GRAND RIVER DAM AUTHORITY

SUBSTATION STEEL – 345 kV

Technical Specifications

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1 SCOPE

1.1 This specification states the minimum requirements for the design conditions, performance criteria, deflections, drawings and calculations, materials, fabrication, protective coatings, quality assurance and shipping requirements for low-profile tapered-tubular steel substation structures. Loading and configuration information shall supplement this specification. GRDA does not necessarily provide 'shop ready' drawings. It is the responsibility of the vendor to verify the design to the loading information and generate any needed shop drawings from the drawings provided.

2 DEFINITIONS

2.1 Purchaser – GRDA or GRDA's authorized representative purchasing low-profile tapered-tubular steel substation structures.

2.2 Fabricator – Company supplying low-profile tapered-tubular steel substation structures.

2.3 NEMA Class A Structure – Class "A" structures are those intended for the support of high-voltage equipment (i.e., air switches, interrupter switches, and circuit interrupting devices).

2.4 NEMA Class B Structure – Class "B" structures are those on which the deflections within the limits do not affect the performance of supported equipment (i.e., dead end structures, bus supports and miscellaneous equipment supports).

2.5 Stress Critical Structure – A structure where the design is typically controlled by stress, is tension loaded or is subject to cyclic loading.

2.6 Deflection Critical Structure – A structure where the design is typically controlled by Deflection.

2.7 Joint Penetration – A measurement from the surface of the parent material to the weld root.

2.8 Inspection and Test Plan – A written procedure defining hold points, for inspecting and testing methods.

2.9 Component – An item or sub-assembly designated for field installation.

2.10 Equipment Cut-Sheets – Drawings of the equipment, which includes the equipment weight, center of gravity, wind area and mounting footprint.

3 REFERENCES

3.1 Unless shown on the drawings, references may be made to the latest applicable revision of American National Standards Institute specifications as commonly used by domestic electric utilities. The following abbreviations shall be used:

Specification	Abbreviation	Reference
3.1.1	ASCE	American Society of Civil Engineers
3.1.1.1	ASCE 72	Design of Steel Transmission Pole Structures
3.1.2	NESC	National Electric Safety Code
3.1.3	NEMA	National Electrical Manufacturers Association
3.1.3.1	NEMA TT-1	Standard for Tapered Tubular Steel Structures
3.1.3.2	NEMA SG 6	Power Switching Equipment
3.1.4	AISC	Code of Standard Practice for Steel Buildings & Bridges
3.1.4.1	AISC ASD	Manual of Steel Construction – Allowable Stress Design
3.1.5	AWS	American Welding Society
3.1.5.1	AWS D1.1	Structural Welding Code - Steel
3.1.6	ACI	American Concrete Institute
3.1.6.1	ACI 318-83	Building Code Require. for Reinforced Concrete, 1983
3.1.7	IEEE	Institute of Electrical & Electronic Engineers
3.1.8	UBC	Uniform Building Code
3.1.9	ASNT	American Society of Nondestructive Testing
3.1.10	ASTM	American Society for Testing & Materials
3.1.11	ANSI	American National Standards Institute

4 DESIGN CONDITIONS

4.1 As a minimum, the following conditions shall be used for structure design.

4.1.1 ICE + WIND: The structure is to be loaded with all equipment, structure dead weight and a coating of radial ice on both equipment and structure. The degree of loading due to ice shall be considered as heavy in accordance with the geographical areas shown in the loading map in ANSI C2, Part 2, Section 250. A wind pressure will be applied to the ice-coated equipment and to the structure. The wind speed will be 80 miles per hour.

4.1.2 EXTREME WIND: The structure is to be loaded with all equipment and structure dead weight without ice. A wind pressure shall be applied to the equipment and structure. The extreme wind speed will be 100 miles per hour.

4.1.3 SEISMIC: Where applicable, the structure is to be loaded with all equipment and structure dead weight without ice or wind. Seismic loading shall be applied to the equipment and structure as recommended by UBC.

4.1.4 SHORT CIRCUIT: A horizontal force, equal to 100% of the rated cantilever strength of the insulator, shall be applied perpendicular to the rigid bus at the top of the insulator. No horizontal or vertical forces from wind, ice or seismic

shall be considered on bus or equipment. Short circuit reactions plus extreme wind shall be applied to the structure.

