4.5 Wipe away excess NO-OX-ID "A-Special" leaving a bead at the connector interface as a moisture seal.

6.0 Inhibitor Information

Description	Ameren Stock #
NO-OX-ID "A-Special" Electrical connection inhibitor, 8-oz tube, use on copper to copper connections. Manufacturer: Sanchem Inc.	31-55-246
Alnox electrical joint compound, 8.82-oz tube, use on aluminum-to-aluminum and aluminum-to-copper connections. Manufacturer: AFL Telecommunications	31-56-316
Alcoa Filler Compound (AFC), 0.45-kg Tube, used to fill barrels of compression dead-ends. Manufacturer: AFL Telecommunications	31-56-049
Alcoa CF-1 compound, tube, use to fill voids in barrels of compression terminal connectors after compression is made; applied through "Zerk" fittings. Manufacturer: AFL Telecommunications	71-91-017

SUBSTATION DESIGN

STANDARD NO. – 16G

DIVISION 16 - ELECTRICAL

General Requirements for

Power Transformer Receiving, Inspection, Assembly & Anchoring



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Rev #	Date	Revisions	By	Approval				
0	12-5-12	Final copy for initials.	MMD LSB	DJP	WJH	RQR	DWW	

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SECTION 16G – POWER TRANSFORMERS

1.0 **WORKMANSHIP**

1.1 General;

Transformer Assembly, Testing, Vacuum and Oil Filling Procedure – See scope of work, Section 1B, and the specific transformer manufacturer’s instruction book for additional requirements.

1.2 Maintaining Dry Air Pressure;

Transformers shipped without oil, should be shipped in dry air. A positive pressure must be maintained at all time that the tanks are open to the atmosphere. To protect against moisture entering the transformer tanks, the units shall be opened only on clear and dry days. The number of openings, exposure time, and the number of persons inside the tanks must be minimized. A continuous flow of proper dry air shall be admitted inside the tanks during the open period. The dew point of each cylinder of dry air shall be checked before connecting it to the transformers. Each cylinder must have a dew point of -50 degrees C or lower. The transformer tanks shall not be opened under the following conditions: (a) the transformer temperature is less than 10 degrees C above the dew point temperature of the outside air, (b) rain or snow is threatening, (c) the relative humidity is 65% or higher, (d) there are high winds, or (e) it is dusty or dirty in the area. Dry air cylinders can be supplied by Ameren. Contractor must off-load cylinders when received and load empty cylinders for return to Ameren’s warehouse.

1.3 Safety;

Fall protection devices shall be used by the worker/s when on top of the transformer. Proper PPE shall be worn by the worker/s when working around and inside the transformer.

Never allow anyone to enter the transformer tank unless an analysis of the air in the tank shows the oxygen content is within the range from 19.5% to 25%. Follow the Ameren Confined Space Entry Procedure.

Purge the tank with dry air and take other precautions as necessary to assure safety of men working inside tank.

Take safety precautions during oil handling operations as defined below and any others deemed necessary to minimize build up of static electricity that might cause electric shock (the capacity of which might be too minute to cause direct injury, but which could cause an involuntary movement which might result in personnel injury) and to prevent the possibility of explosion due to arcing in a explosive atmosphere.

Ground all tankers, storage drums, pumping and filtering equipment, shielded hoses & receiving vessels to a solid common ground.

Ground all bushing terminals or exposed conductors on transformer to the same ground.

Wait eight hours before removing these grounds or before entering transformer in which bushings have not been installed.

After vacuum filling a transformer, relieve the vacuum with nitrogen to prevent air from mixing with the oil vapor and creating an explosive atmosphere.

1.4 Tests;

Arrange through the Company engineer for Company testers to perform a core ground test, and if possible, to check polarity and ratio of bushings current transformers before bushings are installed. Also, perform power factor tests on bushings and lightning arresters before they are installed.

When oil tank trucks are involved, the oil in each tank truck must set for at least one hour and be tested by the Company and accepted before being placed in the transformers. The Contractor shall draw oil samples for acceptance testing by Ameren's Laboratory. Acceptance testing usually takes the laboratory four hours to perform. No oil shall be placed in the transformers until it has been tested and accepted by the Company.

The Contractor shall provide a dielectric test set for testing samples of oil taken during the filling process. Test value must meet or exceed manufacturer's recommendations.

1.5 Assembly;

The Contractor shall assemble, vacuum and oil fill the transformers in exact accordance with the manufacturer's procedures stated in their instruction books and it is required that the Contractor is fully acquainted with the manufacturer's procedures (contact the Project Engineer for a copy).

Take all precautions possible to prevent dropping of tools and hardware inside the tank, including anchoring tools with cords, removing all loose items from shirt pockets, and placing loose nuts and bolts in covered containers.

Critical stages of assembly will be supervised by a manufacturer's field service engineer, whose instructions and decisions will be final on all matters concerning the transformer/s. Assembly of the transformer/s shall be so that the manufacturer's field service engineer need make only a single trip per transformer. The field service engineer must be on-site to supervise bushing installation, and oil-filling. At least a week notice will be required to schedule the arrival of the field service engineer. The Contractor must furnish sufficient notice to all concerned parties to provide for a coordinated job.

After assembly is completed, each transformer main tank shall be pressurized with dry air at approximately 2 psi. Each transformer shall be allowed to sit undisturbed for 24 hours after which an Ameren crew will perform a dew point test. The results of the dew point test will be used to determine the level of dryness of each transformer. The

Contractor shall furnish all equipment and labor for performing any factory required special dry-out procedure during oil filling.

1.6 Vacuum & Oil Filling;

The vacuum oil filling shall be performed in accordance with the manufacturer's instruction leaflets. Vacuum processing shall be done during dry weather only. The temperature of the core and coils must be 10 degrees C or higher during the vacuum processing and oil filling operations. The manufacturer's instruction leaflets describes methods for increasing the temperature of the core and coils.

Contractor shall provide vacuum pumps, oil filters, pumps, hoses, and fittings which are clean, and suitable for operation from contractor's construction power source. Oil filters shall be cartridge type. The Contractor shall provide the proper equipment for vacuum-oil filling and shall include a vacuum pump capable of attaining a blank off pressure of 0.2 Torr or less, clean vacuum lines at least 3 inches in diameter, clean oil lines & connectors, oil pump and filter press, heat exchanger capable of increasing the oil temperature entering the top of the transformers to between 50 and 70 degrees C, and a reliable diesel generator to power the heat exchanger.

The transformer manufacturer requires at least a two week notice to schedule oil delivery. The Contractor must furnish sufficient notice to all concerned parties to provide for a coordinated job. The transformer oil will be shipped to the site in tank trucks which the Contractor shall not hold any longer that necessary. The tank trucks will remain at the job site for testing and unloading. If necessary, the Contractor shall furnish and transfer the new oil into additional tankers at the job site so that the oil hauler's tankers can be released after the oil passes acceptance testing. The Contractor shall provide all labor, equipment, temporary tankers, etc. necessary to transfer the oil.

Drawing a vacuum and final oil filling of the transformer must be a continuous process and often requires overtime. It is considered a normal part of the work to be done by the Contractor.

The Contractor is responsible for completing all required forms and data sheets required per the manufacturer's instruction book for warranty purposes. The Contractor shall return the completed forms to the Ameren construction supervisor.

1.7 Anchoring;

The Contractor shall anchor the transformer to its foundation by welding the base to the steel beams that are imbedded within the foundation pad. The welding shall be in exact accordance with the manufacturer' procedures stated in their instruction books & outline drawing, and in accordance with Ameren's transformer foundation detail drawings.

1.8 Neutral Bushing Grounding;

Verify, per Ameren equipment drawings, that the transformer neutral bushing is grounded properly. The neutral bushing shall only be grounded directly to the transformer tank's bottom ground pad, or through a neutral reactor, but not both.

SUBSTATION DESIGN

STANDARD NO. – 16I

General Requirements for Outdoor Nameplate Installation



Rev No.	Date	Revisions	By	Approvals	
0	12/02/09	First Issue	AHS/MMD 12/2/09	CJB 12/3/09 WJH 12/4/09	KDA 12/4/09
1	10/01/21	Added Adhesive, Tag, and Sticker Mounting Options and Minor Revisions	JSJ/JAG/DOL 9/24/21	JEH 9/30/21	LDK 10/1/21

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SECTION 16I - OUTDOOR NAMEPLATES

1.0 MATERIALS

- 1.1 Machine screws, steel, #10, 1/2" long, with nuts, to attach nameplates to aluminum plates or angle. To be provided by construction crew.
- 1.2 Machine screws, steel, 1/4", length as required, with nuts, to attach aluminum plates to structures. To be provided by construction crew.
- 1.3.1 Adhesive RTV, Ameren Stock# 4901105, should be used to mount nameplates. Adhesive is BOSS® 315 RTV 100% Silicone Sealant.
- 1.3.2 BOSS® 315 RTV 100% Silicone Rubber adhesive/sealant is a paste-like, one component material which cures to a tough, rubbery solid when exposed to moisture in the air. This RTV has good resistance to weathering, vibration, moisture, ozone and extreme temperatures. It may be applied in sub-zero weather without loss of extrusion or physical property characteristics. Fully cured it can be used for extended periods at temperatures up to 400°F. It may be applied to any surface other than wood based structures.

2.0 WORKMANSHIP

- 2.1 Mount nameplates at locations specified by Company Engineer or construction drawings.
- 2.2 Mounting nameplates with screws
 - 2.2.1 Where flat surfaces are available on equipment or structures (PCB mechanism doors, switch operating mechanism channel, etc.) mount nameplates directly to these surfaces with machine screws in manner acceptable to Construction Supervisor. Edges of nameplate must not extend beyond edges of flat surfaces. If edges of the nameplate will extend beyond edges of flat surfaces, then 1/8" aluminum backing plate or angle must be used as in subsequent section 2.2.2.
 - 2.2.2 Where nameplates must be mounted against structure angles, etc., cut 1/8" aluminum plate or angle to size at least 1" larger on all sides than nameplate and mount nameplate to aluminum plate or angle with machine screws. File all edges of aluminum backing plate or angle to eliminate sharp edges and corners. Fasten aluminum plate or angle and nameplate assembly to structure with machine screws in manner acceptable to Construction Supervisor.

2.3 Mounting nameplates with Adhesives

- 2.3.1 Where flat surfaces are available on equipment or structures (Transformer mechanism door, steel structure, etc.), mount nameplate directly to these surfaces in a manner acceptable to Construction Supervisor. Edges of nameplates must not extend beyond edges of flat surfaces. RTV adhesive should be applied in a uniform thickness to back of nameplate and bead around the perimeter of the nameplate to prevent rainwater from entering the back of nameplate. Best adhesion is obtained with a 15 to 30 mil glue line.
Prepping the bonding area: Prior to applying adhesive thoroughly clean and degrease metal and plastic surfaces, then rinse all surfaces, except plastic, with acetone. If edges of the nameplate will extend beyond edges of flat surfaces, then 1/8" aluminum backing plate or angle must be used as in subsequent section 2.3.2.
- 2.3.2 Where nameplates must be mounted against structure angles, etc., cut 1/8" aluminum plate to size at least 1" larger on all sides than the nameplate and mount nameplate to aluminum plate with adhesives. File all edges of aluminum backing plate to eliminate sharp edges and corners. Fasten aluminum plate and nameplate assembly to structure with steel screws or adhesives in manner acceptable to Construction Supervisor. RTV adhesive should be applied in a uniform thickness to back of nameplate and bead around the perimeter of the nameplate to prevent rainwater from entering the back of nameplate. Best adhesion is obtained with a 15 to 30 mil glue line.
Prepping the bonding area: Prior to applying adhesive thoroughly clean and degrease metal and plastic surfaces, then rinse all surfaces, except plastic, with acetone.
- 2.3.3 When removing excess adhesive or replacing nameplates mounted with adhesives, use a straight edge or a knife. Prior to reapplying adhesive thoroughly clean and degrease metal and plastic surfaces, then rinse all surfaces, except plastic, with acetone.

2.4 Tags, tag holders and stickers (typically used by AIC)

- 2.4.1 When mounting using poly tag holders, for air break switch nameplates, mount tag holder vertically on the switch operating pipe. Slide alpha-numeric tags into holder before mounting. #6 Aluminum wire ties are preferred to mount tag holder to the switch operating pipe. Tag holders may be mounted to nearby steel, with construction supervisor's permission, using steel screws.
- 2.4.2 Where flat surfaces are available on equipment or structures (PCB mechanism doors, transformer cabinets, single phase switching devices, etc.) mount stickers directly to these surfaces in manner acceptable to Construction Supervisor. Edges of stickers must not extend beyond edges of flat surfaces.

SUBSTATION DESIGN

STANDARD NO. 16J

DIVISION 16 – ELECTRICAL

GENERAL REQUIREMENTS FOR INSTALLATION OF SUBSTATION BATTERIES AND RACKS – 125VDC



Transmission & Distribution Design Department
ENERGY DELIVERY TECHNICAL SERVICES
AMEREN SERVICES COMPANY

Rev. No.	Date	Revisions	By	Approvals		
0	9/27/07	Original Issue	CEJ/DH/LGM	FF 10/26/07	WJH 10/29/07	PJN 10/31/07
1	10/16/17	General Revision	RSN/VJ/BTK	RAK 12/07/17	DES 12/15/17	

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SECTION 16J—BATTERY

1.0 MATERIALS

1.1 Joint Compound

- 1.1.1 Sanchem NO-OX-ID “A Special” electrical grade contact grease or Engineer approved equal shall be used on all electrical connections.

1.2 Hardware

- 1.2.1 Battery terminal hardware shall be type 304 or 316 stainless steel. Flat and lock washers shall be used on all terminal post connections. Lock washers may be of the split ring or Belleville type.
- 1.2.2 Rack hardware shall be type 304 or 316 stainless steel. Minimum size for bolts used to secure rack to steel flooring shall be ½”-13 UNC.
- 1.2.3 Mechanical concrete anchors shall be zinc plated steel of the wedge or sleeve type. Minimum size shall be ½”-13 UNC.

1.3 Connectors

- 1.3.1 Battery terminal lugs shall be bronze or lead plated copper.
- 1.3.2 Grounding connectors shall be bronze one bolt clamps, Anderson type GC-141 or equal.

1.4 Conductor

- 1.4.1 Conductors installed from battery to DC system termination point and between battery rows shall be neoprene insulated, extra flexible copper “welding cable” rated for 600V. Conductor size shall be specified by the manufacturer or the Project Engineer. If no conductor size has been specified, then the Ameren Construction Supervisor and Project Engineer shall be contacted immediately.
- 1.4.2 Grounding conductors shall be copper, 4/0 AWG or larger in size.

2.0 **WORKMANSHIP**

2.1 **Safety**

2.1.1 Installation shall be performed only by properly trained, knowledgeable personnel. Safety guidelines in manufacturer supplied installation manuals shall be followed. Personal protective equipment shall include but not be limited to: goggles, face shields, acid resistant gloves, protective aprons and overshoes. Portable or stationary eye wash facilities, class C fire extinguishers, insulated tools, adequate lifting devices and spill clean up kits shall be made available at the time of installation.

2.1.2 All installations shall be in conformance with the factory supplied installation manual. Where conflicts exist between this specification and installation manual, Engineer shall be notified for resolution.

2.2 **Rack Assembly**

2.2.1 Assemble rack framing members level and plumb. If necessary, stainless steel shims may be used to correct floor irregularities up to ¼". Hardware shall be tightened to factory specified torque values. Non-conductive, acid resistant rail covers shall be installed prior to battery placement. Racks shall have front and rear restraining rails installed prior to battery placement. Restraining end rails shall be installed after battery placement. End rails shall not be tightened against battery jars.

2.2.2 Rack shall be securely anchored to floor prior to placement of batteries. When set on concrete floors, anchors shall be set in each foot plate through designated holes. When set on steel flooring, floor shall be drilled and tapped for a minimum of ½" bolts. Rack shall not be field drilled in order to anchor it to the floor. Rack shall not be fastened to building walls.

2.2.3 Rack shall be effectively bonded to substation ground system with a #2 bare stranded copper wire to the 4/0 ground loop inside the building.

2.2.4 Battery area and rack shall be thoroughly cleaned of all residual building materials, dust, oils, grease and abrasive materials prior to placement of batteries. Any painted metallic portions of rack which have been damaged shall be touched up with manufacturer approved acid resistant paint.

2.2.5 Removable stainless steel spill containment pans shall be installed under the battery rack. Acid absorbent pillows shall not to be used.

2.2.6 Battery area shall be painted with acid resistant paint prior to battery rack installation. If the area is not painted with acid resistant pain, then the Ameren Construction Supervisor and Project Engineer shall be contacted immediately.

2.3 **Battery Installation**

- 2.3.1 Packaging materials shall be removed carefully to avoid damaging the battery containers. Batteries shall be inspected for concealed damage including cracks, crazing, leaks, and deformed posts. Electrolyte level shall be verified; if damages are found or lead plates are exposed to air above the electrolyte level, then cell must be set aside and the Ameren Construction Supervisor and Project Engineer shall be contacted immediately for cell replacement.
- 2.3.2 Batteries shall be lifted from the underside using lifting slings and spreader devices when applicable. Jars shall not be lifted or moved in any manner by post terminals. Batteries shall not be moved or handled without shipping vents or flame arrestors installed in cover. Batteries shall not be tilted more than 25 degrees from vertical to prevent electrolyte spills.
- 2.3.3 Batteries shall be placed on rails beginning from the center of the rack, working outward. Talcum powder or clean water may be applied to rails to facilitate alignment. Oil, grease or other lubricants shall not be used on rails as these compounds attack jar materials. Batteries shall be spaced on rack rails with a ¼"-½" gap in between jars. Seismically qualified installations shall incorporate factory supplied cell spacers. Battery containers shall be placed on the rails to facilitate inter-cell connector installation. Refer to manufacturer data for proper orientation.
- 2.3.4 Temporary shipping vents or plugs shall be removed and flame arrestors installed in battery covers after jars have been placed on the battery rack.
- 2.3.5 Terminal posts and straps shall be thoroughly cleaned before making electrical connections. Protective shipping/storage grease shall be removed from posts with a clean dry cloth. Any electrolyte on posts shall be neutralized with a solution of one pound sodium bicarbonate (baking soda) to one gallon water, rinsed with clean water and wiped dry. Corrosion or discoloration shall be removed with non-metallic scouring pads, fiber or brass bristled brushes; steel brushes or abrasives shall not be used. Care must be taken to avoid removing any metal plating from terminal post contact surfaces. NO-OX-ID paste shall be warmed to a softened state and applied with a natural fiber brush to all contact surfaces prior to making electrical connections.
- 2.3.6 Bolted terminal post connections shall be tightened to the torque specified by the manufacturer. Where more than one intercell connecting strap is required, straps shall be installed on opposite sides of terminal posts. Connections shall be re-torqued four to six hours after initial bolting to compensate for relaxation of joint components. Electrical resistance shall be measured across each terminal to intercell connector junction. Any connection with resistance exceeding 10% of the

average value shall be re-made. A light coat of NO-OX-ID paste shall be applied to the entire terminal post area after connections have been properly verified.

- 2.3.7 Manufacturer provided terminal post covers shall be installed once the battery has been fully assembled.
- 2.3.8 Manufacturer provided flexible cables installed between battery rows shall be kept to a minimum length leaving approximately 6" slack to facilitate removal and re-connection.
- 2.3.9 Individual cells shall be numbered with acid resistant adhesive tags. The numbering sequence shall be such that the string positive cell shall be numbered "1". Surfaces shall be cleaned per section 2.4 prior to applying adhesive tags.

2.4 **Cleaning**

- 2.4.1 Battery cell containers shall be cleaned with water, no solvents or cleaning agents are to be used.
- 2.4.2 Electrolyte spills shall be neutralized with a solution of one pound sodium bicarbonate (baking soda) to one gallon water. Solutions of strong alkalis such as ammonia, sodium hydroxide or soda ash shall not be used.

3.0 **Revisions**

<u>Date</u>	<u>Description</u>
9/27/2007	Original Issue
10/16/2017	Added spill containment pan requirements, changed clarification on battery handling, removed recommended torque values for bolted terminal posts connections, and made grammar/format corrections.

SUBSTATION DESIGN

STANDARD NO. – 16L

General Requirements for Miscellaneous Furnishings



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Rev. No	Date	Revisions	By	Approvals		
0	12/10/09	Initial Issue for Comments	CTK/ DJP			
1	04/28/20	Scheduled Revision	BFH			

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SECTION 16L – MISCELLANEOUS FURNISHINGS

1.0 **MATERIALS**

1.1 Unless otherwise noted, all materials listed below will be furnished by Ameren.

2.0 **WORKMANSHIP**

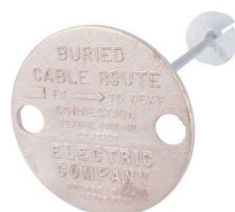
2.1 Assemble as necessary, provide mounting brackets for, and install miscellaneous furnishings as listed below:

Substation Yard:

1. Signs on fence, such as danger signs at 60' intervals and substation identification signs on the fence near the main gate.
2. Signs on outside of control house or switchgear: "DANGER: HIGH VOLTAGE QUALIFIED PERSONNEL ONLY". Sign should be red with white lettering and clearly visible from a distance of 30 feet.
3. Fire Extinguisher 30 lb., Type BC dry chemical fire extinguishers with cartridge and enclosure. Depending on substation equipment layout, a quantity of two to four of these extinguishers are to be supplied.
4. Road markers, driven post type with reflectors.
 - a. Use in substation yard to alert drivers to obstacles, drive location, end of drive and other locations deemed necessary for safety of pedestrians, drivers and workers.



5. Cable route markers
 - a. Used to mark locations of buried power cables
 - b. Top plate of route marker to be top plate is made of copper alloy for high corrosion resistance.



Within the Control Enclosure (if not already supplied with the control enclosure):

1. Two 30 lb. dry chemical fire extinguishers within the control enclosure, one extinguisher to be located at each entrance/exit.
2. Two or more spare nitrogen cylinders for wheeled fire extinguishers.
3. One steel desk, approximately 30" deep x 60" wide.
4. Two chairs, one stationary, one wheeled.
5. Two steel, five drawer file cabinets.
6. One double door steel cabinet, approximately 36" wide x 21" deep x 78" high.
7. One eyewash station near battery.
8. No smoking sign near battery.
9. One bulletin board above the desk.
10. One Emergency Contact Information sign near phone.
11. One clock above the desk.
12. Two 30 gallon trash cans with lids.
13. One blueprint table, approximately 30" deep x 40" wide.

SUBSTATION DESIGN

STANDARD No. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16M – Underground Power Ducts and Manholes



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>		
<i>0</i>	<i>03/08/07</i>	<i>Original Issue</i>	<i>J.A.W. 1/16/07</i>	<i>CJB 3/17/07</i>	<i>WJH 3/7/07</i>	<i>PJN 3/8/07</i>
<i>1</i>	<i>08\27\15</i>	<i>Revised Duct Bank Depth</i>	<i>ARG/LSB</i>	<i>DRW</i>	<i>MJN</i>	

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1.0 General

Work Included – Furnish all material, tools, equipment, labor, and supervision to construct and install the facilities as specified and as shown on the construction drawings except the 36in. diameter manhole frame and cover, Ameren Stk. No. 12-02-085 and the precast concrete manhole neck rings, Ameren Stk. No.'s 12-06-062 and 12-06-063 which will be supplied and delivered to the construction site by Ameren.

2.0 Materials

- 2.1 Power Ducts – Five inch diameter, type EB-35, PVC conduit. All elbows, couplings, plugs, caps, and accessories shall be compatible with the duct. All elbows shall have a minimum 36in. radius.
- 2.2 Duct Spacers – Plastic spacers for 2, 5 inch ducts as manufactured by Underground Devices Inc. part number SW20-2; Ameren stock number 12-56-120. Substitutions shall not be allowed.
- 2.3 Patio Block – Concrete block to provide a solid base underneath each bottom duct spacer; Ameren stock number 11-54-128.
- 2.4 Concrete (for power duct encasement) – 2000 psi minimum 28 day strength, 2in. to 4in. slump. An acceptable formula is 1400 lbs. dry sand, 1860 lbs. dry, clean gravel (3/8in. and under), 423 lbs. cement, (4-1/2 sacks), and 29 gallons water maximum.
- 2.5 Bond Wire – 4/0, soft drawn, stranded (19 strands), bare copper wire per ASTM B-3-45, Class A or B stranding. Ameren stock number 18-52-031.
- 2.6 Buried Cable Markers – Hubbell/Chance cable route markers, Cat. No. C554-0001 or approved equal; used to mark all locations where conduit, ducts, and/or duct banks pass under the substation fence and to mark the location of ducts stubbed for future use.
- 2.7 Manholes – When required, the specific, Ameren standard, traffic rated manhole(s) to be furnished and installed will be called out on the drawings. The manholes will be identified by Ameren designations and/or stock numbers. The only approved supplier is Champion Precast Inc., 2441 Hwy. 61 North, Troy, MO, 63379; telephone (573) 384-5855.

3.0 Execution

3.1 Trenches

- 3.1.1 Trenches shall be 3 to 8 feet deep as required to approach the 90 degree, 36 inch radius bends along a straight and true line.
- 3.1.2 Trenches shall slope away from the switchgear/substation at a 0.5% slope; six inches in 100 feet.
- 3.1.3 Protect excavations by shoring, bracing, sheet piling, underpinning, sloping side walls, or other methods as required to prevent cave-ins and/or loose soil falling into the trench.
- 3.1.4 Grade the top perimeter of the excavation to prevent surface water run-off into the excavation. Trenches and excavations shall be kept free of water.
- 3.1.5 The trench floor shall be undisturbed or well compacted soil or approved backfill for leveling. The trench floor shall be level to within plus/minus 2 inches.
- 3.1.6 The trench width shall be at least 4 inches wider than the duct, for a single duct, and a minimum of 4 inches wider than assembled duct banks. This, in combination with spacer blocks, allows for at least 2 inches of concrete between and cover over, under, and around the ducts and/or duct banks.

3.2 Duct Runs/Duct Banks

- 3.2.1 All power ducts and duct banks shall be concrete encased; minimum two inch encasement.
- 3.2.2 The duct/duct bank runs shall be installed as shown on the drawings. Ducts shall be laid straight and true. Obstructions shall be removed.
- 3.2.3 The centerline location of all duct runs and duct banks shall be marked with buried markers one foot inside and one foot outside the substation fence.
- 3.2.4 The centerline location of all duct runs and duct banks stubbed for future use shall be marked with buried markers.

- 3.2.5 Conduit Spacer shall be used to support the ducts and to maintain conduit spacing. Each 10 foot straight section of duct requires a conduit spacer one foot from each end and one at the center. Each 20 foot straight section of duct requires a conduit spacer two foot from each end and three additional on 4 foot spacing. Additional conduit spacers may be required to maintain proper spacing when/if ducts are transposed.
- 3.2.6 Ducts shall be joined with couplings and PVC cement; joints must be staggered to allow sufficient concrete between the joints.
- 3.2.7 All ducts shall be terminated with a coupling and a removable plug. Ducts which extend or will extend above ground to switchgear or outdoor breakers shall be plumb and square and shall be terminated with the top of the coupling above the finished rock grade and below the foundation's top of concrete.
- 3.2.8 All ducts shall be swabbed clean, have a 2500 pound rated flat pulling tape installed, and be plugged with removable plugs or caps after the concrete has dried. Ten feet of pulling tape shall extend outside the plug.
- 3.2.9 If interfacing with existing duct runs, terminate the new duct runs/duct banks into the existing duct runs/duct banks, complete concrete encapsulation, and Cadweld the bond wires.
- 3.2.10 If the duct runs/duct banks to be interfaced with have not yet been constructed/installed, or if the duct runs/duct banks are being stubbed for future use, do the following:
 - 3.2.10.1 Form the duct runs/duct banks (plywood of equivalent) to match the duct bank interface point profile.
 - 3.2.10.2 Extend the power ducts at least 10in. beyond the form, stagger the ducts (see 3.2.6). Install plugs with 10 feet of pulling tape exposed.
 - 3.2.10.3 Leave 5 feet of bond wire coiled past the form.
 - 3.2.10.4 Place a plywood, or equal, barrier at the end of the ducts to protect the ducts and bond wire against dig-ins and as a conduit location marker.
- 3.2.11 Conduit riser bends at terminal poles shall be plumb and square to the pole in the pole quadrant shown on the drawings. The pole riser bend shall be Schedule 40 PVC and shall be completely below grade. The conduit extension above grade shall Schedule 80 PVC.

