

SUBSTATION CONSTRUCTION STANDARDS

February 15, 2019



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 – 2/15/19 – BMW

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.

Red titles indicate new or updated standards

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	
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1.0 General

1.1 Work Included

- 1.1.1 Excavation for structures and foundations.
- 1.1.2 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 02225 – Trenching
- 1.2.6 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

1.4 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 Protect excavations by shoring, bracing, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavation.
- 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.
- 2.1.7 Prevent surface water run-off into excavation. In excavations where water may collect the Contractor shall establish and maintain pumping capabilities to keep the excavation free of water. This includes a layer of oversize rock (+/- 4") covered by a layer (+/- 2") 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 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. 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.

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 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.
- 2.2.4 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. 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 paint filter test 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 will waive the licensed special waste and manifest requirements for materials that meet delisting requirements.
- 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 Hand dig and/or soft dig techniques shall be utilized for at least the first four feet of any excavation within the fence line of any existing Ameren substation.
 - 2.4.1.1 *With the Construction Supervisor's approval, any excavation required beyond the initial four foot depth may then be completed by conventional mechanical methods of excavation.*
 - 2.4.1.2 *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 Excavate subsoil required for foundations, structures, and/or other work.
- 2.4.3 Hand trim excavation, where required, and leave free of loose matter.
- 2.4.4 Remove lumped subsoil, roots, any other foreign material, boulders, and rock, as required, to obtain specified elevation and grade.
- 2.4.5 Excavated material shall be deposited a proper distance from the edge of all excavations per OSHA regulations. It is the responsibility of the Contractor to ensure that the excavation site meets OSHA safety standards.
- 2.4.6 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.
- 2.4.7 Contact the Construction Supervisor for guidance if soft, unsuitable, and/or unstable soil is discovered under structure bearing surfaces.
- 2.4.8 Contact the Construction Supervisor to determine acceptable locations and depths of all stockpiled excavated material.
- 2.4.9 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".

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	Revision	DJG	GLC	FF	DES

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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 Section 02225 – Trenching
- 1.2.4 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 Grade A, Gravel

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
¾ in.	80 – 100
No. 4	60
No. 10	10 – 35
No. 200	0 – 10

2.1.2.2 Missouri – MoDOT Fine Aggregate

<u>Sieve Size</u>	<u>Percent Passing</u>
¾ in.	100
No. 4	95 – 100
No. 8	70 – 100

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

SUBSTATION DESIGN

STANDARD NO. – 02225

General Requirements for Trenching



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	7-9-13	Issue for Use	GAP	JEL	DWW	

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SECTION 02225

TRENCHING

PART 1 GENERAL

1.01 WORK INCLUDED

- A. Excavation of trench for any underground work or installation.

1.02 RELATED WORK

- A. Section 02222 - Excavation
- B. Section 02223 - Backfilling

1.03 PROTECTION

- A. Perform all Trenching in accordance with OSHA 1926 Subpart P – Excavations.
- B. Protect excavations by shoring, bracing, sheet piling, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavation.
- C. Underpin adjacent structures which may be damaged by excavation work, including service utilities and pipe chases.
- D. Notify Construction Supervisor of unexpected subsurface conditions and discontinue work in affected area until notified to resume work.
- E. Protect bottom of excavations and soil adjacent to and beneath foundations from frost.
- F. Grade excavation top perimeter to prevent surface water run-off into excavation.
- G. Contractor shall not allow any water to collect in trench. Use either a diversion channel or pumping to remove water from trench.

PART 2 EXECUTION

2.01 INSPECTION

- A. Verify stockpiled fill to be reused is approved by Construction Supervisor.
- B. Verify power conduit installation has been inspected by Construction Supervisor.
- C. Verify areas to be backfilled are free of debris, snow, ice, or water, and surfaces are not frozen.

2.02 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. When necessary, compact subgrade surfaces to density requirements for backfill material as shown on plans or called out in construction documents.

2.03 EXCAVATION

- A. Excavate subsoil required for power conduit.
- B. Cut trenches sufficiently wide to enable installation of utilities and allow inspection.
- C. Remove lumped subsoil, boulders, and rock as required to achieve final trench elevation and alignment.
- D. Excavation shall not interfere with normal 45 degree bearing splay of foundations, unless approved by the Engineer.
- E. Correct and report (to Construction Supervisor) any unauthorized excavation or over-excavation in accordance with Section 02223 at no cost to Owner.
- F. Fill over-excavated areas in accordance with Section 02223, at direction of Construction Supervisor, and in accordance with grading plan.
- G. Stockpile excavated material in area designated on site by Construction Supervisor and spread excess subsoil not being reused, on designated area on site. Stockpile removed topsoil separately from excavated subsoils. Remove no rock/soil from site without testing by Ameren environmental department.

- H. Excavator shall not damage above or below-grade facilities, and shall provide immediate notification to Ameren if possible damage is suspected.

2.04 BACKFILLING

- A. Backfill all trenching per Section 02223.

2.05 SOFT DIG/HYDRO-VACUUM EXCAVATION

- A. Soft-dig/hydro-vacuum excavations shall adhere to all points in this specification.
- B. Soft-dig/hydro-vacuum contractor shall submit to Ameren any safety/regulatory specifications which apply to operations for which the contractor has been hired.
- C. All excess material shall not leave site until tested by Ameren environmental department.

2.06 ILLINOIS UNDERGROUND UTILITIES FACILITIES DAMAGE PREVENTION ACT

- A. Any operations taking place in the state of Illinois shall adhere to the Illinois Underground Utilities Facilities Damage Prevention Act.

(http://www.illinois1call.com/law_policies/law.htm)

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	9-26-05	Initial Issue	MJW	DCB	JLH	PJN
1	9/04/12	Added ACI 336.1 reference and Special Inspector requirement	JAB/ SM	DCB	WJH	RQR
2	12/18/18	Major Revision	JLF	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.

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 ½” 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 ½" 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 +/- ¼” nor vertical placement deviation more than +/- ½” from location specified on Project Drawings.

For transmission line piers, anchor bolt horizontal and vertical placement deviation shall not be more than +/- ½” 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>
9/26/05	Initial Issue
9/04/12	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.

CAST-IN-PLACE CONCRETE PIER RECORD
Attachment 1

---To be completed by Contractor and approved by Owner’s Representative – Geotechnical Engineer---

Project: _____

Contractor:_____

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:_____

Concrete Placement Curves									
Attachment 2									
Project:							Date:		
Contractor:							Foundation Number:		
Depth (ft)									
Concrete Volume (yd3)									
Instructions for use:						Legend:			
1. Graph is only required for piers constructed using the slurry displacement method.						◆ - Theoretical Volume			
2. Plot both the theoretical concrete volume vs. depth and actual concrete volume vs. depth on the above graph.						○ - Actual Volume			
3. Plot volume at elevation intervals not exceeding the shaft diameter.									

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

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1.0 General

1.1 Work Included

- 1.1.1 Yards located in Missouri; 3 inch thick bottom layer of AASHTO Size/Grade 24 limestone covered with 3 inches of MoDOT Grade 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 Grade D, Limestone

<u>Sieve Size</u>	<u>Percent Passing</u>
1 in.	100
¾ in.	90 – 100

3/8 in.	15 – 45
No. 4	0 – 8

2.1.4 Missouri - AASHTO Size/Grade 24, Limestone

<u>Sieve Size</u>	<u>Percent Passing</u>
3 in.	100
2 ½ in.	90 – 100
1 ½ in.	25 – 60
¾ in.	0 – 10
½ in.	0 – 5

3.0 Execution

3.1 Preparation

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

3.1.2 Complete all grading and compaction of yard area.

3.2 Surfacing

3.2.1 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 roller is required.

3.3 Tolerances

3.3.1 Top surface of yard rock: Plus or minus one inch.

4.0 Cross Section Examples

4.1 Yard rock used in Missouri Substations

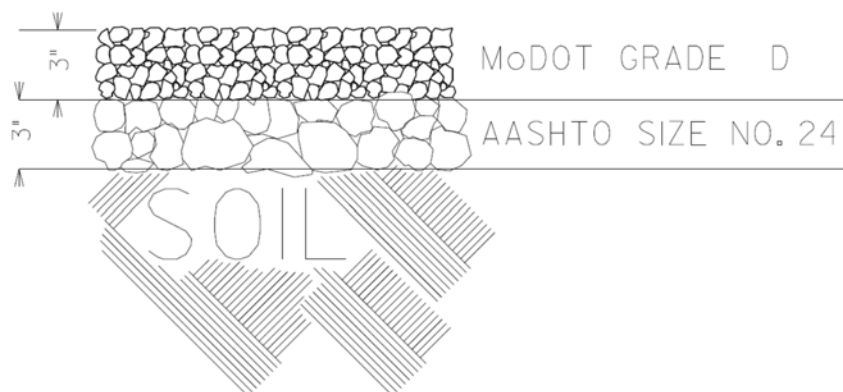


Figure 1 – Yard Rock Cross Section (Missouri Substations)

4.2 Yard rock used in Illinois Substations

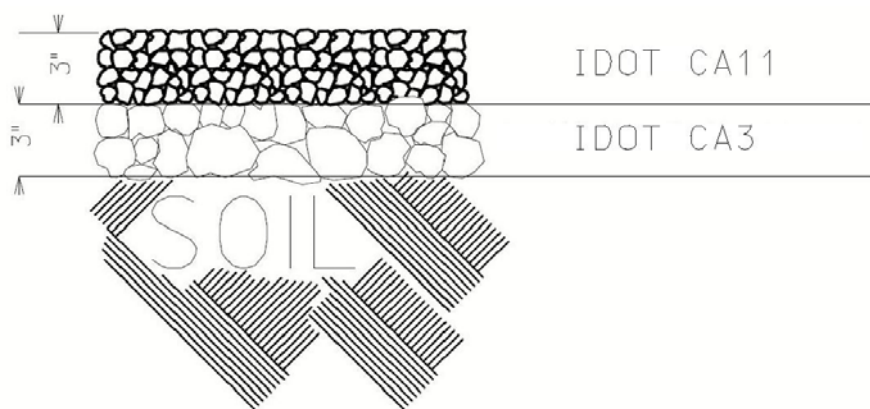


Figure 2 – Yard Rock Cross Section (Illinois Substations)

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

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Figure 2 – Yard Rock Cross Section (Illinois Substations)	5

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

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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 AASHTO Size No. 24 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	40 – 60
No. 40	15 – 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	40 – 60
No. 30	15 – 35
No. 200	0 – 15

2.1.5 Missouri - AASHTO Size/Grade 24, Limestone

<u>Sieve Size</u>	<u>Percent Passing</u>
3 in.	100
2 1/2 in.	90 – 100
1 1/2 in.	25 – 60
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 (10) ton roller. 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/vibrating-plate 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 other wise 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 (10) ton roller.
- 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: Plus or minus one inch.

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

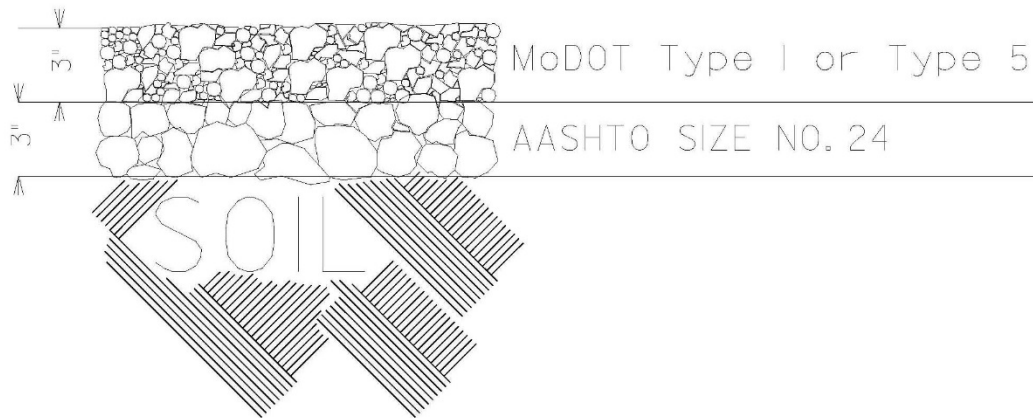


Figure 1 – Roadway and Drive Rock Cross Section (Missouri Substations)

5.2 Roadway and drive rock used in Illinois Substations

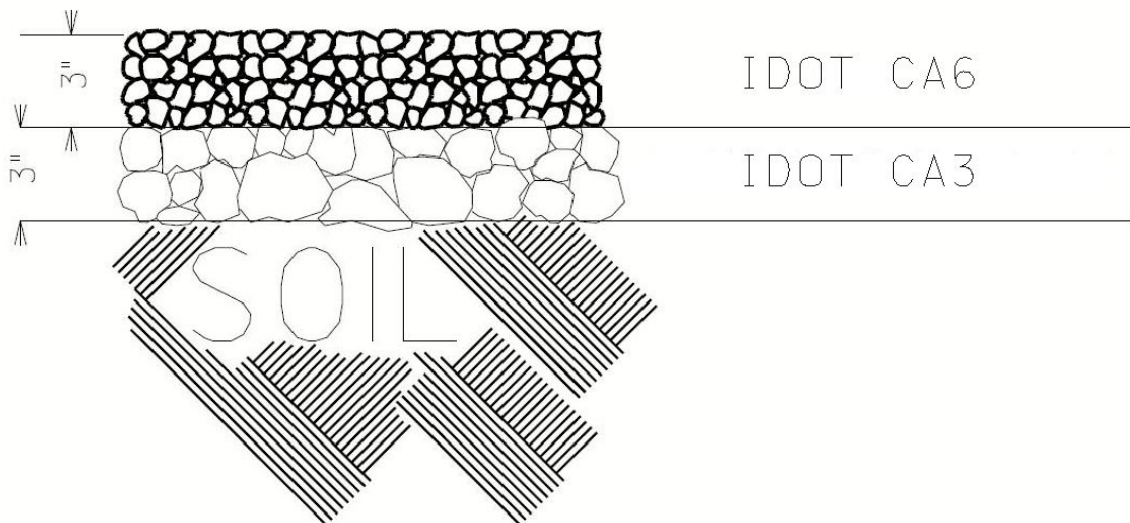


Figure 2 – Roadway and Drive Rock Cross Section (Illinois Substations)

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

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SUBSTATION DESIGN
STANDARD NO. – 02513

General Requirements for
Asphaltic Concrete Paving



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Rev. No	Date	Revisions	By	Approvals		
0	9-26-05	Initial Issue	BLC	DCB	JLH	PJN
1	7-9-13	Issue for Use	GAP	JEL	DWW	

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SECTION 02513

ASPHALTIC CONCRETE PAVING

PART 1 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

- A. Missouri State Highway Commission - Standard Specification for State Roads, current edition.
- B. Asphalt Institute Manual MS-4 - The Asphalt Handbook.
- C. Asphalt Institute Manual MS-13 - Asphalt Surface Treatments and Asphalt Penetration Macadam.
- D. ASTM D946 - Asphalt Cement for Use in Pavement Construction.
- E. AASHTO Hot-Mix Asphalt Paving Handbook
- F. Illinois Department of Transportation – Standard Specifications for Road and Bridge Construction

PART 2 PRODUCTS

2.01 MATERIALS

A. Geotextile Fabric: (Use only where noted or shown on the drawings)
Mirafi HP-Series as manufactured by TC Mirafi or approved equal.

B. Stone Base:

- a. For Missouri: Aggregate conforming to the Missouri Standard Specification for Highway Construction - Type 1 Aggregate Base.

<u>Sieve Size</u>	<u>Percent Passing</u>
One inch	95 to 100
1/2 inch	60 to 90
No. 4	40 to 60
No. 40	15 to 35

- b. For Illinois: Aggregate conforming to the I.D.O.T. 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.

CA-6

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

CA-10

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

- C. Primer (Aggregate Base): Light grade cutback asphalt conforming to the Asphalt Institute designation MC-70 (Missouri) or MC-30 (Illinois); free of water and showing no separation or curdling prior to use.
- D. Tack Coat: RS-1 liquid asphalt emulsion.
- E. Sand Cover:
 - a. Missouri: Natural river bank sand; washed; free of silt, clay, loam, or soluble materials, and organic matter.

<u>Sieve Size</u>	<u>Percent Passing</u>
No. 4	100
No. 40	2 to 0

- b. Illinois: CA-18

<u>Sieve Size</u>	<u>Percent Passing</u>
Three inch	100
One inch	90 to 100
No. 4	50 to 100
No. 16	30 to 80
No. 50	0 to 10
No. 200	0 to 2

- F. Asphalt Cement: ASTM D946
- G. Seal Coat: Tarfex Pavement Sealer (by Bitucote), MAC 52 (by McConnell & Assoc.), or approved equal.

A. Asphalt:

- a. Missouri: Type B asphaltic concrete base course, with a Type C asphalt concrete wearing surface course; compacted thickness of each course as detailed in Section 1B and on the project drawings. (See Section 1.03, item A for reference.)
- b. Illinois: Illinois Low ESAL Mixture – IL-19.0L Binder, IL-9.5L surface

Low ESAL, MIXTURE COMPOSITION (% PASSING)				
Seive 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

PART 3 EXECUTION

3.01 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.

3.02 WEATHER LIMITATIONS

- A. Bituminous materials shall be applied only when the temperature of the air in the shade is above 60 degrees F. No work shall be started if local conditions indicate that rain is imminent.

Type of Construction	Bituminous Material Recommended for Weather Conditions Indicated	
	Warm [60-85 degrees F]	Hot [85+ degrees F]
Prime	MC-30, PEP	MC-30, PEP
Cover Coat and Seal Coat	RS-2, CRS-2, MC-800, MC-3000, SC-3000, HFE-90, HFE-150, HFE-300	RS-2, CRS-2, MC-800, MC-3000, SC-3000, PG 46-28, PG 52-28, HFE-90, HFE-150, HFE-300

3.03 STONE BASE

- A. Remove and replace all soft or unstable subgrade.
- B. Proof rolling shall be done on top of granular base material, and the amount of deflection of the base and the amount of indentation of the truck wheels in the granular base course material shall be noted. If the condition of the granular material is not satisfactory, as decided by the Construction Supervisor, the base course should be reworked or stabilized until it is in the proper condition for overlaying.
- C. Install a layer of Construction Supervisor -approved non-woven geotextile fabric over original subgrade. Fabric shall cover the full width of the aggregate base, as shown in the plans, in one piece or shall be lap spliced per the manufacturer's recommendations.
- D. Place stone in to bring the base to the elevations specified less the asphaltic paving thickness.
- E. Base shall be laid in lifts not to exceed 4" thick when compacted. Compact the stone base to not less than 100 percent of standard laboratory density, using appropriate equipment.

- F. 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.

3.04 BASE PRIME

- A. The prime coat material should be applied to the base course with a pressure distributor at least 48 hours before paving is to begin.
- B. Apply primer over aggregate base at a uniform rate of 0.4 gallons per square yard.
- C. Apply primer per manufacturer's instructions using a pressure distributor at a temperature between 50°F and 150°F.
- D. After 24 hours, use clean sand to blot excess primer. All excess sand shall be swept from the base before commencing asphalt placement.
- E. Apply primer to contact surfaces of any existing asphalt which abuts new asphalt paving.

3.05 PLACING 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. 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.
- C. 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.
- D. The asphaltic mixture shall have a minimum temperature of 250°F when delivered to the spreading and finishing machine.
- E. Asphalt shall be spread only when the prepared grade or preceding course is dry.
- F. 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.

- G. The spreading and finishing machine shall spread the mixture and strike it off so that the surface is smooth and true to cross section, free from all hollows and irregularities, and of uniform density throughout.
- H. Initial breakdown rolling of the mixture shall be performed immediately behind the paver. 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. Compact asphalt to not less than 95% of standard laboratory density.
- I. 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.
- J. Rolling shall be systematic to provide complete coverage; minimum of three complete passes. Operate roller with drive wheel forward in direction of paving.

Type of Roller	Range of Roller Speeds (mph)		
	Operating Position		
	Breakdown	Intermediate	Finish
Static Steel Wheel	2 – 3 ½	2 ½ - 4	3 – 5
Pneumatic	2 – 3 ½	2 ½ - 4	4 – 7
Vibratory	2 - 3	2 ½ - 3 ½	--

- K. 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.
- L. 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.

- M. 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.
- N. The intermediate rolling shall follow the breakdown rolling while the asphalt mix is still plastic and at a temperature that will result in maximum density. This rolling shall be performed with a rubber tired pneumatic roller with a tire contact pressure of 80 pounds per square inch. Wheels of the roller shall be arranged to provide equal distribution of weight between wheels. Alternately, a vibratory steel drum roller (described earlier) may be used for the intermediate rolling.
- O. 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 mix shall be rolled until thoroughly compacted to the specified density. The roller shall not be turned on the paving mix.
- P. 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.
- Q. Paving that receives traffic between lifts shall be thoroughly cleaned, flushed and allowed to dry before receiving the next lift.
- R. Whenever the wearing surface does not immediately follow placement of the base course, apply a uniform tack coat of RS-1 emulsified asphalt (0.1 gallons per square yard of paving) between the courses. Allow tack coat to cure before applying asphaltic concrete. Traffic shall be kept off tack coat. Blot excess material before placing asphalt.
- S. 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.
- T. 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.
- U. Hand compact areas inaccessible to rolling equipment.

- A. After all new asphaltic concrete has cured and aged (per the sealer manufacturer's recommended waiting period, thirty (30) day minimum), 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.

3.07 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 (2.778 lb/cu.yd.).
- C. Asphaltic Concrete: Acceptable on the basis of 100 pounds of material being supplied per square yard, per compacted inch of asphalt surfacing (2.778 lb/cu.yd.).
- D. Asphalt Sealant: A minimum total of 0.2 gallons of sealant per square yard of paving surface. All pinholes, voids, and uncoated areas must be sealed to the satisfaction of the Construction Supervisor.

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

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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 02225 - Trenching: Trenching for underground utilities, stormwater drainage, piping and roadway culverts.
- D. 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. Bedding, fill materials, and compaction shall be as specified in Section 02223, Type A or C, 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 be 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. Install Type A or C (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.
- 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.