4.2 WIND PRESSURE

4.2.1 Calculate wind pressure as follows: $P = 0.00256 \times V^2 \times Cd$

Where: P = Wind pressure in pounds per square foot
V = Wind velocity in miles per hour
Cd = Drag coefficient:
1.1 for 12 or more sided surfaces
1.3 for 8 or 6 sided surfaces
1.6 for flat surfaces

4.2.2 Apply the wind in the most severe direction. Investigate a diagonal wind load for the design of anchor bolts. Wind shade factors are not allowed. Increase the wind profile of equipment by the radial ice thickness before calculating the wind load.

4.3 ICE LOAD

4.3.1 To account for the increase in equipment and structure weight due to ice, multiply the dead weight of the equipment and structure by these factors:

¼ in. – use 1.25 ½ in. – use 1.50

4.4 RIGID BUS

4.4.1 Unless otherwise shown on the drawings, round aluminum bus, schedule 40, of the following diameter and span length will be assumed:

Equipment Voltage (kV)	>/=345 kV	230 to 161kV	138 to 15 kV
Bus Diameter (in.)	6	4	3
Bus Span (ft.)	50	40	30

4.5 WIRE LOAD

4.5.1 Unless shown on the drawings, the maximum loading associated with wire(s) connections shall be designed for 5,000lbs / phase wire & 3,000 lbs./static wire.

4.5.2 Structure shall be designed to account for wire loading angle resulting in the greatest overall resultant force on the structure. Wire loading angle shall not exceed 15 degrees in any incoming angle without approval of Purchaser's engineer.

4.5.3 Design for terminating wires on one side of the structure.

4.6 EQUIPMENT

4.6.1 The Purchaser shall provide the Fabricator with the equipment classification.

4.6.2 Unless shown on the drawings or Equipment Cut-Sheets, the rated cantilever strength shall be taken as the value assigned for a "Standard Strength" insulator.

4.7 ANCHOR BOLTS

4.7.1 Anchor bolts, furnished by the Fabricator, are considered as a part of the structure and shall be designed for leveling the structure.

4.7.2 The distance from the top of the concrete to the bottom of the steel base plate shall be 1 inch plus one anchor bolt diameter.

4.7.3 Grout shall not be applied between the top of concrete and the bottom of steel.

4.7.4 Bolt holes for anchor bolts shall be oversized ¼" for anchor bolts less than and equal to ¾" diameter. Bolt holes for anchor bolts shall be oversized 5/16" for anchor bolts greater than and equal to 1" diameter.

4.8 SLIP JOINTS

4.8.1 Slip joints shall not be used.

5 PERFORMANCE CRITERIA

5.1 STRESS

5.1.1 For design conditions 4.1.1, 4.1.2 and 4.1.3, structural member stress shall remain below the allowable stress as defined by AISC ASD.

5.1.2 For design condition 4.1.4, structural member stress shall not exceed the yield strength of the material or the allowable stress as defined by ASCE 72.

5.1.3 Width to Thickness ratios or diameter to thickness ratios for tubular steel members shall be in accordance with the requirements set forth in ASCE 72.

5.1.4 Computer aided analysis and design shall include secondary moments from non-Linear effects (p-delta) for structure stresses.

5.1.5 Anchor bolts shall be long enough to transfer the foundation loads into the footing through bond stress.

5.1.5.1 For design conditions 4.1.1, 4.1.2 and 4.1.3, smooth bar anchor bolts shall be designed with a bond stress of 50% of the value calculated in NEMA TT-1, Appendix A. Deformed bar anchor bolts shall be designed for bond stress at 60% of the value calculated by the ACI 318-83 (see ASCE 72).

5.1.5.2 For design condition 4.1.4, smooth bar anchor bolts shall be designed with a bond stress calculated by NEMA TT-1, Appendix A. Deformed bar anchor bolts shall be designed for bond stress calculated by the ACI 318-83 (See ASCE 72).