3.3 Bond Wire

- 3.3.1 A bond wire shall be installed in the center of the bottom row of each duct run/duct bank as shown on the drawings.
- 3.3.2 The bond wire shall run the full length of the duct run/duct bank outside the substation fence only. There shall be no bond wire in the substation.
- 3.3.3 The bond wire shall be thermic (Cadweld) welded to the substation ground grid conductor running outside the fence perimeter where the duct run/duct bank crosses under the substation fence.
- 3.3.4 When a duct bank splits and individual duct runs go in different directions, additional bond wires (one for each individual duct run) shall be thermic (Cadweld) welded to the main bond wire. The additional bond wires shall be run with the individual duct runs. If the duct run is to be installed later by others, leave 5 feet of bond wire coiled past the end of the plugged duct.
- 3.3.5 When a duct or ducts extend above grade, the bond wire shall exit the concrete encasement 2ft-0in. below grade. Leave a minimum 10 feet of bond wire coiled at the exit point.
- 3.3.6 When the bond wire extends into a manhole, leave enough bond wire coiled in the manhole to reach the floor and run the perimeter of the manhole at 6 inches above the floor level.

3.4 Backfilling and Concrete (Duct Runs/Duct Banks)

- 3.4.1 Refer to Division 2- Site Work, Section 02223 for backfilling.
- 3.4.2 **No reinforcement** of any kind, including bonding agents, shall be used on or installed in the duct runs/duct banks.
- 3.4.3 The concrete shall be poured as close as possible to the duct run or formed duct bank to prevent deformation.
- 3.4.4 The concrete cover above the top duct or top row of ducts shall be at least 2in.. The top of the encasement shall be at least 36in. below final earth grade.
- 3.4.5 Vertical bends (conduit risers to switchgear, outdoor breakers) shall be restrained with a nominal 5in., minimum 3in., thick concrete encasement with a 15in. square cap at sub grade.

- 3.4.6 Vertical bends, risers to terminal poles, shall be restrained with a nominal 5in., minimum 3in., thick concrete encasement with a 15in. diameter cap flush against the terminal pole extending 18in. above grade. The duct shall extend at least 6in. above the concrete encasement.
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- 3.5 Manholes and Accessories
 - 3.5.1 The manholes are all two piece (top and bottom), steel-reinforced concrete with 6in. thick walls. All manholes have a 12in. diameter sump hole centered in the floor and a 36 in. diameter opening centered in the roof for a man-way to support a frame and cover.
 - 3.5.2 The manhole(s) shall be set at the elevation shown on the drawings on a level, minimum 6in. thick base of clean $\frac{3}{4}$ in. crushed rock or flowable fill.
 - 3.5.3 The manhole shall be backfilled with flowable fill or a weak 2-sack cement, “grout”, mix.
 - 3.5.4 If required construction details for manhole neck extensions, instructions for using end-wall knockouts, instructions and details for encasing end-wall ducts, construction details for wing-wall bays , and instructions and details for encasing wing-wall bay ducts shall be shown on the drawings or on appropriate sections of Ameren’s Distribution Construction Standards which will be provided as part of the bid package.

SUBSTATION DESIGN

STANDARD No. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16N – Temporary AC Generator Installation



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>		
<i>0</i>	<i>12/19/16</i>	<i>Original Issue</i>	<i>GME</i>	<i>MJE</i>	<i>RJR</i>	

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1. Introduction / Scope

This document provides general guidelines and considerations when connecting a generator for temporary station service power. This guide is not all encompassing; each substation service scheme is unique and requires engineering evaluation to determine an appropriate method for connection.

A detail procedure shall be provided by engineering prior to the installation of a generator for temporary station service power. (See sample procedure)

2. Schematic Markup

For all generator connections, a marked up AC Schematic must be provided to the construction crew with the following information:

- Date, revision, and author of sketch
- Generator connection points
- Generator ground connection
- Bonding location of neutral to ground (typically generators are internally bonded)
- Indication of energized circuits during generator operation
- Status of all applicable station service circuit breakers and disconnect switches

3. Creating the Procedure Document

For simpler connections, a full procedure may not be required. However, in situations with phase, arc flash, or sequencing concerns a full procedure will be required.

At a minimum, the following sections are required for the procedure:

3.1. Safety Notes

The following safety notes may apply when connecting a temporary generator. The Safety Manager will review any additional notes that may be needed.

- Temporary cables that are used during this procedure must be secured and marked to reduce tripping hazards
- Appropriate notification/signage and energy control procedures (WPA/Lock Out Tag Out) must be utilized to ensure employee safety
- Attaching a generator may back-feed power. As such, equipment may be energized that would normally be de-energized. For example, the load side of an open disconnect switch may become energized. Follow appropriate electrical procedures and never assume anything is de-energized, always test for voltage.
- Check ground connections prior to energizing the generator.
- The generator Operation Manual must be followed.
- The control enclosure lights will be temporarily disabled for portions of this work. Ensure adequate battery powered lighting is available for safe work.

Safety Notes (continued)

- Arc flash ratings shall be provided for all racking, switching, and energized conductor work: (for 480 V circuits)

3.2. Project Contacts

The following personnel’s contact information should be included in the procedure:

- Project Engineer
- Construction Supervisor
- Safety Manager
- Generator Rental Contact
- Refueling Contact

3.3. Electrical Phase Statement

If the generator will be powering AC motors, the following information must be included in the procedure.

- 3.3.1. Transformer cooling fans will run backward if the phase rotation is not correct. The transformer cooling fans breakers shall be “bumped” to visually determine the correct fan rotation after the installation of the generator.
- 3.3.2. The generator phase must be verified with the other sources disconnected. This is to reduce the risk of an automatic transfer instantaneously reversing the phase on a running motor.

3.4. Generator Refueling

The full-load fuel usage of the generator and the size of the tank must be indicated. If needed, a refueling company should be used to periodically fill the tank.

3.5. Generator Settings

Using the generator manual, provide the correct voltage and overcurrent protection settings based on the application.

3.6. Procedure Steps

The procedure shall go through each step required, similar to a startup procedure. It may be beneficial to structure the procedure into the below subcategories:

Startup:

- Place in Auto Transfer Sw. in manual
- Clear the existing AC sources and loads
- Connect the generator
- Restore station service from the generator
- Check phasing
- Restore load in sequence

Shutdown:

- Clear the generator and loads
- Restore station service from the AC sources
- Check phasing
- Restore load in sequence
- Place Auto Transfer Sw. in automatic

4.0 Revisions

12/19/16
GME

Initial Issue

Appendix #1 – Sample Generator Connection Procedure:



SAMPLE

Generator Connection Procedure

XXXXX Substation – 480 V Station Service Automatic Transfer Scheme and Arc Flash Mitigation

Revision 0
November 2, 2015
Greg Eddings

JS500909

1. Introduction

1.1. Scope

This document provides guidelines for connecting a 300 kVA diesel generator to temporarily power critical substation equipment. This is required to support the ongoing 480 V station service retrofit project.

1.2. Reference Documents

- Temporary Generator Connection Sketch Rev. 0 – Ameren Schematic XXXXXX
- Operator Manual C300 D6R (Spec A)

2. Safety

- Temporary cables are used during this procedure; they must be secured and marked to lessen tripping hazards
- Appropriate notification/signage and energy control procedures must be utilized to ensure employee safety.
- Attaching a generator may back-feed power flow. As such, equipment may be energized that would normally be de-energized. For example, the load side of an open disconnect switch may become energized.
- Follow appropriate electrical procedures and never assume anything is de-energized, always test for voltage.
- Check ground connections prior to energizing the generator.
- The generator Operation Manual must be followed.
- The control enclosure lights will be temporarily disabled for portions of this work. Ensure adequate battery powered lighting is available for safe work.
- Arc flash ratings:
 - Category 3 from Source 1 – 138 kV Power Pots
 - UNSAFE from Source 2 – 34 kV Area Distribution, NO ENERGIZED WORK

3. Required Notifications

- During the transfer to temporary generator power, circuit breaker charging motors will be deactivated. These breakers will not be able to reclose. Notify Transmission Operations when the station service is disabled and when returned to normal operation.
- Notify United Rentals upon restoration of the station service to return the generator
- Notify Sieveking of any generator refueling needs
- The Substation Design Engineer and the Safety Manager must be informed of any safety concerns

4. Contacts

Name

Ameren – Substation Design
Engineer

O: XXX-XXX-XXXX

C: XXX-XXX-XXXX

Email

Jason Hamlin

Ameren – Safety Manager,
ATX

O: 314-554-3188

C: 314-458-5543

JHamlin2@ameren.com

Diane Beck

Sieveking, Inc – Generator
Refueling

O: 636-677-4355

DBeck@sievekinginc.com

Name

Ameren – Construction
Supervisor

O: XXX-XXX-XXXX

C: XXX-XXX-XXXX

Email

Cindy Arnold

United Rentals

O: 314-729-0903

C: 314-943-0161

carnold@ur.com

5. Non-Critical Loads

The generator is adequately sized to continuously support the entire station service load. However, to preserve fuel non-critical loads should be disabled. The procedure below provides instructions on how to disable non-critical loads.

- YARD LTG. CAB Y1
- BLDG HTR #1
- BLDG HT CONTROL
- BLDG (sic) EXH FAN
- SW BD RCPT
- BLDG RCPT GONG&CLCK N.&W WALLS
- MISC AC BUS
- RELAY TEST
- YARD LTG. CONTROL
- NIGHT LTS
- BLDG RECEIPT

6. Electrical Phasing Requirements

The transformer cooling fans will run backward if the phase rotation is not correct. The transformer cooling fans breakers shall be “bumped” to visually determine the correct fan rotation after the installation of the generator.

7. Generator Refueling

Refuels can be scheduled by contacting Diane Beck with Sieveking 24 hours in advance. Sieveking has an Ameren credit card on file for the fueling cost.

The generator uses approximately 23 gallons of fuel per hour at full load. The tank holds enough fuel for 17 hours.

8. Generator Settings

The generator must be run in the 480 V_{LL} (Hi Wye) mode. Check the generator output voltage prior to energizing the station service bus. Generator overcurrent protection shall be set per manufacture recommendations.

9. Generator Installation Procedure

9.1. Clearing the 34.5 kV area distribution source

1. **Set** the 480 V Automatic Transfer Scheme to “Secondary” source
 - a. 480 V Breaker 52-1 will **open**
 - b. 480 V Breaker 52 will **close**
 - c. 480 V Breaker 52-2 will **close**
2. **Open** 34.5 kV–480/277 V, 750 kVA high side fuses, S&C Type SMD-2C
3. **Rack out** 480 Breaker 52-1, **REQUIRES ARC FLASH CATEGORY 3 PPE**

9.2. Clearing the 138 kV power pot source

4. Inform Transmission Operations that the station service will be temporarily disabled, preventing operation of the following pieces of equipment:
 - a. 138 kV PCB H1 Reclosing
 - b. 138 kV PCB H2 Reclosing
 - c. 138 kV PCB H5 Reclosing
 - d. 138 kV PCB H7 Reclosing
 - e. 138 kV PCB H9 Reclosing
 - f. 345 kV PCB V11 Reclosing
 - g. 345 kV PCB V31 Reclosing
 - h. XMFR-1 Cooling System
 - i. Battery Charger #1
 - j. Battery Charger #2
5. **Open** 480 V Breaker 52-2, **LIGHTING WILL BE DISABLED**
6. **Open** 480 V Breaker 52
7. **Open** 138 kV power pot secondary safety disconnect switch, **REQUIRES ARC FLASH CATEGORY 3 PPE**
8. **Rack out** 480 V Breaker 52
9. **Rack out** 480 V Breaker 52-2

9.3. Isolating A.C. Dist. Cabinets from the existing 480 V Automatic Transfer Scheme

10. **Open** all breakers on A.C. DIST. CAB. 1 (3 Φ 480/277V); all breakers must be in the open position before proceeding
11. **Open** all breakers on A.C. DIST. CAB. 2 (3 Φ 480/277V); all breakers must be in the open position before proceeding
12. **Open** all breakers on A.C. DIST. CAB. 3 (3 Φ 208/120V); all breakers must be in the open position before proceeding
13. **Open** all breakers on A.C. DIST. CAB. 4 (3 Φ 208/120V); all breakers must be in the open position before proceeding

9.4. Connecting the generator

14. **Disconnect** and **isolate** the following cables from A.C. DIST. CAB. 1 (3 Φ 480/277V)
 - a. CA-97 (4-350 MCM)
 - b. CA-98 (4-350 MCM)
15. **Disconnect** and **isolate** the following cables from A.C. DIST. CAB. 2 (3 Φ 480/277V)
 - a. CA-94 (4-350 MCM)
 - b. CA-95 (4-350 MCM)
16. **Connect** 480 V Diesel Generator U, V, W, and O to AC DIST. CAB 1 (480/277V) with one set of temporary 350 MCM conductors; *parallel conductors are not required*
17. **Connect** 480 V Diesel Generator U, V, W, and O to AC DIST. CAB 2 (480/277V) with one set of temporary 350 MCM conductors; *parallel conductors are not required*
18. Install the 4/0 bare copper ground cable for the generator to the ground connection at the 750 kVA pad-mounted transformer ground
19. **Engage generator**
20. Adjust the output voltage to 480 V_{LL}

9.5. Energizing critical loads

21. **Close** the generator output breaker per the generator operations manual
22. **Close** breaker 3 "BLDG LTG" on A.C. DIST. CAB. 2 (3 Φ 480/277V); verify building lights operate
23. **Close** breaker 1 "XFMR-1" on A.C. DIST. CAB. 1 (3 Φ 480/277V)
24. Set XFMR-1 cooling fans to MANUAL mode briefly; observe the fan rotation
 - a. If the fans are rotating in the correct rotation, continue through the procedure
 - b. If the fans are rotating in the opposite direction, power down the generator and swap two of the three phases, re-energize and re-test
 - c. Leave the cooling fans in AUTO after phase rotation is verified
25. **Close** breaker 6 "BATT CHGR #1" on A.C. DIST. CAB. 1 (3 Φ 480/277V)
26. Verify amperage is registered on the battery charger front indicator
27. **Close** breaker 19 on A.C. DIST. CAB. 1 (3 Φ 480/277V)
28. **Close** breaker 1 "PCB POSN H1" on A.C. DIST. CAB. 3 (3 Φ 208/120V)
29. **Close** breaker 2 "PCB POSN H2" on A.C. DIST. CAB. 3 (3 Φ 208/120V)
30. **Close** breaker 5 "PCB POSN H5" on A.C. DIST. CAB. 3 (3 Φ 208/120V)
31. **Close** breaker 8 "BATT CHGR #2" on A.C. DIST. CAB. 2 (3 Φ 480/277V)
32. Verify amperage is registered on the battery charger front indicator
33. **Close** breaker 21 on A.C. DIST. CAB. 2 (3 Φ 480/277V)
34. **Close** breaker 3 "PCB POSN H7" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
35. **Close** breaker 4 "PCB POSN H9" on A.C. DIST. CAB. 4 (3 Φ 208/120V)

36. **Close** breaker 9 "ANNUN" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
37. **Close** breaker 11 "DFR" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
38. **Close** breaker 14 "345 KV POSN V4 PRI RLY" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
39. **Close** breaker 16 "JMUX" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
40. **Close** breaker 17 "PCB POSN-V11" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
41. **Close** breaker 18 "PCB POSN-V31" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
42. Inform Transmission Operations that the station service has been restored
 - a. 138 kV PCB H1 Reclosing
 - b. 138 kV PCB H2 Reclosing
 - c. 138 kV PCB H5 Reclosing
 - d. 138 kV PCB H7 Reclosing
 - e. 138 kV PCB H9 Reclosing
 - f. 345 kV PCB V11 Reclosing
 - g. 345 kV PCB V31 Reclosing
 - h. XMFR-1 Cooling System, source 1 only
 - i. Battery Charger #1
 - j. Battery Charger #2

10. Station Service Restoration

10.1. Removing the generator

1. Inform Transmission Operations that the station service will be temporarily disabled, preventing operation of the following pieces of equipment:
 - a. 138 kV PCB H1 Reclosing
 - b. 138 kV PCB H2 Reclosing
 - c. 138 kV PCB H5 Reclosing
 - d. 138 kV PCB H7 Reclosing
 - e. 138 kV PCB H9 Reclosing
 - f. 345 kV PCB V11 Reclosing
 - g. 345 kV PCB V31 Reclosing
 - h. XMFR-1 Cooling System
 - i. Battery Charger #1
 - j. Battery Charger #2

NOTE: LIGHTING WILL BE DISABLED

2. **Open** the generator output breaker per the generator operations manual
3. **Disengage** the generator
4. **Open** all breakers on A.C. DIST. CAB. 1 (3 Φ 480/277V); all breakers must be in the open position before proceeding
5. **Open** all breakers on A.C. DIST. CAB. 2 (3 Φ 480/277V); all breakers must be in the open position before proceeding
6. **Open** all breakers on A.C. DIST. CAB. 3 (3 Φ 208/120V); all breakers must be in the open position before proceeding
7. **Open** all breakers on A.C. DIST. CAB. 4 (3 Φ 208/120V); all breakers must be in the open position before proceeding
8. Remove temporary 350 MCM conductor from 480 V Diesel Generator U, V, W, and O to AC DIST. CAB 1 (480/277V)
9. Remove temporary 350 MCM conductor from 480 V Diesel Generator U, V, W, and O to AC DIST. CAB 2 (480/277V)

10.2. Restoring Station Service

10. **Verify Open** 138 kV power pot secondary safety disconnect switch – Source 2
11. **Verify Open** 34.5 kV transformer secondary safety disconnect switch – Source 1
12. **Connect** permanent conductors to the automatic transfer switch junction box and AC Distribution Cabinets:
 - a. CA-94
 - b. CA-95
 - c. CA-97
 - d. CA-98
13. **Close** 138 kV power pot secondary safety disconnect switch – Source 2 **REQUIRES ARC FLASH CATEGORY 3 PPE**

14. Upload settings to the GE Zenith ZTG ATS
15. Verify the GE Zenith ZTG ATS automatically selects source 2
16. **Set** the GE Zenith ZTG ATS to INHIBIT mode to prevent automatic source switching
17. **Close** breaker 3 "BLDG LTG" on A.C. DIST. CAB. 2 (3 Φ 480/277V); verify building lights operate
18. **Close** breaker 1 "XFMR-1 SUPPLY #1" on A.C. DIST. CAB. 1 (3 Φ 480/277V)
19. Set XFMR-1 cooling fans to MANUAL mode briefly; observe the fan rotation
 - a. If the fans are rotating in the correct rotation, continue through the procedure
 - b. If the fans are rotating in the opposite direction, re-trace conductors and correct
20. Leave the cooling fans in AUTO after phase rotation is verified **Open** breaker 1 "XFMR-1 SUPPLY #1" on A.C. DIST. CAB. 1 (3 Φ 480/277V)
21. **Tape over** breaker 1 "XFMR-1 SUPPLY #1" on A.C. DIST. CAB. 1 (3 Φ 480/277V) to prevent accidental closing
22. **Close** 34.5 kV transformer secondary safety disconnect switch – Source 1
23. **Close** 34.5 kV–480/277 V, 750 kVA high side fuses, S&C Type SMD-2C
24. **Set** the GE Zenith ZTG ATS to select Source 1; verify the correct LED indication on the ATS front panel
25. **Verify** correct phase rotation with source 2 (power pot)
26. **Remove tape** on breaker 1 "XFMR-1 SUPPLY #2" on A.C. DIST. CAB. 2 (3 Φ 480/277V)
27. **Close** breaker 1 "XFMR-1 SUPPLY #2" on A.C. DIST. CAB. 2 (3 Φ 480/277V)
28. Set XFMR-1 cooling fans to MANUAL mode briefly; observe the fan rotation
 - a. If the fans are rotating in the correct rotation, continue through the procedure
 - b. If the fans are rotating in the opposite direction, re-trace conductors and correct
 - c. Leave the cooling fans in AUTO after phase rotation is verified
29. **Set** the GE Zenith ZTG ATS to AUTO

30. **Close** breaker 6 "BATT CHGR #1" on A.C. DIST. CAB. 1 (3 Φ 480/277V)
31. **Close** breaker 8 "BATT CHGR #2" on A.C. DIST. CAB. 2 (3 Φ 480/277V)
32. **Close** breaker 21 on A.C. DIST. CAB. 2 (3 Φ 480/277V)
33. **Close** breaker 22 "BLDG. HTR #2" on A.C. DIST. CAB. 2 (3 Φ 480/277V)
43. **Close** breaker 3 "PCB POSN H7" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
44. **Close** breaker 4 "PCB POSN H9" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
45. **Close** breaker 9 "ANNUN" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
46. **Close** breaker 10 "YARD LTG. CONTROL" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
47. **Close** breaker 11 "DFR" on A.C. DIST. CAB. 4 (3 Φ 208/120V)

48. **Close** breaker 12 "NIGHT LTS." on A.C. DIST. CAB. 4 (3Φ 208/120V)
49. **Close** breaker 13 "BLDG RECEPT" on A.C. DIST. CAB. 4 (3Φ 208/120V)
50. **Close** breaker 14 "345 KV POSN V4 PRI RLY" on A.C. DIST. CAB. 4 (3Φ 208/120V)
51. **Close** breaker 16 "JMUX PANEL" on A.C. DIST. CAB. 4 (3Φ 208/120V)
52. **Close** breaker 17 "PCB POSN-V11" on A.C. DIST. CAB. 4 (3Φ 208/120V)
53. **Close** breaker 18 "PCB POSN-V31" on A.C. DIST. CAB. 4 (3Φ 208/120V)
54. **Remove tape** on breaker 1 "XFMR-1 SUPPLY #1" on A.C. DIST. CAB. 1 (3Φ 480/277V)
55. **Close** breaker 1 "XFMR-1 SUPPLY #1" on A.C. DIST. CAB. 1 (3Φ 480/277V)
56. **Close** breaker 3 "YARD LTG. CAB Y1" on A.C. DIST. CAB. 1 (3Φ 480/277V)
57. **Close** breaker 19 on A.C. DIST. CAB. 1 (3Φ 480/277V)
58. **Close** breaker 20 "BLDG HTR #1" on A.C. DIST. CAB. 1 (3Φ 480/277V)
59. **Close** breaker 1 "PCB POSN H1" on A.C. DIST. CAB. 3 (3Φ 208/120V)
60. **Close** breaker 2 "PCB POSN H2" on A.C. DIST. CAB. 3 (3Φ 208/120V)
61. **Close** breaker 5 "PCB POSN H5" on A.C. DIST. CAB. 3 (3Φ 208/120V)
62. **Close** breaker 9 "BLDG HT CONTROL" on A.C. DIST. CAB. 3 (3Φ 208/120V)
63. **Close** breaker 10 "BLGD (sic) EXH. FAN" on A.C. DIST. CAB. 3 (3Φ 208/120V)
64. **Close** breaker 11 "SW BD. LTS." on A.C. DIST. CAB. 3 (3Φ 208/120V)
65. **Close** breaker 12 "SW BD RCPT" on A.C. DIST. CAB. 3 (3Φ 208/120V)
66. **Close** breaker 13 "BLDG RCPT. GONG&CLCK N.&W WALLS" on A.C. DIST. CAB. 3 (3Φ 208/120V)
67. **Close** breaker 14 "MISC A.C. BUS" on A.C. DIST. CAB. 3 (3Φ 208/120V)
68. **Inform** Transmission Operations that the station service has been restored; the following equipment has been returned to normal operation:
 - d. 138 kV PCB H1 Reclosing
 - e. 138 kV PCB H2 Reclosing
 - f. 138 kV PCB H5 Reclosing
 - g. 138 kV PCB H7 Reclosing
 - h. 138 kV PCB H9 Reclosing
 - i. 345 kV PCB V11 Reclosing
 - j. 345 kV PCB V31 Reclosing
 - k. XMFR-1 Cooling System
 - l. Battery Charger #1
 - m. Battery Charger #2

TRANSMISSION ENGINEERING DESIGN

DIVISION 16

Specification 160

FIBER OPTICS INSTALLATION, TESTING, AND CONSTRUCTION STANDARD



Transmission & Distribution Design
Department
ENERGY DELIVERY TECHNICAL
SERVICES

AMEREN SERVICES
COMPANY

Rev No.	Date	Revisions	By	Approvals	
0	12/06/17	Initial Issue- several specifications combined into as standard DIV issue.	DWD	MJE	RJR
1	04/12/2020	Updated with Splice performance data under Digital scope, and clarity of verbiage	DWD	RJR	

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1.0 General Expectations

- 1.1 The Contractor shall act as a complete fiber installation, splicing and testing organization to furnish all skilled labor, supervision, tools, and equipment required for and incidental to the splicing, testing, identification, and administration of fiber optic cables as described within this section.
- 1.2 Contractor shall reference drawings issued for execution and documentation purposes of splicing.
- 1.3 Contractor shall provide all materials, tools, and equipment needed for fiber splicing and testing; and all equipment and tools necessary for fiber installation.
- 1.4 Contractor shall issue any approved revisions to documentation and testing records, per Ameren processes, timeframes, and formats, described in later sections.
- 1.5 Contractor(s) shall use an Ameren approved splicing vendor and Ameren approved equipment, exceptions must obtain approval from Ameren Construction Supervision and/or Ameren Project Engineer. Approved vendors must at a minimum meet/exceed the requirements described in the sections below. Approved vendor list can be obtained from the Ameren Project Engineer, Ameren Telecom, or Construction Supervision and is located in Appendix 4.
- 1.6 Contractor shall use equipment in good working order and be able to provide calibration reports upon request. Equipment will need to be able to test a broad spectrum of wavelengths and produce reports. More information is outlined in later sections.
- 1.7 Testing of a new fiber will occur in **BOTH** directions as outlined in Appendix 1 and all segments will be tested from start to finish.

2.0 Codes & Standards

The quality of workmanship, clearances, protection of workers, etc., shall be governed by applicable laws, ordinances and regulations of authorities having jurisdiction as well as applicable sections of standards as set up by the following organizations:

- American National Standards Institute (ANSI)
- American Society for Testing & Materials (ASTM)
- Institute of Electrical and Electronic Engineers (IEEE)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- Occupational Safety and Health Administration (OSHA)
- Telecordia GR-765
- Federal Communications Commission (FCC)
- Fiber Optic Association (FOA)
- International Telecommunication Union (ITU)
- Telecommunications Industry Association (TIA)

Standards specifically addressed are the following with Ameren clarifications:

- TIA RS-359-A - EIA Standard Colors for Color Identification and Coding
- TIA 598-A – Optical Fiber Cable Color Coding
- TIA-526-7-1998, Optical Power Loss Measurements of Installed Single-mode Fiber Cable Plant-OFSTP-7
- TIA/EIA 568 Building Telecommunications Wiring Standards
- GR-20-CORE – Generic Requirements for Optical Fiber and Optical Fiber Cable (Optical Fiber only).
- GR-771-CORE – Generic Requirements for Fiber Optic Splice Closures
- GR-196-Generic Requirements for Optical Time Domain Reflectometer (OTDR) Type Equipment
- IEEE 1428-2004 – Guide for Installation Methods for Fiber Optic Cables in Electric Power Generating Stations and in Industrial Facilities.



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- IEEE 812-1984 – Standard Definitions of Terms Relating to Fiber Optics
- ITU-T G.652 (Category D) General Requirements for Optical Fiber and Optical Fiber Cable (Optical Fiber only)
- ITU-T L.12 Series L: Construction, installation and Protection of Cables and Other Elements of Outside Plant
- IEC-61300-3-25 – Fiber Optic Connector Visual End Face Inspection
- ANSI Z136.2 – Safe Use of Optical Fiber Communications.

Where conflicts arises in standards or direction unless specifically stated in contractual documentation, the conflicts shall be sent to Ameren to give clarification and direction.

