



Appendix 1 to BOT Scope Book Collector Substation

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APPENDIX 1

TO BOT SCOPE BOOK

COLLECTOR SUBSTATION

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Appendix 1: Collector Substation

1 INTRODUCTION

1.1 Purpose

This Appendix 1 to the Scope Book (this “Appendix 1”) provides design requirements and reference material for the design of renewable energy (solar, wind, battery storage) collector substations (the “Collector Substations”) that will be built in or connected to the Project. This Appendix 1 is intended to provide to Seller and others acting at Seller’s request requirements, recommendations, and guidance in the planning, design, construction, asset management, use, and operation of the Collector Substations.

1.2 Scope

This Appendix 1 applies to all new Collector Substations.

This Appendix 1 primarily describes technical requirements, both performance-based and prescriptive for the design and installation of Collector Substations. Refer to the Scope Book and other parts of the Agreement for information regarding project sequencing and milestones, the project execution plan, project schedule and schedule management, project controls reporting, health and safety information, factory acceptance tests, training, required submittals, design reviews, equipment records, specified deliverables, project documentation, and other relevant matters not covered by this Appendix 1.

1.3 General Data

This Appendix 1 addresses aspects of the Work relating to Collector Substations. It is not intended to be, and shall not be construed to be, a comprehensive list of each and every element or other requirement applicable to the Work and shall in no way limit Seller’s obligations under the Agreement or any Ancillary Agreement. Seller shall comply with, any cause its Contractors and Subcontractors to comply with, the terms of this Appendix 1, the Scope Book, all Laws (including codes) and applicable Permits.

This Appendix 1 provides the minimum functional specification (MFS) for the Collector Substations, including scope and design requirements. In addition to the requirements set forth in the Agreement (including the Scope Book), the Collector Substations shall comply with all requirements specified in the GIA or any other Required Deliverability Arrangement.

This Appendix 1 is part of the Scope Book.

Article, Section, Table, Figure, and Attachment references in this Appendix are to this Appendix 1 unless otherwise provided or the context otherwise requires.

1.4 HV Collector Substation Work

The Work includes the supply, assembly, and installation of the following components:

- HV switchgear, if applicable
- MV switchgear, if applicable
- MV/HV transformer(s)
- Switchyard buses
- Revenue metering
- Circuit breakers
- Disconnect switches
- Overhead line
- Normal AC and DC Power Distribution
- Backup power supply/emergency generator
- UPS, if applicable
- HVAC
- Grounding (grid and conductors)
- Lightning protection system, if applicable
- Conduits and cable trays
- Cables
- Relay Protection
- Relay and Control Panels
- DC Control Power (including batteries, chargers, and motoring)
- Lighting systems (including emergency lighting)
- I&C system (including fire alarm system), if applicable
- Earthwork
- Structures
- Control enclosure
- Fencing

1.5 Deviations

Any deviations from the MFS for the Collector Substations or the terms of this Appendix 1 shall require Buyer's prior approval and will be subject to the terms of the Agreement.

2 DEFINITIONS, TERMINOLOGY AND ACRONYMS

Terms with initial capital letters used but not defined in this document shall have the meanings ascribed to such terms in the Agreement, unless the context manifestly requires otherwise. For the avoidance of doubt, the rules of interpretation set forth in the main body of the Agreement shall apply to this document.

Equipment support structures: Generally, refers to all structures within the Collector Substation other than the control house.

System Voltage: The root-mean-square (rms) phase-to-phase voltage of a portion of an alternating-current electric system. Each system voltage pertains to a portion of the system that is bounded by transformers or utilization equipment. (All voltages are rms phase to-phase or phase-to-neutral voltages.) (ANSI C84.1)

Nominal System Voltage: The voltage by which a portion of the system is designated, and to which certain operating characteristics of the system are related. Each nominal system voltage pertains to a portion of the system bounded by transformers or utilization equipment. (ANSI C84.1)

Maximum System Voltage: The highest system voltage that occurs under normal operating conditions, and the highest system voltage for which equipment and other components are designed for satisfactory continuous operation without derating of any kind. In defining maximum system voltage, voltage transients and temporary overvoltages caused by abnormal system conditions such as faults, load rejection, and the like are excluded. However, voltage transients and temporary overvoltages may affect equipment operating performance and are considered in equipment application. (ANSI C84.1)

Low Voltage (LV): Nominal system voltage less than 1000 volts. This term is also used as an adjective to designate the low voltage winding of a power transformer and for referring to the low voltage side of a distribution substation.