5.1.5.3 Unless shown on the drawings, the compressive strength of concrete shall be 3000 psi.

6 DEFLECTIONS

6.1 For design condition 4.1.1, member deflections shall be limited as follows:

6.1.1 EQUIPMENT STAND – NEMA Class A Structure

Horizontal members–with respect to their supports:	Vertical members–at equip. mounting elev.:
Horizontal deflection – Span/200	Horizontal deflection – Height/100
Vertical deflection – Span/200	Angular deflection - 0.01 Radian
Angular deflection – 0.005 Radian	

6.1.2 EQUIPMENT STAND – NEMA Class B Structure

Horizontal members – with respect to their supports:	Vertical members-at equip. mounting elev.:
Horizontal deflection – Span/100	Horizontal deflection – Height/50
Vertical deflection – Span/200	Angular deflection – 0.02 Radian
Angular deflection – 0.005 Radian	

6.1.3 LINE TERMINATION STRUCTURE – NEMA Class A Structure

Horizontal members supporting equipment – with respect to their supports:	Vertical members – at equip. mounting elevations:
Horizontal deflection – Span/200	Horizontal deflection – Height/100
Vertical deflection – Span/200	

6.1.4 Line termination Structures requiring both NEMA Class A and NEMA Class B limits shall meet Class A limits at Class A equipment elevation and Class B limits for elevations above those equipment mounting elevations.

6.1.5 LINE TERMINATION STRUCTURE & MASTS – NEMA Class B Structure

Horizontal members-with respect to their supports:	Vertical members-with respect to the structure base:
Horizontal deflection – Span/100	Horizontal deflection – Height/50
Vertical deflection – Span/200	

6.2 Do not apply deflection limits to design conditions 4.1.2, 4.1.3 or 4.1.4.

7 DRAWINGS AND CALCULATIONS

7.1 GRDA shall provide Equipment Cut-Sheets showing mounting hole dimensions with the purchase order, if they are available at the time of order.

7.2 Equipment mounting bolts are to be furnished by the GRDA. Anchor bolts and cages shall be furnished by the Steel Fabricator.

7.3 The Fabricator shall prepare detailed structure drawings for manufacturing and assembly purposes. These drawings shall include the following:
- 7.3.1 Anchor bolt details and patterns
- 7.3.2 Assembly and erection details
- 7.3.3 Structure members, connections and equipment mounting details.

7.4 The Fabricator shall mail (1) set of design calculations and foundation loads, in accordance with the Purchase Order, to the GRDA Project Engineer (mailing address is listed later in this specification).

7.5 Approval and final drawings will be sent in accordance with the Purchase Order, to the GRDA Project Engineer e-mail address, as electronic media.
- 7.5.1 If requested by the GRDA, paper or reproducible copies of approval and final drawings shall be transmitted to the GRDA Project Engineer's mailing address.
- 7.5.2 The engineer assigned to review these drawings is:

Deanna Patschke, Substation, email: deanna.patschke@grda.com
Gayan Herath, Transmission, email: gayan.herath@grda.com
Cameron Ibbetson, Transmission, email: Cameron.Ibbetson@grda.com

7.5.3 The drawings are to be submitted in .pdf format for approval, and AutoCad for final drawings. Check with the engineer for the proper version of cad drawing.

7.6 Fabrication shall not begin until all drawings are marked "APPROVED" or "APPROVED AS NOTED" and have been returned to the Fabricator.

8 MATERIALS

8.1 All steel materials shall conform to ASTM specifications, as required by design, and shall be suitable for use in welded and galvanized structures. The steel is to be manufactured in the United States. The vendor is to supply certification that the steel is manufactured by a domestic source in the US.

8.2 Unless shown on the drawings, all steel material shall conform to one of these ASTM specifications:
- 8.2.1 STRUCTURES – A-36, A-53 Gr. B, A-500 Gr. B, A-572, A-588, A-595, A-633 Gr. E and A-871.
- 8.2.2 ANCHOR BOLTS – A-36 bar with A-563 Gr. A nuts A-615 Gr. 75 (NORSCO 75S) deformed bar with A-194 Gr. 2H nuts.
- 8.2.3 CONNECTION BOLTS – A-325 Type(s) I and III with Anco locknuts A-354 Gr. BC with Anco locknuts .

8.3 Steel that will receive a galvanized finish shall be limited in silicon content as follows:
- 8.3.1 $Si < 0.06\%$ or $0.15\% < Si < 0.40\%$
- 8.3.2 This limit is not available for A-500 Gr. B material.

8.4 Charpy "V" notch test qualifications shall be determined in accordance with ASTM A-370, A-673 and ASCE 72. These qualifications will not be required for A-36, A-53 Gr. B, A-500 Gr. B or A-595 materials.