3.0 Worker Qualifications

- 3.1 Technicians performing any work included in this specification shall have the following Fiber Optic Association (FOA) certifications: CFOT, CFOS/S, and CFOS/T and shall be trained to handle AFL and Corning with both OPGW and ADSS products.
- 3.2 Light Brigade training through AFL is required. Training required at a minimum shall have consisted of the Fiber Optics 1-2-3 (four day course) and Advanced OSP technician training. Those technicians performing work shall obtain the ETA FOI certification and/or the FOT-OSP certifications.
- 3.3 The Contractor shall be fully qualified to work in space owned by the Owner, and must be vetted through Ameren systems, procedures, and Engineering.
- 3.4 Technician shall have a minimum two (2) years' experience in Fiber Optic splicing and testing, resumes made available upon request.

4.0 Scope of Work

4.1 Fiber Installation

- 4.1.1 The contractor shall provide mechanical protection to the cable where it runs along the surface or edge of a structure or pulling devices.
- 4.1.2 At the locations where a splice is required, additional cable length must be provided to physically accommodate the splicing process.
 - 4.1.2.1 For cable outdoors at a structure, the length of each cable end shall be not less than 165 feet from the base of the structure (ground level), or as otherwise noted on the Drawings, remembering that about 20 feet of cable shall be cut off to assure no damaged fiber is used.
 - 4.1.2.2 If additional length is required, due to limited access for splicing vehicles, it shall be included, as required, and with the approval of the Ameren Construction Services or Ameren Engineering.
 - 4.1.2.3 For a cable indoors located at a panel the additional length shall be a minimum of 50 ft., knowing 20 feet is required for bad fiber due to pulling, and additional length of 15ft is required for splicing breakout correctly.
 - 4.1.2.4 Fiber black jacket cable shall be sheaved to the splice container and secured in proper locations per manufacturer's direction. Additional buffer tube length shall be coiled and placed in the splice container neatly, maintaining bend radii at all times, and in a way that does not pinch the buffer tubes.
- 4.1.3 The fiber shall be neatly coiled and securely attached to the structure on bracketing of the splice enclosure, as specified on the Drawings referenced in the Appendices. The diameter of the coil shall be a minimum of three feet or as required based on the minimum allowed bending radii specified by the manufacturer.



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- 4.1.4 The Contractor shall handle all fiber optic cable in strict accordance with the cable manufacturer's specifications and procedures.
- 4.1.5 If any Owner-provided materials appear to be damaged or defective, the Contractor shall immediately report the details to Construction Supervision, who shall provide written directions regarding the corrective actions, storage, or disposal of these materials.
- 4.1.6 If the cable must be temporarily stored overnight while in the process of splicing, the cable ends shall be sealed to prevent water migration and the cable coils stored out of the reach of vandals. It is unacceptable to temporarily store cable at the base of the pole, unless the structure is in a safe and secured location.
- 4.1.7 All cables splice boxes, and associated components shall be fully assembled, sealed from rodents and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.
- 4.1.8 Fiber shall be segregated by tray, conduit, innerduct, or other innerduct methods approved by Ameren for protection.
 - 4.1.8.1 Where ADSS fiber is placed underground, it shall have its own conduit and be designated as such, or be segregated by using innerduct within the conduit or trench system.
 - 4.1.8.2 Innerduct will also be used in the main cable tray application within the control house.
 - 4.1.8.3 Within the confines of an enclosure, fiber jumpers should be segregated by a separate tray system, to ensure bend radii and cable weight concerns are mitigated.
 - 4.1.8.4 Where microduct is used path must be continuous and all micro tubes either plugged or sealed appropriately with proper connections
- 4.1.9 Contractor shall mark conduits leaving Ameren Property with approved marking methods that should be prescribed in project documentation, typically with Marker buoys showing the route as prescribed in project documentation.

4.2 Splicing

- 4.2.1 Contractor shall reference documentation and reference drawings issued for execution and documentation purposes of splicing. Single fusion splices only are accepted; **ribbon splicing will not be accepted and will cause additional work for all concerned if it is found.**
- 4.2.2 All splicing performance data listed in Appendix 1 shall be met or exceeded in performance.
- 4.2.3 Standard optical cable color codes and fiber types shall be observed when fusion splicing two fiber optic cables together unless otherwise directed by the Owner's Representative. For instance, when butt splicing OPGW fibers to all dielectric loose tube cable fibers, G.652 standard single mode fibers shall be spliced to G.652 standard single mode fibers and G.655 fibers shall be spliced to G.655 fibers in order based on the TIA/EIA-598 color code scheme. G.655 fibers shall be spliced as the last group in the fiber cable count.
- 4.2.4 Contractor shall refer to manufacturer's OPGW installation procedures pertaining to preparing the OPGW for splicing. Contractor shall read and understand the procedure completely before attempting field installation. The manufacturers recommended maximum bend radii and tensions shall be observed at all times so not to exceed these values.
- 4.2.5 All fiber optic splicing shall be fusion type. Splicing shall be performed in an environmentally protected enclosure to ensure high quality splice performance. Splicing shall be accomplished on the ground and not in an aerial bucket. The excess cable at splice points shall be properly secured by the Contractor and mounted in/on the appropriate location using Velcro or encapsulated padding with zip ties. Zip ties alone are not acceptable fasteners.
- 4.2.6 Splice equipment must also meet or exceed minimum performance standards as in Appendix 1.



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- 4.2.7 Approved Fusion Splicing Equipment can be referenced in Appendix 1. Under splicing and testing requirements.
- 4.2.8 All spliced fibers shall be protected by a fiber optic heat shrink sleeve. Tyco/ Raychem SMOUV heat shrink or equivalent are acceptable products. A heat oven shall be the only method used to shrink the sleeves. The acrylic coating on the fiber should not be removed beyond the areas that will be covered by the heat shrink sleeves.
- 4.2.9 Visual inspection of each splice shall be required. The visual inspection requires that the splicing technician inspect the splice for abnormalities such as a narrowing, thickening, or bubble at the splice point. If abnormalities exist, the splice shall be broken and re-spliced. After passing visual inspection and profile alignment qualifications, the splice shall be subject to a tension test to ensure the fiber splice and adjacent fiber are of proper quality.
- 4.2.10 Contractor shall review splicing data and re-splice those fibers not meeting the minimum specifications outlined herein. Final acceptance of a splice will be determined by the Owner/Owner's Representative, referenced in Appendix 1, upon successful completion of the bi-directional OTDR testing phase.
 - 4.2.10.1 If specification cannot be achieved, written notice shall be sent project Manager/ Engineer and Ameren Telecom representative for resolution, represented in the process in Appendix 6. Resolution plan will be made within 10 business days and communicated to the contractor.
- 4.2.11 Contractor shall obtain approval from Construction Supervision before performing work on any pole.
- 4.2.12 Time to correct splicing issues shall be less than 15 days and should be coordinated with communication to construction supervision and Ameren Telecom.
- 4.2.13 Splicing shall be assumed straight through unless otherwise noted on a drawing issued by the project engineer, meaning each like colored tube will be spliced together. (blue to blue orange to orange...etc.)
- 4.2.14 Project documentation will be issued under standard means and methods in accordance with Ameren Project Procedures.
- 4.2.15 Contractor should be aware that when working with OPGW, the contractor is handling a system shield wire that may have some associated induced stray currents or voltages and this cable should be properly grounded prior to performing work-scope. The fiber itself is immune from these voltages, but the cabling, box, and rack should be approached with caution and safety in mind. Contractor shall consult construction supervision prior to work scope start to verify circuit safety and proper grounding is applied.
- 4.2.16 Additional splicing and testing requirements can be found in Appendix 1.

5.0 Labeling

- 5.1 Labeling shall conform to the requirements specified within ANSI/TIA/EIA-606-A or to the requirements specified by the Owner or the Owner's representative in project documentation.
- 5.2 Shall meet the legibility, defacement, exposure and adhesion requirements of Marking and Labeling Systems - UL 969. **Handwritten labels are not acceptable.**
- 5.3 Labeling shall be done per Ameren guidance and standardization from the Ameren Fiber mapping system and conform to proper formats as noted on the issued documentation.
- 5.4 The modules shall be labeled per drawings and labeled according to below stated standardization. The modules should be terminated in order. Fibers 1-12 (Blue tube) to module A; Fiber 13-24 (Orange tube) to module B; Fiber 25-36 (Green tube) to module C; Fibers 37-48 (Brown tube) to

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module D. If 72 count fiber exists fiber 49-60 (slate tube) will be module E and fibers 61-72 (white tube) will be module F.

6.0 Documentation Submittals

- 6.1 Test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within five (5) working days of completion of tests. The Contractor shall retain a copy to aid preparation of as built information.
- 6.2 Testing files should be submitted in both Native format (specify Program used AFL, Fujitsu, Fluke,..Etc.); and also submitted in .xlsx format (excel). The splicing information will be placed on the SharePoint site with a notification email sent to the Ameren Project Engineer, and corresponding Ameren Telecom Engineer. Please reference the process diagram in Appendix 6.
 - 6.2.1 These should be labeled per the same as the field label, and as defined in attachment 1, which includes the line name & number and substation information
- 6.3 All mark-up or redline drawings to be returned to the Project Engineer and Ameren Digital engineer within 3 weeks of project completion.
- 6.3 The detailed test / splice results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the information listed in Attachment #1.
- 6.4 Record copy drawings at the end of the project shall be in .PDF (redlines) and/or a CAD format (.DGN or .DWG) and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths, splice boxes, cable numbers/ types, and termination points.

7.0 Warranty

- 7.1 The Contractor shall provide a one-year warranty on the quality of all fiber optic splicing and testing work.
- 7.2 Contractor shall make good on items within the warranty timeframe should issues arise, that were produced under their work scope.

8.0 Material Requirements

Where contractor has scope to provide material the contractor must use the material as specified below.

- 8.1 Use of only low water peak or zero water peak single mode Fiber is permitted for use, meeting or exceeding the specifications of the Corning SMF 28 or 28e fiber. Specifically, the fiber-optic cable satisfies requirements of ITU-T G.652.D recommendation. Ameren will have the final decision on whether, specification is met for substitutions, and per Ameren material specification 23.
- 8.2 Miscellaneous material used shall be an item off the list of standard details, Bill of Material, and Construction Details is shown in Appendix #2 for Transmission Lines and Appendix #3 for Substations with standard substation drawing 668387. If material differs contractor shall supply datasheets and must be authorized by Ameren to use material as directed below.
- 8.3 Contractors are allowed to provide equivalent material provided material meets the same level of performance and provided that any such substitution shall be:
 - a. Submitted with the contractor work plan, and
 - b. Be fully documented with any / all manufacturer's catalog and performance data sheets for any proposed substitution, and
 - c. Approved in writing by Owner prior to contract execution / Notice to Proceed.



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8.4 Contractor shall provide a bid response that uses the Owner's specified products for comparison, including any details regarding the change in price / performance that would result if the alternative products are accepted by Owner.

8.5 Cable ties are not an acceptable cable fastener for fiber cables of any type or kind, for Ameren usage.

Contractor shall always supply those items needed inside the splice cases to complete work scope, that are not supplied by Ameren, items typically include but are not limited to: labeling, heat-shrink, cable fasteners, and furcation kits (if required).

9.0 Schedule

9.1 Contractor shall give Ameren work schedule updates and work scope progress reports. The frequency of the reports is at the discretion of Ameren schedule management procedures.

9.2 Contractor shall coordinate with Ameren for schedule management and outage concerns at per the request of Ameren. Typically this is at a minimum of an update every two weeks.

10.0 Communication

10.1 Communications shall first be with Construction Supervision for questions on job scope and safety. If a resolution cannot be obtained, contractor shall issue an RFI, using the Ameren RFI process, with the attention of Ameren Digital or Ameren Project Engineering.

10.2 Communication of scope will be with the project documentation from Ameren digital and Ameren project engineering and will be digital communication (email, FTP, Ameren project release folder structure, ...etc.).

11.0 Appendix and Attachments

See attached documentation.

END OF SECTION 160



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Revision History		
Issue Date	Engineer	Revision Information
11/21/2017	D. Dettenmeier	Initial Issue with changes to the BOM and requirements for the contractor was originally designed as 16N but changed to 16O, in standardization process.
4/12/2019	D. Dettenmeier	Updated with appendices and additional splice loss information and requirements as well as process for documentation. Updated with IT and Coordinated documentation



ATTACHMENT #1
Sample Splice Diagram To be Created/ Supplied to Contractor

Splice Status		Planned																		
Circuit ID	Comments	Splice Type	Start	End	Tray	Planned			Tray	Planned			Tray	In Service						
						Status Code	Southwest Campus - U of I Main			Status Code	Entrance cable with unknown routing CPI7CDB9			Status Code	CP17CDB9PG001HNCMPCT13					
						Fiber Cable Name				Fiber Cable Name				Fiber Cable Name						
						Size/Type				Size/Type				Size/Type						
						Manufacturer				Manufacturer				Manufacturer						
						Cable Length	5,436'			Cable Length	163'			Cable Length	10,467'					
						Fiber Count	48 CT			Fiber Count	48 CT			Fiber Count	48 CT					
Fiber#	Bundle	Fiber	Description	Fiber#	Bundle	Fiber	Description	Fiber#	Bundle	Fiber	Description	Fiber#	Bundle	Fiber	Description					
						1	BL	BL												
						2	BL	OR												
						3	BL	GR												
						4	BL	BR												
						5	BL	SL												
						6	BL	VH												
						7	BL	RD												
						8	BL	BK												
						9	BL	YL												
						10	BL	VI												
						11	BL	RS												
						12	BL	AQ												
						13	OR	BL												
						14	OR	OR												
						15	OR	GR												
						16	OR	BR												
						17	OR	SL												
						18	OR	VH												
						19	OR	RD												
						20	OR	BK												
						21	OR	YL												
						22	OR	VI												
						23	OR	RS												

*This drawing or excel spreadsheet should be issued from NEO/Coms department at Ameren it may look slightly different but will give information on how the strands should be spliced; it will come from a computer generated source.



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Appendix

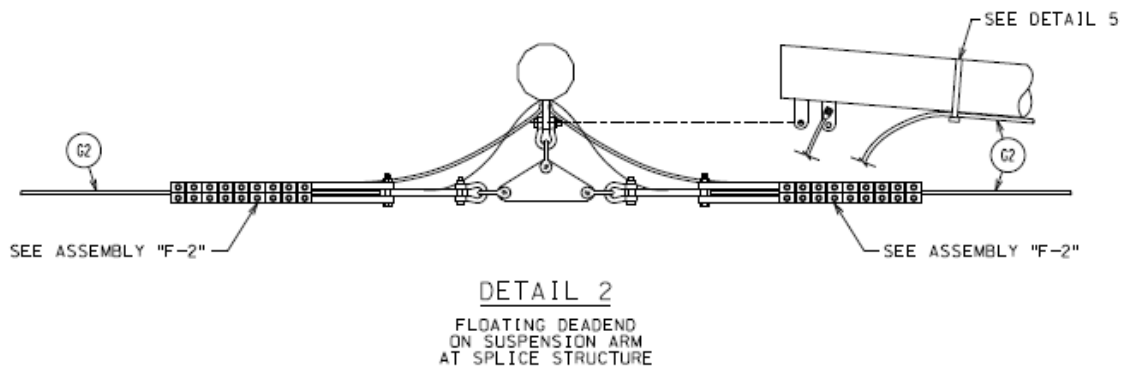
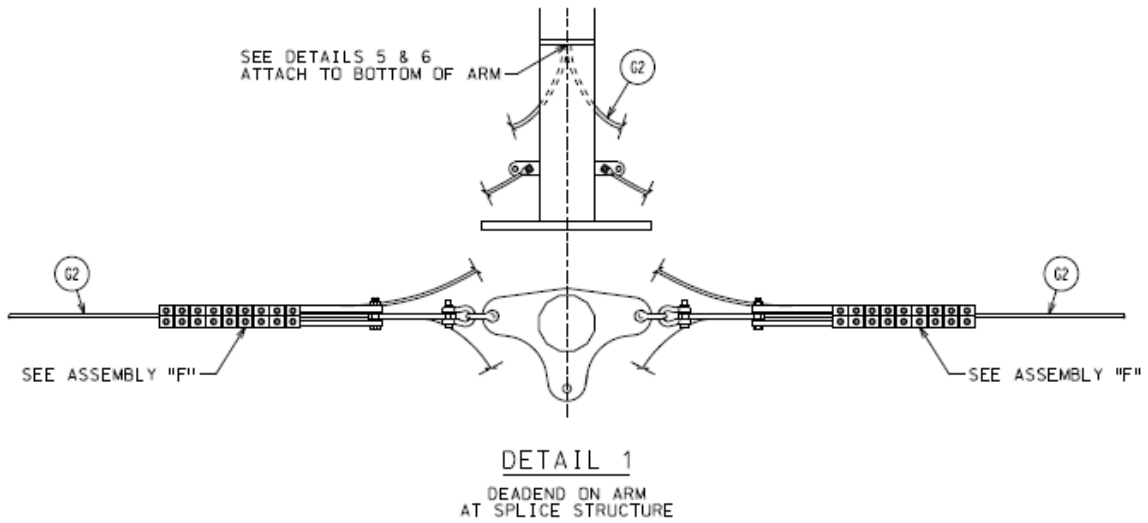


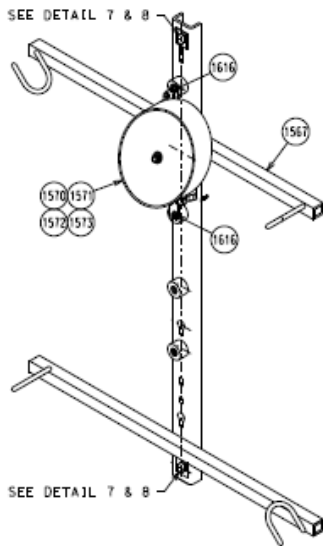
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APPENDIX #1 Fiber Splicing and Testing Requirements (IT Maintained) see attached

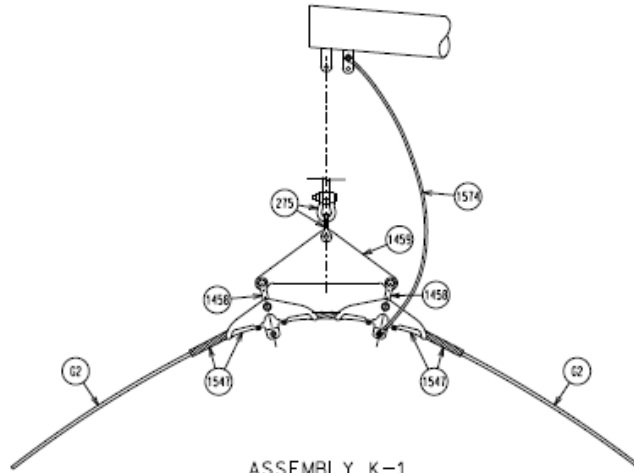
APPENDIX #2 Standard Transmission Line Details and Bill of Material

NOTE: This is only a sample of the details that are typical and could be encountered. The contractor shall refer to project documentation before performing work.

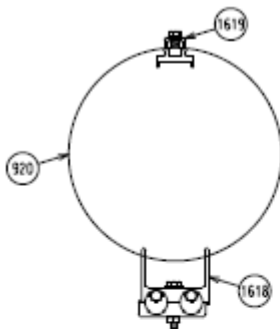




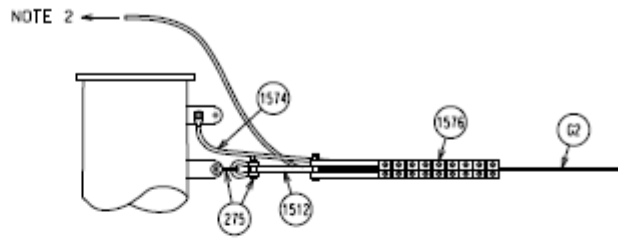
DETAIL 9
OPGW ENCLOSURE ASSEMBLY
NOTE 3



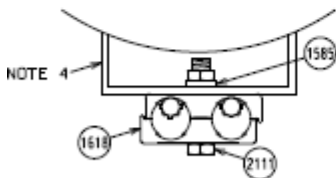
ASSEMBLY K-1
OPGW SUSPENSION ASSEMBLY
30°-60° LINE ANGLE
(ROTATED FOR CLARITY)



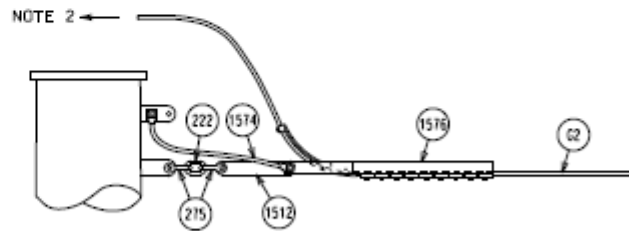
DETAIL 5
OPGW DOWNLEAD CLAMP
ASSEMBLY



ASSEMBLY F
OPGW DEADEND ASSEMBLY



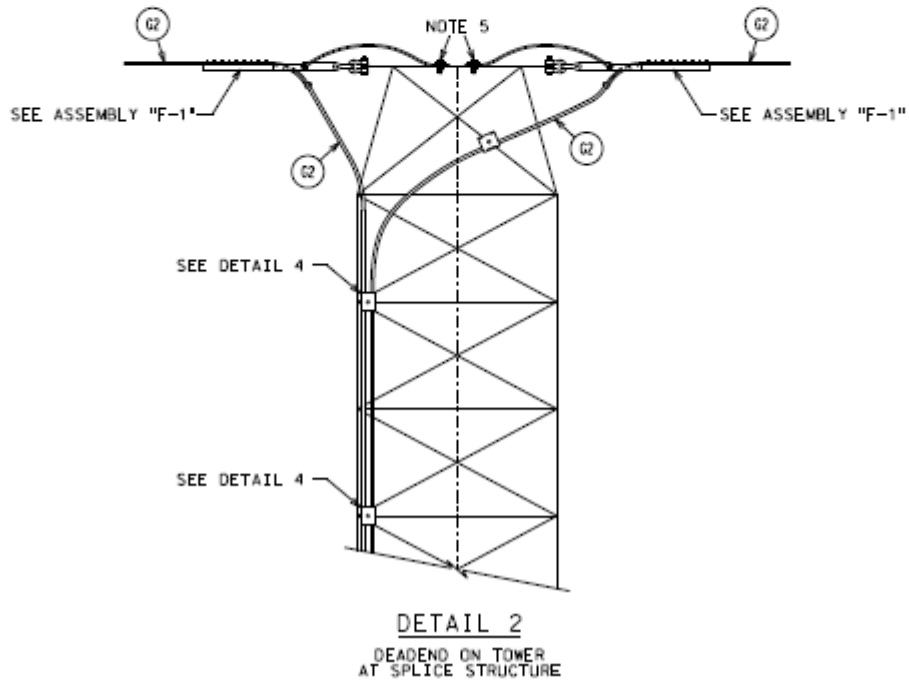
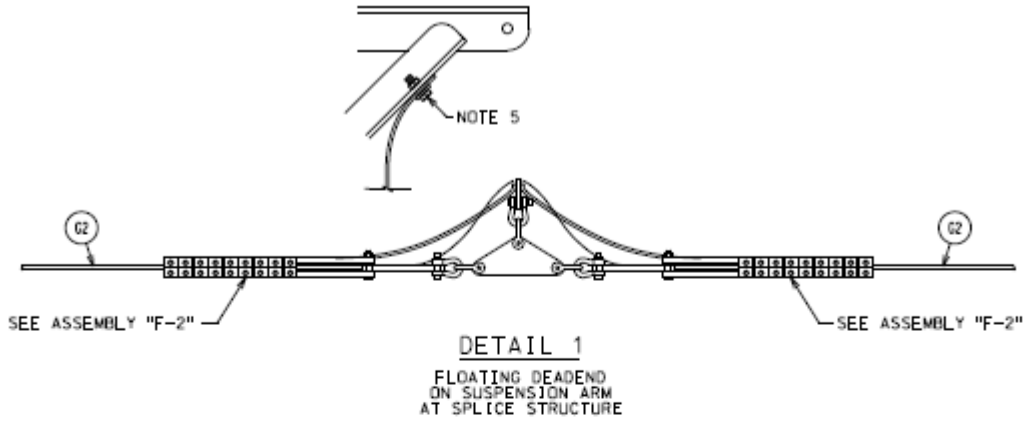
DETAIL 6
OPGW DOWNLEAD CLAMP
DETAIL, POLES
WITH BRACKET