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	

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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 02225 - Trenching: Trenching for underground utilities, stormwater drainage pipe and roadway culverts.
- D. 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 under the provisions of Section 1B.
- B. Submit 5 copies of shop drawings indicating dimensions, layout of piping, gradient of slope, fabrications, couplings, special sections, and accessories.
- C. Submit 5 copies of product data indicating pipe accessories and materials.
- D. Submit 5 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. Bedding, fill materials, and compaction shall be as specified in Section 02223, Type A or C, unless superseded by the requirements and specifications of the governing authority.

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. Install Type A or C (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.
- 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

4.01 Revisions

- A. 09-01-17: This document was reviewed and no one from ATX, AIC or UEC had any recommended changes.

SUBSTATION DESIGN

STANDARD NO. – 02831

General Requirements for Substation Fence

And Gates



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

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	MKH	CJB 11/17/11	WJH 11/18/11	RQR 11/29/11

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Substation Fence and Gates

1.0 GENERAL REQUIREMENTS

This specification sets forth all general requirements pertaining to chain link fence, Ameristar Impasse fence, and gates to be supplied for Ameren Substation perimeter security. This will include: fence framework, fabric, accessories, gates, removable panels, roll-back sections, and fence post foundations.

1.1 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

2.0 DRAWINGS AND DATA

2.1 The fence shall be constructed in accordance with the appropriate customer drawings.

3.0 Materials and Requirements

Substation perimeter security fencing and gates can be constructed from one of two choices: Chain Link, Section 3.1 and Ameristar Impasse, Section 3.2.

3.1 Chain Link

3.1.1 Chain Link Fabric: In accordance with ASTM Standard A491, latest revision; 7'-0" high, made of No. 9 gauge steel wire, woven in a 1" mesh and coated with a Class II aluminum coating of 0.4 oz/sf. Top and bottom selvages shall have a twisted and barbed finish.

3.1.2 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™. The privacy slats which are pre-inserted at the time of manufacture shall be double wall, self-locking (without staples), and wide to provide a tight fit in the fence fabric. The slats shall be manufactured from virgin, high density polyethylene. Color shall be as specified by customer.

3.1.3 Chain Link Fence Installation: The fence shall follow the earth grade unless otherwise specified. It shall be neat, plumb, aligned true, stretched taut, and free from sags and bellies. Sufficient terminal posts must be provided to insure that bottom closure shall be within one inch of the earth grade surface elevation.

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

3.1.5 Tension Bar: The tension bar for fabric to SS-40/WT-40 pipe and gate posts shall be a minimum 1/4" dia. galvanized steel bar and shall conform with ASTM A153. (Heavy gauge wire is not acceptable.)

3.1.6 Posts: Posts shall be made of Allied SS-40 or Wheatland WT-40 pipe, sized as follows:

SS-40 or WT-40

Line Posts.....	2.375" OD (3.12 lb/ft)
Terminal (end/corner/pull) Posts.....	4.00" OD (6.57 lb/ft)
Gate Posts, for openings	
(a) Single to 6' or double to 12' include.....	4.00" OD (6.57 lb/ft)
(b) Single over 6' to 13' 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"

3.1.7 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™ chain link fabric.

3.1.8 Gates: Gates shall be constructed of SS-40/WT-40 1.875" O.D. pipe (2.28 lb/ft), top of gate shall be 8' above earth grade and match top of fence barbed wire and top fence fabric with 8" of space below gate to allow installation of 6" of crushed rock, (as shown in Exhibit 1 sheets 3 and 4).

3.1.9 Gate Hardware: As Follows:

For man gates: Latch – gate, with 2" O.D. collar for gate frame and fork for 4" O.D. gate post. Pioneer Latch Model No. 2509 as manufactured by Merchants Metals, Minneapolis, MN.

For drive gates: Latch – drive gate for 2" O.D. gate frames. Pioneer Latch Model No. 2507 as manufactured by Merchant Metals, Minneapolis, MN.

3.1.10 Removable Panels: Removable panels shall be of standard construction, framed with SS-40/WT-40 1.625" OD (1.84 lb/ft).

- 3.1.11 Braces: Braces shall be made of SS-40/WT-40 1.625" OD (1.84 lb/ft). Braces shall be installed between each terminal and gate posts and the first adjacent post, midway between the top rail and the ground. All braces shall use two 5/16" galvanized steel truss rods complete with truss tightener that shall conform to ASTM F626 with one installed from the bottom of all gate posts and terminal posts to the center of the adjacent line posts and the second installed from the middle of all gate posts and terminal posts to the top of the adjacent line posts.
- 3.1.12 Top Rails: The top rail shall be made of SS-40/WT-40 1.625" OD (1.84 lb/ft), provided with couplings approximately every 20 feet that shall conform to ASTM F626. Couplings shall be outside sleeve type and at least 7" long. One coupling in every five shall have a heavy spring to take up expansion and contraction of the top rail. The rail shall pass through the base of line post tops and form a continuous brace from end to end of each stretch of fence. The top rail shall be securely fastened to terminal posts by means of malleable iron or pressed steel clamps.
- 3.1.13 Barbed Wire: Barbed wire shall be Copperweld Steel Co. "Alumoweld" Four Point Type Light Weight (two 0.080" diameter strands). If Alumoweld barbed wire is not available, two 12.5 gauge strands, with an aluminum coating equal to that specified per the fence fabric may be substituted and shall conform to ASTM F626.
- 3.1.14 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.
- 3.1.15 Galvanizing and Steel Pipe: Galvanized steel pipe for posts, gates, top rail and removable panels shall be in accordance with ASTM standard A53, latest revision. No used, re-rolled, or open seam material will be permitted. Other fittings, hardware, and gate hardware shall be galvanized according to ASTM Standard A153, latest revision.
- 3.1.16 Bottom Tension Wire: The bottom tension wire should be No. 7 gauge aluminum coated spring coil or crimped wire and conform to ASTM A491. Minimum weight of coating shall be 0.40 oz/sf of wire surface. Tension wire shall be stretched taut from terminal to terminal post and evenly fastened to each intermediate post 6 inches above the grade line. Tension wire shall be attached to the fence fabric with steel hog rings (aluminum hog rings are not permitted) every 24 inches.
- 3.1.17 Painting: When required fence shall be painted using the following process:
- 3.1.17.1 The fence fabric, posts, gates, and hardware shall be cleaned with PORTERPREP™ Heavy Duty Cleaner per the manufacturer's recommendations and then power washed with clean water.
- 3.1.17.2 The fence fabric, posts, gates, and hardware shall then be sprayed with Henkel METALPREP® 79 per the manufacturer's recommendations.
- 3.1.17.3 The fence fabric, posts, gates, and hardware shall be painted with PORTER GUARD® DTM Acrylic Primer/Finish per the manufacturer's recommendations.

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

3.2 Ameristar Impasse Fence

3.2.1 The Ameristar fence shall be the Impasse Gauntlet 3 Rail Fence, 8 foot tall and manufactured per the following Ameristar Drawings:

Exhibit 2 Sheet 1: 3PX3120-SP-ST, Rev. a – Impasse I-Beam Post

Exhibit 2 Sheet 2: 3GX30948, Rev. a – Impasse Gauntlet 3 Rail 96" Tall X 8' panel

Exhibit 2 Sheet 3: 33-100-0084, Rev. a – Impasse Gauntlet 3 Rail 96" Tall X 6' panel

Exhibit 2 Sheet 4: [3GX3096-60-SP00P, Rev. a - Impasse 3 Rail Gauntlet 8' Tall, 5' Opening Single Gate](#).

Exhibit 2 Sheet 5: [3GX3096-60-Panel, Rev. a - Impasse 3 Rail Gauntlet 8' Tall, 60" Gate Leaf](#)

Exhibit 2 Sheet 6: 3GX3096-112-DP00P, Rev. a - Impasse 3 Rail Gauntlet 8' Tall, 18' Opening Double Gate

Exhibit 2 Sheet 7: 3GX3096-112-LEFT-Panel, Rev. a - Impasse 3 Rail Gauntlet 95 1/2" Tall Left Gate Leaf

Exhibit 2 Sheet 8: 3GX3096-112-RIGHT-Panel, Rev. a - Impasse 3 Rail Gauntlet 95 1/2" Tall Right Gate Leaf

Exhibit 2 Sheet 9: 6-6-SP, Rev. a – 6" Square gate post

Exhibit 2 Sheet 10: 3-3-SP, Rev. a – 3" Square gate post

3.2.2 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.

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

3.2.4 Gate Hardware: As Follows:

For man gates: Latch – Ameristar DSB300

For drive gates: Latch – Ameristar DDB200

3.3 Support Footings

3.3.1 Chain Link Footings: Post shall be set in the center of concrete footings and extend 34" below the finished earth grade. Footings shall be set 1" above and extend 36" below the finished earth grade. The top of the footing shall be sloped away from the post to drain moisture. In most instances, fence posts are installed before yard rock is placed. The installer shall make sure that the concrete footing extends one inch above earth subgrade but a minimum of 4 inches below finished rock surface after the rock is placed.

3.3.2 Chain Link Footing Size: Footings shall be 10" or greater in diameter for Line Post and 15" or greater for Terminal and Gate Posts.

- 3.3.3 Ameristar Impasse Footings: Post shall be set in the center of concrete footings and extend 36" below the finished earth grade. Footings shall be set 1" above, extend 48" below the finished earth grade for Line Posts, and extend 54" below the finished earth grade for Gate Posts. 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.
- 3.3.4 Ameristar Impasse Footing Size: Footing shall be 18" in diameter for Line Post and 24" for Gate Posts.
- 3.3.5 Footing Concrete: Unreinforced concrete with a minimum compressive strength of 4,000 psi at 28 days. See Ameren Standard No. 03001 for concrete mix requirements.
- 3.4 Fence Gaps: Any gaps in fencing at gates or termination of fence at control house, switchgear, other equipment, or non conductive fencing shall be no more than 4" and must be uniform.
- 3.5 Gate Spacing:
- The space between the double leaf drive gates when in the closed position shall not be less than 2 inches, nor greater than 4 inches.
- The space between the man gate and the fence post when in the closed position shall not be less than 2 inches, nor greater than 4 inches.
- The space below all gates to the top of rock when in the closed position shall not be less than 2 inches, nor greater than 4 inches.
- 3.6 Gate Catches: All double gates shall be provided with semi-automatic outer catches to secure gate in the open position.
- 3.7 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 or in the immediate vicinity 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.
- 3.8 Reference Drawings: Attached for reference are typical details
- 3.8.1 Chain Link Line Post Section: See Exhibit 1 Sheet 1
- 3.8.2 Chain Link Corner Section: See Exhibit 1 Sheet 2
- 3.8.3 Chain Link Man Gate Section: See Exhibit 1 Sheet 3

- 3.8.4 Chain Link Drive Gate Section: See Exhibit 1 Sheet 4
- 3.8.5 Impasse I-Beam Post: Exhibit 2 Sheet 1
- 3.8.6 Impasse Gauntlet 3 Rail 96" Tall X 8' Panel: Exhibit 2 Sheet 2
- 3.8.7 Impasse Gauntlet 3 Rail 96" Tall X 6' Panel: Exhibit 2 Sheet 3
- 3.8.8 Impasse 3 Rail Gauntlet 8' Tall, 5' Opening Single Gate: Exhibit 2 Sheet 4
- 3.8.9 Impasse 3 Rail Gauntlet 8' Tall, 60" Gate Leaf: Exhibit 2 Sheet 5
- 3.8.10 Impasse 3 Rail Gauntlet 8' Tall, 18' Opening Double Gate: Exhibit 2 Sheet 6
- 3.8.11 Impasse 3 Rail Gauntlet 95 1/2" Tall Left Gate Leaf: Exhibit 2 Sheet 7
- 3.8.12 Impasse 3 Rail Gauntlet 95 1/2" Tall Right Gate Leaf: Exhibit 2 Sheet 8
- 3.8.13 6" Square Gate Post: Exhibit 2 Sheet 9
- 3.8.14 3" Square Gate Post: Exhibit 2 Sheet 10
- 3.8.15 Typical Ameristar Post Foundations: Exhibit 2 Sheet 11

REVISIONS

Last revisions on each sheet are shown by vertical lines in the right-hand margin.

8/8/05 Original Issue

JWL 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.

6/13/06 Minor Revisions

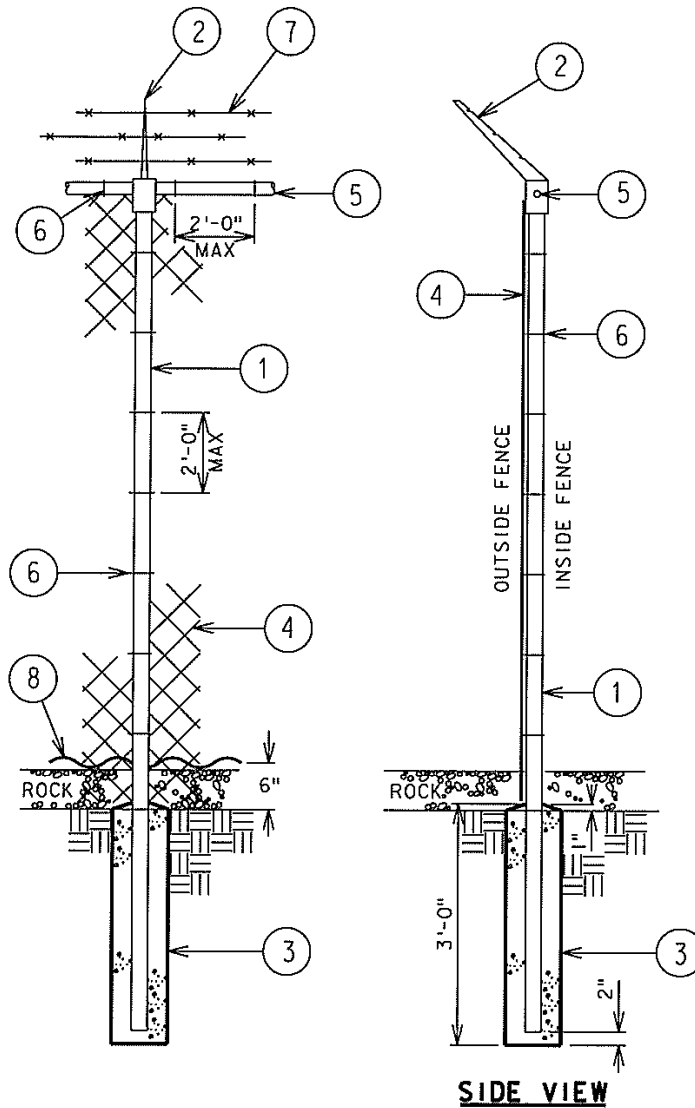
JWL Disallowed heavy gauge wire for tension bar use. Increased Terminal (end/corner/pull) Posts and Smaller Gate opening posts to 4" O.D. to match sizes provided by manufactures. Revised top of gate and top of fence lines to align in section 3.5. Revised bracing for terminal and gate posts in section 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.

CHAIN LINK FENCING DETAIL DRAWINGS
TRANSMISSION AND DISTRIBUTION DESIGN
SUBSTATION DESIGN STANDARDS



ITEM	DESCRIPTION
1.	LINE POST
2.	EXTENSION ARMS
3.	4000 psi CONCRETE
4.	84" FENCE FABRIC
5.	TOP RAIL
6.	FABRIC TIES
7.	BARBED WIRE
8.	TENSION WIRE

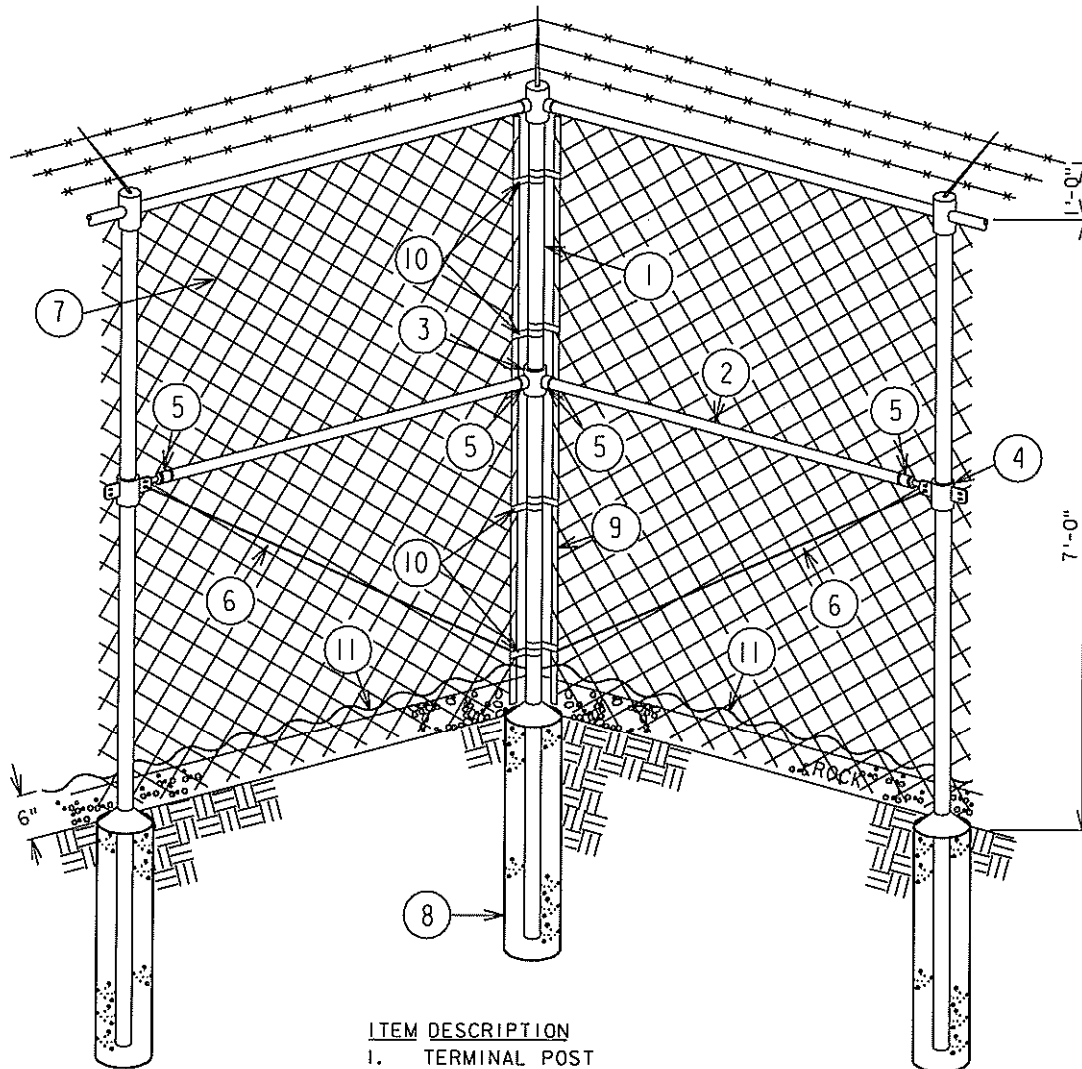
NOTES:

1. CHAIN LINK FABRIC BOTTOM TO BE FLUSH WITH TOP OF CURB IN LOCATIONS OF FENCING ON CURB

TYPICAL LINE POST SECTION

EXHIBIT 1

Sheet 2
Date: 08/17/11



ITEM DESCRIPTION

1. TERMINAL POST
2. BRACE RAIL
3. RAIL BAND
4. BRACE RAIL BAND w/2 ATTACHMENTS
5. SOCKET FITTING
6. TRUSS ROD w/TRUSS TIGHTENER
7. 84" FABRIC (AS REQUIRED)
8. 4000psi CONCRETE (AS REQUIRED)
9. TENSION BAR
10. BAND, TENSION BAR
11. TENSION WIRE

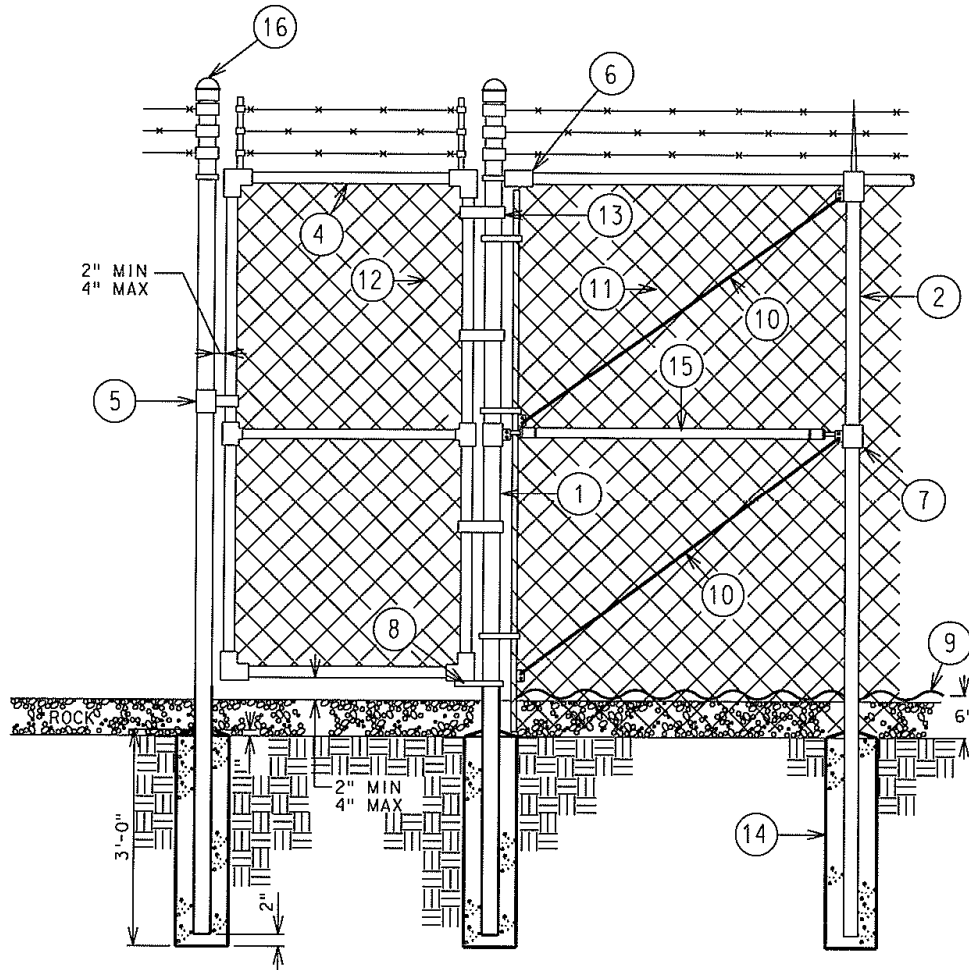
NOTES:

- I. CHAIN LINK FABRIC BOTTOM TO BE FLUSH WITH TOP OF CURB IN LOCATIONS OF FENCING ON CURB

TYPICAL CORNER SECTION

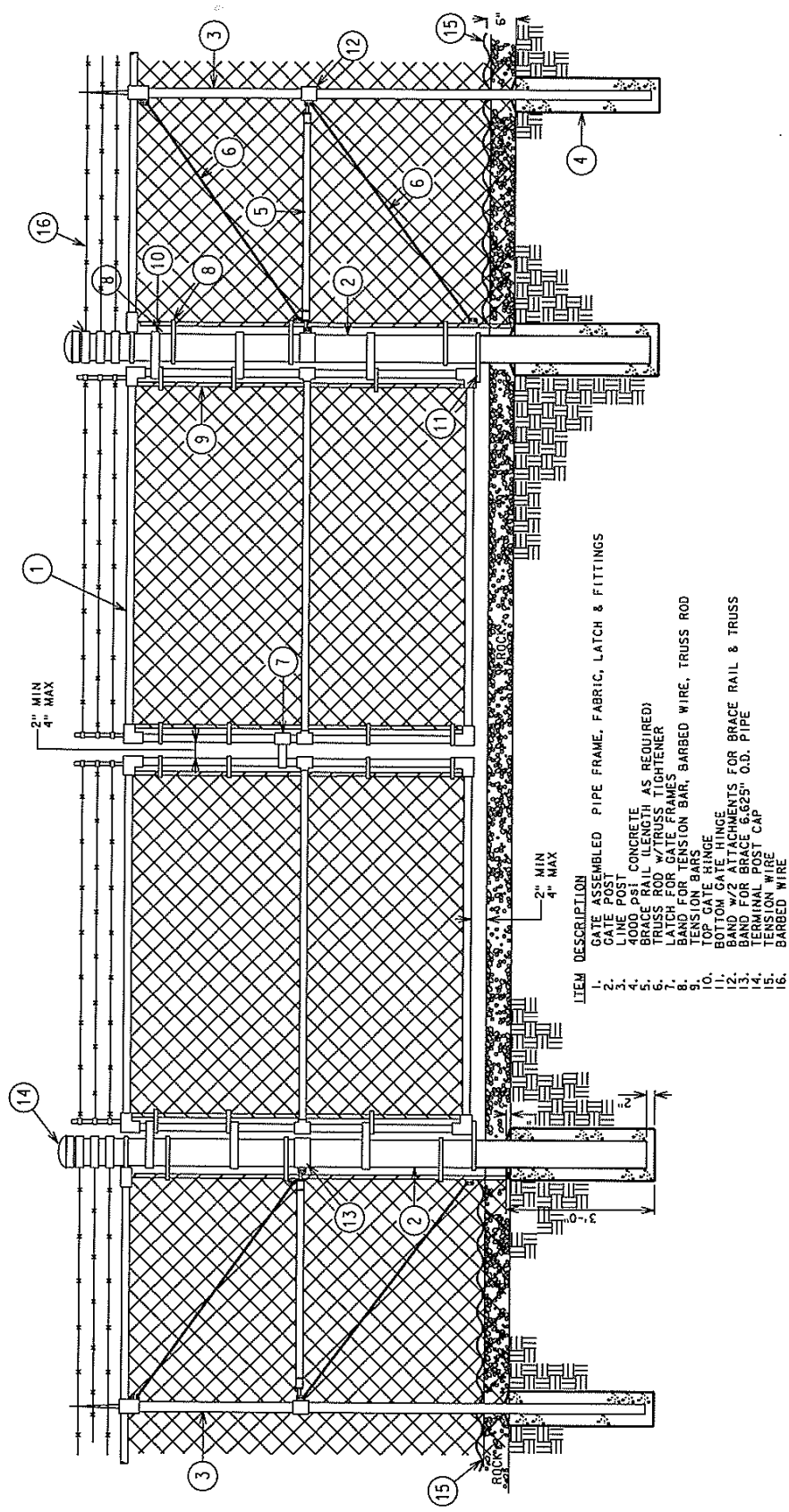
EXHIBIT 1

Sheet 3
Date: 08/17/11



ITEM	DESCRIPTION
1.	TERMINAL GATE POST
2.	LINE POST
4.	GATE FRAME (AS REQUIRED)
5.	MAN GATE LATCH
6.	BRACE RAIL (LENGTH AS REQUIRED)
7.	BAND FOR RAIL
8.	BAND W/2 ATTACHMENTS FOR BRACE RAIL AND TRUSS
9.	BOTTOM GATE HINGE
10.	TENSION WIRE
11.	TRUSS ROD W/TRUSS TIGHTENER
12.	120" FENCE FABRIC (AS REQUIRED)
13.	FENCE FABRIC (AS REQUIRED) (HEIGHT VARIES)
14.	TOP GATE HINGE
15.	4000 psi. CONCRETE
16.	BRACE RAIL (LENGTH AS REQUIRED)
17.	POST CAP

TYPICAL MAN GATE SECTION



TYPICAL DRIVE GATE SECTION

AMERISTAR IMPASSE FENCING DETAIL DRAWINGS
TRANSMISSION AND DISTRIBUTION DESIGN
SUBSTATION DESIGN STANDARDS

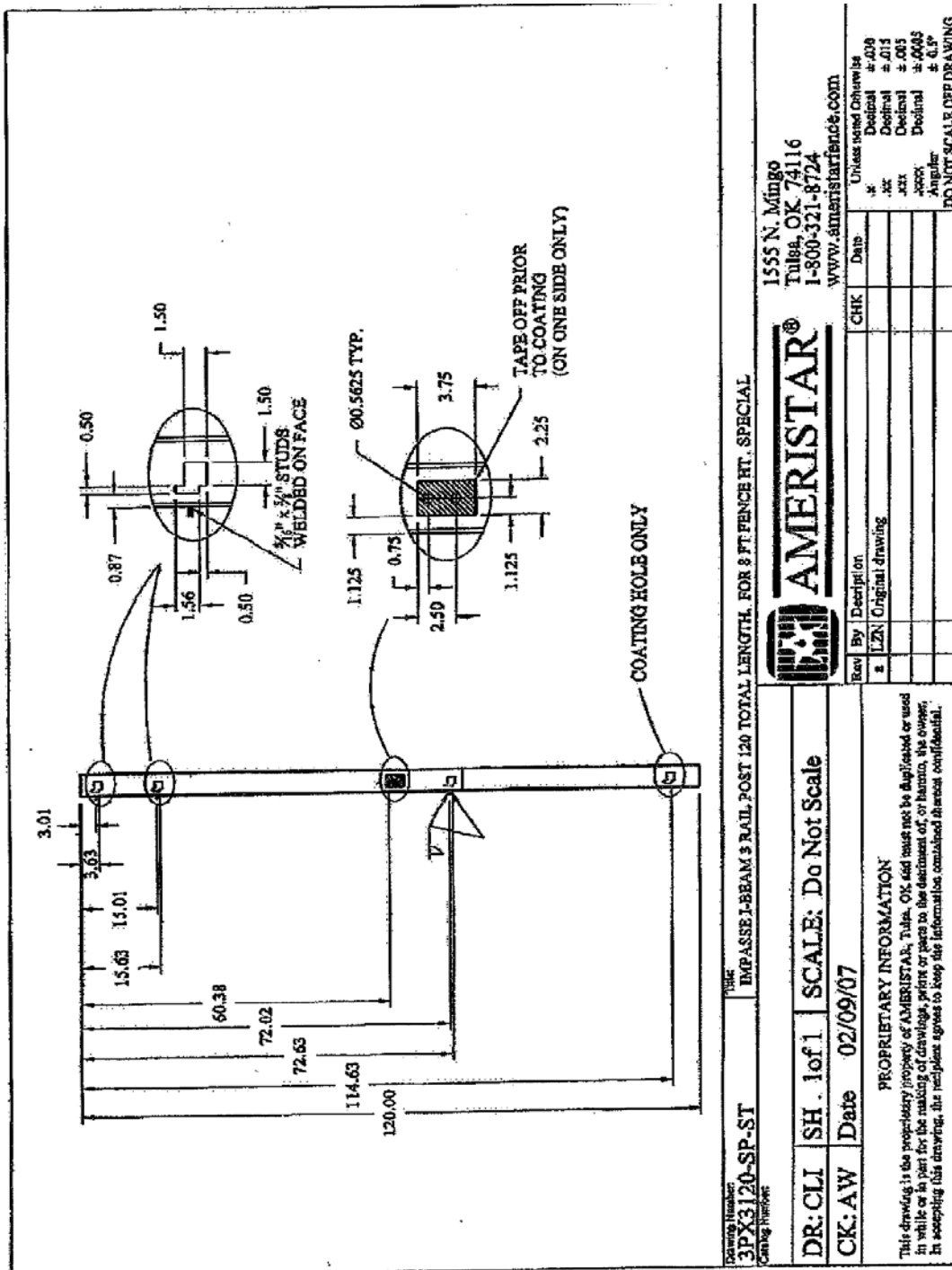
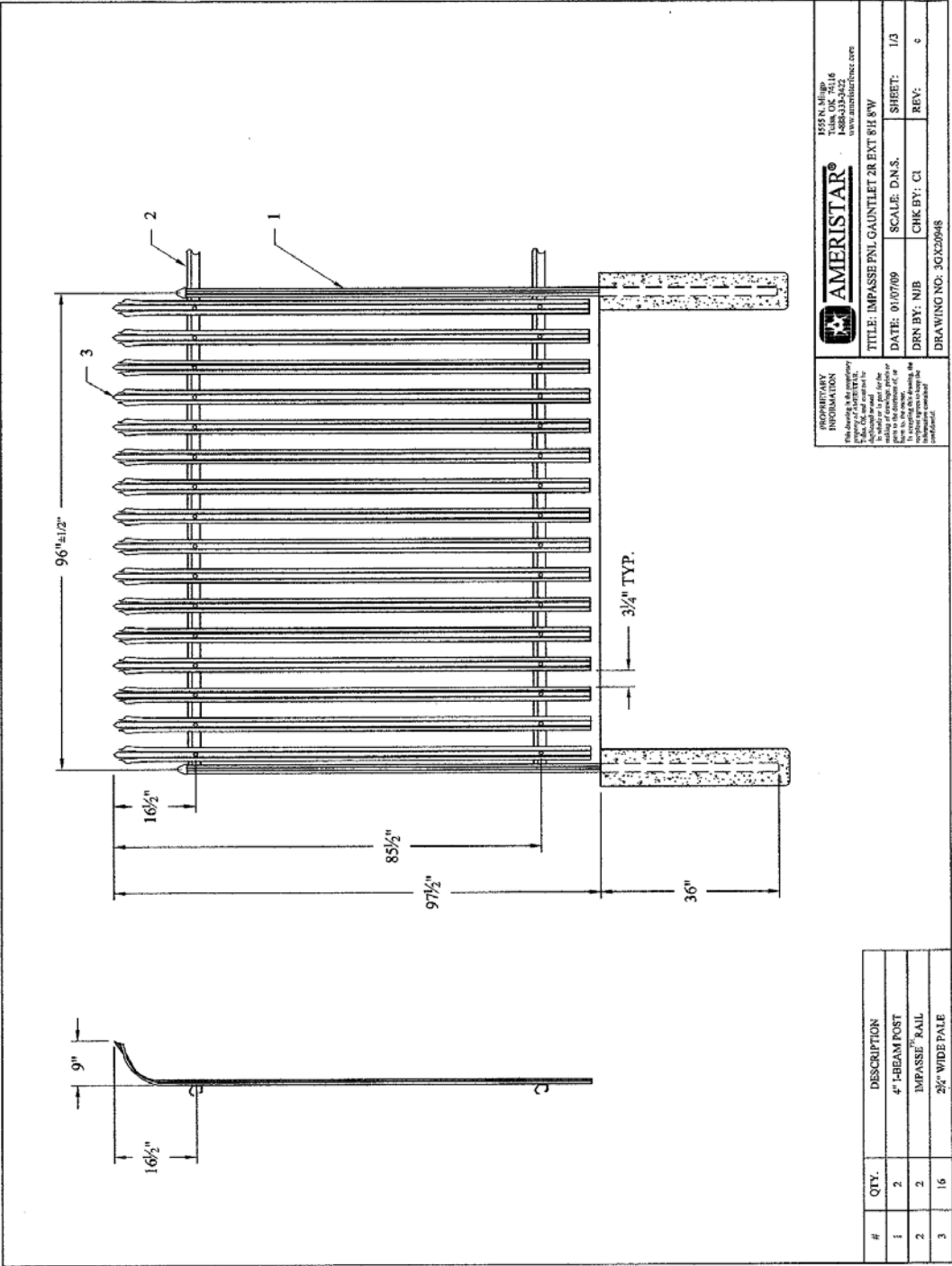
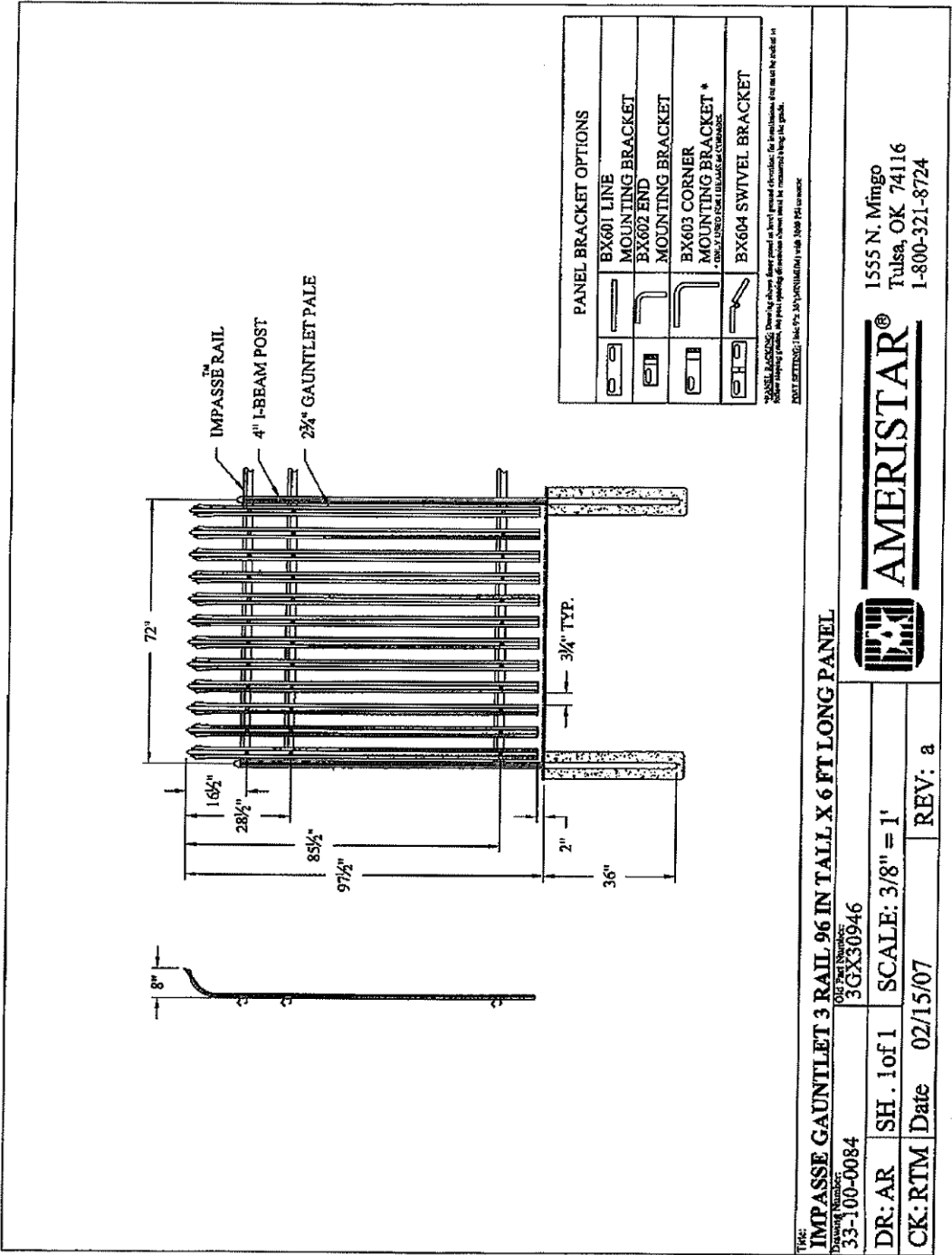
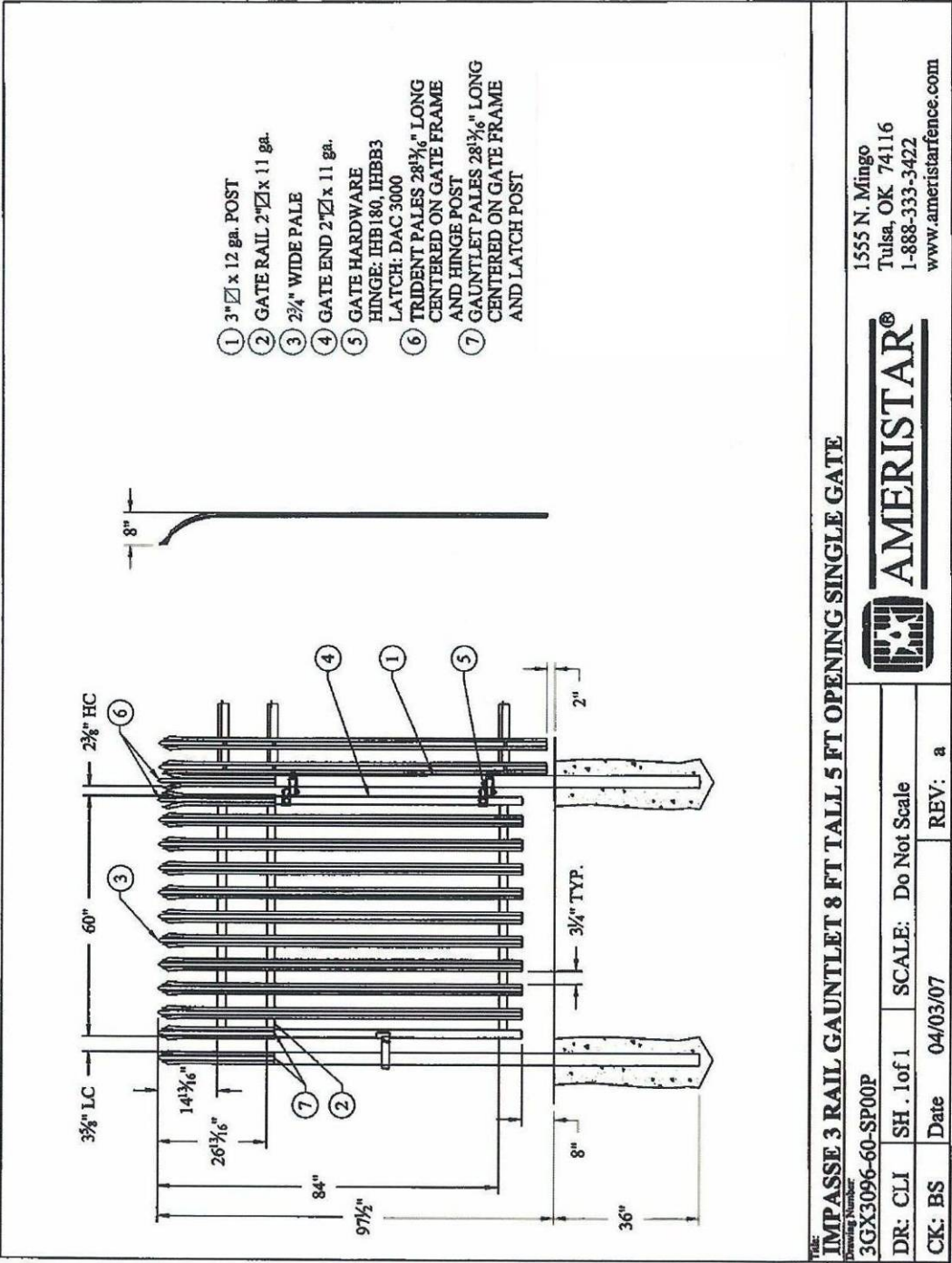