8.5 Provide weld material that is compatible with the parent material, as defined by AWS D1.1. The weld material must meet the Charpy "V" notch test qualifications in this specification for the lowest toughness qualification of the plates being joined.

9 FABRICATION

9.1 Fabrication tolerances shall conform to the AISC, AWS D1.1. Fabrication shall be preformed in strict compliance with the shop detail drawings.

9.2 Stress Critical Structures shall meet the requirements of AWS D1.1, Section 9.

9.3 Deflection Critical Structures shall meet the requirements of AWS D1.1, Section 8.

9.4 Holes in plates may be punched, drilled or burned. All burned holes shall be done by machine-guided torch, no manual burning will be allowed.

9.5 Plates may be sheared or burned. All burning shall be done by machine-guided torch, no manual burning will be allowed.

9.6 The roughness of gas-cut surfaces shall not exceed the tolerance defined by AWS D1.1.

9.7 SPECIAL WELD CONSIDERATIONS

9.7.1 Shaft/Base plate or Shaft/Splice plate:

9.7.1.1 The weld shall be 100% joint penetration for all Stress Critical structures.

9.7.1.2 The weld shall be as required by design stress for all Deflection-Critical structures.

9.7.2 All circumferential welds between shaft sections shall be 100% joint penetration.

9.7.3 Longitudinal Welds – Other than at a slip joint:

9.7.3.1 The weld shall be 60% joint penetration in all materials ¾" thick or less.

9.7.3.2 The weld shall be 80% joint penetration in all materials thicker than ¾".

9.7.3.3 The weld shall be 100% joint penetration for a minimum length of six inches from any base plate/splice weld or any circumferential weld requiring 100% joint penetration.

9.7.4 Longitudinal Welds – In Slip Joints:

9.7.4.1 The weld at the end of the female section shall be 100% joint penetration for a minimum length equal to the slip joint design length plus six inches.

9.7.4.2 The weld at the end of the male section shall be 100% joint penetration for a minimum length of six inches.

9.7.5 Other Welds:

9.7.5.1 All other welds shall be fillet, bevel or a combination of both, as required by design.

9.8 Clearly mark components by stamping prior to galvanizing. Stamped marks shall be a minimum of ½" high letters.

9.9 Perform welding using welders, welding operators and tackers in accordance with AWS D1.1.

10 PROTECTIVE COATINGS

10.1 All materials to be coated shall be completely fabricated prior to the coating process.

10.1.1 Preparation and fabrication for galvanized structures shall be in accordance with ASTM A-385.

10.1.2 Galvanize members in accordance with ASTM A-123.

10.1.3 Safeguards against embrittlement shall be in accordance with ASTM A-143.

10.1.4 A Magnetic Coating Thickness Gauge per ASTM E-376 shall measure the galvanized coating thickness.

10.1.5 Repair damaged hot dip galvanized surfaces in accordance with A-780.

10.1.6 Galvanize fasteners in accordance with ASTM A-153.

10.1.7 Anchor bolts shall be galvanized the threaded length plus at least six inches.

11 QUALITY ASSURANCE

11.1 Inspection criteria shall be as defined in AISC, AWS D1.1.
11.2 Inspectors shall be qualified to ANSI recommended practice SNT-TC-1A.
11.3 All welding, welder certification and weld procedures shall meet the requirements of AWS D1.1
11.4 All material shall meet the certification requirements of AISC.
11.5 The Fabricator shall maintain a system, which allows verification of all materials meeting specified requirements.
11.6 Certified test reports shall be available, upon request by GRDA.
11.7 All cold-formed parts, in material over ½" thick, shall have the corners inspected along the entire length for cracks by a magnetic particle procedure. All discontinuities shall be repaired and re-inspected per the requirements of AWS D1.1.
11.8 All other formed parts shall be subjected to close visual inspection.
11.9 The Fabricator shall maintain an Inspection and Test Plan available for review by GRDA.
11.10 GRDA shall specify, in the Request for Quotation, any special inspection, load testing or pre-shipment assembly requirements.
11.11 The bidding company shall have on staff a licensed professional engineer to oversee the quality of completed product.

12 SHIPPING REQUIREMENTS

12.1 All materials shall be shipped with distinct marks for positive identification at the site.
- 12.1.1 The identification system will use component numbers as shown on the fabrication drawing submitted for approval.
- 12.1.2 Every component shall be marked with the assembly number assigned to it in the fabrication drawings.