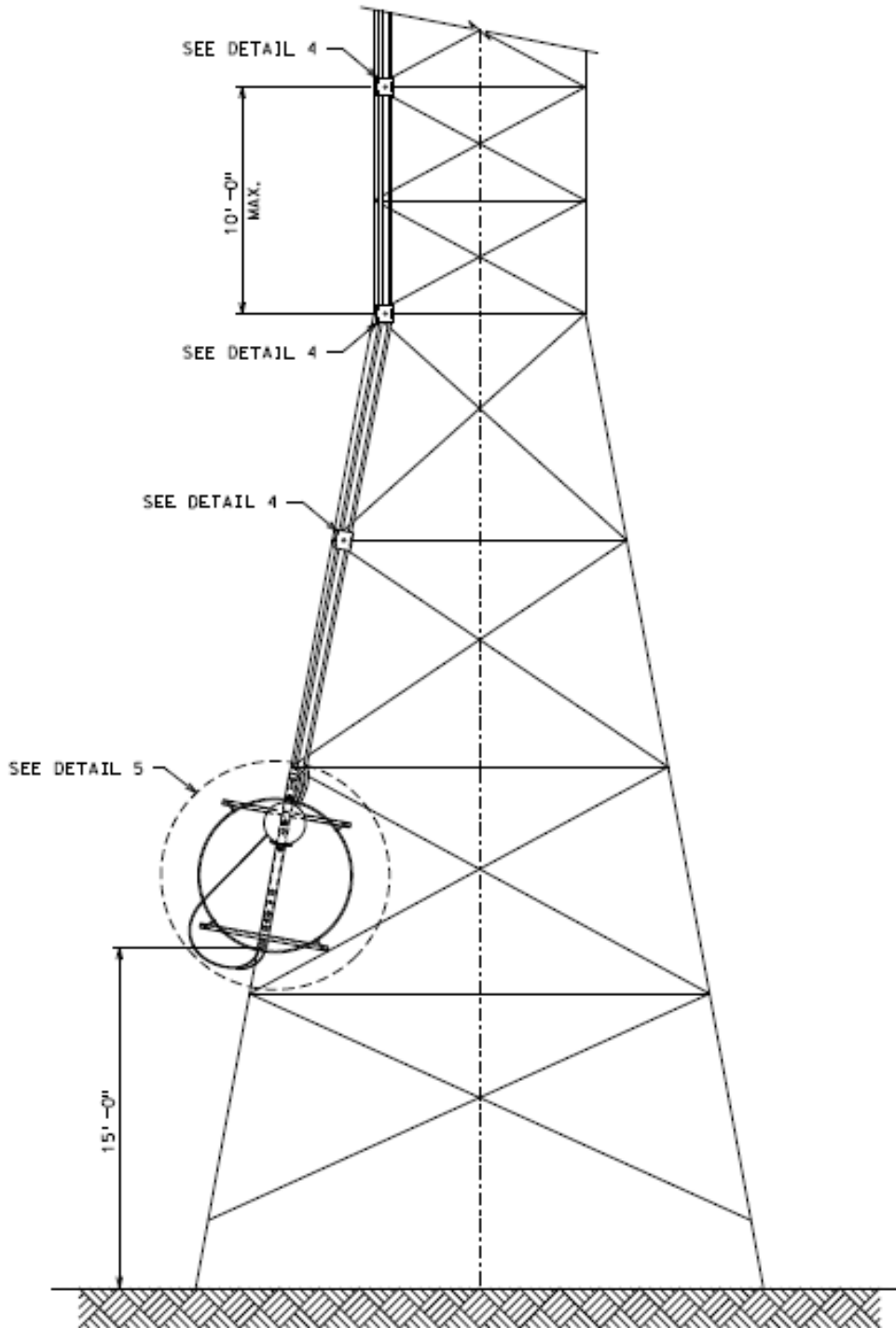


ASSEMBLY F-1
OPGW DEADEND ASSEMBLY

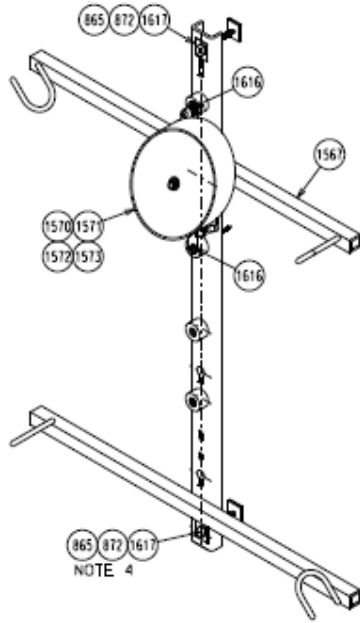
BILL OF MATERIAL								
	ITEM	QTY.	UNIT	DESCRIPTION	MFR.*	CAT. NO.*	AMEREN SERVICES STOCK NO.	REMARKS
DETAIL 5	G2	AS REQ'D	FT.	FIBER OPTIC S.W., 48 FIBER OPGW, 0.508" DIA.	AFL	DND-7330	27-59-080	ULT=19,837 lbs.
	920	AS REQ'D	EA.	BANDING, STAINLESS STEEL, 1/2"x0.03"	BAND-IT	C-204	22-12-084	PART OF DETAILS 1, 2, 3 & 4
	1618	AS REQ'D	EA.	DOWNLEAD CLAMP FOR OPGW, # RANGE 0.501" - 0.600"	AFL	FDDAB5B5A	17-52-219	PART OF DETAILS 1, 2, 3 & 4
DETAIL 6	1619	AS REQ'D	EA.	BANDING CLAMP, W/ 5/8" BOLT	NEHRWESS	OB-112	23-67-500	PART OF DETAILS 1, 2, 3 & 4
	1618	AS REQ'D	EA.	DOWNLEAD CLAMP FOR OPGW, # RANGE 0.501" - 0.600"	AFL	FDDAB5B5A	17-52-219	PART OF DETAILS 1, 3 & 4
	1585	AS REQ'D	EA.	LOCK WASHER, 1/2" #, GALV.	JOSLYN	J138	23-66-005	PART OF DETAILS 1, 3 & 4
DETAIL 7	2111	AS REQ'D	EA.	BOLT, 1/2"x3" W/ NUT, GALV.			23-52-354	PART OF DETAILS 1, 3 & 4
	865	AS REQ'D	EA.	NUT, LOCK, FOR 5/8" BOLT, GALV.	JOSLYN	J8583	23-65-043	PART OF DETAIL 9
	872	AS REQ'D	EA.	WASHER, SQUARE 2/4"x2/4"x3/8", 1/8" DIA. HOLE, GALV.	JOSLYN	J-1075	23-66-027	PART OF DETAIL 9
DETAIL 8	920	AS REQ'D	EA.	BANDING, STAINLESS STEEL, 1/2"x0.03"	BAND-IT	C-204	22-12-084	PART OF DETAIL 9
	1567	AS REQ'D	EA.	COIL BRACKET	AFL	CB-44	40-54-480	PART OF DETAIL 9
	1620	AS REQ'D	EA.	BANDING CLAMP, W/ 5/8" STUD AND NUT	NEHRWESS	OB-112-S	23-67-499	PART OF DETAIL 9
DETAIL 9	872	AS REQ'D	EA.	WASHER, SQUARE 2/4"x2/4"x3/8", 1/8" DIA. HOLE, GALV.	JOSLYN	J-1075	23-66-027	PART OF DETAIL 9
	1567	AS REQ'D	EA.	COIL BRACKET	AFL	CB-44	40-54-480	PART OF DETAIL 9
	1585	AS REQ'D	EA.	LOCK WASHER, 1/2" #, GALV.	JOSLYN	J138	23-66-005	PART OF DETAIL 9
DETAIL 9	2111	AS REQ'D	EA.	BOLT, 1/2"x3" W/ NUT, GALV.			23-52-354	PART OF DETAIL 9
	1567	1	EA.	COIL BRACKET	AFL	CB-44	40-54-480	PART OF DETAIL 3
	1570	10	PKG.	SPLICE PROTECTOR SLEEVE 60mm LG, SUPPLIED IN PACKAGES OF 10	AFL	S000065	17-60-734	PART OF DETAIL 3
DETAIL 9	1571	1	EA.	SPLICE ENCLOSURE, INCLUDES TRAYS FOR UP TO 72 FIBERS	AFL	SB01-72	40-54-478	PART OF DETAIL 3
	1572	2	EA.	SB01 FURCATION KIT, ORDER ONE PER S.S. TUBE PER PORT	AFL	SB01FK	40-54-479	PART OF DETAIL 3
	1573	2	EA.	CONNECTOR KIT FOR OPGW SPLICE ENCLOSURE	AFL	APCK507/521	40-54-481	PART OF DETAIL 3
ASSY F	1616	2	EA.	MACHINE BOLT, GALV., 1/2"x1/4", W/NUT	ALLIED BOLT	8202	23-52-024	PART OF DETAIL 3
	275	2	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1512	1	EA.	DEAD END LINK PLATE, 12" LONG, 10" C.C., 40K	AFL	ODELPI0	23-68-731	
ASSY F-1	1574	1	EA.	ALUMINUM BONDING WIRE, 4/0 19 STR, 60" LONG, (2) 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
	1576	1	EA.	STRAIN CLAMP, OPGW, 0.500"-0.509" RANGE	AFL	DDEC500 /509G09	23-68-732	
	222	1	EA.	CHAIN LINK, 30K	HUBBELL	LK-30	23-68-249	
ASSY F-2	275	2	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1512	1	EA.	DEAD END LINK PLATE, 12" LONG, 10" C.C., 40K	AFL	ODELPI0	23-68-731	
	1574	1	EA.	ALUMINUM BONDING WIRE, 4/0 19 STR, 60" LONG, (2) 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
ASSY F-2	1576	1	EA.	STRAIN CLAMP, OPGW, 0.500"-0.509" RANGE	AFL	DDEC500 /509G09	23-68-732	
	222	2	EA.	CHAIN LINK, 30K	HUBBELL	LK-30	23-68-249	
	275	6	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
ASSY K	1512	2	EA.	DEAD END LINK PLATE, 12" LONG, 10" C.C., 40K	AFL	ODELPI0	23-68-731	
	1574	2	EA.	ALUMINUM BONDING WIRE, 4/0 19 STR, 60" LONG, (2) 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
	1576	2	EA.	STRAIN CLAMP, OPGW, 0.500"-0.509" RANGE	AFL	DDEC500 /509G09	23-68-732	
ASSY K-1	1609	1	EA.	YOKER PLATE, 30 ULT, 3/4" THK., 18" SPACING	HUBBELL	YP0-30-18437-3	23-17-306	
	1506	1	EA.	SUSPENSION CLAMP, 0.500"-0.527" RANGE, W/ ARMOR RODS, 25K	AFL	SLIME 500/527	23-67-502	
	1507	1	EA.	Y-CLEVIS EYE, 90°, 30K ULT.	AFL	YC90E-750-1750	23-58-128	
ASSY K-1	1574	1	EA.	ALUMINUM BONDING WIRE, 4/0 19 STR, 60" LONG, (2) 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
	275	2	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1458	2	EA.	CLEVIS-EYE, 30K ULT.	AFL	CE-SC	23-58-127	
ASSY K-1	1459	1	EA.	YOKER PLATE, 18", TRIANGULAR, 40K	AFL	SUMEPY	23-17-437	
	1547	1	EA.	SUSP. CLAMP, DOUBLE, 0.500"-0.527" RANGE, W/ ARMOR RODS, 25K	AFL	ODSME 500/527	23-67-501	
	1574	1	EA.	ALUMINUM BONDING WIRE, 4/0 19 STR, 60" LONG, (2) 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	

* INDICATION OF MANUFACTURER & CATALOG NUMBER IMPLIES *OR EQUAL*.

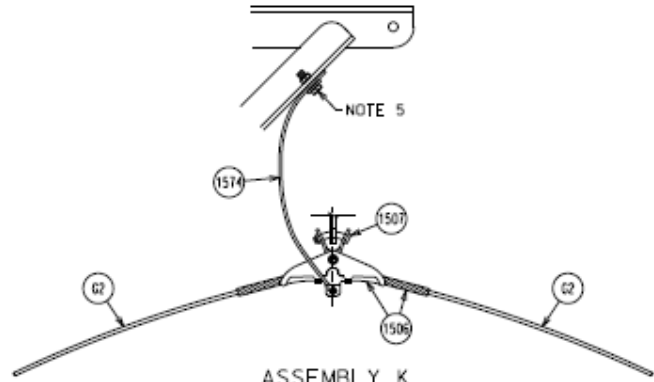




DETAIL 3
TYPICAL OPGW SPLICING



DETAIL 5
OPGW ENCLOSURE ASSEMBLY
NOTE 2



ASSEMBLY K
OPGW SUSPENSION ASSEMBLY
0°-30° LINE ANGLE



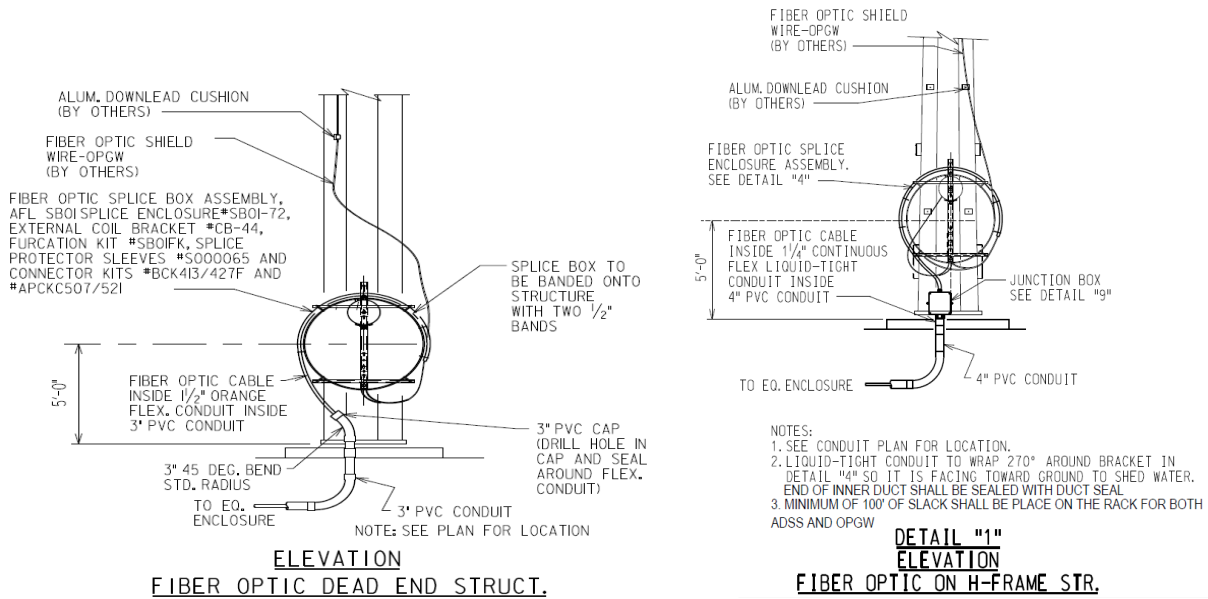
BILL OF MATERIAL								
	ITEM	QTY.	UNIT	DESCRIPTION	MFR.*	CAT. NO.*	AMEREN SERVICES STOCK NO.	REMARKS
DETAIL 5	02	AS REQ'D	FT.	FIBER OPTIC S.W., 48 FIBER OPGW, 0.508" DIA.	AFL	DND-7330	27-59-080	ULT=19,837 lbs.
	1519	1	EA.	DOWNLEAD CLAMP FOR OPGW, 0.501"-0.600" DIA. RANGE	AFL	FDDA-8585B	17-52-221	PART OF DETAILS 2 & 3
	865	2	EA.	LOCKNUT, 3/8" DIA.	JOSLYN	J8583	23-65-043	PART OF DETAIL 3
	872	2	EA.	WASHER, SQUARE, 2 1/4"x2 1/4"x 3/16", 1/8" DIA. HOLE	JOSLYN	J-1075	23-66-027	PART OF DETAIL 3
	1567	1	EA.	COIL BRACKET	AFL	CB-44	40-54-480	PART OF DETAIL 3
	1570	10	PKG.	SPLICE PROTECTOR SLEEVE, 60mm LG., SUPPLIED IN PACKAGES OF 10	AFL	S000065	17-60-734	PART OF DETAIL 3
	1571	1	EA.	SPLICE ENCLOSURE, [INCLUDES TRAYS FOR UP TO 72 FIBERS]	AFL	SB01-72	40-54-478	PART OF DETAIL 3
	1572	2	EA.	SB01 FURCATION KIT, ORDER ONE PER S.S. TUBE PER PORT	AFL	SB01FK	40-54-479	PART OF DETAIL 3
	1573	2	EA.	CONNECTOR KIT FOR OPGW SPLICE ENCLOSURE	AFL	APCK507/521	40-54-481	PART OF DETAIL 3
	1616	2	EA.	MACHINE BOLT, GALV., 1/2"x1 1/4", W/NUT	ALLIED BOLT	8202	23-52-024	PART OF DETAIL 3
1617	2	EA.	MACHINE BOLT, GALV., 3/8"x4", W/NUT	HUGHES	B64-1-1/2	23-52-200	PART OF DETAIL 3	
ASSY F	275	2	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1512	1	EA.	DEAD END LINK PLATE, 12" LONG, 10" C.C., 40K	AFL	ODELP10	23-68-731	
	1574	1	EA.	ALUMINUM BONDING WIRE, # 19 STR., 60" LONG, 2 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
	1576	1	EA.	STRAIN CLAMP, OPGW, 0.500"-0.509" RANGE	AFL	ODEC500 /509G09	23-68-732	
ASSY F-1	222	1	EA.	CHAIN LINK, 30K	HUBBELL	LK-30	23-68-249	
	275	2	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1512	1	EA.	DEAD END LINK PLATE, 12" LONG, 10" C.C., 40K	AFL	ODELP10	23-68-731	
	1574	1	EA.	ALUMINUM BONDING WIRE, # 19 STR., 60" LONG, 2 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
	1576	1	EA.	STRAIN CLAMP, OPGW, 0.500"-0.509" RANGE	AFL	ODEC500 /509G09	23-68-732	
ASSY F-2	275	6	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1512	2	EA.	DEAD END LINK PLATE, 12" LONG, 10" C.C., 40K	AFL	ODELP10	23-68-731	
	1574	2	EA.	ALUMINUM BONDING WIRE, # 19 STR., 60" LONG, 2 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
	1576	2	EA.	STRAIN CLAMP, OPGW, 0.500"-0.509" RANGE	AFL	ODEC500 /509G09	23-68-732	
	1609	1	EA.	YOKE PLATE, 18" TRIANGULAR, 30K	HUBBELL	YPD-30-18M3T-3	23-17-306	
ASSY K	1506	1	EA.	SUSPENSION CLAMP, 0.500"-0.527" RANGE, W/ ARMOR RODS, 25K	AFL	SUME 500/527	23-67-502	
	1507	1	EA.	Y-CLEVIS EYE, 90°, 30K	AFL	YC90E-750-1750	23-58-128	
	1574	1	EA.	ALUMINUM BONDING WIRE, # 19 STR., 60" LONG, 2 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
ASSY K-1	275	2	EA.	ANCHOR SHACKLE, LONG, 30K	HUBBELL	AS-25-L-BNK	23-68-368	
	1458	2	EA.	CLEVIS-EYE, 30K	AFL	CE-SC	23-58-127	
	1459	1	EA.	YOKE PLATE, 18", TRIANGULAR, 40K	AFL	SUMEYP	23-17-437	
	1547	1	EA.	SUSP. CLAMP, DOUBLE, 0.500"-0.527" RANGE, W/ ARMOR RODS, 25K	AFL	OOSME 500/527	23-67-501	
	1574	1	EA.	ALUMINUM BONDING WIRE, # 19 STR., 60" LONG, 2 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	

* INDICATION OF MANUFACTURER & CATALOG NUMBER IMPLIES "OR EQUAL".

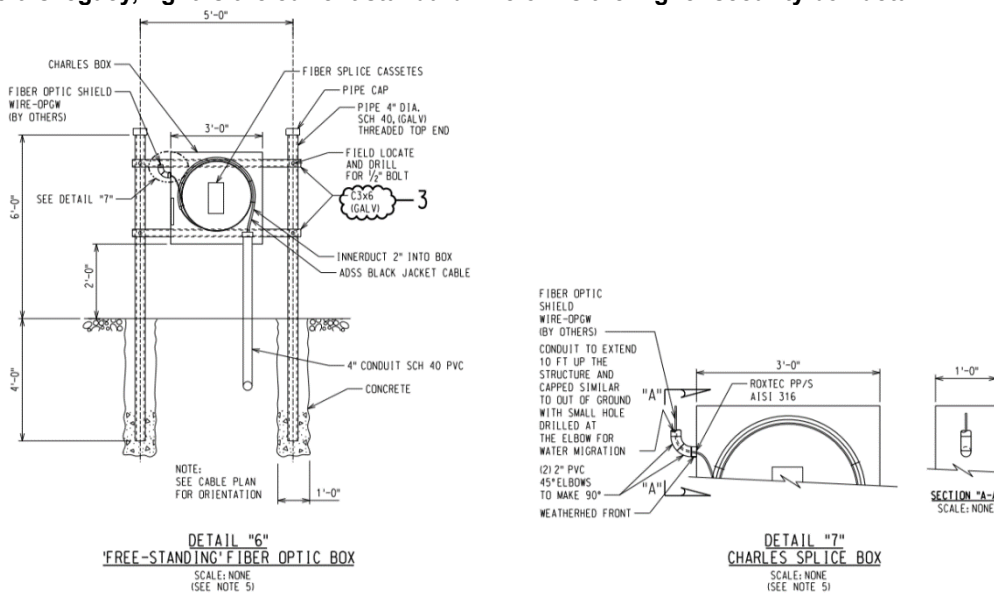
APPENDIX #3 Standard Substation Details and Bill of Material*

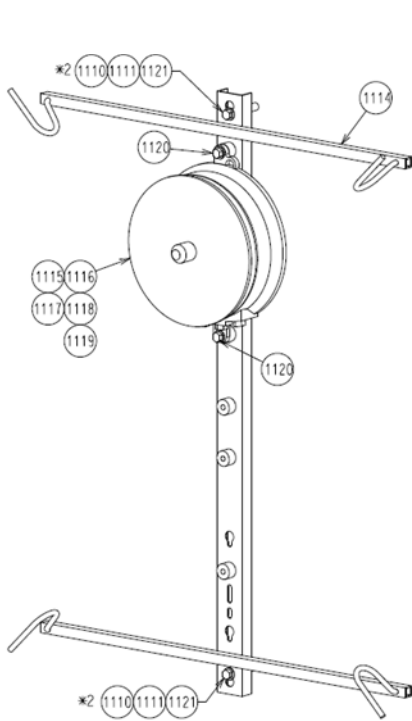
*The details provided herein are standard details for reference. Contractor shall use actual project documentation when performing splicing work.

Other physical installation Details can be referenced on Ameren Standard Drawing 668387, project documentation, and Issued for Construction drawings. For sites needing additional security review with the standard drawing and consult the security team for additional requirements.

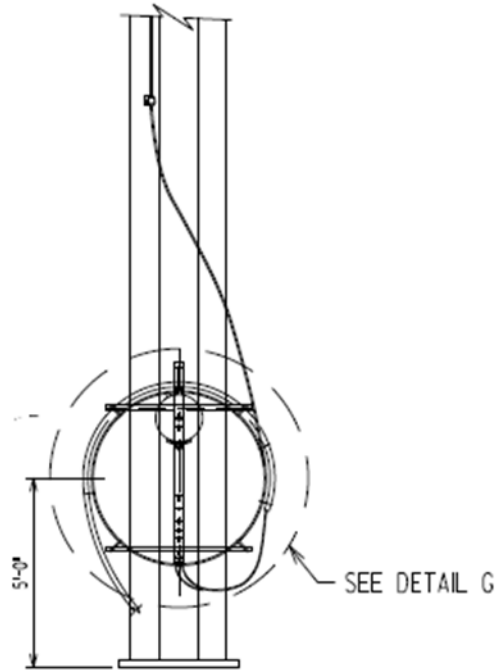


Left is legacy, right is the current standard. Below is the higher security box detail.



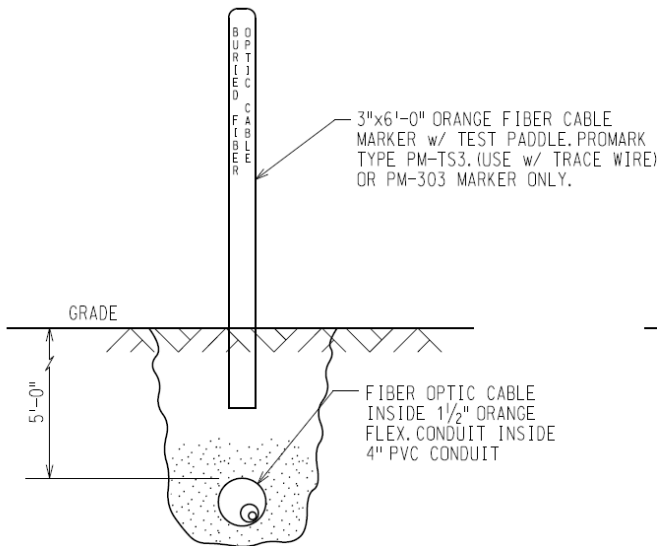


DETAIL "G"
OPGW ENCLOSURE ASSEMBLY



DETAIL "F"
TYPICAL OPGW SPLICING

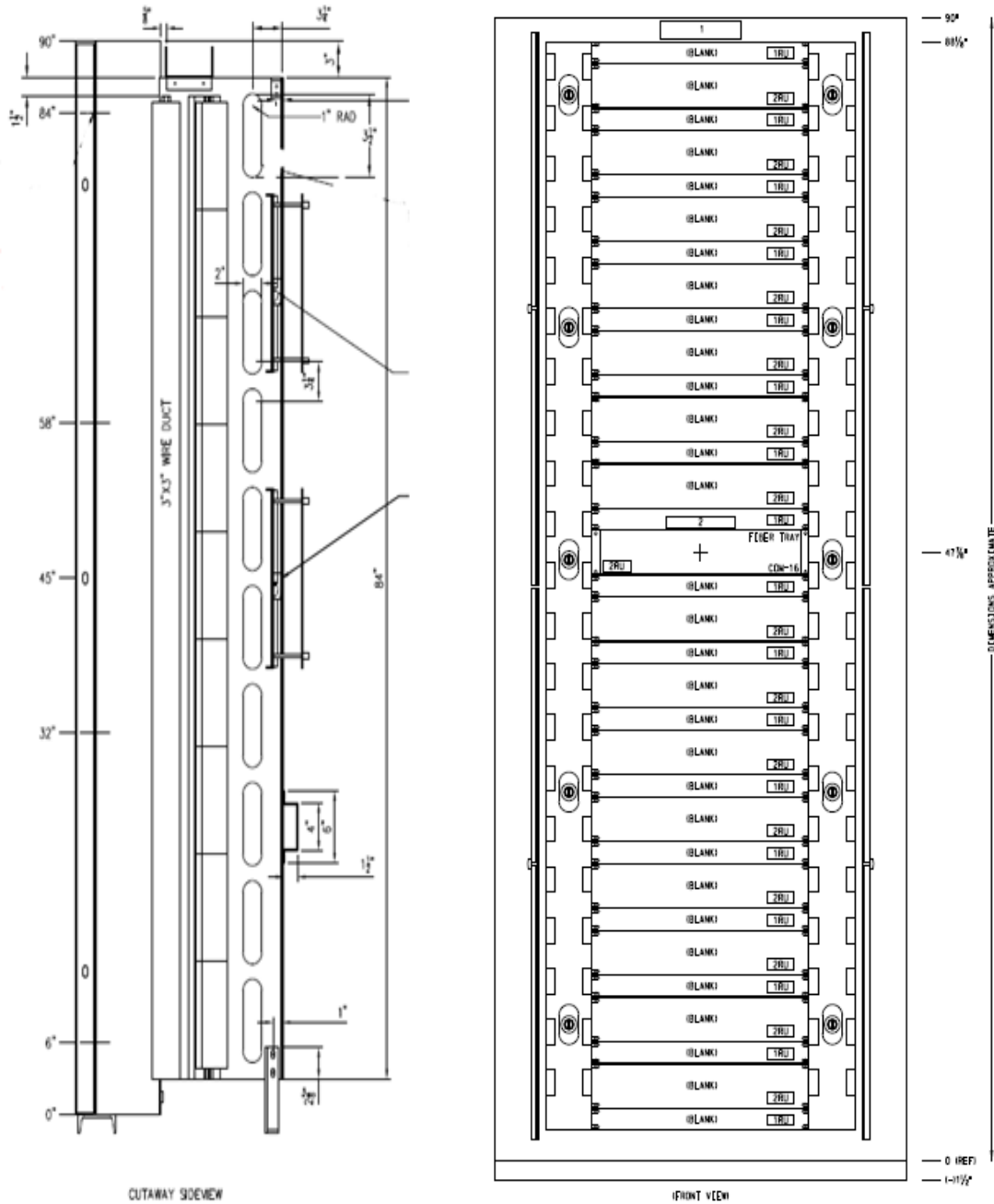
NOTE: Detail G Typically provided by the Line Contractor. Slack must be installed with a minimum of 100ft of slack placed on the rack.



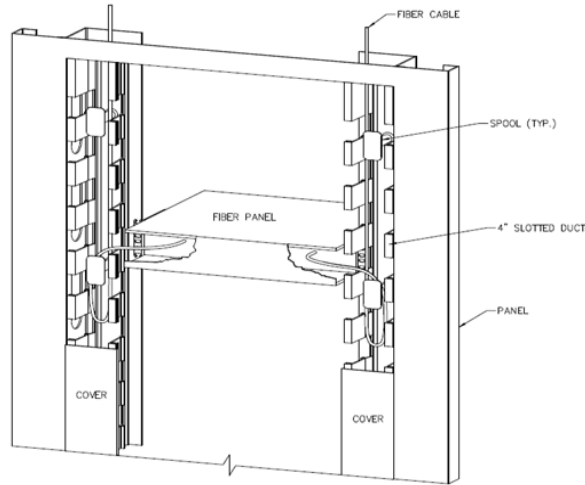
**DETAIL IN FARM FIELD
OR UNDEVELOPED AREAS**
(OUTSIDE SUBSTATION FENCE)

Note: Typical use for marker in the farm fields leaving outside the substation fence, for others reference project documentation, others exist for other area types.