EXHIBIT 2







IMPASSE 3 RAIL GAUNTLET 8 FT TALL 5 FT OPENING SINGLE GATE

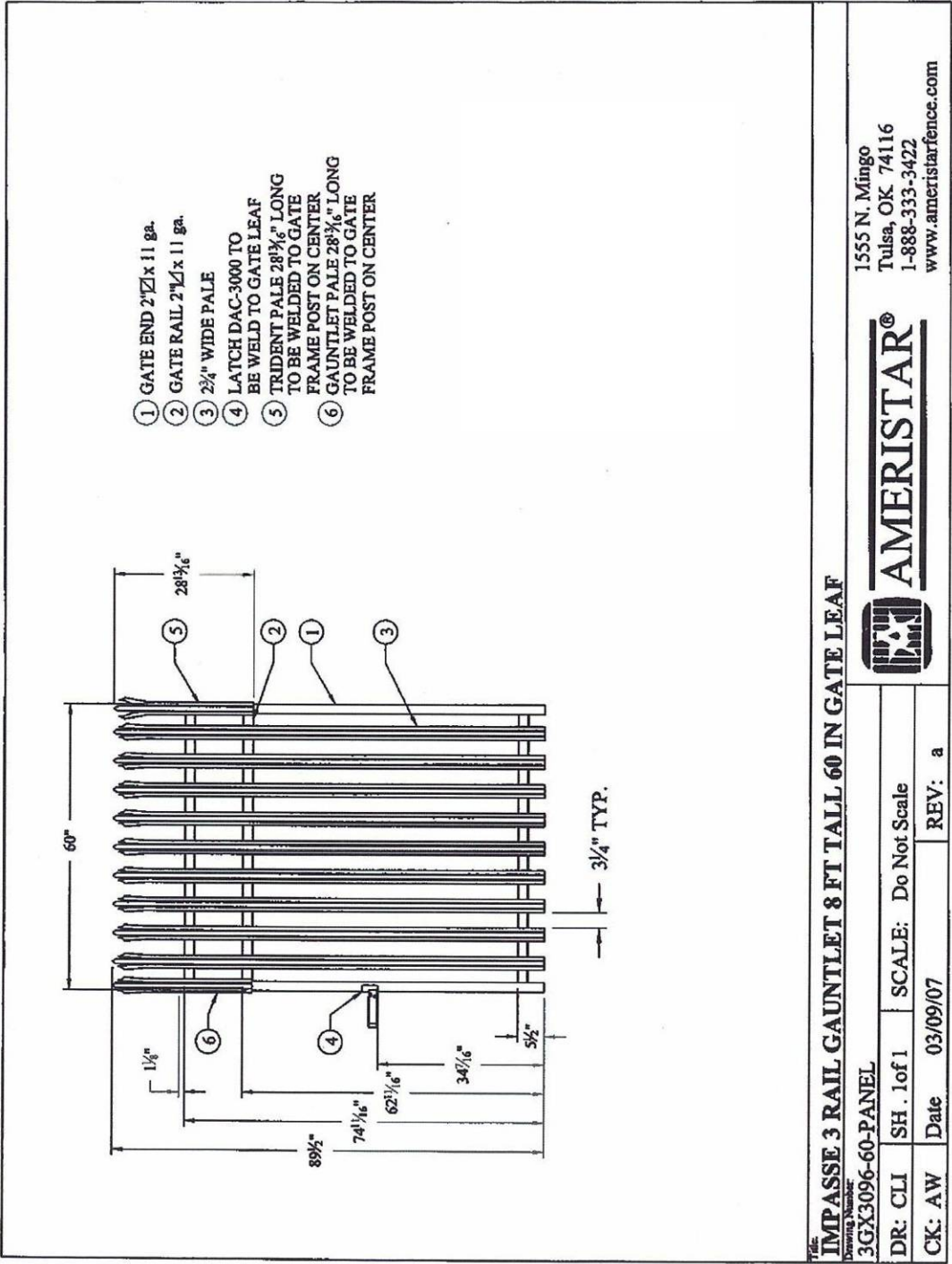
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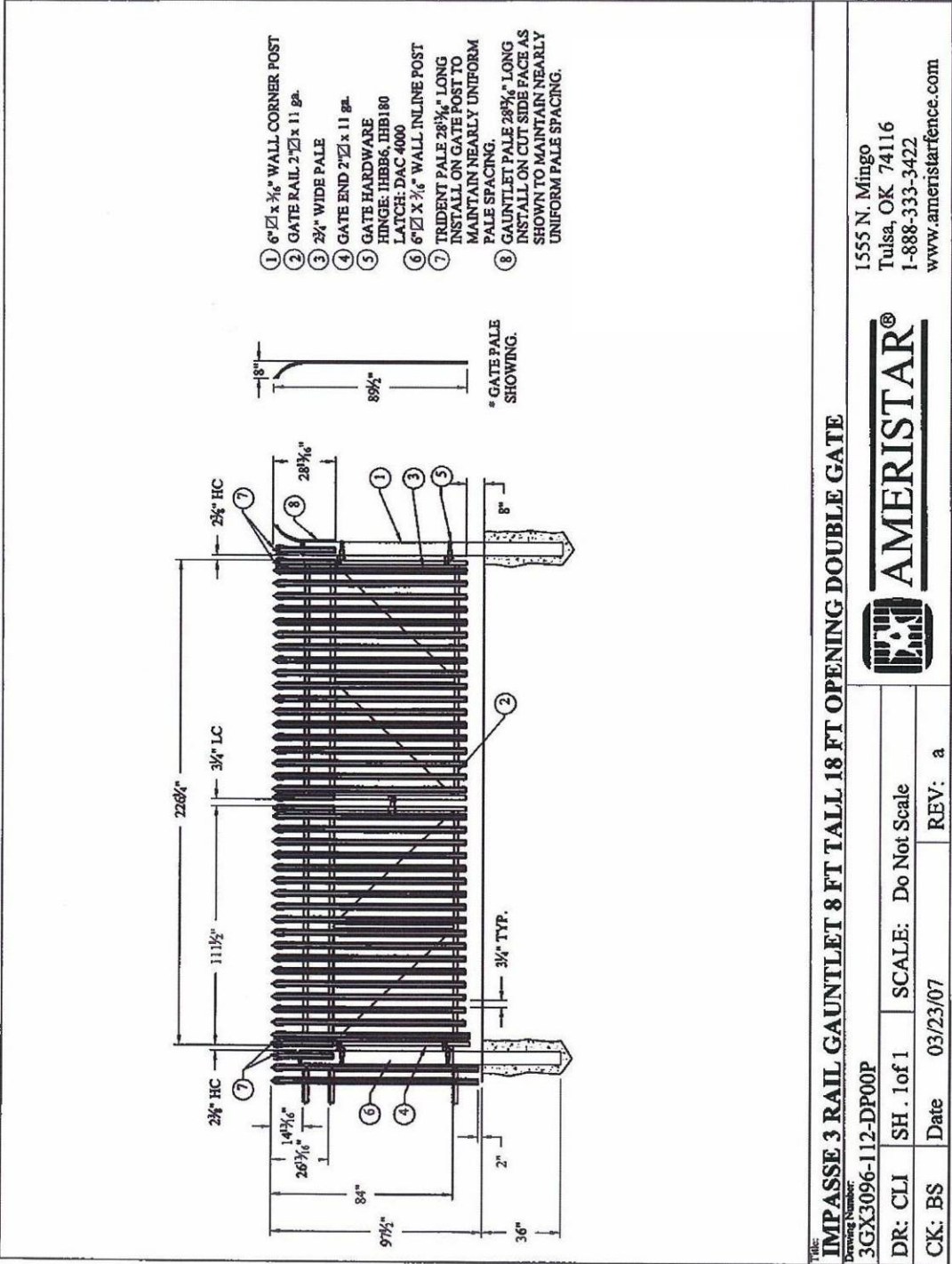
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CK: BS Date 04/03/07 REV: a

1555 N. Mingo
Tulsa, OK 74116
1-888-333-3422
www.ameristarforce.com



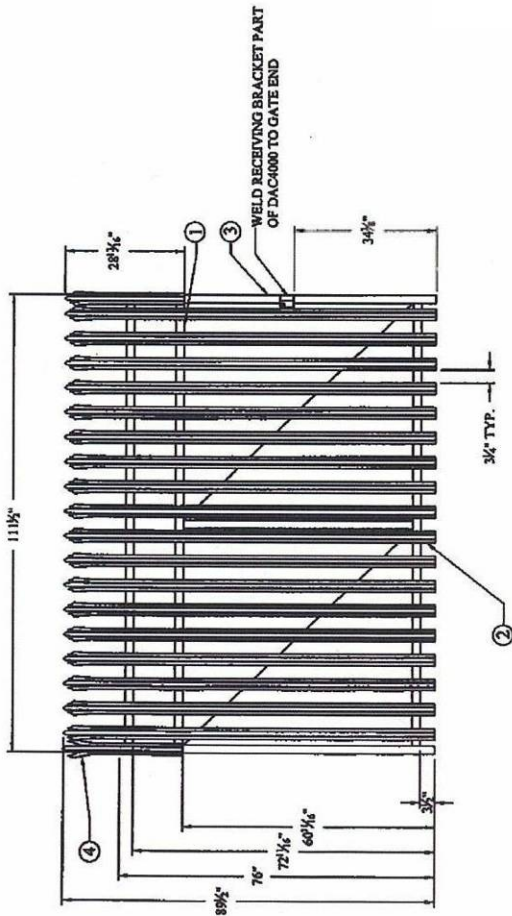




IMPASSE 3 RAIL GAUNTLET 8 FT TALL 18 FT OPENING DOUBLE GATE

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CK: BS	Date 03/23/07	REV: a	
1555 N. Mingo Tulsa, OK 74116 1-888-333-3422 www.ameristarfence.com			





- ① GATE RAIL 2"x11 ga.
- ② 2 3/4" WIDE PALE
- ③ GATE END 2"x11 ga.
- ④ TRIDENT PALE 28 3/8" LONG CENTERED ON GATE FRAME

WELD RECEIVING BRACKET PART OF DAC4000 TO GATE END

IMPASSE 3 RAIL GAUNTLET 95 1/2" TALL LEFT GATE PANEL

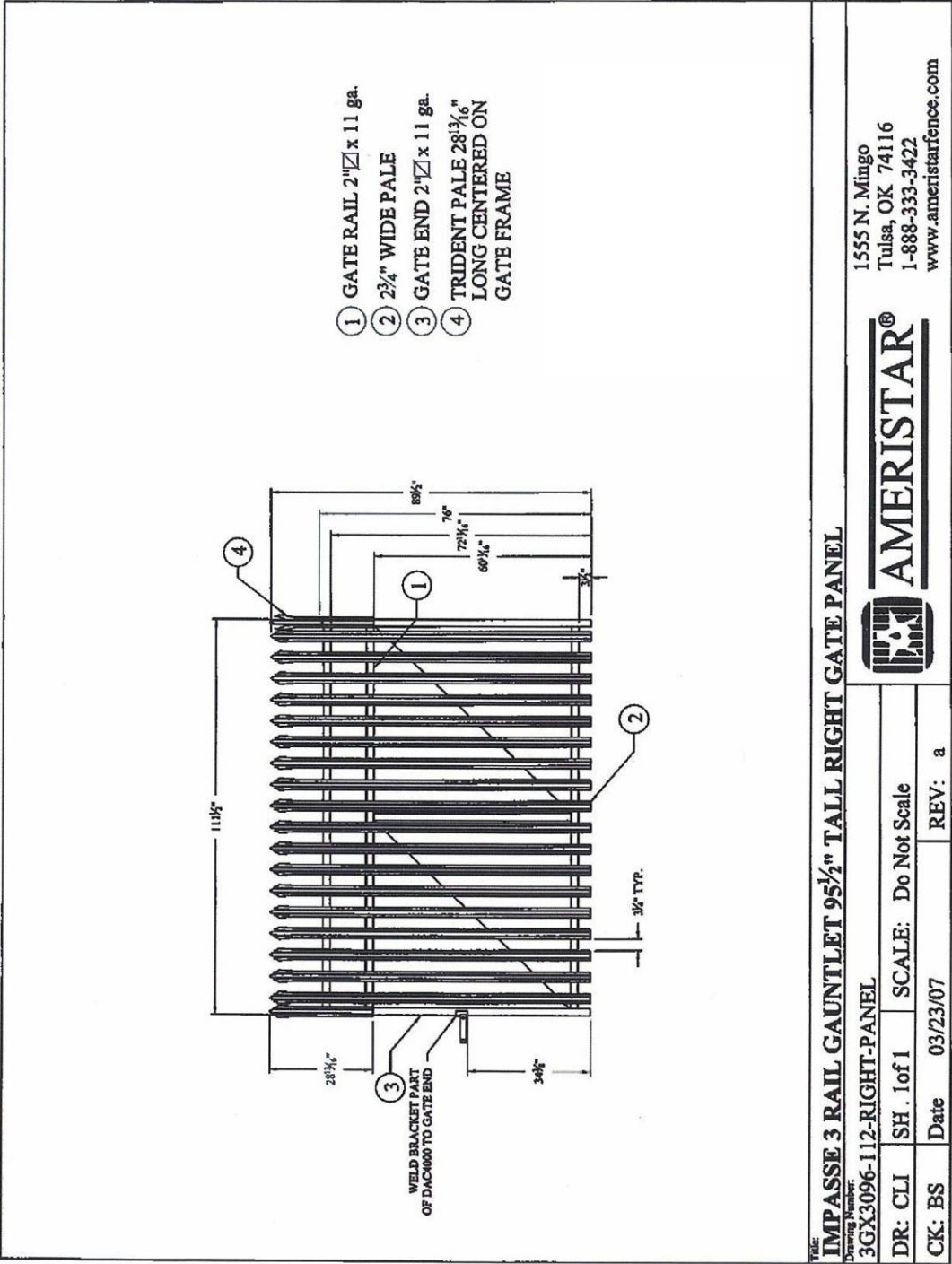
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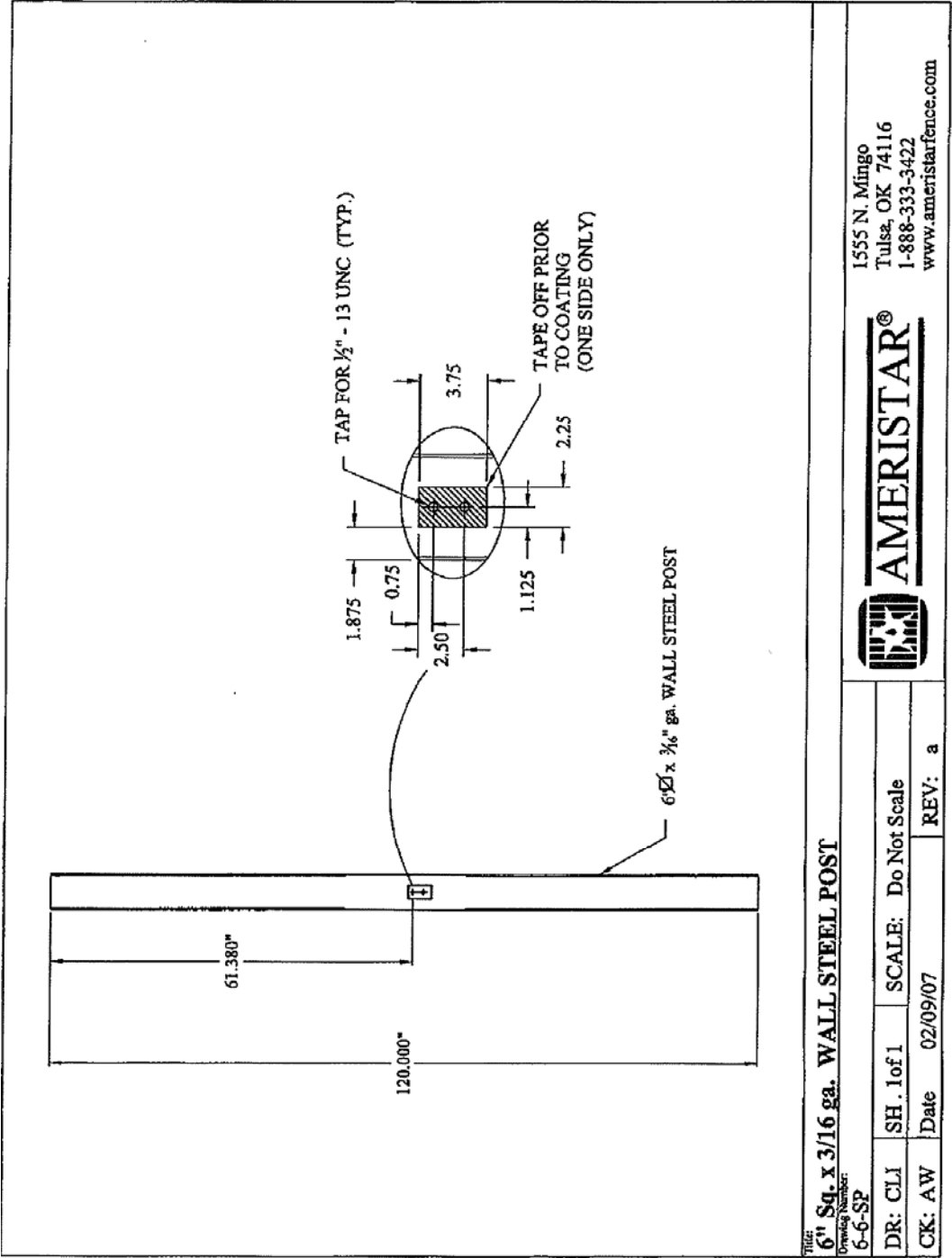
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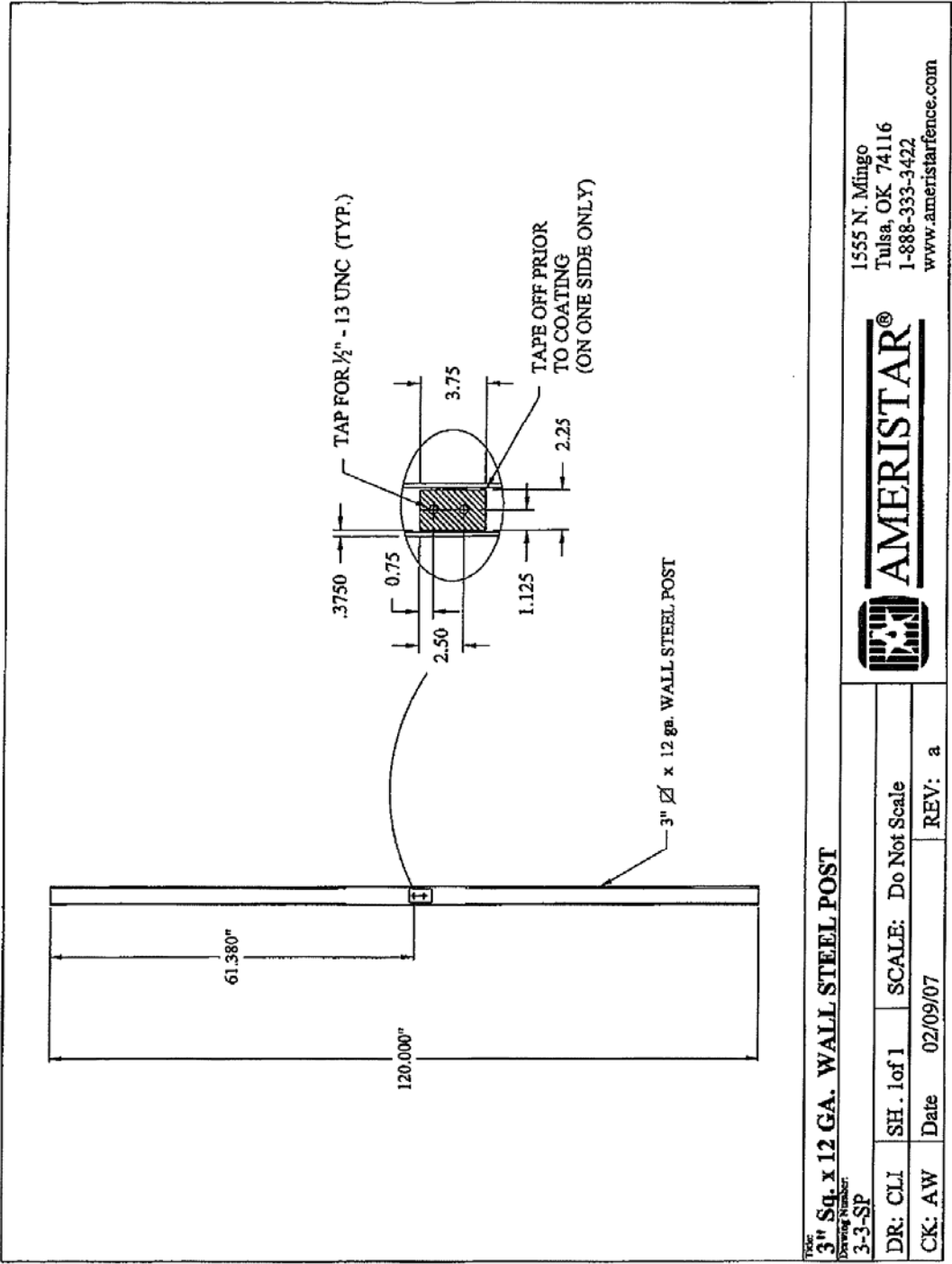
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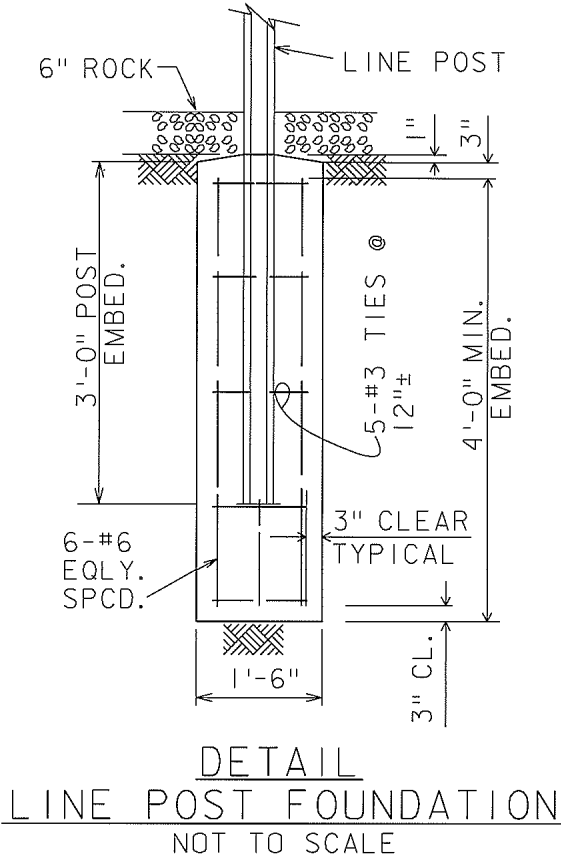
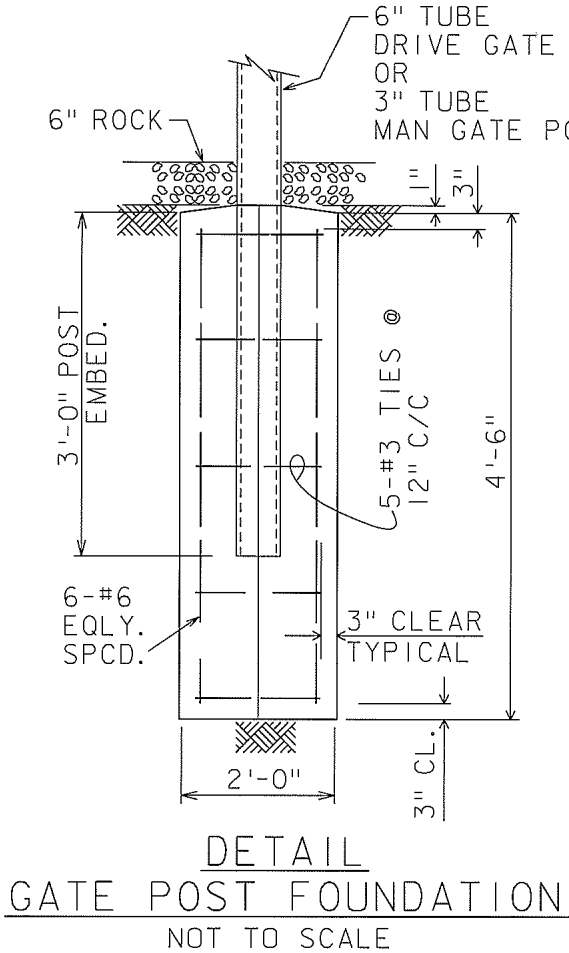
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TYPICAL AMERISTAR POST FOUNDATIONS

SUBSTATION DESIGN

STANDARD NO. – 02936

General Requirements for SEEDING



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

Rev. No	Date	Revisions	By	Approvals		
0	12-19-05	Initial Issue	BLC	WJH	JLH	PJN

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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. 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. 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. Water Saver with 40% RTF 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: Arn-Tak, as manufactured by American Excelsior or approved equal. Emulsion designed to retain moisture and heat in the soil. Mulch shall be chemically inert, 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: 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.
- B. Beginning of installation means acceptance of existing site conditions.