12.2 All materials shall be carefully loaded for protection during shipment.
- 12.2.1 Small parts, lightweight components and fasteners shall be carefully boxed, crated or otherwise protected for shipment.
- 12.2.2 Components requiring bundling shall be banded with rustproof strapping to prevent staining.
- 12.2.3 All material shall be properly blocked on cars or trucks to prevent damage to the coating or distortion of members during transit.
- 12.2.4 All material shall be arranged to allow safe unloading at the site.

12.3 Each shipment shall have a detailed packing list included, specific to that shipment. Each crate shall be labeled with the content of the crate.
12.4 All shipments shall be made to:

GRDA Transmission Warehouse
635 E Hwy 69A
Pryor, OK 74361
Receiving hours M-F 0700-1530

GRDA may provide an alternate shipping location with the Purchase Order.

12.5 GRDA shall be provided with a 48 hour (week day) pre-delivery notification by the fabricator. Notification shall be to:

Laurel Swift, Project Coordinator
Phone: 918-824-7807
Laurel.swift@grda.com

Robert Wheeler, Warehouse
Phone: 918-824-7850
Robert.wheeler@grda.com

Deanna Patschke, Substation Engineering Manager
Phone: 918-610-9789
Deanna.patschke@grda.com

Steven Kroll, P.E., Sr. Manager, T&D Engineering
Phone: 918-610-9669
Steven.kroll@grda.com

John Ladd, Sr. Project Manager
Phone: 918-824-7528
John.ladd@grda.com

13 GUARANTEE

13.1 The Fabricator shall furnish warranty for all materials and workmanship for a period of one (1) calendar year from the date of receipt against all defects due to faulty workmanship or materials and shall agree to replace same at no expense to GRDA.

14 DOCUMENTATION

14.1 The Fabricator shall provide one (1) CD copy and one (1) paper copy, per substation, of the final drawings.

14.2 All drawings will be generated using IBM compatible computers utilizing the Windows platform and using AutoCAD V. 2010 software by AutoDesk. Electronic copies of the final drawings in the DWG file format will be required.

14.3 Required documents shall consist of:

Bill of Material
Steel Detail Drawings
Steel Assembly Drawings
Calculations

14.4 The address for all correspondence and drawing submittals is:

Deanna Patschke, Substation Engineering Manager
Grand River Dam Authority
9933 E. 16th Street
Tulsa, OK 74145
Email: deanna.patschke@grda.com

Steven Kroll, P.E., Sr. Manager, T&D Engineering
Grand River Dam Authority
9933 E. 16th Street
Tulsa, OK 74145
Email: steven.kroll@grda.com

John Ladd, Sr. Project Manager
Grand River Dam Authority
9933 E. 16th Street
Tulsa, OK 74145
e-mail: John.ladd@grda.com

14.5 The address for shipment is:

GRDA Transmission Warehouse
635 E Hwy 69A
Pryor, OK 74361
Receiving hours M-F 0700-1530

14.6 All correspondence, documents, and shipments shall be labeled with the appropriate project name.

15 ACCEPTANCE OF EQUIPMENT

15.1 After delivery, the steel will be inspected by GRDA for visible damage, missing items, and signs of poor workmanship. Equipment or materials that are not acceptable shall be repaired, corrected, or replaced by the Fabricator at no additional cost to GRDA before the steel is accepted.

15.2 Acceptance does not occur until all equipment and documentation required by the specification and necessary to install the equipment is received by GRDA.

15.3 Acceptance of the equipment by GRDA does not relieve the Fabricator of the responsibility for the adequacy of materials and proper operation of equipment.

16 TERMS OF PAYMENT AND CONDITIONS

16.1 All proposals, bids, or quotations shall be FOB Destination.
16.2 No partial payments shall be made for partial shipments.
16.3 Conditions of the "Acceptance of Equipment" must be met before any payment will be made.

17 Evaluations of Bids

17.1 Bids shall be evaluated based on the following:

- Price: original cost and life cost (the bid may include an option for different prices for different delivery dates).
- Delivery: as needed for the project
- Suitability: ability to meet the needs of the project

The bid must include enough technical data and information to allow the evaluator to understand what is being bid, and how this meets the needs of the project.

Any and/or all exceptions shall be specifically enumerated with reference to the item in the specification that they are taking exception to. If these are not specifically listed, it will be assumed that the bidder will meet the specification, and will be held to it.