Fiber Distribution Panel in the Substation

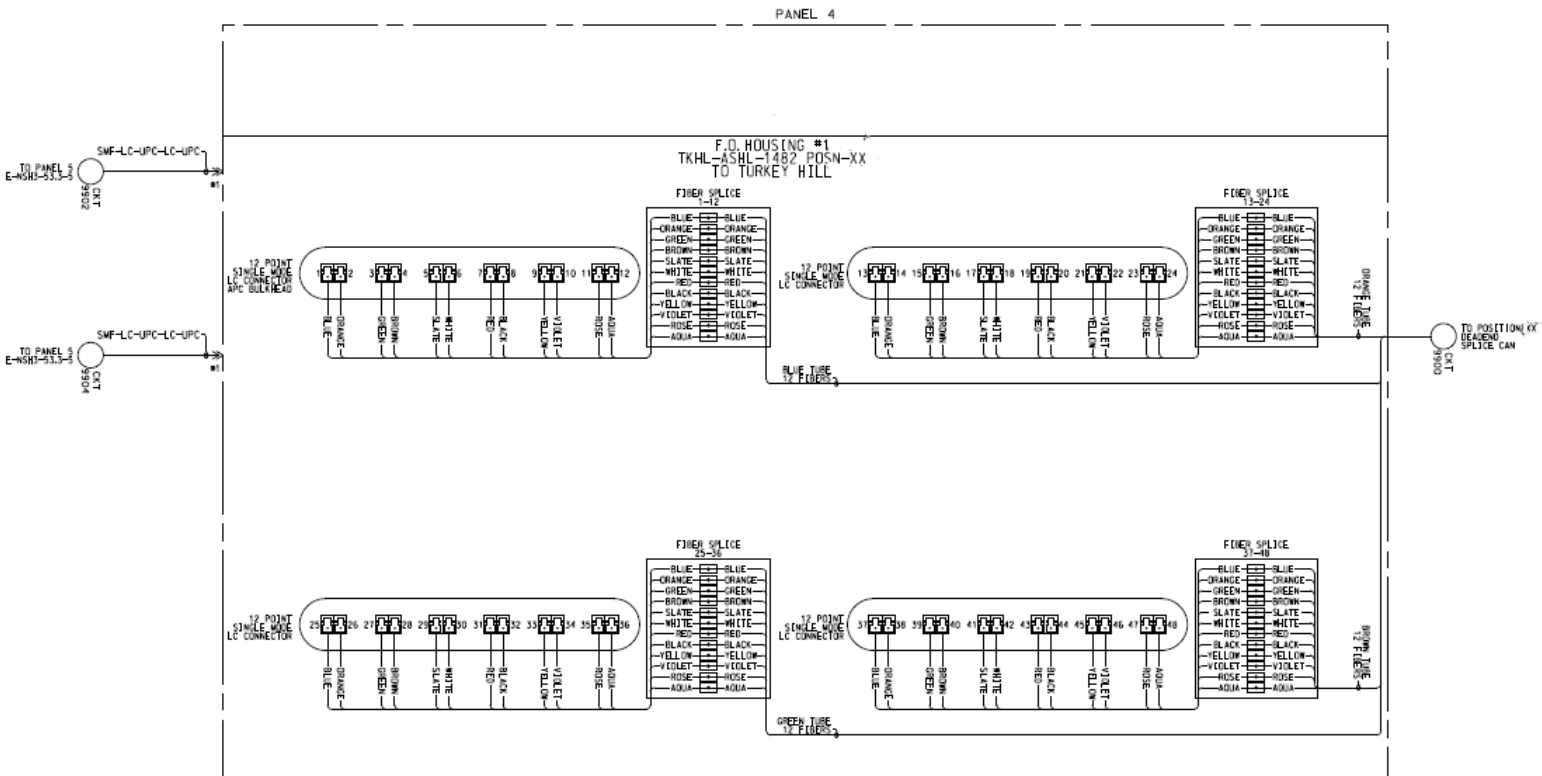


Note: Typically provided by Ameren through stock system, or by panel vendor approved by Ameren. Reference standard 15 for Equipment that is available for use inside panel.



NOTE: Typically only the fiber jumpers will go into the spooled trough areas, the black Jacket cable (ADSS) will come down the reverse side of the panel attached to wall and into the back of the fiber splice cassette housing. The ADSS black jacket portion will come all the way in to the CCH housings. The orange inner duct will come all the way into the panel as well. 15-20 ft. of Black jack cable slack is required at the panel.

Fiber Patch Panel



Note: The modules labeled A-D should be terminated in order. Fibers 1-12 (Blue tube) to module A; Fiber 13-24 (Orange tube) to module B; Fiber 25-36 (Green tube) to module C; Fibers 37-48 (Brown tube) to module D; additionally for 72 strand -Fibers 49-60 (slate tube) to module E; and Fibers 61-72 in module F.



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Approved Material List

Item #	Material Description	Preferred Supplier	Part Number	Ameren STK Code	Notes
	ADBJ- All dielectric gel free Black Jacket 48 str. SM fiber	Corning/ Anixter	048eu4- t4701d20 SMF- 28	1866671	
	ADSS OD 0.575 48str SM fiber PE jacket	AFL	DNA 3092	Pending	
	Outdoor Splice enclosure 72 count fiber	AFL	SB01-72	Pending	
	Outdoor Splice Enclosure 144 count fiber	AFL	sb01-144	Pending	
	SB01 furcation kits	AFL	Sb01-Fk	Pending	Need 1 per SB01 enclosure
	Connector Kit for enclosure ADSS/BJC	AFL	BCK-size	Pending	OD of cable dependent
	Connector Kit for enclosure OPGW	AFL	APCKC-size	Pending	OD of cable dependent
	Corning Fiber Patch Panel	Anixter	CCH02U	Pending	
	Corning Fiber Patch Panel LC module	Anixter	CCH-CS12-A9- p00RE	Pending	Need 4 per CCH02U
	Fiber jumper cable LC-LC SM fiber bend insensitive 3m	Specialized	682x291	Pending	
	Fiber jumper cable LC-LC SM fiber bend insensitive 1m	Specialized	682x290	Pending	
	Corning Fiber jumper cable LC-LC any length SM fiber OS2	Anixter		Pending	
	Corning Fiber Patch Panel	Anixter	CCH02U	Pending	
	Corning Fiber Patch Panel LC module	Anixter	CCH-CS12-A9- p00RE	Pending	Need 4 per CCH02U
	Fiber jumper cable LC-LC SM fiber bend insensitive 3m	Specialized	682x291	Pending	
	Fiber jumper cable LC-LC SM fiber bend insensitive 1m	Specialized	682x290	Pending	
	Corning Fiber jumper cable LC-LC any length SM fiber OS2	Anixter		Pending	
	Corning Fiber jumper cable LC-LC 1m length SM fiber OS3	Anixter	257340	Pending	
	Corning Fiber jumper cable LC-LC 3m length SM fiber OS4	Anixter	278139	Pending	
	1.5 " innerduct FR orange	Anixter	273727	Pending	
	Corning Fiber jumper cable LC-LC 1m length SM fiber OS3	Anixter	257340	Pending	
	Corning Fiber jumper cable LC-LC 3m length SM fiber OS4	Anixter	278139	Pending	
	1.5 " innerduct FR orange	Anixter	273727	Pending	
	OPGW	AFL	DND-7330	2759080	
	Fiber Marker Orange with Test paddle 3"x6'	Promark	PM-TS3	Pending	
	Fiber Marker 3"x6'	Promark	PM-303	Pending	



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	Altos fiber kit include pulling eye, 800ft cable, 800ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckmann or Tracy Meyr-Ritter pricing is Ameren price blanketed
	Altos fiber kit include pulling eye, 1200ft cable, 1200ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckmann or Tracy Meyr-Ritter pricing is Ameren price blanketed
	Altos fiber kit include pulling eye, 1600ft cable, 1600ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckmann or Tracy Meyr-Ritter pricing is Ameren price blanketed
	ADSS fiber kit include pulling eye, 800ft DNA 30953 cable, 800ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckmann or Tracy Meyr-Ritter pricing is Ameren price blanketed
	ADSS fiber kit include pulling eye, 1200ft DNA 30953 cable, 1200ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckmann or Tracy Meyr-Ritter pricing is Ameren price blanketed
	ADSS fiber kit include pulling eye, 1600ft DNA 30953 cable, 1600ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckmann or Tracy Meyr-Ritter pricing is Ameren price blanketed
	Fiber distribution panel with Right side skirt	Stock		7120081	
	Fiber distribution panel with left side skirt	Stock		7120080	
	Fiber distribution panel with both side skirts	Stock		7120079	

For other materials associated with hardware see typical details and their respective Bills of Material. These materials listed and those in the standard details are approved; substitutions must be approved by Project Engineer.

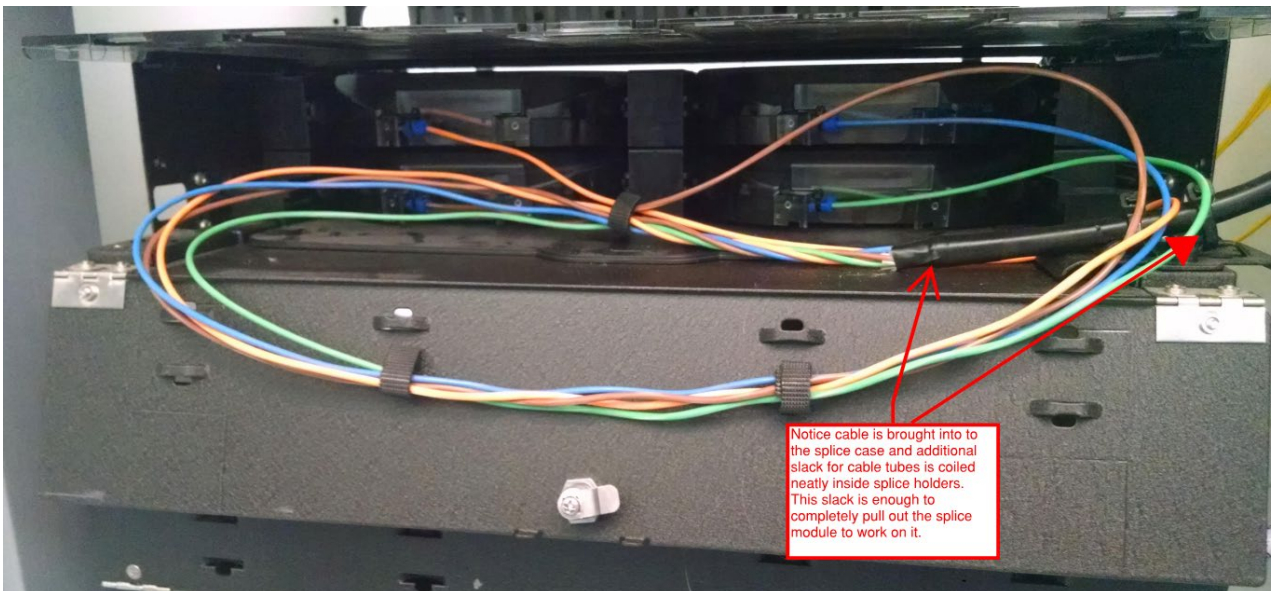
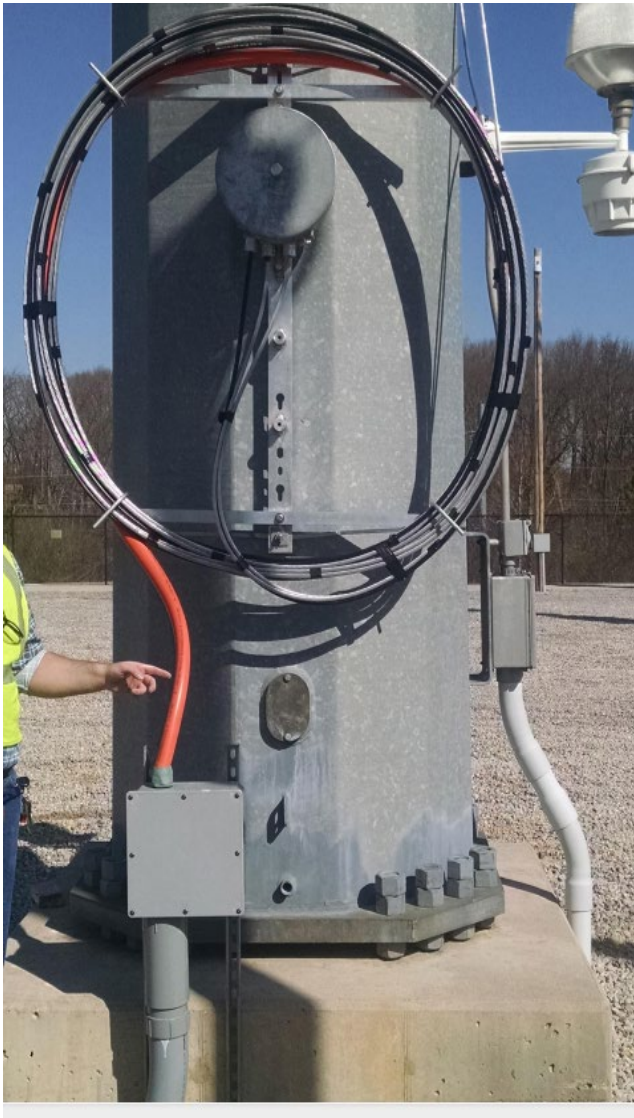
Some items in material list are pending stock code and will be added in the future revision.

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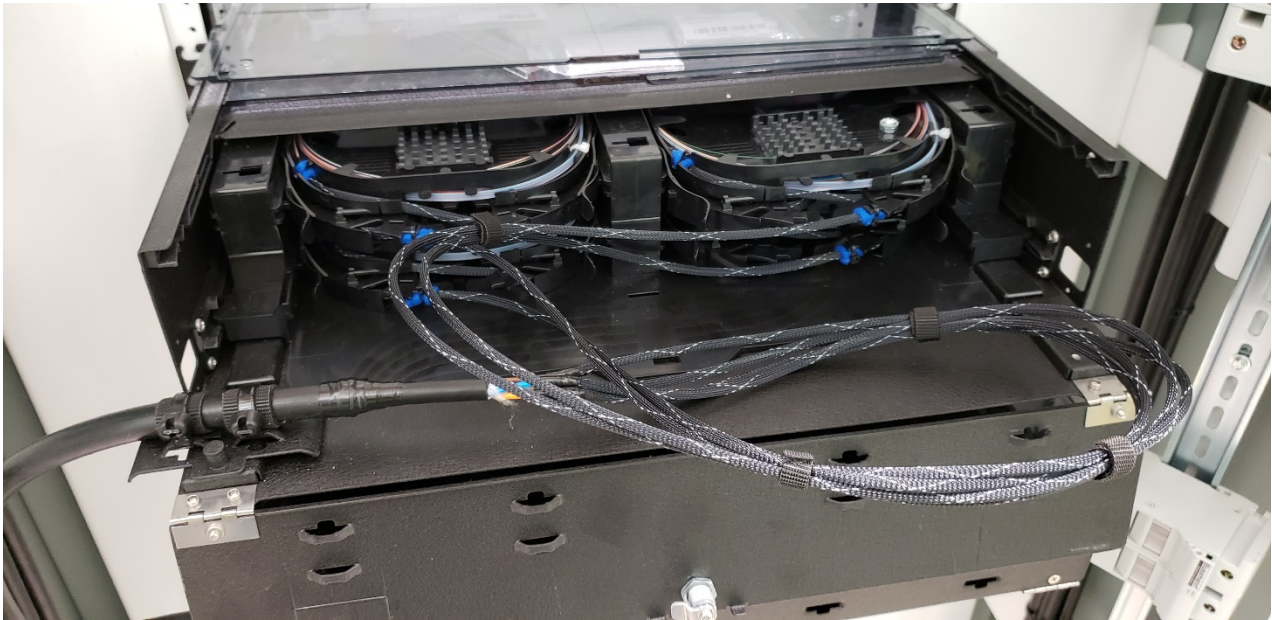
Appendix 4 : Acceptable vs. Unacceptable Examples

Acceptable





Start of a proper installation above



Proper install note usage of elastic wraps

Unacceptable Installations



Use a Pipe cap and seal around the top or junction box or use standard installation shown in above sections.



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Do not do this, should be in proper fiber panel and should be spaced to allow cable entry to rear access to the panel.



ADSS Protective sheaf should be into the enclosure with 10-15ft of tube wrapped inside. Innerduct should be tied/ fixed at the top of the panel

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Innerduct should go 270 degrees and be open at the bottom to not allow moisture egress.



When outside the fence use steel reinforced conduit or galvanized steel from the junction box, with proper height.



Ribbon Splicing is not acceptable

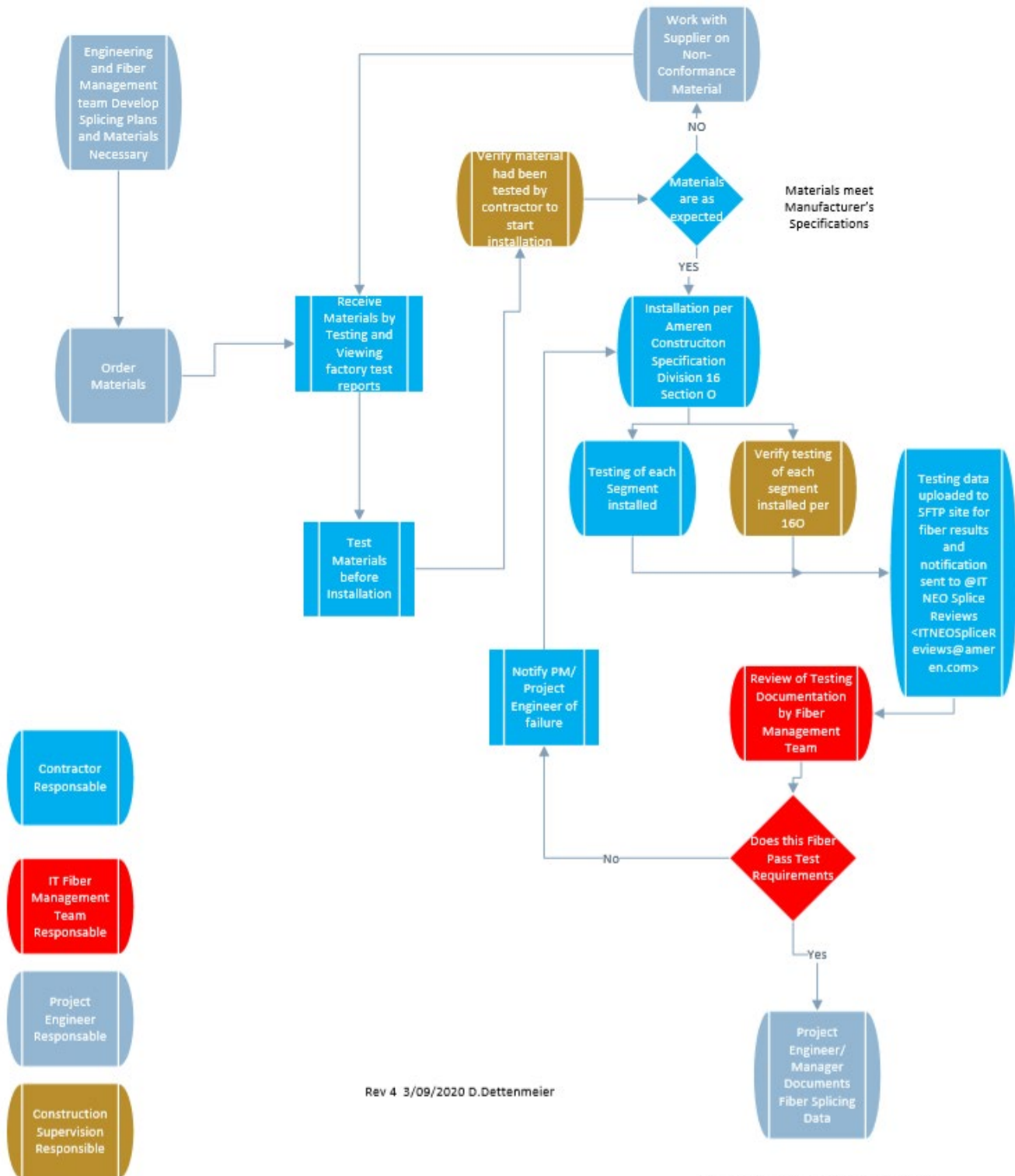


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Appendix 5: Approved Splicing Contractors List (maintained by IT)

See attached document

Appendix 6: Documentation Submittal Process Flowchart



Rev 4 3/09/2020 D.Dettenmeier

Testing Data to be uploaded to SFTP site
ftp.ameren.com (credentials required contact
Ameren Digital for access)

EXHIBIT 1 - FIBER SPLICING AND TESTING

Contents

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 2.01 materials: 5

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 3.01 Splicing Requirements 5

 3.02 General Testing Requirements 7

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 3.04 End to End Acceptance testing 8

Appendix A

FIBER SPLICING AND TESTING: continued

Revision	Changes/Author	Date
0	Initial Document Creation	4/17/18
1	Added revision tracking. Updated instances of 1650nm to 1625nm. Updated required testing for splicing contractor to 1550. Per notes from field increased allowable pulse width from 30ns to 100ns-Alex Porter	11/13/18
2	Added location to find approved vendors	12/18/18
3	Changed 3.01 sections 3&4 to 25 feet minimum slack	4/3/2019

FIBER SPLICING AND TESTING: continued

PART 1 - GENERAL

1.01 SUMMARY:

- A. This specification covers splicing and testing of the single-mode and multimode fiber optic cables for use by Ameren and approved companies listed in Approved Fiber Splicers which can be found on the IT Network Engineering & Ops SharePoint under Standards and Design/Specifications.

1.02 REFERENCES:

- A. Telecommunications Industry Association (TIA):
 - 1. TIA RS-359-A - EIA Standard Colors for Color Identification and Coding
 - 2. TIA 598-A – Optical Fiber Cable Color Coding
 - 3. TIA-526-7-1998, Optical Power Loss Measurements of Installed Single-mode Fiber Cable Plant-OFSTP-7
 - 4. TIA/EIA 568 Building Telecommunications Wiring Standards
- B. Bell Communications Research Standard (Bellcore/Telcordia):
 - 1. GR-20-CORE – Generic Requirements for Optical Fiber and Optical Fiber Cable (Optical Fiber only).
 - 2. GR-771-CORE – Generic Requirements for Fiber Optic Splice Closures
 - 3. GR-196-Generic Requirements for Optical Time Domain Reflectometer (OTDR) Type Equipment
- C. Institute of Electrical & Electronics Engineers, Inc. (IEEE):
 - 1. 1428-2004 – Guide for Installation Methods for Fiber Optic Cables in Electric Power Generating Stations and in Industrial Facilities.
 - 2. 812-1984 – Standard Definitions of Terms Relating to Fiber Optics
- D. International Telecommunication Union (ITU):
 - 1. ITU-T G.652 (Category D) General Requirements for Optical Fiber and Optical Fiber Cable (Optical Fiber only)
 - 2. ITU-T L.12 Series L: Construction, installation and Protection of Cables and Other Elements of Outside Plant
- E. International Electrotechnical Commission (IEC):
 - 1. IEC-61300-3-25 – Fiber Optic Connector Visual End Face Inspection
- F. American National Standards Institute (ANSI)
 - 1. ANSI Z136.2 – Safe Use of Optical Fiber Communications.
 - 2. Telcordia GR-765-CORE.
- G. In cases where the above standards are in conflict, unless specifically noted elsewhere in the Contract Documents, the Contractor shall request clarification from Ameren IT.

1.03 SUBMITTALS:

- A. Submittals
 - 1. Submittals are documentation provided by the Contractor for review and comment.

FIBER SPLICING AND TESTING: continued

- B. Compliance Submittals:
1. Tools and Test Equipment List
 2. Provide a list of all tools and test equipment that will be used in the performance of the work, including make, model, description, and proof of date of last calibration (calibration certificate). The test equipment used must be calibrated within the timeframe recommended by the manufacturer of the equipment or within a year if not specified by the manufacturer.
 3. Qualifications of Contractor, to be submitted for approval.
 - (1) Contractor shall provide proof of their fiber optic technicians' qualifications experience, and certificates with their bid.
 - (2) No personnel will be allowed to do work until qualifications have been approved by Ameren.
 4. Post-installation photos of splice cans and mounting
 - (1) After installation of splice closure Contractor shall create field reports, consisting of the field report form and digital photos. Contractor shall take no less than five digital photos per splice closure sufficient to show a clean and organized finished installation following these specifications. Digital photos will be taken of each completed splice trays, trays mounted inside of the splice closure, and the final installed closure on the structure showing a complete and organized installation. Submit digital photos to the Contractor within 14 days of completed installation
 5. Pre and post-installation test reports as described herein
 - (1) Contractor shall create and supply test reports to Ameren for approval of the end-to-end final optical testing of the completed fiber optic splicing installation. These reports will consist of the completed OLTS test report and the electronic OTDR trace files as described in the post-installation testing section described below.
 - (2) All files shall be uploaded to the Ameren IT fiber testing SFTP site.
 - (3) Contract shall record the sequential values at each splice point, Splice can serial number; splice distance from the ground; and slack on the rack and in and he splice enclosure.

1.04 OTHER GENERAL REQUIREMENTS

1. All Work shall be performed in accordance with accepted standards and practices within the fiber optic cable industry unless specified otherwise.
2. Ameren will assign a single point of contact for all fiber optic cable submittals and communications for the Project and the Contractor shall do the same.
3. Contractor shall give Ameren at least 48 hours advance notice of all work activities including locations and approximate times so that access to facilities can be arranged and the necessary inspectors present.

1.05 QUALIFICATION OF TECHNICIAN:

1. Technicians performing any work included in this specification shall have the following Fiber Optic Association (FOA) certifications: CFOT, CFOS/S, and CFOS/T and shall be trained to handle AFL and Corning with both OPGW and ADSS products.

FIBER SPLICING AND TESTING: continued

2. Light Brigade training through AFL is required. Ameren will provide further details on this requirement.
3. The Contractor shall be fully qualified to work in space owned by the Owner, and must be vetted through Ameren systems, procedures, and Engineering.
4. Technicians shall have been trained of the use of the specific make and model of equipment being used and shall poses a training certificate.
5. Technicians shall have a minimum of two experience in fiber optic splicing and testing.

1.06 WARRANTY:

- A. The Contractor shall provide a one-year warranty on the quality of all fiber optic splicing and testing work.

PART 2 - PRODUCTS

2.01 MATERIALS:

- A. Contractor-Furnished Materials:
 1. Fiber splice protective shrink tubes.

2.02 EQUIPMENT:

- A. Contractor-Furnished Equipment:
 1. Test equipment acceptable manufactures:
 - (1) EXFO (preferred)
 - (2) Viavi
 - (3) AFL
 - (4) Fluke
 2. Approved Fusion Splicing Equipment Manufacturer's include the following:
 - (1) AFL
 - (2) Corning
 - (3) Sumitomo Electric

PART 3 - EXECUTION

3.01 SPLICING REQUIREMENTS

- A. General
 1. Assemble splice closures and fiber distribution panels (FDP) in compliance with the manufacturer's written recommendations or as approved by Ameren in writing. Close the splice closure ensuring that no fibers or buffer tubes are pinched in the process. Using the cable interface end plates and gaskets, seal the closure per the manufacturer's recommended installation procedures.
 2. Install all fiber optic cables such that they are properly protected as they enter the splice closures or FDP as per the manufacturer's instructions.
 3. Store a minimum of 25 feet of each fiber cable on the cable storage assembly on the A-frame to allow for future maintenance.
 4. Store a minimum of 25 feet of each fiber cable inside the fiber rack.

FIBER SPLICING AND TESTING: continued

B. Fiber Splicing

1. Splicing Prerequisites – Contractor shall verify that they have all required equipment, material, and documentation, including splice plans, ahead of splicing. If splice plans were not provide with the Purchase Order, Contractor is responsible for requesting the plan, from Ameren, two weeks prior to splicing.
2. Splice the number of fibers in the locations and manner indicated on the project drawings.
3. Where not specified by project drawings, all fibers will be spliced straight through, meaning that the 1st fiber of any cable should always be spliced to the 1st fiber of another cable. This will result in the port 1 of an FDP connected to port 1 of the alternate end FDP. All rolled fibers will be corrected before final testing begins.
4. All fiber optic splicing shall be fusion type. Splicing shall be performed in an environmentally protected enclosure to ensure high quality splice performance. Splicing shall be accomplished on the ground and not in an aerial bucket. The excess cable at splice points shall be properly secured by the Contractor and mounted in/on the appropriate location. Fusion Splicing shall use Single Mode Fiber Active Core Alignment and LID (Light Injection and Detection) splicing methods per Telcordia GR-765-CORE.
5. Splice equipment must also meet or exceed minimum performance standards as described within Rural Development Utilities Program (RDUP, formerly RUS – Rural Utilities Service) Bulletin 1753F-401 RUS Standard for Splicing Copper and Fiber Optic Cables.
6. The splice attenuation performance shall be a gain or loss of no greater than 0.05dB as measured by the fusion splice machine directly after fusing. Fusion splices will be broken and remade until the splice meets this criterion.
7. Each fusion splice shall be visually inspected for abnormalities such as thickening or a bubble at the splice point. If visual abnormalities exist, the splice shall be broken and re-spliced.
8. After passing visual inspection, the splice shall be subjected to a tension test to ensure the fiber splice and adjacent fibers are of proper quality.
9. Buffer tubes shall be secured to splice trays using nylon cable ties with a buffer of felt cloth in such a manner as to prevent slippage of the tubes when removing the tray. The use of black electrical tape is prohibited. Kinked or damaged buffer tubes shall be re-spliced, with the damaged section completely removed.
10. Dissimilar fiber types or colors shall not be spliced together unless explicitly stated in project drawings or per Ameren’s written instructions.
11. The prepared fibers or buffer tubes shall be of sufficient length to make at least two loops around the splice tray before entering the splice points or holders. Contractor shall follow the Manufacturer’s recommended installation procedures.
12. Contractor shall refer to splice closure manufacturer’s installation procedures to prepare the OPGW or AD cables for splicing. Contractor shall read and understand the procedure completely before attempting field installation.
13. All spliced optical fibers shall have an individual heat shrink protector sleeve directly covering the splice point. The acrylic coating on the individual fiber should not be removed beyond the areas that shall be covered by the heat shrink protector sleeves.