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 HAND OR MECHANICAL SEEDING (ALTERNATE METHOD)

- A. Apply seed evenly in two intersecting directions at a minimum total rate of 8 lbs per 1000 sq ft. 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 area are to be mulched using peat most at a thickness of not more than ¼ 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 to 4 inches of soil.

3.05 SEED PROTECTION

- A. Cover seeded slopes (Not Hydroseeded) with erosion protection fabric wherever grade is 4 inches (vertical) per foot (horizontal) (1:3) or greater. All swale bottoms shall be covered with erosion protection fabric regardless of seeding method. Roll fabric onto slopes without stretching or pulling.
- B. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Provide 12 inch overlap of adjacent rolls. Backfill trench and rake smooth, level with adjacent soil.
- C. Secure outside edges and overlaps at 36 inch intervals with stakes.
- D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

- E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges a minimum of 6 inches.

3.06 MAINTENANCE

- A. Maintain and water seeded areas as requested. Reimbursement will be in accordance with the contract documents. The original watering of the seeded areas shall be part of the work covered by the Contractors lump sum bid.
- 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.

SUBSTATION DESIGN

STANDARD NO. 03001

GENERAL REQUIREMENTS FOR CONCRETE



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

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	-

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SUBSTATION DESIGN STANDARD NO. 03001
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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
- Section 02222 – Excavation
 - Section 02223 – Backfilling
 - Section 02371 – Cast-In-Place Concrete Piers
 - Section 02831 – Chain Link Fence and Gates
 - 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.
- ACI 207.1R – Guide to Mass Concrete
 - ACI 211.4R – Guide for Selecting Proportions for High-Strength Concrete Using Portland Cement and Other Cementitious Materials
 - ACI 301 – Specifications for Structural Concrete for Buildings
 - ACI 305 – Hot Weather Concreting
 - ACI 306 – Cold Weather Concreting
 - ACI 308 – Standard Practice for Curing
 - ACI 309 – Guide for Consolidation of Concrete
 - ACI 318 – Building Code Requirements for Structural Concrete
 - ACI 336.1 – Specification for the Construction of Drilled Piers
 - ACI 347 – Guide to Formwork for Concrete
 - IBC – International Building Code
 - ASTM C31 – Making and Curing Test Specimens in the Field
 - ASTM C33 – Concrete Aggregates
 - ASTM C39 – Compressive Strength of Cylindrical Concrete Specimens
 - ASTM C42 – Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
 - ASTM C94 – Ready-Mixed Concrete

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- ASTM C138 – Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
- ASTM C143 – Slump of Hydraulic Cement Concrete
- ASTM C150 – Portland Cement
- ASTM C172 – Sampling Freshly Mixed Concrete
- ASTM C173 – Air Content of Freshly Mixed Concrete by the Volumetric Method
- ASTM A185 – Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
- ASTM C231 – Air Content of Freshly Mixed Concrete by the Pressure Method
- ASTM C260 – Air Entraining Admixtures for Concrete
- ASTM C309 – Liquid Membrane-Forming Compounds for Curing Concrete
- ASTM C470 – Molds for Forming Concrete Test Cylinders Vertically
- ASTM C494 – Chemical Admixtures for Concrete
- ASTM C511 – Moist Cabinets, Moist Rooms, & Water Storage Tanks for Testing Concrete
- ASTM C595 – Blended Hydraulic Cements
- ASTM A615 – Deformed and Plain Billet-Steel Bars for Concrete
- ASTM C618 – Coal Fly Ash and Raw of Calcined Natural Pozzolan for Use in Concrete
- ASTM C989 – Slag Cement for Use in Concrete and Mortars
- ASTM C1017 – Chemical Admixtures for Use in Producing Flowing Concrete
- ASTM C1064 – Temperature of Freshly Mixed Hydraulic Cement Concrete
- ASTM C1240 – Silica Fume Used in Cementitious Mixtures

1.05 Definitions

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

1.06 Submittals

1.06.01 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.

1.06.02 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.

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1.06.03 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

1.06.04 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

1.07.01 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

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- 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.

1.07.02 Time Limits

Concrete without cure-delaying admixture(s) must be delivered to the job site and completely discharged within 90 minutes from time loaded or first mixing of cement as recorded on batch ticket. Concrete supplier shall note on mix design if discharge time should be < 90 minutes. Concrete deliveries to the same site shall be spaced ≤ 90 minutes apart. The 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 shall be required in order to receive Engineer approval. The suggested time limit extension and admixture dosage provided by the concrete supplier shall be included with the mix design for approval. **Field addition of cure-delaying admixtures is not permitted.**

1.07.03 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.

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

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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.

1.07.03.01 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.

1.07.03.02 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.

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- 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.

1.07.03.03 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

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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 $\frac{1}{4}$ ". 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.

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- 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 $< 0.75f'_c$.

1.07.03.04 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.)

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- 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.)

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Part 2 – Materials

2.01 Reinforcing Steel

- 2.01.01 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.
- 2.01.02 Welded wire fabric shall be plain wire in flat sheets with an uncoated finish and in accordance with ASTM A185.

2.02 Concrete Materials

- 2.02.01 Cement – Portland Cement Type I or Type II, in accordance with ASTM C150.

- 2.02.02 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

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2.02.03 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

2.02.04 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.

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

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

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

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

2.02.09 Calcium Chloride – SHALL NOT BE USED

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

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2.03 Concrete Mix

- 2.03.01 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.
- 2.03.02 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.
- 2.03.03 Nominal maximum size of aggregate shall not exceed $\frac{3}{4}$ ".
- 2.03.04 Air content shall be 6.50% with a tolerance of $\pm 1.50\%$.
- 2.03.05 Slump for drilled piers shall be 5 to 9 inches. Slump for all other applications shall be 3 to 6 inches.
- 2.03.06 Any slump over 6 inches shall be achieved using admixtures, not water.
- 2.03.07 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.
- 2.03.08 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.

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2.05 Concrete Curing

- 2.05.01 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.
- 2.05.02 Curing material shall be placed immediately after concrete finishing.
- 2.05.03 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.
- 2.05.04 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

- 2.06.01 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.
- 2.06.02 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

- 3.01.01 Prior to erection of forms, verify that structure of interest complies with the Project Drawings.
- 3.01.02 After formwork erection, verify location, lines, levelness or plumbness, and all structure dimensions before proceeding with concrete placement.
- 3.01.03 All earth formed sides of the structure shall be hand trimmed to prevent loose soil from falling into the excavation during concrete placement.
- 3.01.04 All formwork shall be installed in accordance with ACI 347 “Guide to Formwork for Concrete”.
- 3.01.05 Do not apply form release agent to concrete surfaces receiving concrete, special finishes or coatings that may be affected by the release agent.
- 3.01.06 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

- 3.02.01 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.
- 3.02.02 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.
- 3.02.03 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.
- 3.02.04 All anchor bolts shall be plumbed and secured prior to placement of any concrete.

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- 3.02.05 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.
- 3.02.06 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.
- 3.02.07 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

- 3.03.01 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.
- 3.03.02 All reinforcement shall be braced to prevent movement during placement of concrete.
- 3.03.03 The required concrete cover over reinforcing bars shall be maintained for all structures through use of spacers, chairs, bolsters, etc.
- 3.03.04 All reinforcement shall be free of mud, concrete splatter, oil or other materials that may adversely affect or reduce the bond.
- 3.03.05 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.
- 3.03.06 Reinforcement shall not be heated for purpose of bending for any reason.
- 3.03.07 All lap lengths, splices, and development lengths shall conform to ACI 318.

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3.04 Existing Concrete

- 3.04.01 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.
- 3.04.02 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

- 3.05.01 Concrete in any single structure shall come from a single batch plant.
- 3.05.02 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.
- 3.05.03 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.
- 3.05.04 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.

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- 3.05.05 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: temperature control of concrete prior to placement, use of admixtures to modify curing, protection after placement and during curing, as required.
- 3.05.06 Concrete shall not be placed during rain, sleet or snow without approval of the Construction Supervisor.
- 3.05.07 Dry concrete piers shall be vibrated from 3'-0" below the bottom of the anchor bolt cage to the top of concrete.
- 3.05.08 All concrete placed for slabs, spread footings, retaining walls, cable pits, and cast-in-place stairs shall be vibrated.
- 3.05.09 All vibration of concrete shall be internal vibration per ACI 309.
- 3.05.010 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
- 3.06.01 Tops of exterior foundations shall have a light broom finish.
- 3.06.02 All exposed concrete slab edges shall be chamfered $\frac{3}{4}"$ with a 45° bevel.
- 3.06.03 All exposed concrete pier edges shall be chamfered $\frac{3}{4}"$ with a 45° bevel or finished with a $\frac{3}{4}"$ radius.
- 3.06.04 Tops of all foundations shall be finished such that no water will be retained on the top surface.
- 3.06.05 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.
- 3.06.06 Flatwork shall not be crowned.

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3.07 Inspection

- 3.07.01 The Construction Supervisor and Owner's Representative – Geotechnical Engineer must be notified a minimum of 48 hours prior to the placement of concrete.
- 3.07.02 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
- 3.07.03 When requested, the contractor must provide one assistant and the necessary equipment for the Construction Supervisor or Owner's Representative – Geotechnical Engineer to verify the items listed above. Verification does not release contractor of liability.
- 3.07.04 The contractor must notify the Testing Agency a minimum of 48 hours prior to placement of concrete.

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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 HARDWARE

1.0 WORKMANSHIP

1.1 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.

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

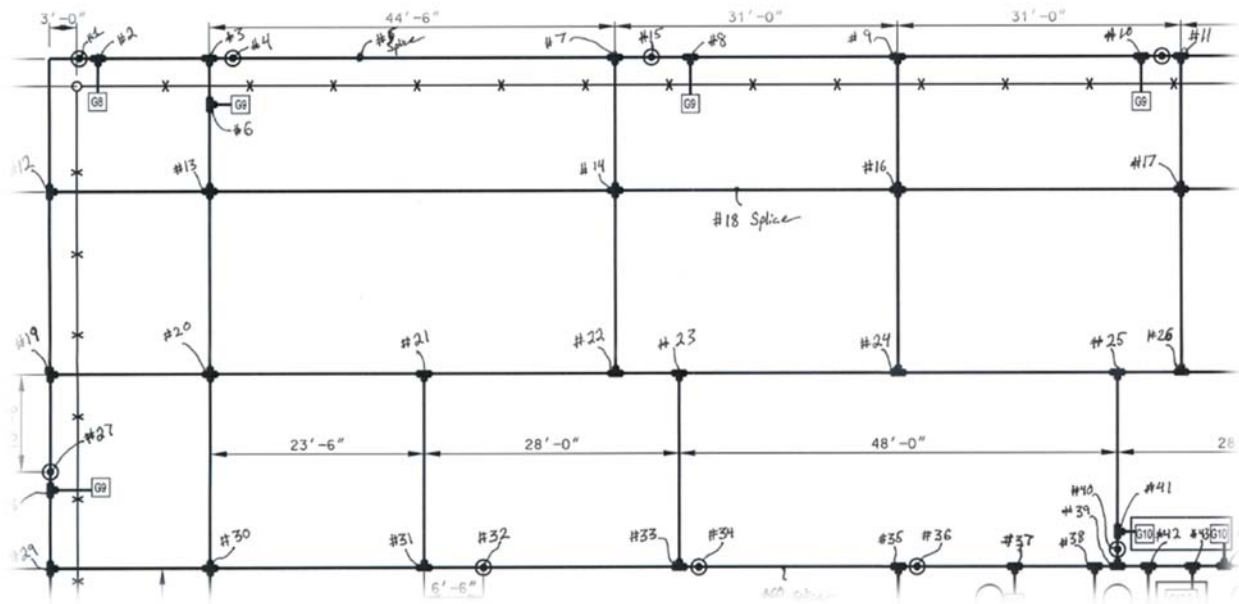


Figure 1: Example of Layout Mark Up

Ameren Substations Final Ground Test

Location: _____

Date: _____

Substation Dimension:

Long side = _____
Short side = _____
Area of Substation = _____
Diagonal Distance = _____

Formula for Area & Diagonal Distance

Area = Longside X Shortside

Diagonal Distance = $\sqrt{(\text{Longside})^2 + (\text{Shortside})^2}$

Circle the row in the table below for the C2 and P2 distances used during the test.

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

SKETCH

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.

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.

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 k Ω)	Resistance of P2 Connection R_S (typ. 0.1 k Ω)	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)

Typical Ground Resistances should be <0.5 Ω or +10% of Modeled Value

Tester: _____

15-Jan

ATX - 22

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

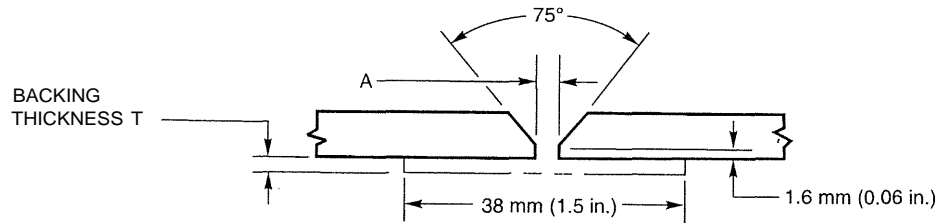
¹ • AWS D10.7M/D10.7:2008 pg. 22

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

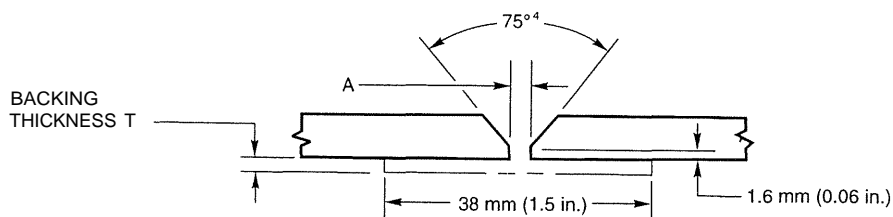
A = 0 FOR NO BACKING RING OR REMOVABLE BACKING RING
A = 6 mm (0.24 in.) MAXIMUM FOR INTEGRAL BACKING RING

Piping Dimensions						Welding Rod Diameter		Approximate Current A-C	Backing Thickness T		Number of Passes ⁴
Nominal Pipe Diameter		Outside Diameter (OD)		Wall Thickness							
NPS	Sch.	mm	(in.)	mm	(in.)	mm	(in.)	amp	mm	(in.)	A=O
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

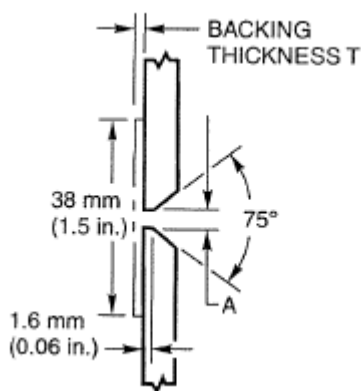
A = 0 FOR NO BACKING RING OR REMOVABLE BACKING RING
A = 6 mm (0.24 in.) MAXIMUM FOR INTEGRAL BACKING RING

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									
NPS	Sch	mm	(in.)	mm	(in.)	mm	(in.)	amp	L./min	(ft³/hr)	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

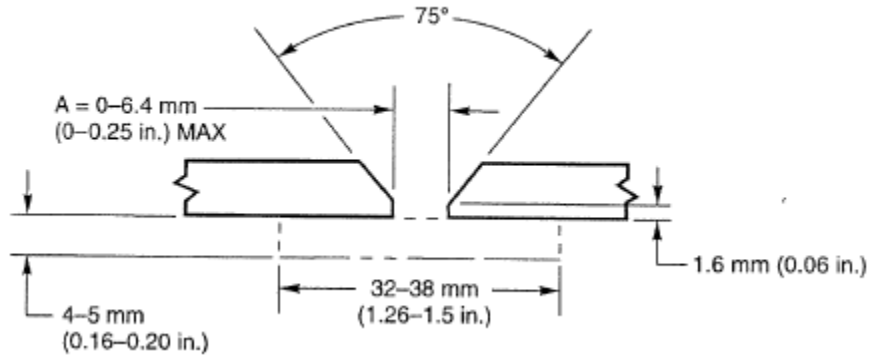
A = 6 mm (0.24 in.) MAXIMUM FOR INTEGRAL BACKING RING

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											
Nominal Pipe Diameter		Outside Diameter (OD)		Wall Thickness							
NPS	Sch.	mm	(in.)	mm	(in.)	mm	(in.)	Current DCEP ³	Approximate Argon Flow		Number of Passes ²
4	40	114.3	(4.50)	6.0	(0.24)	1.2	(3/64)	190-210	L./min	(ft3/hr)	A=O
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
≤ 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 undersize	Throat shall not be undersize
Craters	Underfilled craters in fillet welds are acceptable	Craters must be filled
Fillet weld maximum undersize over no more than 10% of the weld length		
Specified Weld Size	Maximum Undersize	Maximum Undersize
≤ 3/16 [5]	1/16 [2]	1/16 [2]
1/4 [6]	3/32 [2.5]	3/32 [2.5]
≥ 5/16 [8]	1/8 [3]	1/8 [3]
Groove weld maximum reinforcement		
t ≤ 3/8 [10]	3/32 [2]	3/32 [2.5]
3/8 [10] < t ≤ 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>		
<i>0</i>	<i>04/16/09</i>	<i>Original Issue</i>	<i>J. Williamson A. Newman 4/16/09</i>	<i>CJB 5/13/09</i>	<i>WJH 4/16/09</i>	<i>KDA 5/15/09</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)												
	BURNDY TOOLS & DIES						ANDERSON			ALCOA TOOLS & DIES		
DIE REF.	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)
$\frac{3}{8}$ "	168	240
$\frac{1}{2}$ "	300	480
$\frac{5}{8}$ "	480	660
$\frac{3}{4}$ "	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)
$\frac{3}{8}$ "	168	240
$\frac{1}{2}$ "	300	480
$\frac{5}{8}$ "	480	660
$\frac{3}{4}$ "	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)
$\frac{3}{8}$ "	240
$\frac{1}{2}$ "	480
$\frac{5}{8}$ "	660
$\frac{3}{4}$ "	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

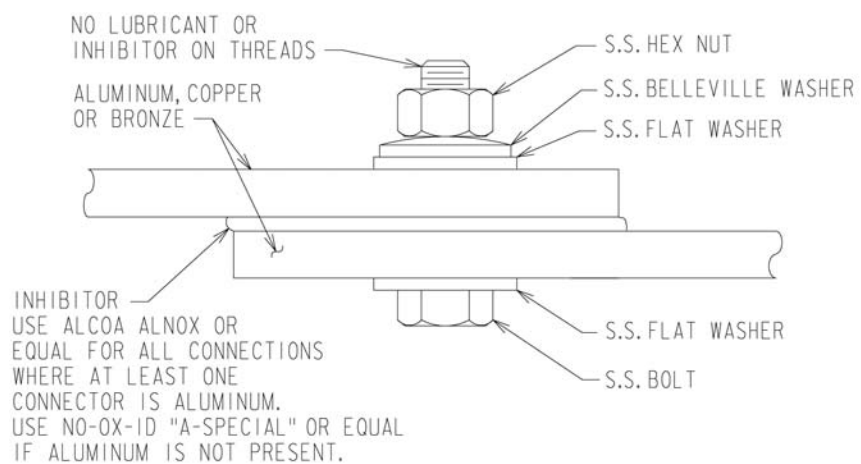
5.2 Workmanship

- 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)
$\frac{3}{8}$ "	240
$\frac{1}{2}$ "	480
$\frac{5}{8}$ "	660
$\frac{3}{4}$ "	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)
$\frac{3}{8}$ "	240
$\frac{1}{2}$ "	480
$\frac{5}{8}$ "	660
$\frac{3}{4}$ "	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)
$\frac{3}{8}$ "	240
$\frac{1}{2}$ "	480
$\frac{5}{8}$ "	660
$\frac{3}{4}$ "	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 than 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's 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



Transmission & Distribution Design Department

ENERGY DELIVERY TECHNICAL SERVICES

AMEREN SERVICES COMPANY

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

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SECTION 16I - OUTDOOR NAMEPLATES

1.0 MATERIALS

- 1.1 Machine screws, brass, #10, 1/2" long, with nuts, to attach nameplates to aluminum plates or angle.
- 1.2 Machine screws, brass, 1/4", length as required, with nuts, to attach aluminum plates to structures.

2.0 WORKMANSHIP

- 2.1 Mount nameplates at locations specified by Company Engineer or construction drawings.
- 2.2 Mounting Bakelite Nameplates
 - 2.2.1 Where flat surfaces are available on equipment or structures (PCB mechanism doors, switch operating mechanism channel, etc.) mount Bakelite nameplates directly to these surfaces with brass screws in manner acceptable to Construction Supervisor. Edges of Bakelite must not extend beyond edges of flat surfaces.
 - 2.2.2 Where Bakelite 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 brass screws. File all edges of aluminum backing plate or angle to eliminate sharp edges and corners. Fasten aluminum plate or angle and Bakelite nameplate assembly to structure with brass screws in manner acceptable to Construction Supervisor.
- 2.3 Mounting nameplates using high intensity reflective yellow on black background decals.
 - 2.3.1 Where flat surfaces are available on equipment or structures (Transformer mechanism door, steel structure, etc.), mount decal nameplate directly to these surfaces in a manner acceptable to Construction Supervisor. Edges of decals must not extend beyond edges of flat surfaces.
 - 2.3.2 Where decals must be mounted against structure angles, etc., cut 1/8" aluminum plate to size at least 1" larger on all sides than decal nameplate and mount decal to aluminum plate. File all edges of aluminum backing plate to eliminate sharp edges and corners. Fasten aluminum plate and decal nameplate assembly to structure with brass screws in manner acceptable to Construction Supervisor.

- 2.4 Mounting nameplates using poly, or aluminum, tag holders.
- 2.4.1 Where any surfaces are available on equipment and structures (wood poles, steel structures, switch operating mechanism channel, etc.) mount tag holder vertically or horizontally in a manner acceptable to Construction Supervisor. Slide alpha-numeric tags into holder. The holders are made with holes for nails or machine screws, and are slotted for mounting cable ties.

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 1/4". 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 1/2" 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			

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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:

- Signs on fence, such as danger signs at 60' intervals and substation identification signs on the fence near the main gate.
- Wheeled, 150lb. dry chemical fire extinguishers with covers. Depending on substation equipment layout, a quantity of two to four of these extinguishers will be supplied.
- Road markers, driven post type with reflectors.
- Cable route markers,

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

- Two 30 lb. dry chemical fire extinguishers within the control enclosure.
- Two or more spare nitrogen cylinders for wheeled fire extinguishers.
- One steel desk, approximately 30" deep x 60" wide.
- Two chairs, one stationary, one wheeled.
- Two steel, five drawer file cabinets.
- One double door steel cabinet, approximately 36" wide x 21" deep x 78" high.
- One eye-wash station near battery.
- No smoking sign near battery.
- One bulletin board above the desk.
- One Emergency Contact Information sign near phone.
- One clock above the desk.
- Two 30 gallon trash cans with lids.
- 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 3/7/07</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.

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 Initial Issue
GME



SAMPLE

Generator Connection Procedure

XXXXXX 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
- BLGD (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 (3 Φ 208/120V)
49. **Close** breaker 13 "BLDG RECEPT" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
50. **Close** breaker 14 "345 KV POSN V4 PRI RLY" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
51. **Close** breaker 16 "JMUX PANEL" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
52. **Close** breaker 17 "PCB POSN-V11" on A.C. DIST. CAB. 4 (3 Φ 208/120V)
53. **Close** breaker 18 "PCB POSN-V31" on A.C. DIST. CAB. 4 (3 Φ 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



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1.0 General

Scope

- 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 Project Engineer or Construction Supervision.
- 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 or 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 fiber testing section below.

2.0 Technical Requirements

2.1 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:

- a. American National Standards Institute (ANSI)
- b. American Society for Testing & Materials (ASTM)
- c. Institute of Electrical and Electronic Engineers (IEEE)
- d. National Electrical Code (NEC)
- e. National Electrical Manufacturers Association (NEMA)
- f. National Electrical Safety Code (NESC)
- g. Occupational Safety and Health Administration (OSHA)
- h. Telecordia GR-765
- i. Federal Communications Commission (FCC)
- j. Fiber Optic Association (FOA)
- k. International Telecom Union (ITU)
- l. Telecommunications Industry Association (TIA)

2.2 Certifications Required

- 2.2.1 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.
- 2.2.2 Light Brigade training through AFL is required.
- 2.2.3 The Contractor shall be fully qualified to work in space owned by the Owner, and must be vetted through Ameren systems, procedures, and Engineering.

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2.3 Fiber Installation

- 2.3.1 The contractor shall provide mechanical protection to the cable where it runs along the surface or edge of a structure or pulling devices.
- 2.3.2 At the locations where a splice is required, additional cable length must be provided to physically accommodate the splicing process.
 - 2.3.2.1 The length of each cable end shall be not less than 115 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.
 - 2.3.2.2 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.
- 2.3.3 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.
- 2.3.4 The Contractor shall handle all fiber optic cable in strict accordance with the cable manufacturer's specifications and procedures.
- 2.3.5 If any Owner-provided materials appear to be damaged or defective, the Contractor shall immediately report the details to the Construction Manager, who shall provide written directions regarding the corrective actions, storage, or disposal of these materials.
- 2.3.6 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.
- 2.3.7 All cables splice boxes, and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.
- 2.3.8 Fiber shall be segregated by tray, conduit, innerduct, or other innerduct methods for protection.
 - 2.3.8.1 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.
 - 2.3.8.2 Innerduct will also be used in the main cable tray application within the control house.
 - 2.3.8.3 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.
- 2.3.9 Contractor shall mark conduits leaving Ameren Property with approved marking methods that should be prescribed in project documentation.

2.4 Splicing

- 2.4.1 Contractor shall reference documentation and reference drawings issued for execution and documentation purposes of splicing.
- 2.4.2 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.

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2.4.3 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.

2.4.4 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.

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.

Approved Fusion Splicing Equipment Manufacturer's include the following:

- a. AFL
- b. Corning
- c. Sumitomo Electric

2.4.5 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.

2.4.7 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.

2.4.8 Final acceptance of a splice will be determined by the Owner/Owner's Representative, referenced below in section 2.6, upon successful completion of the bi-directional OTDR testing phase.

2.4.9 Contractor shall obtain approval from Construction Supervision before performing work on any pole.

2.5 Fiber Testing

2.5.1 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.

2.5.2 Fiber end-faces shall be inspected at 250x or 400x magnification. 250x magnification; is suitable for inspecting multimode and single-mode fibers. 400X magnification should be used for detailed examination of single-mode fibers.

2.5.3 Scratched, pitted or dirty connectors shall be diagnosed and corrected. If the problem cannot be completed by cleaning, it should be reported to the Owner.

2.5.4 It is recommended that the end-face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.

2.5.5 Testing shall be performed on each cabling segment (connector to connector). An "end to end" test is required, examples splice box A to splice box B, cable run structure 100 to 110, substation x to substation y...etc. or per scope required by Project Engineer.

2.5.6 Single mode fiber tests at wavelengths of 1310 nm, 1383 nm, 1550 nm, and 1625 nm at a distance range up to 80km shall be completed using OLTS – Optical Loss Test Set per standards ANSI/TIA/EIA-526-7 Method A.1; and

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- 2.5.7 Single mode fiber tests at wavelengths of 1310 nm, 1383 nm, 1550 nm, and 1625 nm at a distance range up to 80km shall be completed using OTDR – Optical Time Domain Reflectometer Test per standards IEC 60793-1-40 or IEC 61300-3-7 with broadband light sources and spectrum analyzer on the receiving end of the fiber.
- 2.5.8 Optical length shall be measured using an OLTS and OTDR. OLTS fiber calculated length measurements will be used as a reference for all the budget loss calculations.
- 2.5.9 Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with ANSI/TIA/EIA-568-C.1. The polarity of the paired duplex fibers shall be verified using an OLTS.
- 2.5.10 Each fiber segment of the fiber shall be tested at the wavelengths listed above, unless otherwise noted by Project Engineer or Construction Management
- 2.5.11 A final end to end test shall be done (substation patch box to substation patch box) with a loss budget less than 5% over the calculated total loss under ideal conditions per manufacturers published values for the frequencies listed above, after each section of splicing is completed.

2.5.11.1 Patch box, splice enclosure, patch panel, all refer to the same box that gets installed into the fiber distribution panel.

2.6 Acceptance Criteria

- 2.6.1 Changes to the acceptance criteria can only be obtained with approval from the Ameren Project Engineer or those he/she designate.
- 2.6.2 Cabled fiber loss shall be a maximum of:
 - i. 0.35 dB/km at 1310 nm
 - ii. 0.35 dB/km at 1383 nm
 - iii. 0.20 dB/km at 1550 nm
 - iv. 0.23 dB/km at 1625 nm
- 2.6.3 Maximum fusion splice loss for any single splice shall be less than 0.05 dB.
- 2.6.4 A factory terminated connector (type LC) shall not exceed loss of 0.15 dB end to end.

2.7 Labeling

- 2.7.1 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;
- 2.7.2 Shall meet the legibility, defacement, exposure and adhesion requirements of Marking and Labeling Systems - UL 969. **Handwritten labels are not acceptable.**
- 2.7.3 Labeling shall be done per Ameren guidance and standardization from the Ameren Fiber mapping system and conform to proper formats.

2.8 Documentation Submittals

- 2.8.1 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.
- 2.8.2 Testing files should be submitted in both Native format (specify Program used AFL, Fujitsu..etc.); and also submitted in .xlsx format (excel).
- 2.8.3 All Testing documents shall be submitted to Ameren Project Engineer, who will work with the Ameren IT for approval or those they may designate.

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- 2.8.4 All mark-up or redline drawings to be returned to the Project Engineer within 3 weeks of project completion.
- 2.8.5 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 and #2.
- 2.8.6 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.

3.0 Material Requirements

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

- 3.1 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.
- 3.2 Miscellaneous material must use list of standard details and Bill of Material and Construction Details is shown in Appendix #1 for Transmission Lines and Appendix #2 for Substations with standard substation drawing 668387.
- 3.3 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's Test / Splicing Plan package, 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.
- 3.4 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.

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.



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ATTACHMENT #1

TEST FORM (Sample Excel)

Calibration Date of Laser Source: _____

Calibration Date of Optical Power Meter: _____

End #1	End #2	Cable Number	End #1 ORL @ 1550 nm	End #2 ORL @ 1550 nm	Average Fiber Length @ 1310 nm	Average Fiber Length @ 1550 nm	Average Fiber Length @ 1625 nm	Fiber Number	Average End-to-End Loss @ 1310 nm	Average End-to-End Loss @ 1550 nm	Average End-to-End Loss @ 1625 nm
								FIBER01			
								FIBER02			
								FIBER03			
								FIBER04			
								FIBER05			
								FIBER06			
								FIBER07			
								FIBER08			
								FIBER09			
								FIBER10			
								FIBER11			
								FIBER12			
								FIBER13			
								FIBER14			
								FIBER15			
								FIBER16			
								FIBER17			
								FIBER18			
								FIBER19			
								FIBER20			
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								FIBER41			
								FIBER42			
								FIBER43			
								FIBER44			
								FIBER45			
								FIBER46			
								FIBER47			
								FIBER48			



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ATTACHMENT #2

High Splice Loss / Gain Notification Form

Contractor:

Date:

Cable Number:

Cable Length (in feet):

End Location #1:

End Location #2

Test #1:

Fiber Number: _____
Splice Loss/Gain Reading: _____

Fiber Number: _____
Splice Loss/Gain Reading: _____

Fiber Number: _____
Splice Loss/Gain Reading: _____

Date & Time: _____

Test #2:

Fiber Number: _____
Splice Loss/Gain Reading: _____

Fiber Number: _____
Splice Loss/Gain Reading: _____

Fiber Number: _____
Splice Loss/Gain Reading: _____

Date & Time: _____

Contractor Signature: _____

Date:

Construction Supervisor Signature: _____

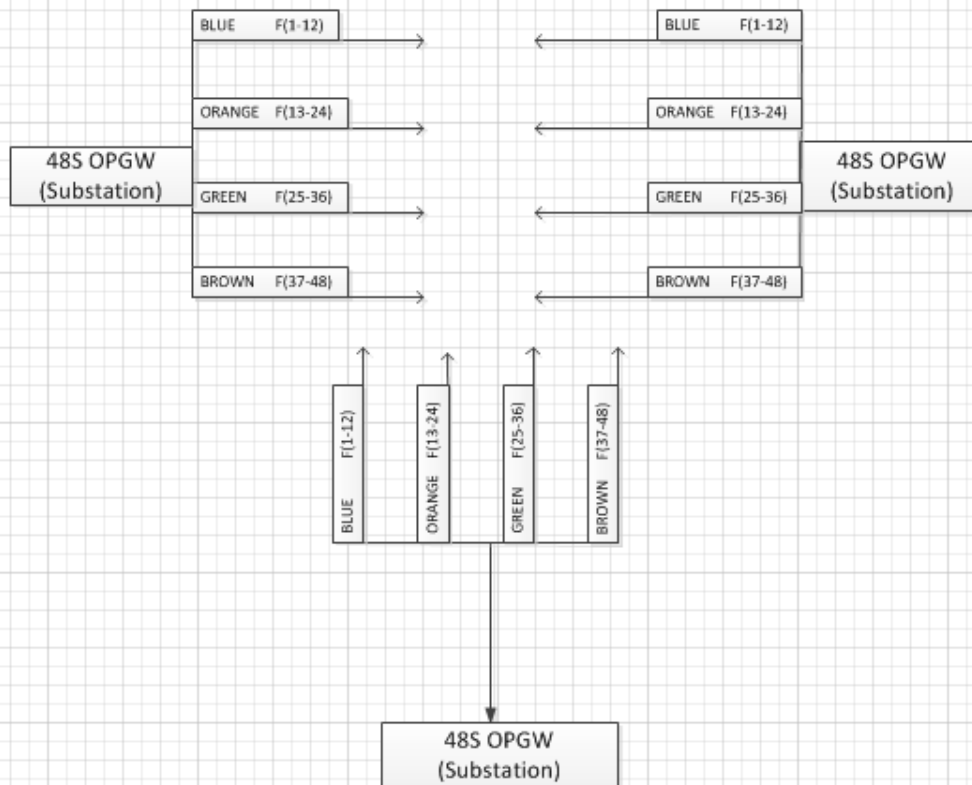
Date:

Engineering Approval Signature: _____

Date:

ATTACHMENT #3
Sample Splice Diagram To be Created/ Supplied to Contractor

Splice Diagram for Structure _____



Location of Splice structure Number
 assigned or Substation Location and GPS
 coordinates

LAT _____

LON _____

Date Inspected _____

Fiber Fan out

Color	Strand #
Blue	1
Orange	2
Green	3
Brown	4
Slate	5
White	6
Red	7
Black	8
Yellow	9
Violet	10
Rose	11
Aqua	12

NOTES

1. If all fibers in Tube are not splice please
 indicate fiber number/color not spliced
 and tube associated

LEGEND

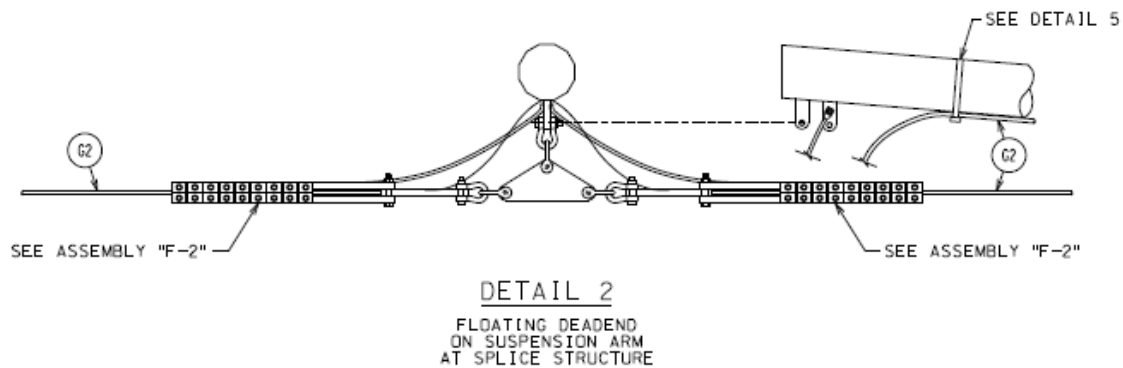
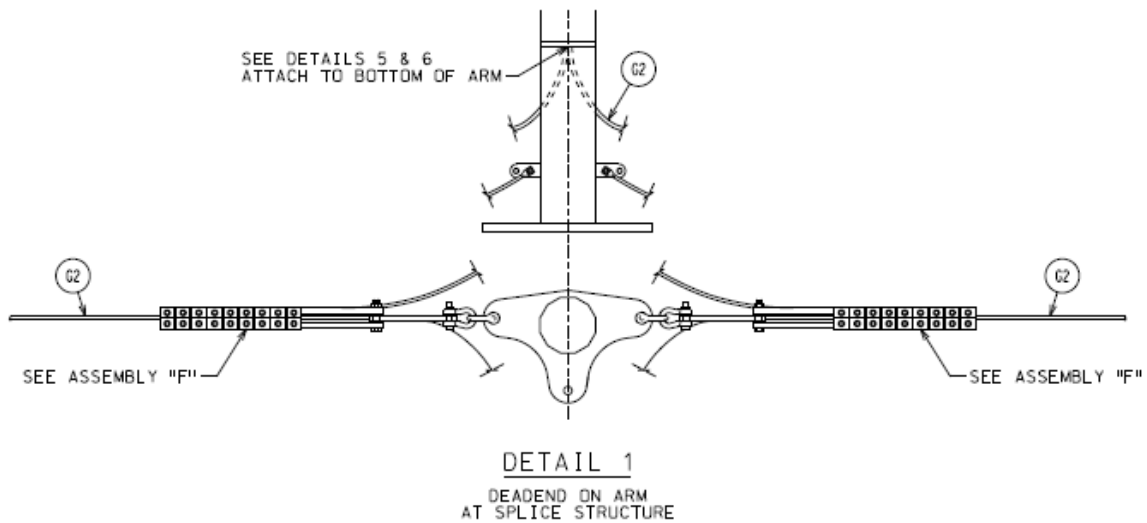
✕	Fiber splice
	Buffers/Fibers lay dead in case.
—	Fiber

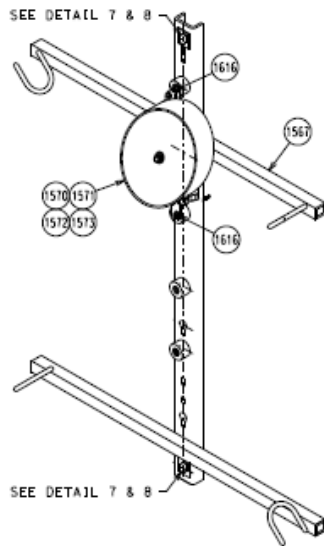
*This drawing should be issued from NEO/Coms department at Ameren it may look slightly different but will give information on how the strands should be spliced; it will come from a computer generated source.

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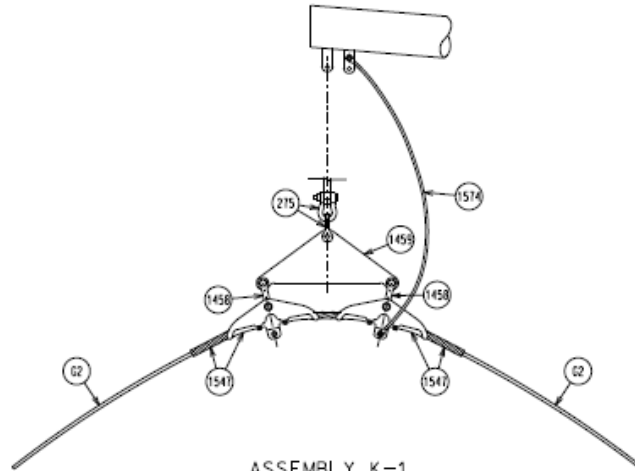
APPENDIX #1 Standard Transmission Line Details and Bill of Material

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.