FIBER SPLICING AND TESTING: continued

14. Any splices that do not meet the following requirements shall be corrected at the Contractor's expense, prior to turning the link over to Ameren for final acceptance testing.
 - (1) Splice loss as measured bi-directionally at 1550nm, Shall not exceed .10 dB.
 - (2) If this criteria cannot be met, an individual splice up to .20 dB will be accepted, provided the average splice loss in the enclosure does not exceed .05 dB.
15. Contractor shall clean up the work space taking care to remove all bare glass fiber fragments, and replace dust caps.
16. In the event that Ameren requires resplicing after the End to End Acceptance Test:
 - (1) Contractor shall correct the bad splices, to meet the standard of this specification.
 - (2) Contractor shall provide OLTS testing and OTDR testing in accordance with the End to End test section of this spec.
 - (3) Contractor shall provide reports on OTDR & OLTS on the corrected splice that adhere to the requirements of the End to End Acceptance Test.
17. In the event that Ameren requires resplicing after the End to End Acceptance Test:
 - (1) Contractor shall correct the bad splices, to meet the standard of this specification.
 - (2) Contractor shall provide OLTS testing and OTDR testing in accordance with the End to End test section of this spec.
 - (3) Contractor shall provide reports on OTDR & OLTS on the corrected splice that adhere to the requirements of the End to End Acceptance Test.

3.02 GENERAL TESTING REQUIREMENTS

- A. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.
- B. Technician shall take extra care while working near in-service fiber connections. FDP panels may already have active circuits. Those fibers will not be tested unless otherwise instructed by Ameren. Care shall be provided to ensure they are not disturbed while working in the FDP panel. The following precautions shall be taken.
- C. Each test jumper shall be tagged, such as with red tape, or is obviously different than the others in the panel. Before disconnecting, the technician shall verify that his fingers are on the test lead by identifying this unique marking.
- D. Opening FDP panels:
 1. Verify fiber jumpers are not bound in any way that by opening the panel you risk bending a jumper tighter than its minimum bend radius.
 2. Visually inspect the panel to identify any unmated connectors before opening the panel and look for any connectors that do not look properly mated.
 3. If the panel door does not swing smoothly, do not force it. Identify what is binding it up and correct the issue. Do not use any other objects to tap or force the door open.

FIBER SPLICING AND TESTING: continued

4. If the panel door is removed lay it on the work table to prevent it from falling and causing damage or an unplanned outage. When replacing door, be sure to put it back on the correct FDP (Fiber Distribution Panel).
 5. When closing the door verify all fiber strands or jumpers are routed in cable managers and secured away from the hinges, latches, or other “pinch-points” to prevent kinking or breaking of fiber.
- E. Cleaning of fiber connections – If a fiber connector is contaminated on inspection cleaning is required:
1. First use a stick, swab, or click style cleaner to clean the connector.
 2. If this method does not work, it requires removing the connector from the back of the panel and using a lint free wipe, cloth, or tissue and a wet/dry method.
 - (1) Follow the FDP opening precautions in previous section when opening the back panel. Extra cautions shall be used as bare 250 μ m fiber strands may be present.
 - (2) If moving of fiber splice trays or cassettes is required care shall be provided to not kink the buffer tubes. They are rigid and susceptible to kinking and cracking of all fibers within.
 - (3) Before removing a connector from the back of the panel care shall be provided to verify the correct fiber is being removed. Fiber colors may not be as expected and translating from front to back near active connections can cause outages if the wrong fiber connector is removed.
 - (4) When cleaning the connector do not place strain on other fibers in the panel which could damage them.

3.03 TESTING FOR SPLICING CONTRACTOR

- A. Required Testing
1. Contractor shall test the fiber the fiber at 1550 nm, using an OTDR as soon as practical after the fiber is spliced, to confirm splice loss is in spec.
 2. Contractor shall test bi-directionally after all splicing is completed to verify bi-directional requirement is met.
- B. Recommended Testing
1. Since final acceptance is based on bidirectional testing, Ameren recommends bidirectional testing on portions of the work, to validate compliance early.

3.04 END TO END ACCEPTANCE TESTING

- A. Purpose – The purpose of Final Acceptance is two-fold:
1. Independent Verification of installation and splicing quality. This work is to be completed by a different supplier than the original Splicing Contractor.
 2. Produce a set base-line test results for the fiber link.
- B. Tests Required – End to End Testing shall cover the following:
1. Connector end face inspection - Inspection using a fiber inspection probe.
 2. OLTS testing is required for all fiber optic connections.
 3. OTDR testing is required for single-mode fiber optic connections only.
 4. Optical Spectrum Analyzer
- C. End Face Inspection

FIBER SPLICING AND TESTING: continued

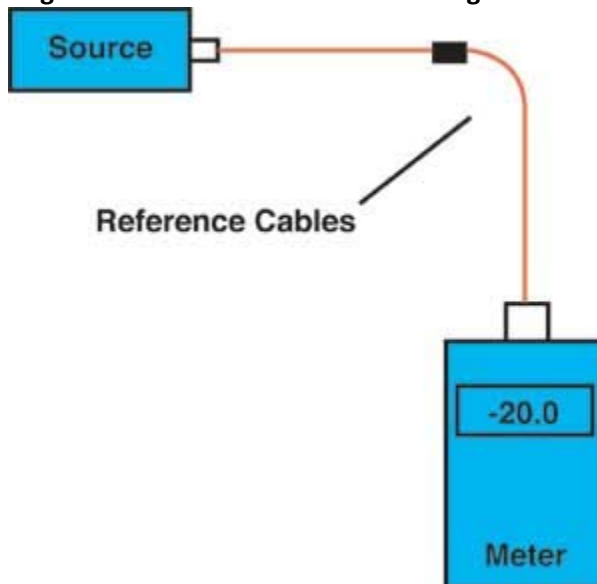
1. A fiber inspection probe shall be used to verify the end face at 400X of every connector is clean every time the connector is mated. Mating of contaminated connectors can damage the connector requiring replacement.
2. The probe shall automatically center the fiber core in the picture window and zoom into high magnification at resolution of at least 350 μm X 350 μm.
3. The probe shall identify the following areas of the connector and consider it passing with the following criteria a met per IEC-61300-3-35 for single mode fiber connections.

Zone Name (diameter)	Scratches	Defects
Core Zone (0-25μm)	< 4 scratches	none
Cladding Zone (25-120μm)	none > 3μm width	no limit < 2μm 5 from 2 - 5μm none > 5μm
Adhesive Zone (120-130μm)	No Limit	No Limit
Contact Zone (130-250μm)	No Limit	none > 10μm

D. OLTS Testing

1. The OLTS test is used to measure the actual optical attenuation of the complete optical connection. Testing shall consist of a calibrated light source injecting a laser signal of known signal level into the FDP connector (transmit side) and a calibrated power meter recording the received level at the FDP connector (receive side).
2. Testing shall be performed at minimum, unidirectional at:
 - (1) For single-mode fiber: 1310 nm, 1550 nm, and 1625 nm, for each individual optical connection within the span.
 - (2) For multimode fiber: both 850 nm and 1300 nm for each individual optical connection within the span.
3. The testing requires the use of the two-jumper reference method as shown in figure 1, according to TIA OFSTP-7.

Figure 1: Double – Ended OLTS testing



FIBER SPLICING AND TESTING: continued

4. The recorded total signal attenuation in decibels (dB) at the power meter less the loss in the reference cables is the total loss across the optical connections. Acceptable optical connection attenuation is dependent on the fiber length, number of connector pairs, and number of splices. The fiber segment shall have an end-to-end attenuation that is equal to or less than the total link loss equation stated below and should be computed for both 1310 and 1550 nm wavelength tests.
 1. LINK LOSS EQUATION
$$\text{Maximum acceptable end-to-end attenuation} = (A \times L) + (S \times N) + (C \times n) \text{ dB}$$
Where "A" is the maximum fiber attenuation per kilometer and defined as:
 - For G.652 (NDSF) fibers at 1310nm A=0.35dB/km
 - For G.652 (NDSF) fibers at 1383nm A=0.35dB/km
 - For G.652 (NDSF) fibers at 1550nm A=0.22 dB/km
 - For G.652 (NDSF) fibers at 1625nm* A=0.24 dB/km"L" is for the installed length of fiber cable
"S" is the loss to fusion splices which is 0.1 dB
"N" is the total number of fusion splices
"C" is the loss of a connector pair which is 0.5 for LC, SC, and ST connectors
"n" is the total number of connector pairs along the segment
* Performing this measurement at 1625nm is acceptable, if the test equipment does not support 1650nm.
- E. OTDR Testing – for single-mode fiber
 1. Contractor shall perform a final OTDR test on each fiber optic connection from FDP to FDP. This test is used to detect distinct reflective events of the optical connection due to kinks, bad fusion splices, or other defects such as dirty end-face connectors.
 2. All OTDR testing shall be bidirectional and performed on every fiber optic connection.
 3. Fusion splice points shall not represent point defects of magnitude higher than 0.1 dB when averaged in both direction or 0.3 dB in any one direction. Splices exhibiting point defects of a greater magnitude shall be re-spliced until test results fall within specified limits.
 4. OTDR Test Settings:
 - (1) A reference launch cable (sometimes called pulse suppressor) and receive cable of 1 km or longer and of known quality shall be used for all measurements. The same length must be used on both ends of the path. A shorter launch cable can be used if the OTDR has variable pulse width control and can overlay multiple traces with narrow pulse widths to visualize the beginning the cable and longer pulses to visualize the end of the cable.
 - (2) Wavelengths: All tests shall be performed at 1310 nm, 1550 nm, and 1625 nm.
 - (3) Pulse width: Use the smallest practical pulse width to optimize resolution. The ideal pulse is one that will reach the fiber end with minimal trace noise at the far end, and shows 5-10 dB dynamic range (as measured from the

FIBER SPLICING AND TESTING: continued

point that the trace meets the fiber end reflection down to the noise floor - aka "grass").

(a) Use of pulse widths larger than 100ns requires written approval from Ameren

(4) Short acquisition: On any fiber >40km a short acquisition OTDR shot (2-10ns pulse width at 2-5km range) will be taken in addition to the full-length shot. The purpose is to isolate the first connector at the end of the launch reel and beginning of the fiber through the dead zone of the full-length pulse.

(5) Distance: Set distance as shown on the fiber optic route map drawing.

(6) Filter out only fusion splice loss results under 0.05 dB.

(7) Set pass fail criteria for 0.1dB in both directions of each fiber or 0.3dB in a single direction.

(8) Set A and B markers at the ends of the fiber under test removing launch cables at both ends.

5. The recorded trace files shall be reviewed for distinct point losses (attenuation) or reflections. Any point that is equal to or greater than .10 dB loss when measured bi-directionally by the OTDR, shall be investigated for cause and explanation noted on submittals to Ameren.

F. Optical Spectrum Analyzer Testing

1. Each fiber shall be tested end to end from 1250nm to 1625nm with an Optical Spectrum analyzer.

G. Reporting of Test Results

1. Reporting shall include all required measurements, analysis, spreadsheet using Ameren provided template, recommendations and a final report, using the Ameren provided template in a .doc and pdf format. All fields in the template must be completed.

2. OLTS Test Report shall be provided electronically (PDF) to Ameren for review and acceptance.

3. Summarized end-to-end OTDR test data shall be provided electronically (PDF format) in the form of a report output from the testing instrument with any explanations of significant point losses or reflections clearly noted.

4. Raw OTDR trace data shall also be provided electronically in the native testing instrument's format, and shall be clearly labeled to identify segment, transmit location, receive location, fiber number, and test wavelength to accommodate automatic bi-directional splice loss averaging using the OTDR companion software as specified below.

(1) Root folder named "Site A - Site B" where Site A is the alphabetically lower of the two.

(a) If the first letters are identical move on to the second, third, fourth character before a difference can be identified.

(2) This root folder will contain five sub folders:

(a) "/Native Files" This folder will contain all the native files from the OTDR

FIBER SPLICING AND TESTING: continued

- (b) "/End Face Inspection" This folder will two subdirectories and nothing else
 - i) "/Site A" This folder will contain the end face inspection photos for the A site
 - ii) "/Site B" This folder will contain the end face inspection photos for the B site
 - iii) Where "Site A" and "Site B" are replaced by their respective site names
 - (c) "/Bi-Directional report" This directory will contain the bi-directional report
 - (d) "/Optical Loss Tests" This directory will contain the optical loss test files
 - (e) Final Report Excel document shall be a single tab, with all averaged losses, for each splice, on each fiber. See Sample Final Report.
 - (3) The root directory will contain only the Final Analysis (Site A-Site B.xlsx)
 - (4) Multiple links will not be combined into a single directory (IE Test results between Poplar and Gratiot will not be in the same directory as Gratiot to Russell)
- H. All OTDR trace data collected shall be supplied in either Exfo .trc format or Telcordia .sor format; Files to be named in the following format
- 1. Native files to be named in the following format
 - 2. "Site A - Site B, WAVELENGTH, ###, A-B.sor (or .trc)"
 - 3. "Site A - Site B, WAVELENGTH, ###, B-A.sor(or .trc)"
 - (1) Note that the words "Site A" and "Site B" are to be replaced by the names of the sites being tested where Site A is the alphabetically lower of the two. Where ### is replaced with the specific fiber being tested. Where WAVELENGTH is replaced with the wavelength used in the test. Where A-B and B-A are left as is to identify which end is being tested. For example when naming the test files for Gratiot to Russell Link 38 fiber 1 testing at 1550nm the OTDR file names would be
"Gratiot - Russell,1550, 001, A-B.sor" For the test files taken at Gratiot
"Gratiot - Russell, 1550, 001, B-A.sor" For the test files taken at Russell



ND&B Standards Manual

Subject: Approved Fiber Splicers	Supersedes: Effective Date: 12/18/2019
Author	
Reference:	Approved By:

Below are the approved vendors for fiber splicing and testing.

CCI Systems, Inc.

Contact: Mike Dellies mike.dellies@ccisystems.com

Rob Mikowski rob.mikowski@ccisystems.com

JF Electric Inc. DBA JF Telecom

Contact: Joe Pearson joep@jftelecom.com Office (618)797 6329 Mobile (618) 791 8262

Sachs Electric Company

Contact: Wade Breen WBreen@sachsco.com Office (314) 743-1193 Mobile (314) 280-3645

Responsibility of Administration:	Section -
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SUBSTATION DESIGN

STANDARD NO. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16Q – Control Enclosures



AMEREN ILLINOIS
AMEREN MISSOURI
AMEREN TRANSMISSION

Rev. No.	Date	Revisions	By	Approvals		
0	12/13/2021	Initial Revision	WS	RJR		

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SECTION 16Q

CONTROL ENCLOSURES

1.0 INTRODUCTION

1.1 Scope

Contractor requirements for the acceptance, installation, and testing of a new control enclosure

1.2 Reference Sections

1.2.1 16T - Control and Protective Relay Panels

1.2.2 16J - 125VDC Substation Batteries and Racks

1.2.3 16N - Temporary AC Generator Installation

1.2.4 16P - Power and Control Cables

1.2.5 39G - Security Installations for Transmission Substations

1.3 Codes and Standards

1.3.1 Work performed under these specifications shall be done in accordance with the following codes and standards:

CODES AND STANDARDS	
Work	In Accordance With
Control Enclosure	The applicable ANSI, NEMA and UL standards

2.0 GENERAL

2.1 The control enclosure will be delivered, mechanically assembled, and set on foundation pad or piers by others.

2.2 Contractor shall be responsible for:

2.2.1. Welding of the control enclosure. It is anticipated that the method of anchoring will be welding the base channel of the enclosure to embedded plates. Welding of the enclosure to the piers will be performed by enclosure vendor.

2.2.2. Contractor shall ground the enclosure as indicated on the grounding plan. Control enclosure shall be grounded on all four corners.

2.2.3. Contractor shall install station service cable to the control enclosure and energize the station service equipment as soon as possible after the control enclosure has been delivered.

2.2.4. Contractor shall verify that the control enclosure AC station service equipment is safe and operational.

2.2.5. Contractor shall verify that all main and secondary power cables are tight on the Safety Switches, Auto Transfer Switch, and AC Panelboards prior to energizing the equipment.

2.2.6. Contractor shall understand the operation of the Auto Transfer Switch prior to initial energizing by reviewing the manual provided with the control enclosure. Company can provide the manual upon Contractor request. Auto Transfer Switch damage caused by the Contractor will be repaired or replaced at the Contractors expense.

2.2.7. If the initial power supply for the control enclosure is a temporary generator, requirements as set out in standard 16N shall be followed.

- 2.2.8. Before energizing station service equipment the Contractor shall verify the correct system voltage by comparing source voltage at the Safety Switch with the equipment rating nameplate on the Auto Transfer Switch.
- 2.2.9. Before energizing station service for the first time the Contractor shall verify that the AC supply to the Battery Charger is switched off, as to not inadvertently energize the battery system.
- 2.2.10. As soon as possible after control enclosure energizing, the Contractor shall verify the proper operation of the control enclosure interior lights, exterior lights, exit lights, doors, receptacles and HVAC. Notify Construction Supervisor of any damage or incorrect operation of control enclosure equipment.
- 2.2.11. Contractor shall secure the control enclosure with a Company padlock during non-work hours. Responsibility to secure the Control Enclosure shall transfer to others if they are working in the enclosure during Contractor non-work hours.
- 2.2.12. Contractor is responsible for sealing building cable tray entrances using materials provided by Ameren or control enclosure manufacturer. These may be fire pillow blocks, Roxtec material, or other engineering approved type. Conduit entrances through the enclosure walls shall be sealed with duct seal.
- 2.2.13. Civil Contractor shall be responsible to provide the stairs and any required handrails to the enclosure. Electrical contractor shall add ground to the stair handrails.
- 2.2.14. Contractor is responsible for inspecting and replacing HVAC and intake filters on the control enclosure throughout the construction duration. Upon final turnover all filters shall be replaced and maintenance transferred to Ameren.
- 2.2.15. Contractor is responsible for removing temporary floor coverings provided with enclosure and cleaning enclosure floors prior to project completion.
- 2.3 For new Control Enclosure; panel to panel wiring, and building internal AC and DC wiring, will be performed by others.
- 2.4 For new Control Enclosures, the batteries, batteries racks and spill containment pan may or may not be installed in the control enclosure prior to shipping. The batteries, racks and spill containment pan shall be installed by the identified party in the main specification per standard 16J. Ameren or its testing contractor will commission the batteries and is responsible for energizing the charger and batteries for the first time.
- 2.5 Termination of Control Enclosure end and yard equipment end of cabling between Control Enclosure and substation yard equipment shall be performed by the Contractor. Cable risers covers should not be left off the control enclosure for extended periods of time when cable pulling is not in process. Leaving the covers off will lead to excessive heat or cooling loss and unnecessary run time for HVAC.
- 2.6 Contractor shall immediately identify any damages to the enclosure during installation to the construction supervisor.
- 2.7 Installation of security related equipment is the responsibilities of others. Contractor is responsible for assisting security installer with security cabling and routing as required. Contractor is responsible for verifying enclosure security signage is installed correctly and in correct locations.
- 2.8 For control enclosure equipped with vent fan timers for circulating air, the timers shall be set to operate fifteen (15) minutes every eight (8) hours.
- 2.9 Control enclosure HVAC should have thermostat set for temperature between 68F and 72F, no more and no less. Temperature alarm points for controller and independent alarm shall be set at 85 degrees rising and 60 degrees falling.

END OF SECTION 16Q

SUBSTATION DESIGN

STANDARD NO. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16R – Steel Erection and Anchors



AMEREN ILLINOIS
AMEREN MISSOURI
AMEREN TRANSMISSION

Rev. No.	Date	Revisions	By	Approvals		
0	12/16/21	Initial Revision	DAB	RGV	SM	

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SECTION 16R

SUBSTATION STEEL ERECTION AND ANCHORS

1.0 INTRODUCTION

1.1 Scope

1.1.1 This section covers proper erection and installation procedures and methods for Ameren steel erection for substations.

1.1.2 This steel erection section is applicable to all substation installations including new and retrofit projects.

1.2 Reference Sections

1.2.1 Section 16C – General Requirements for Grounding installation

1.2.2 Section 16D – Control Conduit, Precast Cable Tray, and PVC Solid Wall Sewer Pipe

1.2.3 Section 16 F – Compression, Bolted and Flat Pad Connections

1.2.4 Section 16I – General Requirements for Outdoor Nameplate Installation

1.2.5 Section 9B – Galvanized Metal Repair

1.3 Codes and Standards

1.3.1 Work performed under these specifications shall be done in accordance with the following codes and standards:

CODES AND STANDARDS	
Work	In Accordance With
General	ANSI / IEEE / ICEA / UL / NESC
General	NESC/NEC
General	ASTM
Structural Welding Code	AWS D1.1
General	AISC
General	OSHA

2.0 STEEL AND ANCHOR REQUIREMENTS

2.1 Equipment/Material

2.1.1 Unless otherwise specified as being furnished by Ameren, Contractor shall furnish all material and equipment as required for a complete steel and anchor installation.

3.0 INSTALLATION

3.1 Steel

3.1.1 Contractor shall verify receipt of steel structure packaging list prior to allowing the shipping contractor to leave the storage area. In case of a conflict between the packaging list and received material Contractor shall notify the Construction Supervisor or the Design Engineer of the discrepancy.

- 3.1.2 Contractor to receive, unload, assemble, and install all steel structures and any other miscellaneous steel items shown on the Equipment Arrangement Plan and the Foundation Plans.
- 3.1.3 Contractor shall inspect each structure, its component parts, and finish for any damage prior to accepting the material at the site. Contractor shall immediately notify Company's Construction Supervisor or Design Engineer of any damage.
- 3.1.4 Contractor shall accept said material and assume responsibility for its protection until final acceptance of work.
- 3.1.5 Contractor shall replace of any lost/damaged/stolen material after receipt and acceptance at no cost to the Company.
- 3.1.6 Contractor shall protect the work until completion, including leaving all incomplete work left unattended or overnight in a safe and secure manner.
- 3.1.7 Contractor shall furnish, install, and remove (as required) all miscellaneous material not provided by the Company but necessary to the structure erection process, including but not limited to cribbing, touch up galvanizing paint, and lifting shackles.
- 3.1.8 Contractor shall know, understand, and follow all of Company's current formal notification procedures regarding non-conformance (NCR process) and requests for information (RFI process) as described in the project Plans, Specifications, and contract documents.
- 3.1.9 Steel members shall not be dragged. Contractor shall transport, and handle all steel members, assembled sections, connections, fasteners, etc. with extreme care to avoid bending members or damaging galvanizing or any coating.
- 3.1.10 Contractor shall store all galvanized members, connections, fasteners, etc. off the ground using wood timbers or wood platform or any other Company-approved method. Oak cribbing and wooden railroad ties are NOT to be used with galvanized material. Timbers shall be provided between layers of stacked materials to permit free air circulation.
- 3.1.11 Storage area shall be free of vegetation, fertilizers, or other objectionable material of any kind.
- 3.1.12 All material shall be stored so as to provide maximum run-off of rainwater or other moisture from galvanized surfaces, to reduce or eliminate accumulation of moisture on such surfaces.
- 3.1.13 Slings for picking steel shall be of such material or protected in such a way as to not cut into the corners of the steel members or otherwise damage galvanizing. Contractor shall utilize slings with nylon or other non-metallic finishes to prevent damage to the steel members coatings/finishes.
- 3.1.14 Because the strength of tubular steel structure types depend on the integrity of their walls and shape, welding and drilling on the tapered tubular or tubular standard shape structures is prohibited unless specifically, and for each case, approved by the Construction Supervisor or Design Engineer. All field welding when approved will be in accordance with AWS D1.1
- 3.1.15 It is possible that fabrication errors will be encountered. However, since the number and severity of these errors cannot be known until the time of assembly, Contractor shall cooperate and work closely with Construction Supervisor, Design Engineer, and the steel fabricator to resolve fabrication and assembly problems in a timely manner. If a fabrication error or assembly problem prevents further work on a given structure, Contractor shall proceed with other productive work under this Scope of Work.
- 3.1.16 Dirt, mud, and other foreign materials shall be removed prior to erecting steel.
- 3.1.17 The Contractor shall erect the structures in accordance with the erection diagrams, drawings, construction lists and other Plans and instructions furnished.

- 3.1.18 The method of assembling and erecting a structure shall be developed by the Contractor and communicated to all onsite personnel and to the Company before, during, and after the erection of the structure. During erection no member of the structure shall be subjected to any stress in excess of that for which it was designed.
- 3.1.19 The method of erection shall be such that forcing the holes by driving drift pins will not be allowed.
- 3.1.20 If, when the steel is assembled by approved methods, blind or partly blind holes are encountered they shall be called to the attention of the Construction Supervisor or Design Engineer and drilled out or otherwise corrected in accordance with their instructions.
- 3.1.21 Misalignment or misfit of adjacent sections or members attributable to the adopted method of erection shall be corrected by adjusting erection methods as necessary to eliminate the trouble.
- 3.1.22 A reasonable amount of drifting will be allowed in assembly, but punching, reaming, or drilling for correction of mismatched holes due to shop errors shall be addressed via NCR process to be approved by the Design Engineer. If any shop errors in the steel are discovered, the Contractor shall notify the Construction Supervisor or Design Engineer and submit an NCR for a disposition by the Design Engineer. The Design Engineer will decide whether the error shall be corrected in the field or the members returned to the manufacturer for correction or replacement.
- 3.1.23 Structures assembled on the ground shall be blocked off the ground using wood blocking so as to be free of dirt, mud and other foreign materials that tend to adhere to the structure. Initial bolting shall be adequate for dead load, live load and erection loads, but shall not be so tight as to prevent aligning and fitting adjacent sections or members.
- 3.1.24 Any galvanized material on which the galvanizing has been damaged shall be repaired per Ameren Specifications Division 9 – Finishes, Section 9B – Galvanized Metal Repair.
- 3.1.25 The surface of damaged steel due to reaming, drilling, punched holes, where the galvanizing or paint is otherwise damaged, and all areas of raw steel exposed by drilling holes shall be repaired per Ameren Specifications Division 9 – Finishes, Section 9B – Galvanized Metal Repair.
- 3.1.26 If damage is extensive, as determined by the Construction Supervisor or Design Engineer. Contractor shall submit an NCR to the Design Engineer for a disposition. The Design Engineer will decide if the material shall be shop stripped and re-galvanized by the hot-dip process with weight of new coating matching original. The work shall be done at the closest galvanizing shop qualified to do the work as determined by Ameren Design Engineer or Construction Supervisor.
- 3.1.27 For bolted connections, members shall be clean at the joints when bolted. Bolts shall be installed with one nut and two flat washers; with one flat washer located under the head of the bolt and one flat washer under the nut. The use of any wrench that may deform the points of the bolt head or nut or cut or flake the galvanizing, is not permitted. All bolts shall be drawn tight; but caution should be exercised so as not to impair the strength of bolts or gouge any galvanized contact surfaces. Bolts shall be oriented in a specific way, unless otherwise specified on the drawings, with the bolts heads facing in and the nuts facing out on vertical members and with the bolts heads on bottom and the nuts on top on horizontal as well as nearly vertical members. Any bolts, nuts or washers that are installed with incorrect orientation or on which the galvanizing is unduly damaged shall be replaced, at the Contractor's expense.
- 3.1.28 Galvanized bolts that have been fully pretensioned or torqued and need to be loosened or removed shall not be re-used. These bolts shall be replaced and pretensioned or torqued to specification when replaced. Re-tightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts shall not be considered as a re-used bolts.
- 3.1.29 Prefabricated anchor bolts shall be installed as specified on the drawings.
- 3.1.30 Contractor shall leave a space between the top of concrete and bottom of the base plate per project drawings but not exceed two (2) times the anchor bolt diameters.