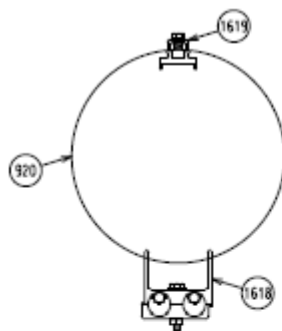




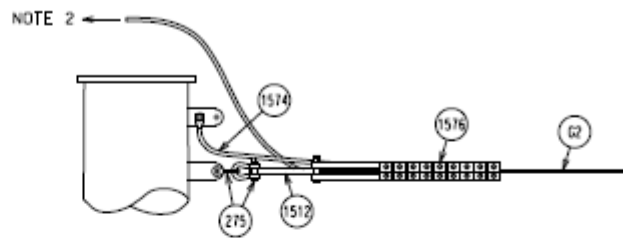
DETAIL 9
OPGW ENCLOSURE ASSEMBLY
NOTE 3



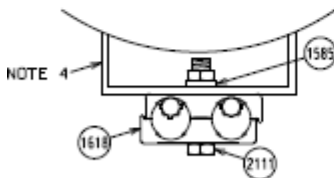
ASSEMBLY K-1
OPGW SUSPENSION ASSEMBLY
30°-60° LINE ANGLE
(ROTATED FOR CLARITY)



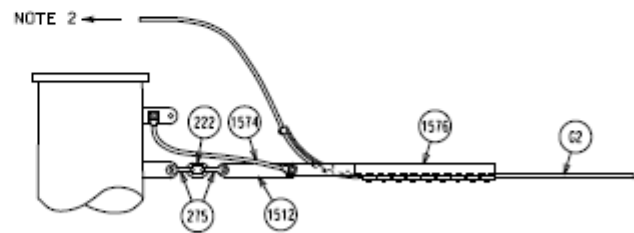
DETAIL 5
OPGW DOWNLEAD CLAMP
ASSEMBLY



ASSEMBLY F
OPGW DEADEND ASSEMBLY



DETAIL 6
OPGW DOWNLEAD CLAMP
DETAIL, POLES
WITH BRACKET

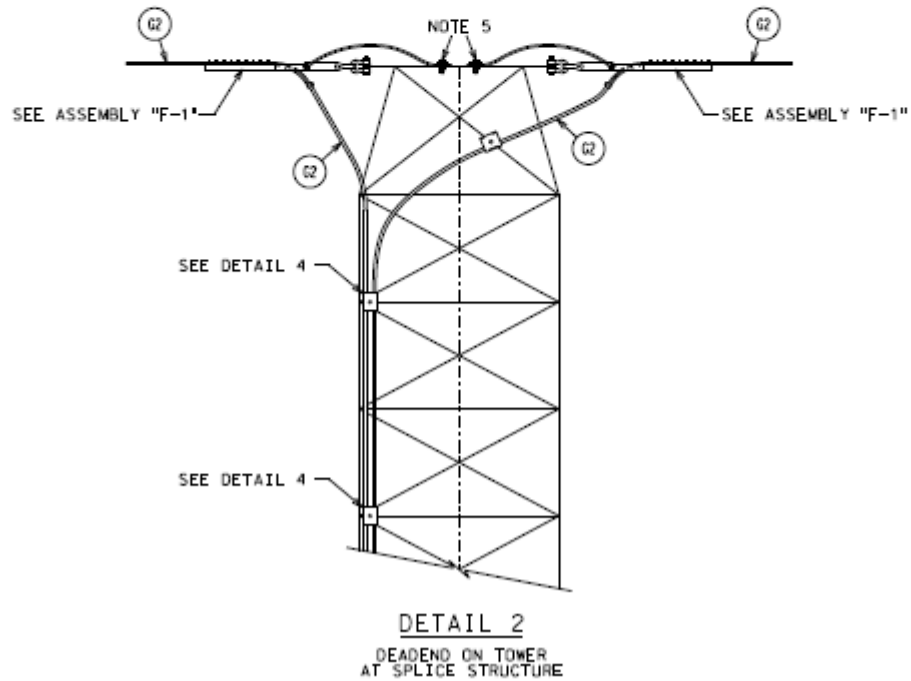
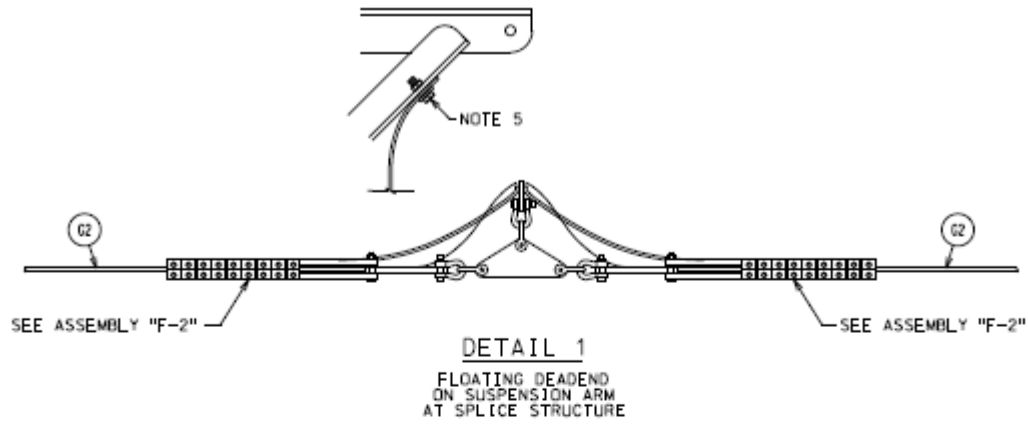


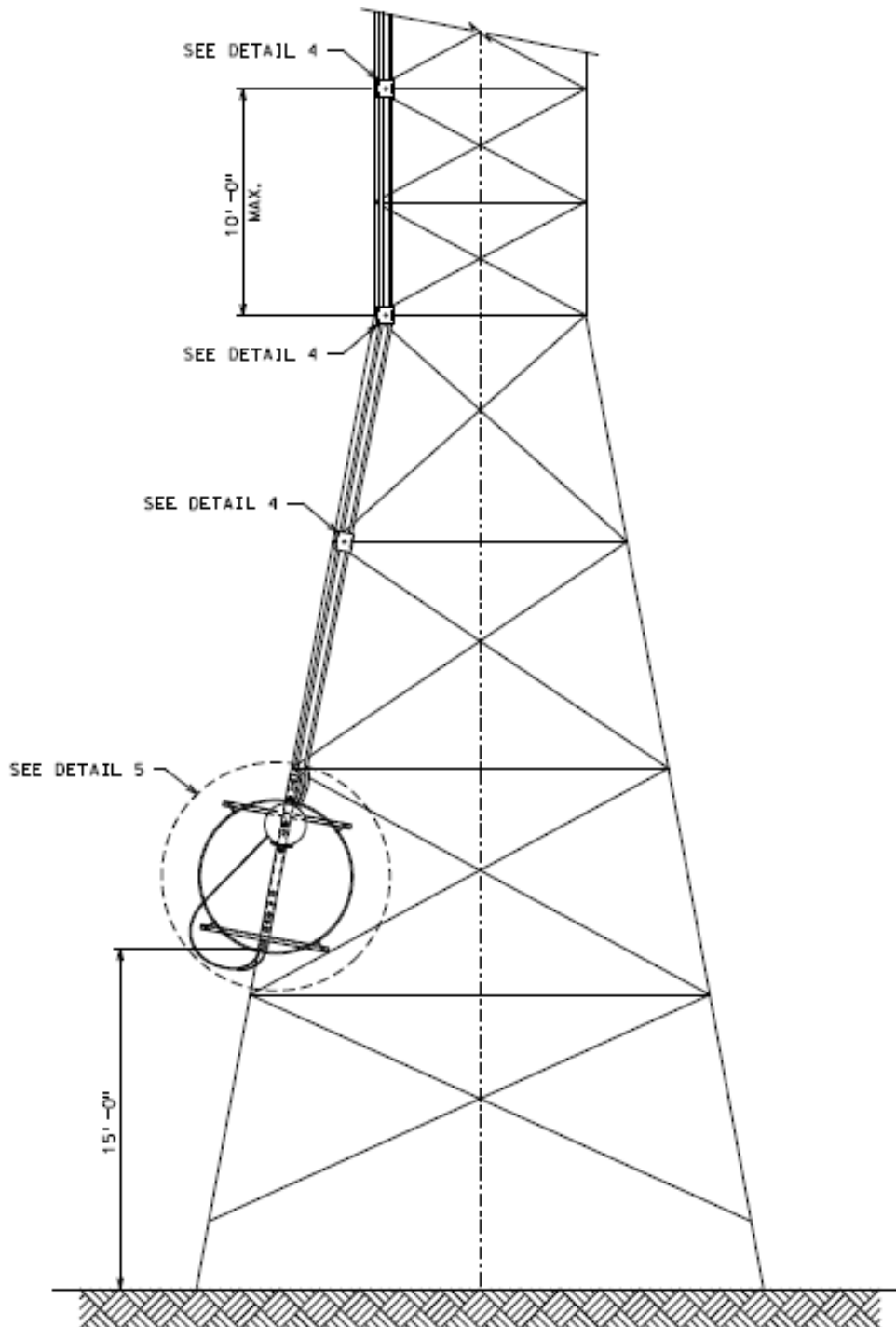
ASSEMBLY F-1
OPGW DEADEND ASSEMBLY

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	QB-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" x 5/8", 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 1/4"x2 1/4"x5/16", 1/8" DIA. HOLE, GALV.	JOSLYN	J-1075	23-66-027	PART OF DETAIL 9
	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	QB-112-S	23-67-499	PART OF DETAIL 9
DETAIL 8	872	AS REQ'D	EA.	WASHER, SQUARE 2 1/4"x2 1/4"x5/16", 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" x 5/8", GALV.	JOSLYN	J138	23-66-005	PART OF DETAIL 9
	2111	AS REQ'D	EA.	BOLT, 1/2"x3" W/ NUT, GALV.			23-52-354	PART OF DETAIL 9
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
	1571	1	EA.	SPLICE ENCLOSURE, INCLUDES TRAYS FOR UP TO 12 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
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, 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	ODEC500 /509G09	23-68-732	
	222	1	EA.	CHAIN LINK, 30K	HUBBELL	LK-30	23-68-249	
ASSY F-1	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, 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	ODEC500 /509G09	23-68-732	
	222	2	EA.	CHAIN LINK, 30K	HUBBELL	LK-30	23-68-249	
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, 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	ODEC500 /509G09	23-68-732	
	1609	1	EA.	YOEK PLATE, 30 ULT. 3/4" THK., 18" SPACING	HUBBELL	YPD-30-18437-3	23-17-306	
	1506	1	EA.	SUSPENSION CLAMP, 0.500"-0.527" RANGE, W/ ARMOR RODS, 25K	AFL	SUME 500/527	23-67-502	
ASSY K	1507	1	EA.	Y-CLEVIS EYE, 90°, 30K ULT.	AFL	YC90E-750-1750	23-58-128	
	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	
ASSY K-1	1458	2	EA.	CLEVIS-EYE, 30K ULT.	AFL	CE-SC	23-58-127	
	1459	1	EA.	YOEK 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	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*.

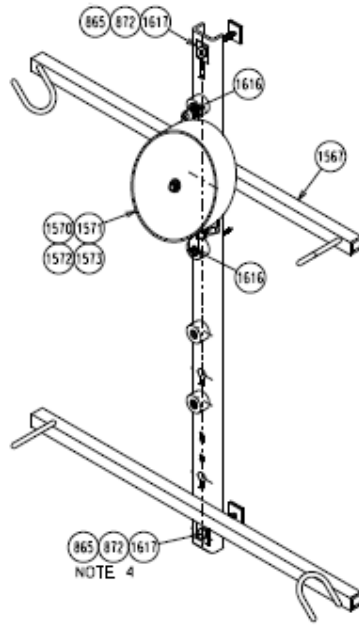
* INDICATION OF MANUFACTURER & CATALOG NUMBER IMPLIES *OR EQUAL*.



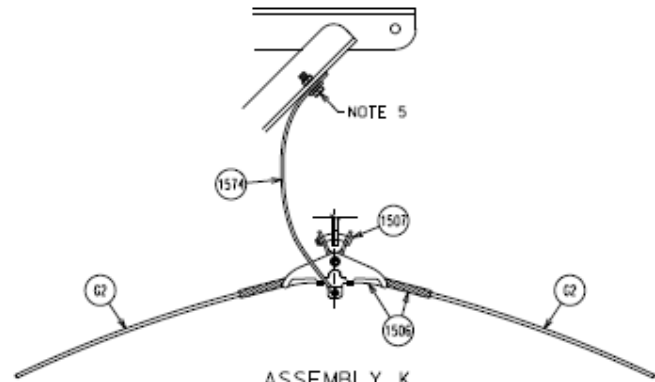


DETAIL 3
TYPICAL OPGW SPLICING

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DETAIL 5
OPGW ENCLOSURE ASSEMBLY
NOTE 2



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

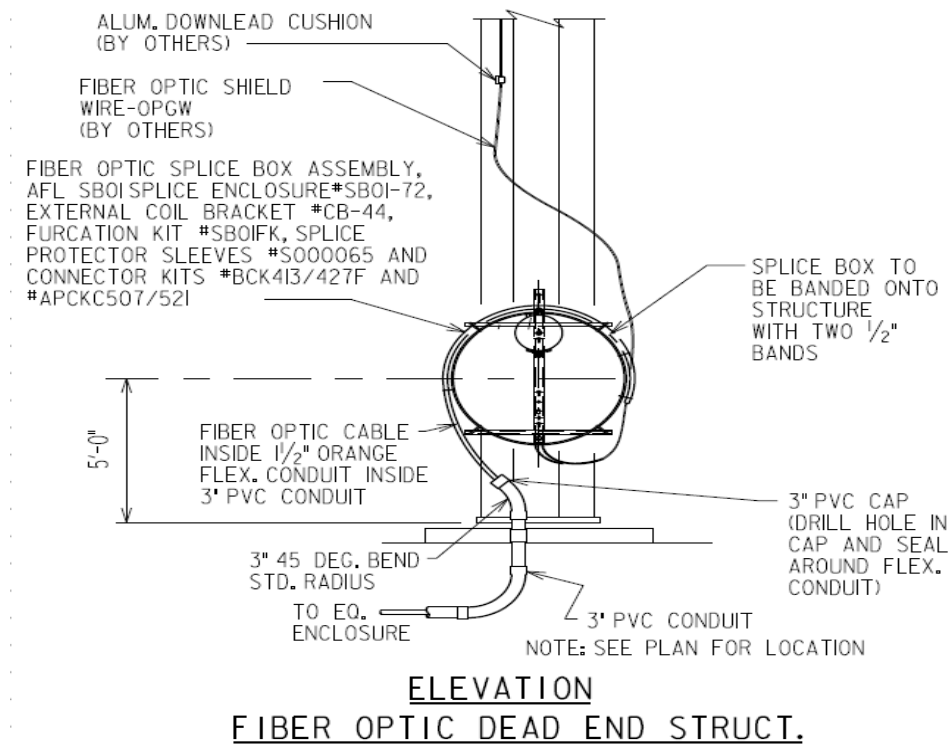
BILL OF MATERIAL								
	ITEM	QTY.	UNIT	DESCRIPTION	MFR.*	CAT. NO.*	AMEREN SERVICES STOCK NO.	REMARKS
DETAIL 4	G2	AS REQ'D	FT.	FIBER OPTIC S.W., 48 FIBER OPGW, 0.508" DIA.	AFL	DND-7330	27-59-080	ULT=19,837 lbs.
	1519	1	EA.	DOWNLEAD CLAMP FOR OPGW, 0.501"-0.600" DIA. RANGE	AFL	FDDA-8585B	17-52-221	PART OF DETAILS 2 & 3
DETAIL 5	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", 3/16" 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	APCKC507/521	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
ASS'Y 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, 1/8" 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	
ASS'Y 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, 1/8" 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	
ASS'Y 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, 1/8" 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-30-18M37-3	23-17-306	
ASS'Y 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, 1/8" STR., 60" LONG, 2 1/2" LUGS, 1 SET OF HARDWARE	AFL	BWAL50/50H60	18-66-678	
ASS'Y 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	ODSME 500/527	23-67-501	
	1574	1	EA.	ALUMINUM BONDING WIRE, 1/8" 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".

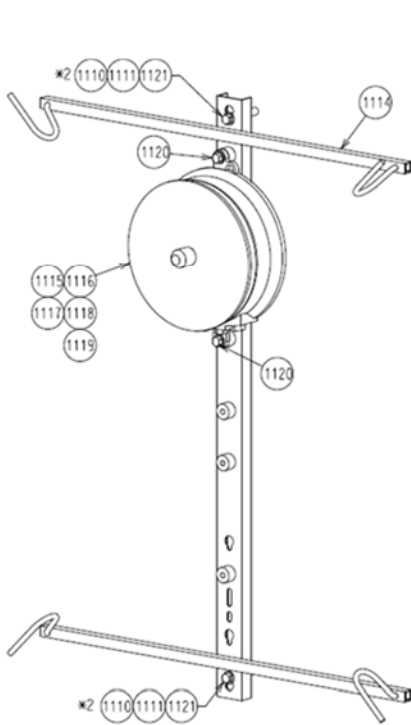
APPENDIX #2 Standard Substation Details and Bill of Material*

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

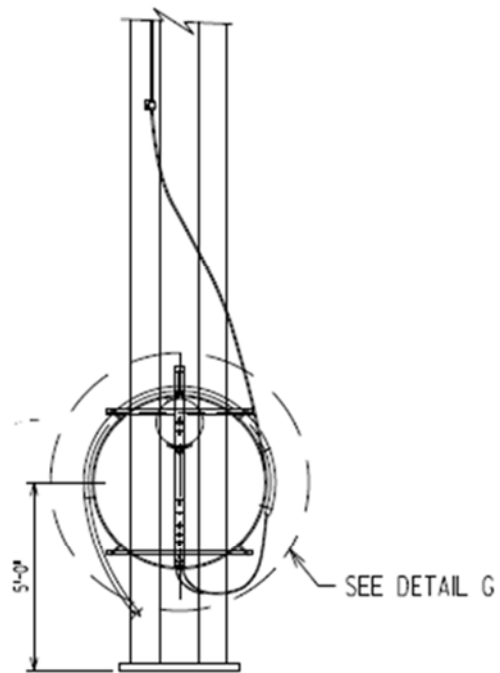
Other physical installation Details can be referenced on Ameren Standard Drawing 668387. For sites needing additional security review with the standard drawing and consult the security team for additional requirements.



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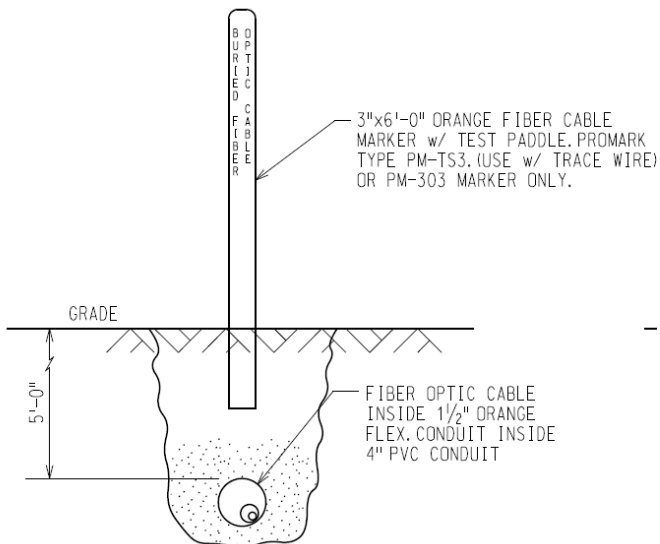


DETAIL "G"
OPGW ENCLOSURE ASSEMBLY



DETAIL "F"
TYPICAL OPGW SPLICING

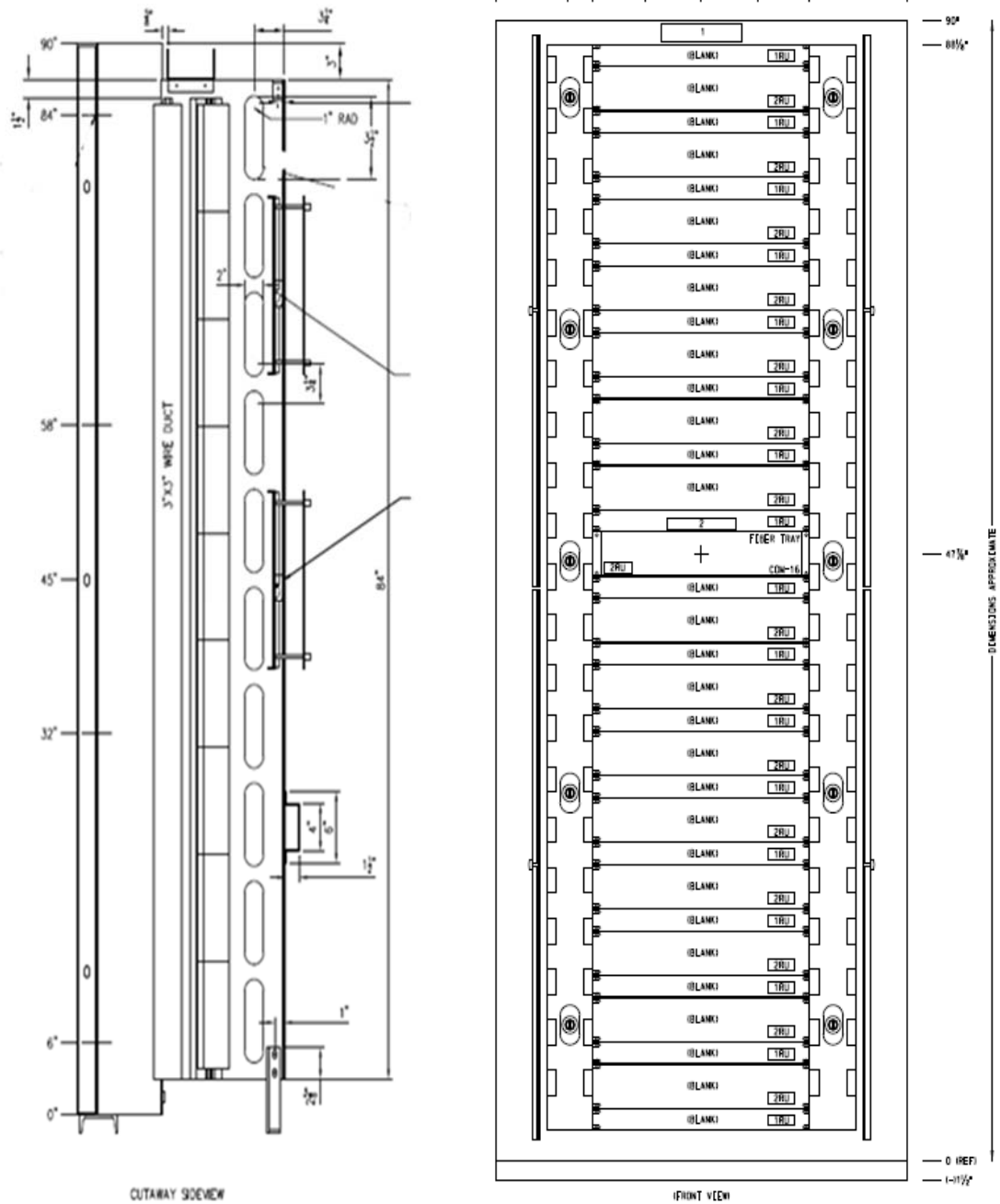
NOTE: Detail G Provided by the Line Contractor.



**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.

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.



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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 strd 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 " interduct 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 " interduct 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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		Rev. 0			

	Altos fiber kit include pulling eye, 800ft cable, 800ft 1.5" innerduct, and corning splice enclosure mentioned above	Anixter		Pending	Anixter kit contact Cherie Beckermann 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 Beckermann 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 Beckermann 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 Beckermann 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 Beckermann 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 Beckermann 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 approved by Project Engineer.

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

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.

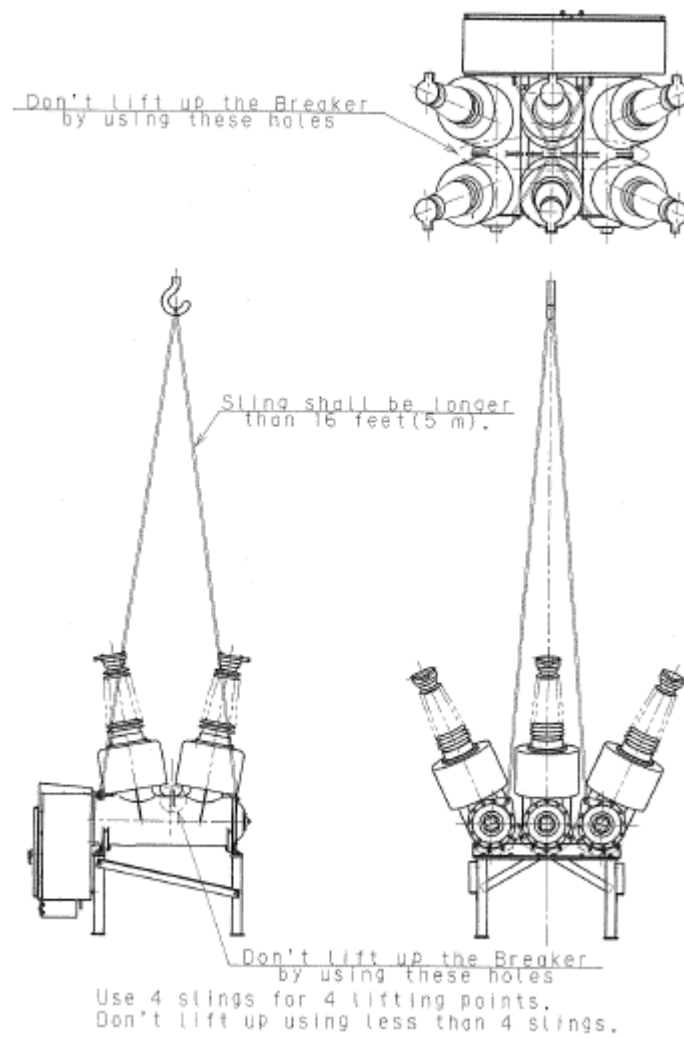
4.5 Anchors

- 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.

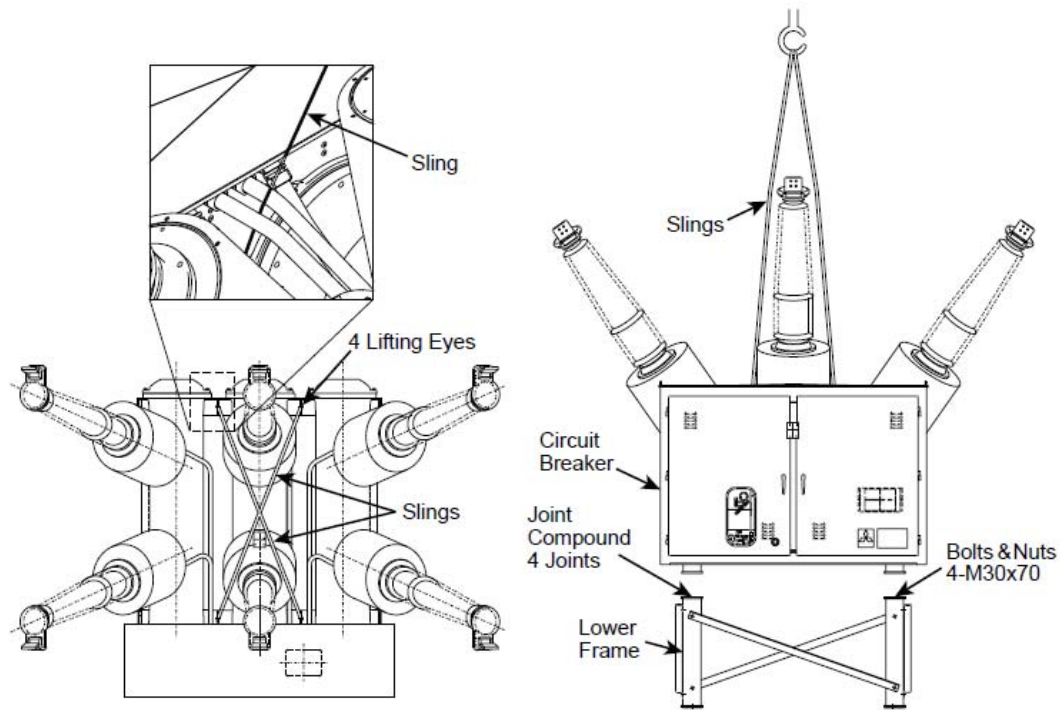
5.0 REVISIONS

Revision 0: Initial Issue

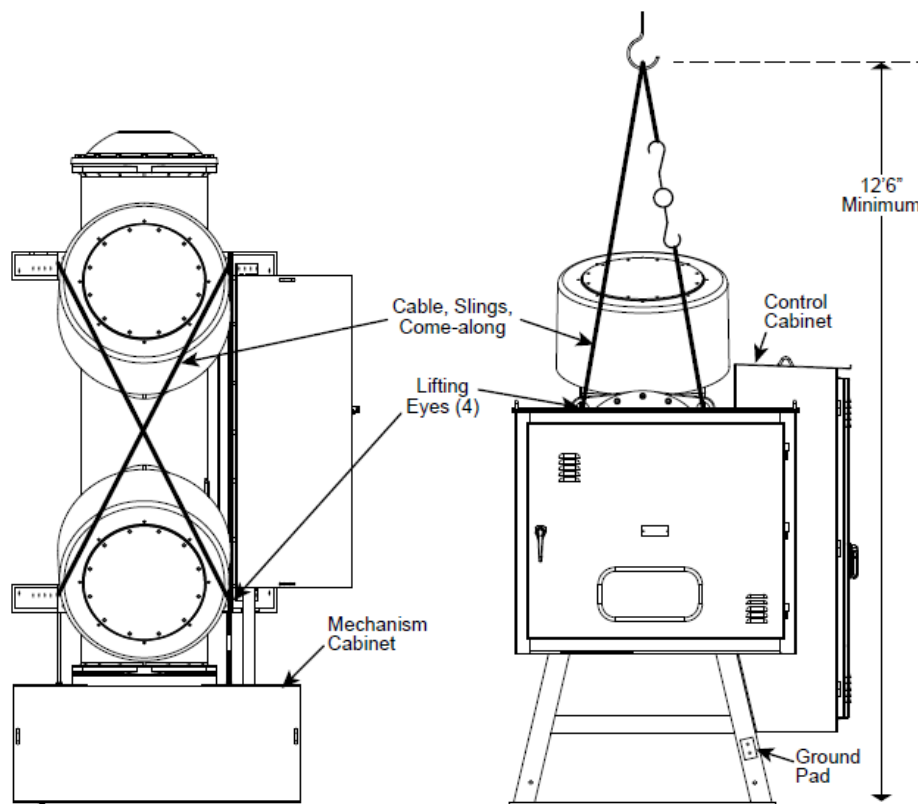
APPENDIX #1: Breaker Lifting Examples



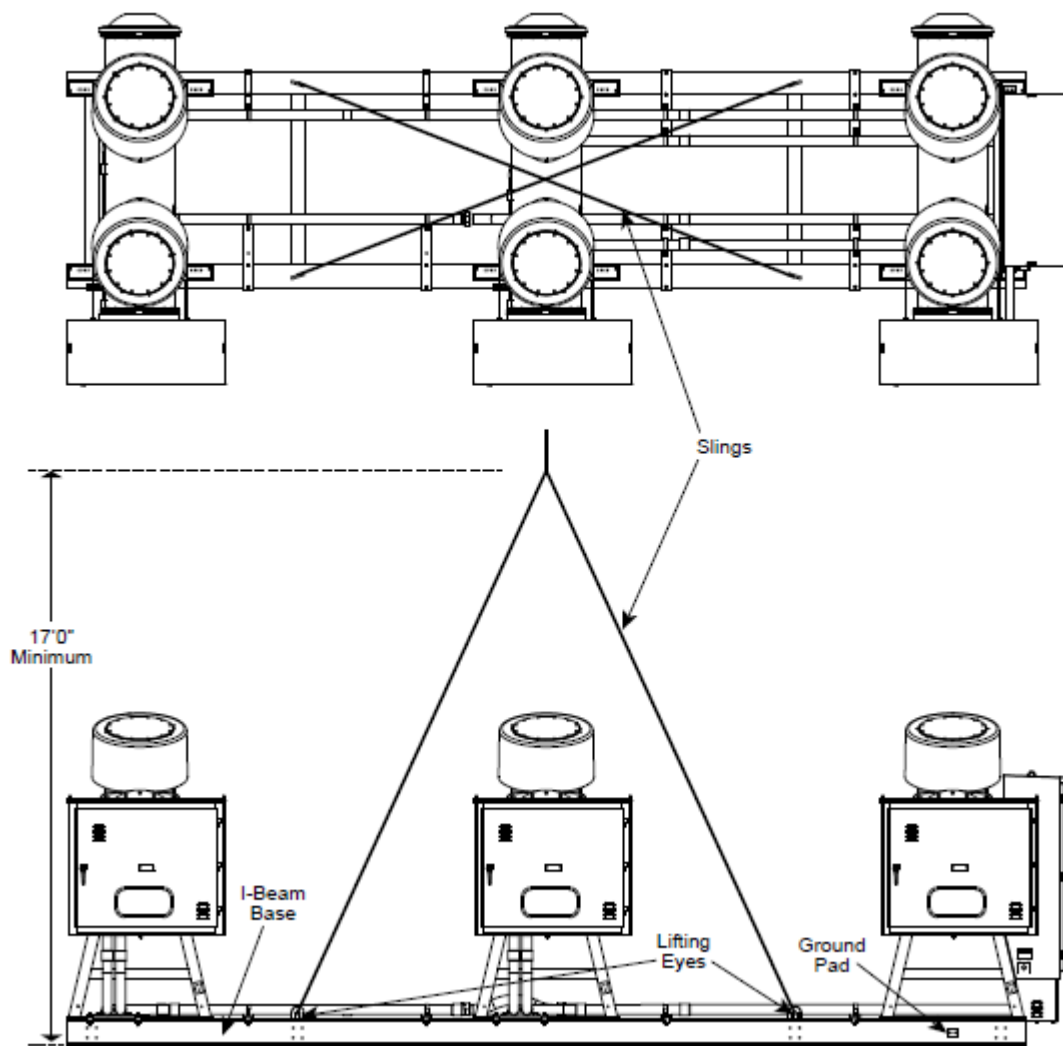
72 kV SF6 or Vacuum Breaker Example



145 kV SF6 Breaker Example

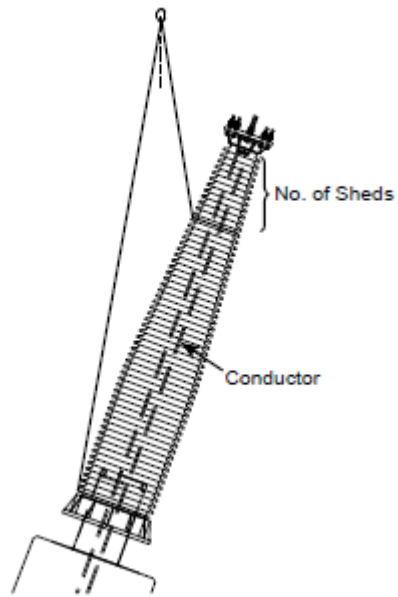


345 kV SF6 Single Pole Example

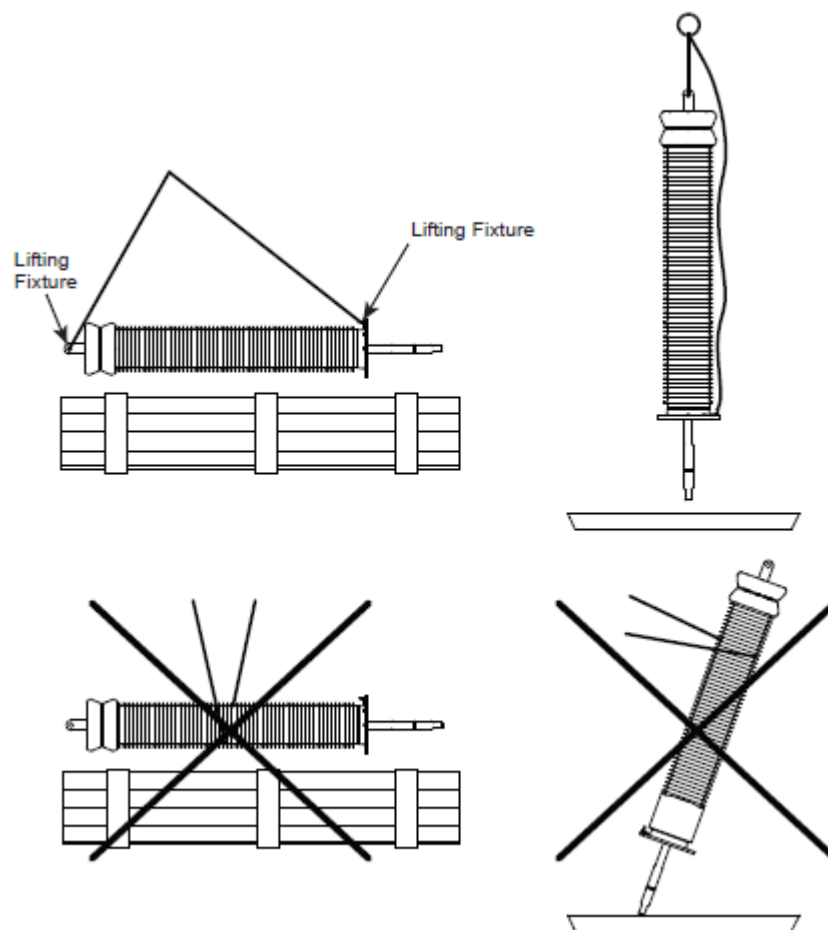


345kV SF6 Common Pole Example

APPENDIX #2: Bushing Lifting Examples



Porcelain Bushing Example



Composite Bushing Example

SUBSTATION 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

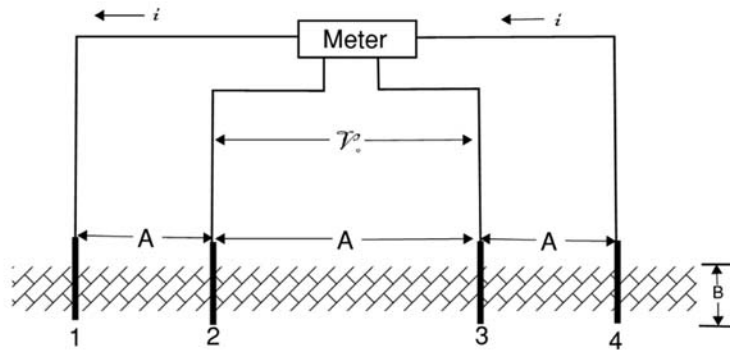
3.1 Equipment

- 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")

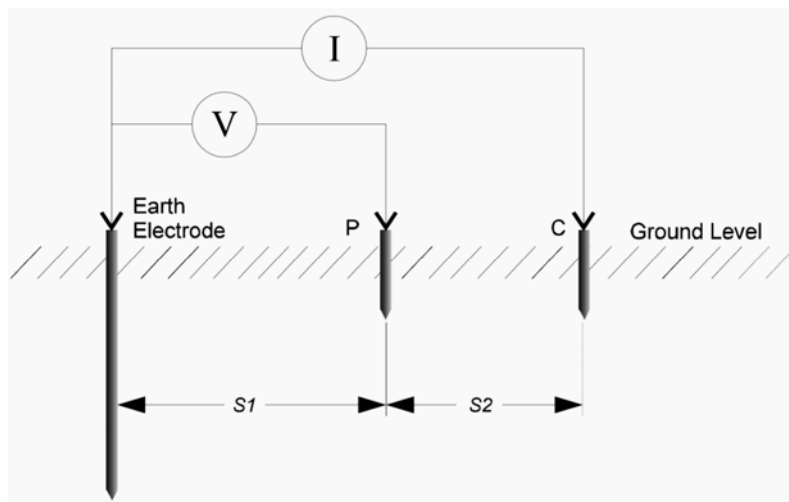


Figure 2 Fall of Potential Method

- 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.

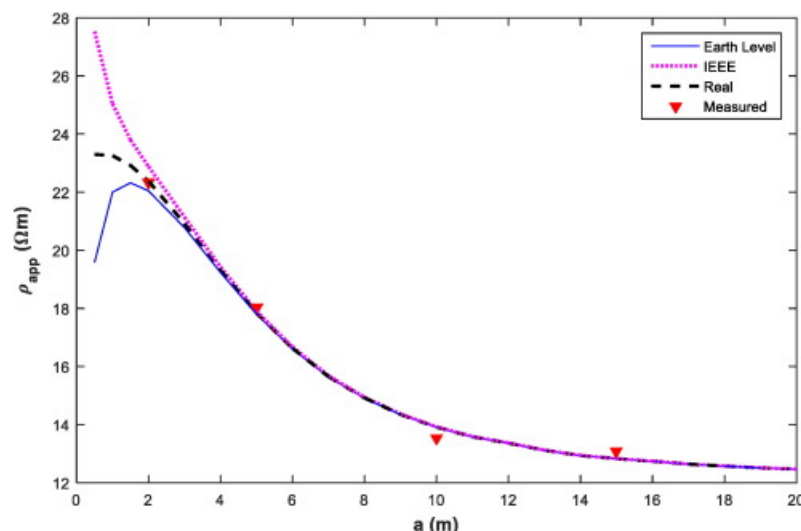


Figure 3. Typical Resistivity Regression Curve

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



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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 $P = 2\pi A R$

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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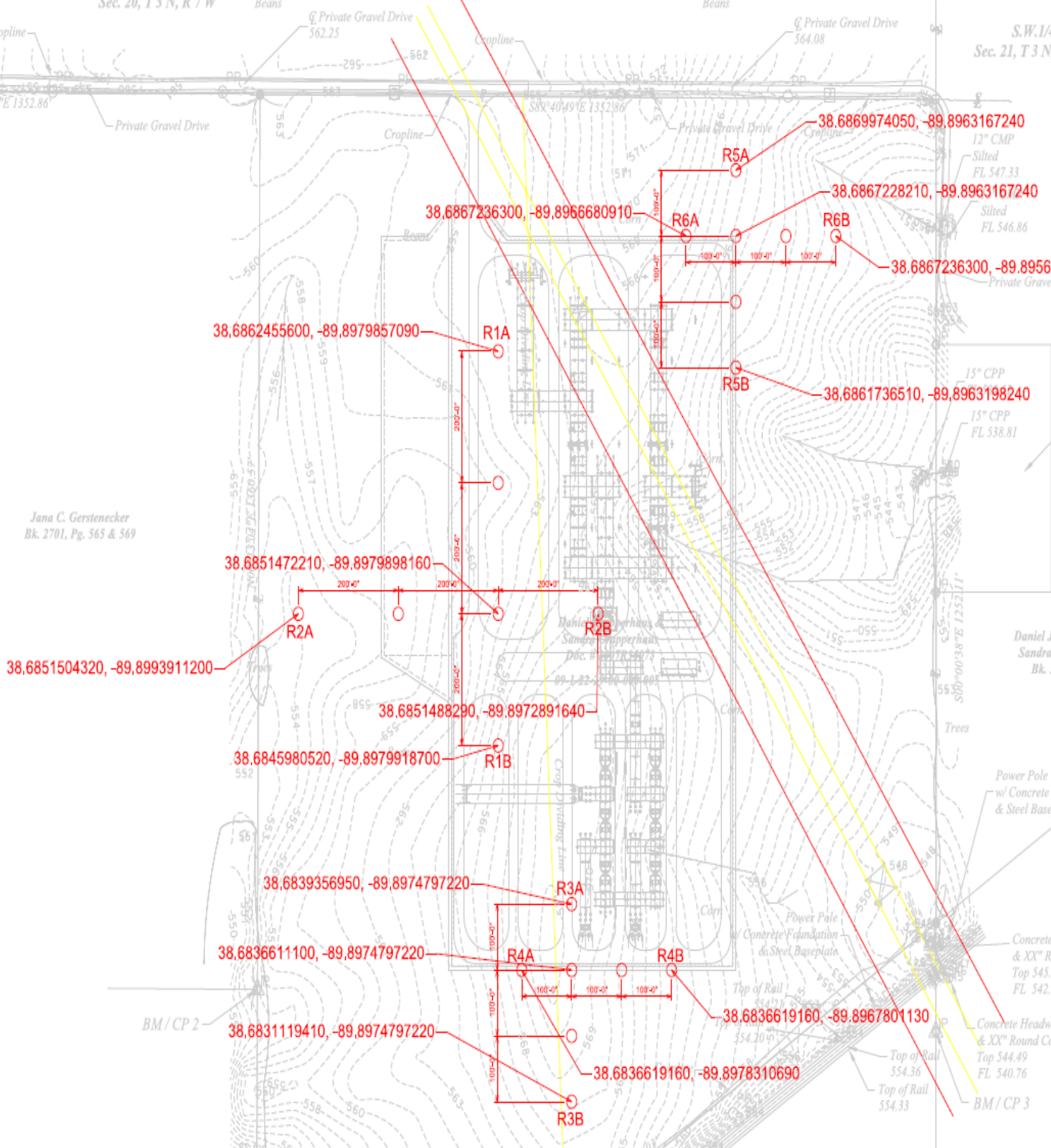
Appendix 3
Typical Submittal to the Report

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



Typical Testing Diagram Overlay to be submitted with Report