- 3.1.31 Contractor shall ensure that two threads of each installed bolt protrude beyond the nut. After final pretension tightening of the bolts, contractor shall clearly mark the nuts, the plates, and the bolts with a paint stick or permanent marker to verify that they do not back off in the future.
- 3.1.32 Contractor shall adjust the height of, as well as level and plumb, steel structures during equipment assembly and bus installation.

3.2 Post Install Anchors

- 3.2.1 Contractor shall supply and install post-install anchors with the exception of Ameren Missouri supplies post install anchors to contractor/Ameren crews. Installation shall be per manufacturer's specifications.
- 3.2.2 Post-install anchors shall be installed as specified on the project drawings.
- 3.2.3 All OSHA requirements for handling crystalline silica dust shall be followed for drilling into concrete for post anchors installation.

3.3 Field Quality Control

- 3.3.1 Structures shall be erected such that the vertical axis through the center of the structure is not out of plumb by more than one (1) inch in 40 feet.
- 3.3.2 Contractor shall ensure the nuts are fully engaged and two threads of the bolts protrude beyond the nuts, including using oversized thread-chasers as necessary to remove excess galvanizing inside the bolt hole.
- 3.3.3 Contractor shall inspect all galvanizing and protective coatings upon completion of structure erection activities. Contractor shall notify Company's Construction Supervisor of any surface damage to the coatings and repair said damage with spray-galvanizing and/or touch up coatings as directed by the Company. All field galvanizing repairs shall be in accordance to Ameren Specifications Division 9 – Finishes, Section 9B – Galvanized Metal Repair.
- 3.3.4 All bolted assemblies shall be tightened by the Turn-of-Nut Method or Calibrated Wrench Method, as detailed in the Specification for Structural Joints Using High-Strength Bolts, with the exception of Ameren Illinois 69kv and 12kv structures that utilize Direct Tension Indicators (DTI) washers. In accordance with the AISC, bolts used in pretension are required to be installed to within 70% of the minimum tensile strength of the bolts. See table below for AISC minimum bolt pretension.

A325 BOLT PRETENSION	
Diameter (in)	Minimum Pretension (Kips)
1/2	12
5/8	19
3/4	28
7/8	39
1	51
1 1/8	56
1 1/4	71
1 3/8	85
1 1/2	103

- 3.3.5 The following bolt manufacturer's published estimated torque values are provided as a guideline only. The use of the torque values is the sole responsibility of the Contractor and it does not relieve the contractor of the responsibilities laid out in the Specification for Structural Joints Using High-Strength Bolts for the use of the Calibrated Wrench Method for tightening of bolts assemblies.

BOLT TORQUES A325 Galvanized+Waxed		
Diameter (in)	Minimum Torque (ftlbs)	Maximum Torque (ft-lbs)
1/2	50	58
5/8	99	120
3/4	175	213
7/8	284	343
1	425	508
1 1/8	600	722
1 1/4	844	1,021
1 3/8	1,111	1,341
1 1/2	1,475	1,788

- 3.3.6 After the structure has been erected, the anchor bolt heavy hex nuts must be properly tightened to ensure that the structure will perform as designed. The contractor shall fully tighten each top anchor bolt heavy hex nut using the full effort of a single man on a four foot wrench with a torque of 200 ft-lbs to 2,000 ft-lbs. Contractor to tighten the heavy hex locking nut in a similar fashion. Contractor to check all bottom hex leveling nuts to ensure that they have not been loosened.
- 3.3.7 For structure with davit arms and cross arms, contractor shall install temporary construction weights at the arm tip to prevent Aeolian vibration. Contractor to install weight specified on the manufacture shop drawings, a minimum of 10% of the arm weight.

END OF SECTION 16R

SUBSTATION DESIGN

STANDARD NO. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16S – Outdoor Power Circuit Breakers



AMEREN ILLINOIS
AMEREN MISSOURI
AMEREN TRANSMISSION

Rev. No.	Date	Revisions	By	Approvals	
0	12/18/18	First Issue	RCF		RJR

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SECTION 16S

POWER CIRCUIT BREAKERS

1.0 INTRODUCTION

1.1 Scope

- 1.1.1 This section covers all design requirements, accepted equipment materials and manufacturers, and installation procedures that have been deemed as the established standards for Ameren power circuit breaker installation.
- 1.1.2 This power circuit breaker section is applicable to all substation installations including new and retrofit projects.

1.2 Reference Sections

- 1.2.1 Section 16C – General Requirements for Grounding installation
- 1.2.2 Section 16D – Control Conduit, Precast Cable Tray, and PVC Solid Wall Sewer Pipe
- 1.2.3 Section 16F – Compression, Bolted, and Flat Pad Connections
- 1.2.4 Section 16P – Cable Requirements

1.3 Codes and Standards

- 1.3.1 Work performed under these specifications shall be done in accordance with the following applicable codes and standards: ANSI / IEEE / ICEA / UL / NESC

2.0 CIRCUIT BREAKER REQUIREMENTS

2.1 Design

- 2.1.1 All circuit breakers and appurtenances are designed per applicable standards.

2.2 Equipment/Material

- 2.2.1 Unless otherwise specified as being furnished by Ameren, Contractor shall furnish all materials as required for a complete circuit breaker installation.
- 2.2.2 Breakers may be shipped preassembled with the lower frame shipped separately. These frames are added at the site to complete assembly.
- 2.2.3 When Breakers are shipped preassembled without the bushings installed, breaker manufacturer representation must be on site to maintain warranty while and prior to bushing covers being removed and bushings installed.
- 2.2.4 SF6 Gas Circuit Breakers shipped with the bushings installed will have minimal SF6 gas provided in the tank for positive pressure, up to 5PSIG. Breakers must maintain this positive pressure during storage. Note that the pressure varies with temperature, and that the pressure gauge is calibrated at the mid-range scale, and may not be accurate at the lower range.
- 2.2.5 SF6 Gas Circuit Breakers shipped without bushings installed are supplied with nitrogen for positive pressure, up to 5 PSIG. Breakers must maintain this positive pressure during storage. Note that the pressure varies with temperature, and that the pressure gauge is calibrated at the mid-range scale, and may not be accurate at the lower range.

- 2.2.6 Vacuum breakers are shipped with 5 PSIG of dry air. If less than 5 PSIG of dry air is present, then vacuum shall be pulled to add dry air per manufacturer's requirements.

3.0 STORAGE

3.1 SF6 Breaker Short Term Storage (less than 3 months)

- 3.1.1 Breaker tanks and bushings are protected from the environment and contain absorbent and SF6 or nitrogen to stay dry.
- 3.1.2 Cabinets must be protected by desiccant and by keeping vents sealed and doors closed.

3.2 SF6 Breaker Long Term Storage (Greater than 3 Months)

- 3.2.1 Breakers must maintain positive pressure up to 5 PSIG in the tanks
- 3.2.2 Cabinet heaters must be connected and powered. Covers and other obstructions from the vents are to be removed to allow air circulation through the cabinet.
- 3.2.3 Breaker shall be stored with the cabinet at least 6 inches off the ground to prevent water from entering the cabinet.
- 3.2.4 Crates and boxes containing components are to be stored out of the weather.
- 3.2.5 If the breakers were not ordered for long term storage the factory must be consulted for complete instructions.

3.3 Vacuum Breaker Storage

- 3.3.1 Verify breaker has positive pressure in each pole, between 5 and 15 PSIG of dry air. Failure to keep between 5 and 15 PSIG can deteriorate interrupter. Do not move breaker with more than 15 PSIG for risk of bushing failure.
- 3.3.2 Cabinet heaters must be powered, and cables should enter through cabinet bottom.
- 3.3.3 All parts boxes should be kept indoors in a controlled environment.

4.0 INSTALLATION

4.1 Lifting and Handling

- 4.1.1 Contractor shall receive, unload, and inspect: power circuit breakers, bushings, gas cylinders, and accessories.
 - 4.1.1.1 Contractor shall use breaker weight provided via ratings nameplate and breaker outline drawings to determine appropriate lifting capacity of equipment to safely lift and maneuver the breaker.
 - 4.1.1.2 Only nylon slings rated for breaker weight shall be used to lift the breaker to protect breaker bushings and paint. Special care should be paid to composite bushings when lifting breakers with composite bushings to avoid tearing sheds.
 - 4.1.1.3 Slings may need to be shortened on the cabinet side, or lengthened on the opposite side to keep breaker from tipping. Verify lifting height with manufacturer instruction diagrams. See listed examples in Appendix #1.

- 4.1.2 Contractor shall receive, unload, assemble, and install all power circuit breakers and any other miscellaneous switch items shown on the Plans and design documents.
 - 4.1.3 Breakers shipped with the bushings removed have the bushings marked for specific poles and alignment on the adapter plates and tank nozzles.
 - 4.1.4 Composite and porcelain bushings must be rigged in specific manners to avoid damage to the bushings. See Appendix #2 for examples of bushing rigging. Manufacturer instruction should be followed for rigging and lifting of bushings for moving and installation.
- 4.2 Breaker Assembly and Installation or Removal
- 4.2.1 For oil power circuit breaker replacements, Contractor shall coordinate with Construction Supervisor to remove oil from existing breakers and equipment.
 - 4.2.1.1 The oil from existing equipment shall be removed prior to equipment removal. Equipment removal shall be performed by Contractor, including moving or delivering to a pre-determined location as specified by Ameren Construction supervisor or maintenance group.
 - 4.2.1.2 Oil Samples shall be taken from oil tanks by Ameren maintenance and sent to the Ameren Chemical Lab for PCB analysis prior to removal.
 - 4.2.1.3 Only Ameren approved oil recycling contractors are to be used.
 - 4.2.1.4 Breaker Recycling will be handled by Ameren approved contractor, but electrical contractor should assume removing the breaker bushings unless otherwise directed by Ameren.
 - 4.2.1.5 Oil Samples shall be taken from the oil bushings and sent to Ameren Chemical Lab for PCB analysis prior to disposal. Oil bushings may require special disposal based on analysis.
 - 4.2.2 For SF6 or gas power circuit breaker replacements, Contractor shall coordinate with Construction Supervisor to remove gas from existing breakers and equipment.
 - 4.2.2.1 SF6 gas shall be evacuated in properly rated empty cylinders and then returned to Ameren approved supplier for reclamation.
 - 4.2.2.2 SF6 and gas filled breakers shall not be removed or relocated with more than 5 PSIG of pressure to avoid safety issues with bushing failures.
 - 4.2.3 Power circuit breaker foundations may be installed without pre-cast anchor bolts. Contractor shall supply and install adhesive anchor bolts to secure each power circuit breaker to its foundation when pre-cast anchor bolts are not installed.
 - 4.2.4 Contractor shall secure power circuit breakers to the respective foundations and ground power circuit breakers in accordance with manufacturer's instructions and the Plans.
 - 4.2.4.1 A thin layer of NO-OX ID or equivalent contact grease shall be applied to the mating surfaces between the upper breaker and lower breaker galvanized frames to allow electricity to flow freely from breaker frames to ground terminal connections.
 - 4.2.5 Power circuit breakers may be equipped with revenue meter class bushing current transformers (BCTs), or specific BCT ratios, and shall be installed per the Plans with the orientation of the breaker cabinet to match both one-line, three-line, and station plan drawings.
 - 4.2.6 When noted, Contractor shall provide and install all conduit and conduit fittings necessary to run cables into each power circuit breaker control cabinet.
 - 4.2.7 Contractor shall tag and label each cable and shall wire all power circuit breakers per supplied drawings.

- 4.2.8 Contractor shall leave cable tails inside the power circuit breaker control cabinet long enough to reach the furthest terminal block and to provide wire slack inside the cabinet.
- 4.2.9 Contractor shall plug all control cabinet conduit entrances with Duct Seal compound to prevent moisture and rodent entrance.
- 4.2.10 Breakers shall not be operated until filled to minimum operating pressure.
- 4.2.11 Contractor shall refer to manufacturer instructions for additional requirements.

4.3 Gas Processing and Filling

- 4.3.1 The power circuit breakers to be installed use sulfur-hexafluoride (SF6) gas or dry air as the insulation medium.
- 4.3.2 Ameren or Contractor when required shall fill and process each power circuit breaker with the manufacturer-specified amount of SF6 gas, dry air, or mixed gas per manufacturer specified filling process.

4.3.2.1 Prior to filling the breaker with SF6 gas or dry air each gas cylinder shall be tested for appropriate dryness as specified in manufacturer instructions. New gas is typically under 100 ppm.

4.3.2.2 SF6 cylinders provided by the manufacturer of the circuit breaker shall not be used. Ameren procedures require SF6 to be provided through Ameren blanket contract. The Ameren stock number for SF6 cylinders is #1403044, Sulfur Hexafluoride 115lb cylinder.

4.3.2.3 Typical SF6 Gas Requirements are as follows by voltage class

72kV 40kA	One 115lb cylinder per two breakers
145kV 40kA	One 115lb cylinder per breaker
145kV 50/63kA	One 115lb cylinder per breaker
161kV 40kA	One 115lb cylinder per breaker
161kV 50/63kA	One 115lb cylinder per breaker
345kV 50/63kA	Four 115lb cylinders per breaker

4.3.2.4 Ameren requires SF6 cylinders to be weighed and recorded prior to installation and after installation into the breaker to determine amount of SF6 gas installed into the breaker.

4.3.2.5 When filling breakers it is recommended to use a bottle heater to help all gas to be evacuated from each cylinder.

4.4 Miscellaneous

4.4.1 Contractor shall supply temporary power to cabinet heaters if permanent power supply is not available for final connection.

4.4.2 The power circuit breakers will be tested by others. Contractor shall assist testing personnel by removing leads, wires, jumpers, etc. as needed. Primary jumpers shall not have connecting hardware tightened on breaker bushings until testing is complete.

4.4.3 Contractor shall clean all porcelain insulators with clean cotton rags when Work is completed.

4.4.4 Contractor shall clean all composite insulators with water or a denatured alcohol.

4.4.4.1 Consult the manufacturer if cleaning with any other solvent.

4.4.4.2 Do not energize the equipment for 24 hours after cleaning to allow hydrophobicity to return to normal.

4.5 Anchors

4.5.1 When pre-case anchors are not installed, the Contractor shall supply and install adhesive anchors. Installation shall be per manufacturer's specifications.

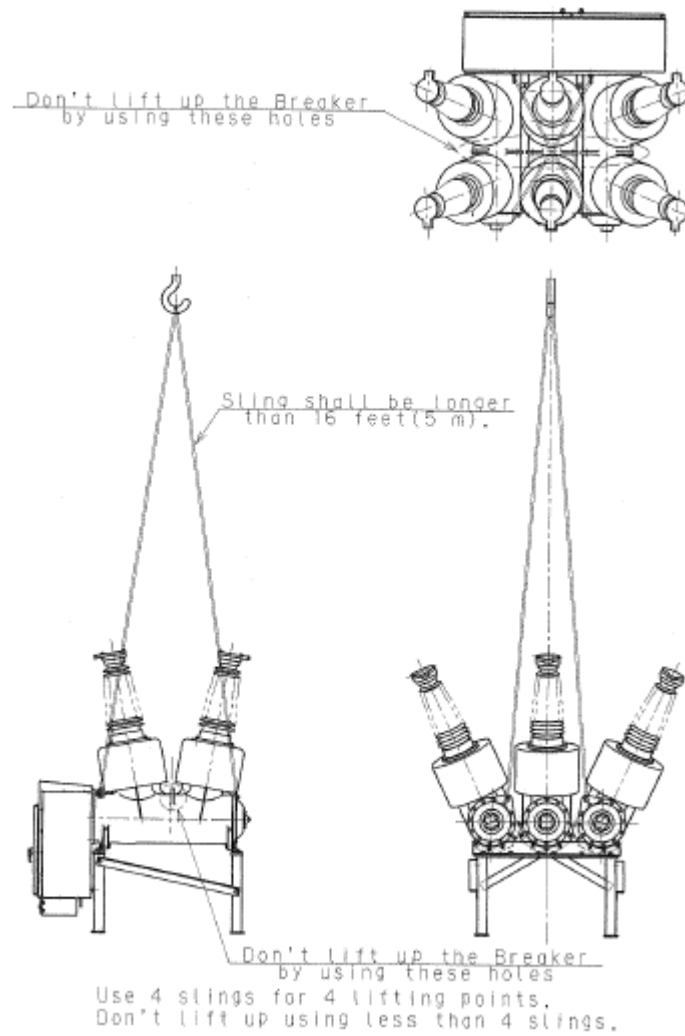
4.5.2 Post-install anchors shall be Powers Fasteners PE1000+ Adhesive Anchoring System.

4.5.3 When shim or hold down plates are installed, Contractor shall weld to breaker base frames and coated with a galvanized coating. Contractor is to provide the shim or hold down plates when required.

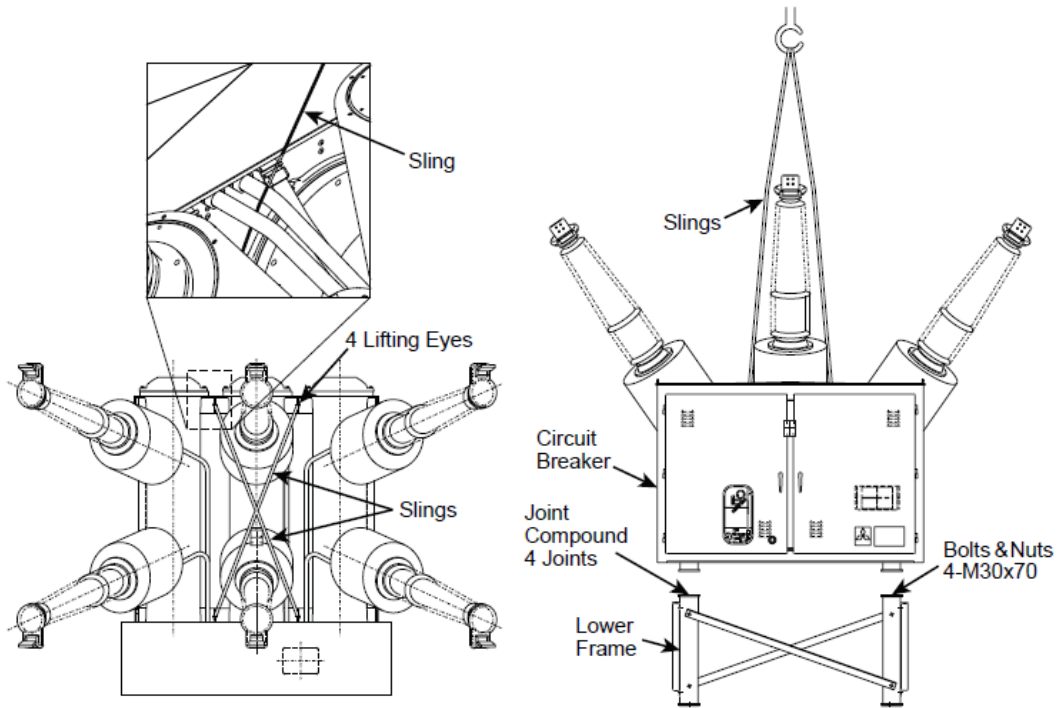
5.0 REVISIONS

Revision 0: Initial Issue

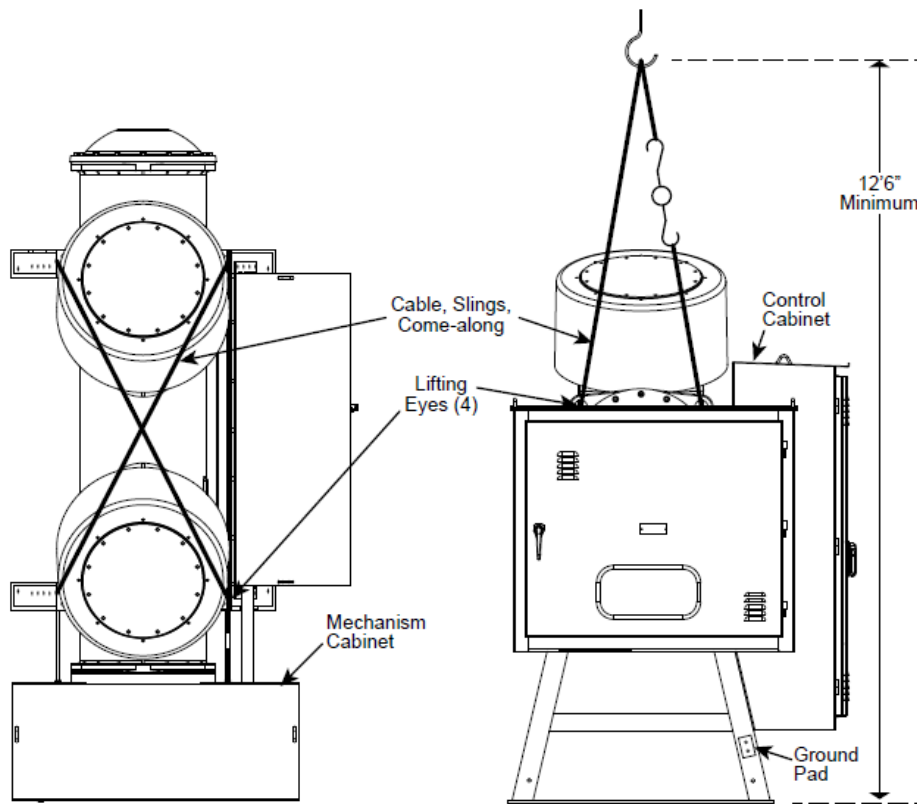
APPENDIX #1: Breaker Lifting Examples



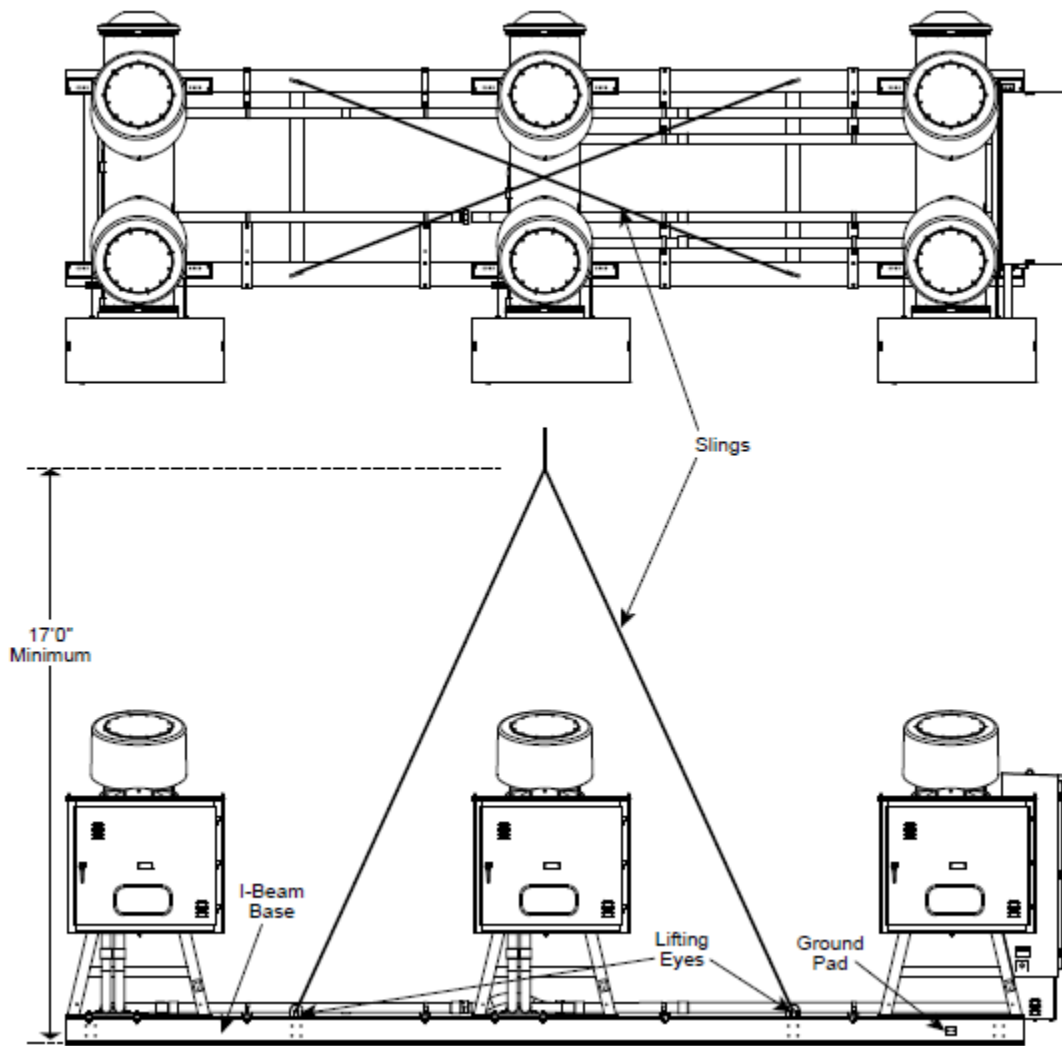
72 kV SF6 or Vacuum Breaker Example



145 kV SF6 Breaker Example

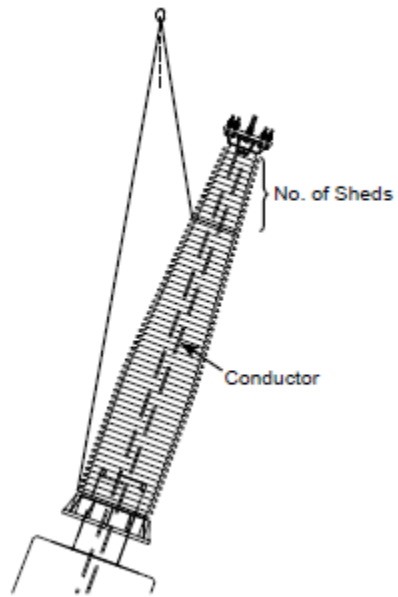


345 kV SF6 Single Pole Example

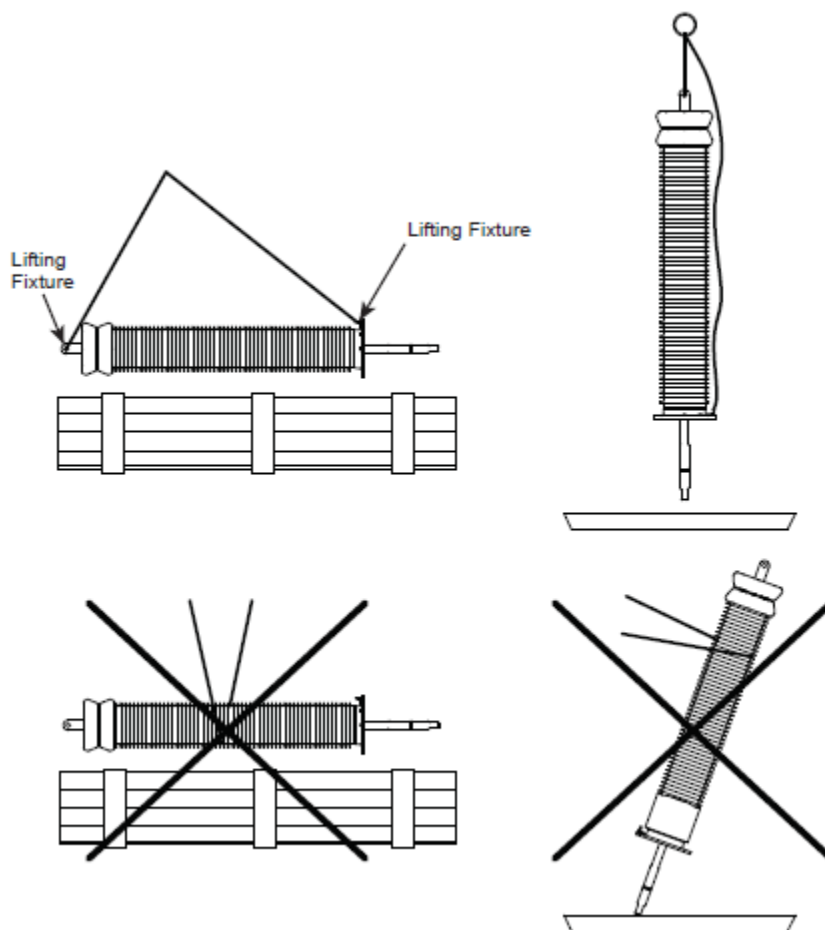


345kV SF6 Common Pole Example

APPENDIX #2: Bushing Lifting Examples



Porcelain Bushing Example



Composite Bushing Example

SUBSTATION DESIGN

STANDARD NO. 6 – SITE CONSTRUCTION

GENERAL REQUIREMENTS FOR SITE/ELECTRICAL CONTRACTORS

DIVISION 16 - ELECTRICAL

Section 16T – Protection and Control Panels



AMEREN ILLINOIS
AMEREN MISSOURI
AMEREN TRANSMISSION

Rev. No.	Date	Revisions	By	Approvals		
0	12/13/2021	Initial Issue	WS	RJR		

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SECTION 16T

CONTROL AND PROTECTIVE RELAYING PANELS

1.0 INTRODUCTION

1.1 Scope

1.1.1 Scope of supply shall include installing control panels/cabinets and installing protective relaying panels/cabinets as outlined on the design documents and Plans.

1.1.2 The specification includes all design, material and equipment, and installation guidelines by which all control and protective relaying panels shall be provided.

1.2 Reference Sections

1.2.1 16P – Power and Control Cables

1.2.2 16O – Fiber Optic Installation

1.3 Codes and Standards

1.3.1 Work performed under these specifications shall be done in accordance with the following codes and standards:

CODES AND STANDARDS	
Work	In Accordance With
Protective relaying panels	The applicable ANSI, NEMA and UL standards

2.0 GENERAL

2.1 Design

2.1.1 Protective Relaying Design

2.1.1.1 Protective relaying design shall be per Ameren Standards.

2.1.1.2 Vertical protective relaying panels shall be supplied to accommodate the protective relaying systems as required by project scope.

2.1.2 Control Panel/Cabinet Design

2.1.2.1 Control panel/cabinet design shall be per applicable codes and standards.

2.2 Equipment/Material

2.2.1 Unless otherwise specified as being furnished by Ameren, Contractor shall furnish all materials as required for a complete panel installation.

2.2.2 Special Shipping Requirements

2.2.2.1 Panels shall be shipped upright and crated. Doors and covers may be removed and packaged separately for installation in the field if necessary.

2.2.2.2 Panels may either be fully assembled panels shipped mounted in a crate, panel fronts mounted to a wooden frame and crated, or partial panels mounted to a wooden frame and crated.

2.2.2.3 Loose materials may be provided with control panels such as fiber jumpers, converters, modems, fuses, and terminal blocks.

2.2.3 Storage Requirements

- 2.2.3.1 Panels shall be stored in enclosed job trailers, connex boxes, or inside control enclosures or buildings free from weather. Electronic devices inside the panels can be damaged by water.
- 2.2.3.2 Panels shall be stored in the upright position to avoid damage to components.
- 2.2.3.3 Storing Panels with crating removed is acceptable if crating material is kept intact for relocating panel or if panel is within final enclosure.
- 2.2.3.4 Temporary connection of DC or AC power is allowed for panels within storage to allow preliminary testing and loading of relay settings.

3.0 INSTALLATION

3.1.1 Panel Installation

- 3.1.1.1 Contractor shall unload, inspect, and install control/relay panels, cabinets, and lighting cabinets.
- 3.1.1.2 Contractor shall install protective relaying panels and control panels/cabinets according to design documents and Plans.
- 3.1.1.3 Each free-standing panelboard shall be carefully aligned and adjusted until its edges are parallel to the adjacent panelboards. Panels shall be anchored to the enclosure floor, adjacent panels, and utilizing bracing when required for panel support.
- 3.1.1.4 Replacement panel fronts and partial panel fronts shall be installed according to design documents and Plans. Special care shall be taken when cutting existing panels to ensure no vibration sensitive relaying in-service is affected. This may require the use of special cutting tools, such as plasma torches. Cut Edges should be free of burrs and enough edge of panel should remain for attaching panel front.
- 3.1.1.5 Stainless steel hardware shall be used for anchoring, attaching panel fronts, or panel accessory material.
- 3.1.1.6 Contractor shall assemble panel covers and doors per panel manufacturer's instructions.
- 3.1.1.7 All wiring used within the panel may be installed and tested at the factory. Contractor shall supply additional internal panel wiring and field wiring as specified on the design documents and Plans.
- 3.1.1.8 Internal panel wiring shall be soft drain, stranded, tinned, No. 14 gauge or size specified on drawings, copper, 600 volt, type, sis construction or engineering approved equivalent. CT wiring circuits shall be No. 12 gauge.
- 3.1.1.9 Insulated ring tongue terminals shall be used for wiring inside of the panel attaching on the back of relays and lock out relays where terminals are very close in proximity and possible shorting of contacts could occur. Terminals shall be Sta-Kon Type nylon or AMP PDIG nylon insulated pressure crimp connectors.
- 3.1.1.10 Non-insulated ring tongue terminals shall be used for wiring of field cables and panel internal wiring to panel terminal blocks. Terminals shall be Burndy Type YAV (or equivalent) pressure crimp connectors.
- 3.1.1.11 All connectors shall be installed with certified crimpers and have test crimps made daily and tested via a pull test for tightness.

- 3.1.1.12 All wiring shall be neatly and carefully installed in wiring gutters or raceway. All terminations should be made in a manner which does not produce tension or stress to relay terminals or terminal blocks.
 - 3.1.1.13 Contractor shall ensure continuity of field wiring and check terminations against drawings prior to turnover. Miss-wired elements shall be corrected by Contractor at no additional cost to Ameren.
 - 3.1.1.14 For panels and cabinets pre-installed in a new control house, panel-to-panel wiring will be completed by the control house manufacturer as much as possible at the manufacturer's factory. Wires lifted across control enclosure shipping splits will be completed by the control house manufacturer's representatives once the control house is delivered and set in its final destination.
 - 3.1.1.15 Contractor shall be responsible for terminating all outdoor control and power cables within the control house. Contractor are also responsible for pulling and terminating all security related cables (both inside the control enclosure and at the outdoor yard).
 - 3.1.1.16 Contractor is responsible for installing all fiber optic patch cords. Termination of fiber from the yard and testing will per performed by separate contractor.
 - 3.1.1.17 All wiring to equipment external and between panels shall be brought to terminal blocks at each panel. Any wires which enter or leave a control or relay panel must be connected through terminal blocks at their entry or exit point.
 - 3.1.1.18 When terminal blocks are installed, terminal blocks are to be mounted with the long dimension vertical unless otherwise indicated. Slide link terminal blocks shall be mounted to slide open toward the external wiring connections. If a slide link terminal block needs to be mounted horizontal, the slide links should fall open if a loose connection is made.
 - 3.1.1.19 Shielded field cable grounding (when indicated on the prints) shall be installed using an AMP#330003 foil tape barrel type connector with #10 gauge bare copper wire. This wire shall be connected to the panel ground bar when present. If the panel ground bar is not present it shall be connected to the 4/0 ground loop using a split bolt connector.
 - 3.1.1.20 Field wiring shall be pulled into the same panel where terminations take place (do not use adjacent panels as pull boxes to route field wiring through).
 - 3.1.1.21 All field cable designated spare conductors shall be cut at sufficient length to reach the bottom of the relay panel, or furthest field terminal block within the respective panel, whichever is longer.
 - 3.1.1.22 Label all field wiring with cable and wire numbers per the design documents.
 - 3.1.1.23 All intra panel wiring shall be labeled with the destination point, such as AA1, etc.
 - 3.1.1.24 All control and relay panels shall be connected to existing panel ground loop either via the continuous copper ground bus at the bottom of the panels, or via the 4/0 ground loop along the cable tray.
 - 3.1.1.25 All panels shall be cleaned of dust, dirt, debris and other foreign matter prior to turnover to Ameren.
- 3.1.2 Relays, Meter, Controls and Instruments
- 3.1.2.1 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. Contractor shall mount devices as specified on the design documentation and Plans.

3.1.3 Panel Nameplates

- 3.1.3.1 Panel nameplates shall be installed on control and relay panels on both the front and rear side of the panels above the equipment as identified on project drawings.
- 3.1.3.2 Nameplates will be adhesive backed and should have panel surface prepped and cleaned prior to attaching.
- 3.1.3.3 Any panel nameplate of removed equipment or outdated labeling shall be removed and new nameplates installed. New nameplates shall not be installed on top of existing nameplates.
- 3.1.3.4 If backlite nameplates are not available at time of panel install printed labels shall be used to identify equipment. Using marker on panels is not an approved means of labeling equipment.

END OF SECTION 16T

SUBSTATION ENGINEERING DESIGN

DIVISION 16 - ELECTRICAL

Section 16U – Soil Resistivity Testing



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

<i>Rev No.</i>	<i>Date</i>	<i>Revisions</i>	<i>By</i>	<i>Approvals</i>		
<i>0</i>	<i>12/19/18</i>	<i>Original Issue</i>	<i>DWD</i>	<i>DWD</i>	<i>MJE</i>	<i>RJR</i>



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1.0 General

- 1.1 This specification describes the requirements for measurement and documentation of site soil resistivity on Ameren Project sites. Questions or clarifications on the methods described herein shall be submitted to Ameren Engineering. Other testing methods require written authorization by the Engineer.
- 1.2 The soil resistivity parameters measured using this specification will be used in the design of a safe and economical grounding system for the given project. These parameters will be analyzed using a computer aided design tool, by the Engineer.
- 1.3 The following items will be issued for reference by Engineering to the Contractor to complete testing within the scope. Examples of items given can be seen in the Appendix. Any deviations of references shall be approved by engineering:
 - 1.3.1 GPS Coordinates of the approximate location testing shall be performed.
 - 1.3.2 Approximate address (new site) or existing registered address.
 - 1.3.3 Orientation needed to perform test (i.e. distances and testing setup in relation to an existing Ameren line).
 - 1.3.4 Engineering contact information
- 1.4 Contractor to conform to all Company safety practices, inquiries or clarifications regarding these safety practices to be directed to the Company Inspector.

2.0 DEFINITIONS

- 2.1 Company - Shall refer to Ameren or its designated agents
- 2.2 Engineer - Shall refer to Ameren's engineer or engineering representative.
- 2.3 Inspector - Shall refer to Ameren's field Construction Engineer or Construction Supervision designated for a given installation project.
- 2.4 Contractor - Shall refer to the party or parties proposing to perform the work and provide the material specified herein.
- 2.5 Subcontractor - Shall refer to any party or parties that the contractor has assigned any portion of the proposed construction project.

3.0 SPECIFIC REQUIREMENTS

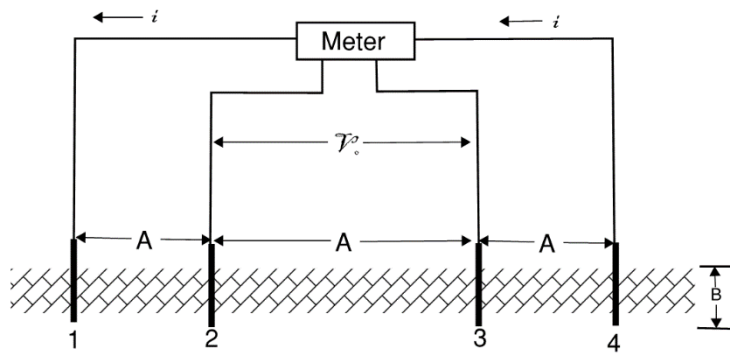
3.1 Equipment

- 3.1.1 The testing shall be performed by equipment in good working order with service records available upon request.
- 3.1.2 Equipment used in testing shall be calibrated within one (1) month prior to the test. Proof of calibration date is to be submitted with the report.
- 3.1.3 Equipment is required to use injection frequencies in the range of 15-50 Hz. Other frequencies are not acceptable, unless device utilizes a frequency rejection filtering capability.

3.2 Soil Resistivity Testing

- 3.2.1** Approved methods for testing resistivity are Wenner method (also called the Wenner Four-Electrode method) [preferred] and the Three Point Method (also called the Fall of Potential method) only. Details on the Fall of Potential method are discussed in 3.2.8, although it is not the preferred method. More details on performing these methods are described in IEEE Std 81. Additional details on the methods can be obtained from resources located in the reference section herein.
- 3.2.2** Access to the project location shall be coordinated with the Engineer, as well as the Company Inspector.
- 3.2.3** Use of a Subcontractor must be approved by the Company.
- 3.2.4** Testing shall be performed on soil where soil depths greater than two feet have been undisturbed for a period of at least one-year. Recently disturbed soil and fill material which has been compacted to the Company's specifications shall be considered undisturbed two weeks following final compaction.
- 3.2.5** Testing shall be performed on soil with no known conductive paths through the site that may influence the test results. Conductive paths known to influence test results include overhead transmission and distribution lines, grounding and shielding conductors, underground pipes, springs, railroad tracks, and large foundations. Conductive paths perpendicular to the test line or conductive paths that are located at a distance away from the test line of not less than 1.5 times the maximum pin spacing shall not be assumed to influence the test results.
- 3.2.5.1** Typical distances from distribution lines shall be greater than one-hundred feet (100ft).
- 3.2.5.2** Typical distances from transmission lines shall be three-hundred feet (300ft) or greater.
- 3.2.5.3** Typical testing layouts for distribution and transmission should be at least the minimum seen in the Appendix 2. For transmission projects, readings should be made out to 200ft minimum to avoid the skin effect phenomena with voltage/current injection penetration. Greater distances and multiple data points produce better data.
- 3.2.6** The Contractor shall be responsible for providing testing equipment with the required filtering where resistivity measurements are required near energized electric lines described above.
- 3.2.7** In the Wenner method Two (2) sets of twenty (20) resistivity measurements in the North-South direction and Two (2) sets of twenty (20) resistivity measurements in the East-West direction shall be obtained in the approximate locations. Parallel tests should be differ in distance by 50ft or more. If space allows testing at the site shall be done twice in each direction, preferably at differing locations within the outlined project perimeter. The typical meter setup can be seen in Figure 1 for the Wenner method, where the inner probes (2,3) are potential electrodes and the outer probes (1,4) are current electrodes.

Figure 1. Wenner Method Setup



3.2.8 The Fall of Potential typically method requires more space to perform the measurements as it requires the test to be performed at 5-6 times the distance of the diagonal of the proposed project area. The simple setup requires the distances to be measured in the setup seen in Figure 2. This test is not preferred due to special limitations and distances required but approved for use.

3.2.8.1 The test requires varying the distances S1 and S2 by percentages of the longest diagonal (d) linear length and for simplicity assume that S1 and S2 are equal.

3.2.8.2 The testing data shall include the following distances of S1/S2:

3.2.8.2.1 20%

3.2.8.2.2 40%

3.2.8.2.3 60%

3.2.8.2.4 65% should be the resistivity of the area at approximately 62%

3.2.8.2.5 70%

3.2.8.2.6 90%

3.2.8.2.7 120%

3.2.8.2.8 150%

3.2.8.2.9 160%

3.2.8.2.10 Depth of earth electrode shall be eight feet (8ft), P and C shall remain at six inches (6")

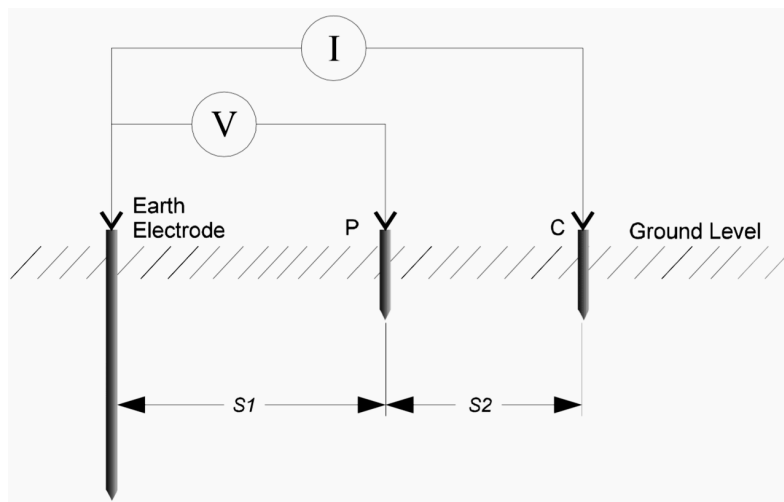


Figure 2 Fall of Potential Method

- 3.2.9** The measurement locations relative to the proposed property dimensions are shown in documentation submitted by the Engineer. The Contractor shall be responsible for locating the tests on the property using the Company's property layout drawing.
- 3.2.10** Where measurements at the specified locations in accordance with these specifications are not possible as a result of existing structures, disturbed soil, or conductive paths, the Contractor shall notify the Engineer and the Engineer may revise the specified testing locations.
- 3.2.11** Using the Wenner method the probe depth "B" for all soil resistivity measurements shall be **twelve (12)** inches (0.304m). Probe spacing "A" is shown in the second column of the test data table found in Appendix 2.
- 3.2.12** Soil Resistivity Measurements shall be recorded at the time the testing is performed and submitted to the Engineer within one week following the completion of all testing.
- 3.2.13** If the test cannot be performed due to field conditions, the Inspector and Engineer shall be notified and testing rescheduled. Testing can be rescheduled due to the following field conditions or as determined by the Engineer or Inspector:
- 3.2.13.1** Wet soil conditions-greater than or equal to 50% moisture content
 - 3.2.13.2** Field found soil impediments
 - 3.2.13.3** Previously unknown rocky soil or pavement in location
 - 3.2.13.4** Inclement weather
- 3.2.14** Any noteworthy field conditions difficulties in performing the measurements, or special procedures shall be noted in the report.
- 3.2.15** Following receipt of the Contractor's documented measurements, the Engineer will analyze the measurements using ground grid design software. The individual measurements will be curve fitted using mathematical regression techniques into a two-layer soil model. The curve fitted error margin will be evaluated and the soil model will be compared to the soil boring data from the geotechnical investigation to determine if the measurements are valid. The resistivity trending curve should show a regression, the one shown below in figure 3, is from IEEE documentation.

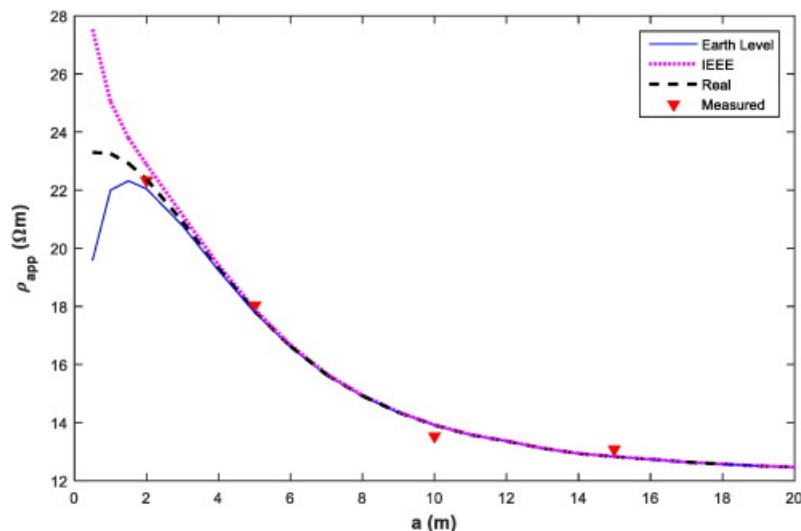


Figure 3. Typical Resistivity Regression Curve



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3.2.16 The Engineer may request additional measurements following analysis of the initial measurements provided by the Contractor. Additional requested measurements shall be made, documented, and submitted by the Contractor within one week of the Engineer's request. All additional measurements (if in excess of the original requested measurements) shall be extra work for which the Contractor will be reimbursed by the Company. The defined change management process will be followed.

3.3 Documentation

3.3.1 Testing documentation shall be submitted in report form not exceeding 1 business week from the date test was performed.

3.3.2 Documentation shall include at a minimum, but not be limited to the information found found in Appendix 2.

3.3.3 Tester shall include apparent resistivity in the data with an example calculation shown and submit this in both native Excel format and with the report.

3.3.4 A .KMZ, and .PDF overlay, with the layouts of where the testing was performed, shall be included in the submittal with the report. An example can be seen in Appendix 3.

4.0 **REFERENCES**

- 4.1** IEEE Standard 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.
- 4.2** IEEE Standard 81.2, Guide for Measurement of Impedance and Safety Characteristics of Large, Extended, or Interconnected Ground Systems.
- 4.3** IEEE Standard 80, Guide for Safety in AC Substation Grounding.
- 4.4** ASTM G57 – 95a, Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method
- 4.5** "Getting Down to Earth, A Manual on Earth Resistance Testing for the Practical Man", AVO Int., Fifth Edition, February, 1998.
- 4.6** IEEE C2, National Electric Safety Code (NESC)
- 4.7** NFPA, 70, National Electrical Code (NEC)



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Revision Notes

Date	Editing Engineer	Notes
12-19-2018	D. Dettenmeier	Initial issue combining specifications into a standard



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Appendix 1

Typical Engineering Deliverable to the Contractor



Typical Engineering
Deliverable to the Contractor

- KEY**
- Soil Resistivity
 - Approx. Property Boundary
 - Dimensions
 - Approx. Location of Future Fence
 - Approx. Location of Soil Borings



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Engineer should also include Approximate Locations of Soil Resistivity Measurements including the following information

Project/Substation X

Someplace Rd
Some City, IL/MO ZIP
Lat: Long: -.....



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Appendix 2
Typical Soil Resistivity Data Form



Soil Resistivity Testing

Conditions

Date _____ Site _____ Temperature _____ °F Humidity _____ %

Recent Weather Conditions (last 48 hours) _____

Test Equipment Description (Mfgr., type, model, etc.) _____

Test equipment calibration date _____

Test Probe Data: Material _____ Diameter _____ Length _____

Test Personnel _____ Names _____

Approximate distance from nearest existing lines if test is performed parallel in accordance with 16U _____

Observed Soil Condition

Description:

_____ Top soil, Clay, Gravel, limestone, sandstone, rock granite, street,
other...etc. _____

Moisture condition of soil _____ % if higher than 50% test should be rescheduled

Testing Notes:

- 1) Test #2 should be performed in a direction perpendicular to Test #1.
- 2) Stay away from transmission lines, railroad tracks, pipes, etc. (if possible, perform test perpendicular to these objects).
- 3) Do not make the test if the surface is wet.
- 4) Best to have the test made in the months of May, June, October, or November
- 5) Report shall point out if tester has documented apparent resistivity or only measured resistivity.

$$P = \frac{4 \pi A R}{1 + \frac{2A}{\sqrt{A^2 + 4B^2}} - \frac{A}{\sqrt{A^2 + B^2}}}$$

Where: P = Apparent resistivity in ohm-meters
 R = test reading
 A = distance between adjacent probes (meters)
 B = depth of probe (meters)

If A > 20 (b), then P = 2π A R

1 foot = 0.305 meters



Measurement Set 1, North-South- repeat for a 1B

Measurement	Spacing "A" [ft]	Inner Probe [ft]	Outer Probe [ft]	Measurement (Ohms)	(P) Resistivity (Ohm*Meter)
1	0.5	0.5	1.5		
2	1	1	3		
3	1.5	1.5	4.5		
4	2	2	6		
5	2.5	2.5	7.5		
6	3.5	3.5	10.5		
7	5	5	15		
8	7.5	7.5	22.5		
9	10	10	30		
10	12.5	12.5	37.5		
11	15	15	45		
12	17.5	17.5	52.5		
13	20	20	60		
14	25	25	75		
15	30	30	90		
16	35	35	105		
17	40	40	120		
18	45	45	135		
19	50	50	150		
20	55	55	165		

Field Notes



Measurement Set 2, East-West- repeat for a 2B

Measurement	Spacing "A" [ft]	Inner Probe [ft]	Outer Probe [ft]	Measurement (Ohms)	(P) Resistivity (Ohm*Meter)
1	0.5	0.5	1.5		
2	1	1	3		
3	1.5	1.5	4.5		
4	2	2	6		
5	2.5	2.5	7.5		
6	3.5	3.5	10.5		
7	5	5	15		
8	7.5	7.5	22.5		
9	10	10	30		
10	12.5	12.5	37.5		
11	15	15	45		
12	17.5	17.5	52.5		
13	20	20	60		
14	25	25	75		
15	30	30	90		
16	35	35	105		
17	40	40	120		
18	45	45	135		
19	50	50	150		
20	55	55	165		

Field Notes



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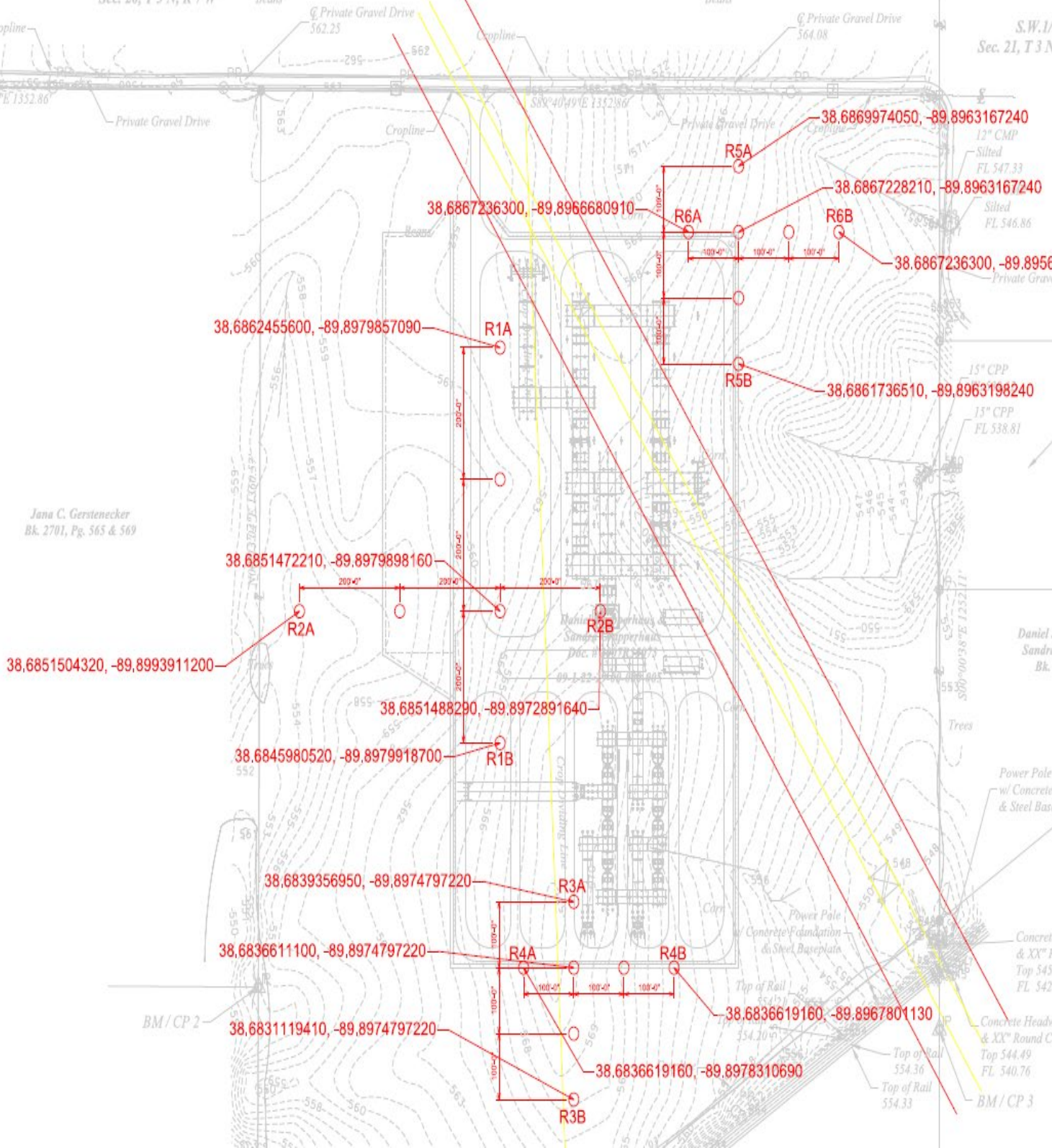
Appendix 3
Typical Submittal to the Report

Mary O. Grapperhaus
Doc. # 2014R02898

S.E.1/4
Sec. 20, T 3 N, R 7 W

Mary O. Grapperhaus
Doc. # 2014R02898

S.W.1/4
Sec. 21, T 3 N, R 7 W



Typical Testing Diagram Overlay to be submitted with Report