Medium Voltage (MV): Nominal system voltage above 1 kV and up to 38 kV. (Note that ANSI C84.1 defines medium voltage as nominal system voltage above 1 kV and below 100 kV).

High Voltage (HV): Nominal system voltages 69 kV and higher up to 230 kV. (Note that ANSI C84.1 defines high voltage as nominal system voltage between 100 kV and 230 kV). This term is also used as an adjective to designate the high voltage winding of a power transformer and for referring to the high voltage side of a distribution substation.

Extra High Voltage (EHV): Nominal system voltage 345 kV and above.

Ampacity: The current-carrying capacity, expressed in amperes, of an electric conductor under stated thermal conditions.

Distribution Substation: A substation whose combination of switching equipment and step-down power transformers are arranged to reduce incoming transmission and distribution voltages, from Transmission up to 230 kV, to Distribution at 34.5 kV and below, for distribution of power to rural, residential, commercial, and industrial loads. It may or may not contain transmission breakers. Distribution substations may also be a combination of switching equipment and step-down transformers arranged to reduce distribution voltages to lower distribution voltages.

Switching Station: A substation that connects three or more transmission lines 69 kV or above without power transformers. A switching station does not serve distribution load and does not include transformation.

Transmission Substation: A substation, 69 kV or above, containing switches, circuit

breakers, busses, and transformers for switching power circuits and to transform power from one voltage to another or from one system to another.

Note: the terms switching station and substation are commonly used as interchangeable.

Finished Grade (or Subgrade): Design site elevation, after site grading.

Substation Designer: For the purposes of this guide, any person, regardless of business unit or contractor or employment status, who makes decisions pertaining to the equipment to be used in a substation, or the manner in which it will be used. Generally, the term “Substation Designer” includes substation layout and relay designers.

Base flood means the flood level having a one percent chance of being equaled or exceeded in any given year. Base flood is also known as 100-year flood. Note that a 100 year flood does not mean that such a flood occurs once every 100 years; instead, it means that there is a one in one-hundred (or 1%) chance of such a flood occurring in a given year. There is approximately a 63.4% chance of one or more 100 year floods occurring in any 100 year period.

3 Applicable Codes and Standards

The Collector Substation shall be designed and constructed in accordance with all applicable and up to date codes, ordinances and standard industry practices including, without limitation, ANSI, IEEE, NEMA, standards and FERC, NERC and OSHA regulations. This includes, without limitation, the standards and guidelines for substation design established by the following sources:

Applicable Standards and Organizations	
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
APLIC	Avian Power Line Interaction Committee
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing Materials
AWS	American Welding Society
CRSI	Concrete Reinforcing Steel Institute
IBC	International Building Code
ICE	Institution of Civil Engineers
ICEA	Insulated Cable Engineers Association
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IESNA	Illuminating Engineering Society of North America
ISO	International Standardization Organization
NEC	National Electrical Code

Applicable Standards and Organizations	
NEMA	National Electrical Manufacturers Association
NERC	North America Electric Reliability Corporation
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
OSHA	Occupational Health & Safety Administration
SSPC	Steel Structures Painting Council
UL	Underwriters Laboratories
	ACI 318: Building Code Requirements for Structural Concrete
	AISC 360: Specification for Structural Steel Buildings
	ANSI/TIA-568-C.0-2009 Generic Telecommunications Cabling for Customer Premises
	ASCE 113: Design of Substation Structures
	ASCE 48: Design of Steel Transmission Pole Structures
	American Welding Society (AWS) D1.1
	IEEE Std 605-2008: IEEE Guide for Bus Design in Air Insulated Substations
	IEEE Std 693-2018: IEEE Recommended Practice for Seismic Design of Substations
	IEEE Std 1527-2018: IEEE Recommended Practice for the Design of Buswork Located in Seismically Active Areas
	NECA/FOA 301-2009 Installing and Testing Fiber Optics
	RUS Bulletin 1724-200 Rural Utilities Service Design Manual for High Voltage Transmission Lines Electrical System Requirements
	RUS Bulletin 1724-300 Rural Utilities Service Design Guide for Rural Substations

The latest issued Standards and Codes at the issuance of the effective date of the Agreement shall be used. Earlier editions are not allowed unless specifically identified in this Appendix 1.

If a revision to a standard or code is issued, it is not required to be implemented unless the Authority Have Jurisdiction (AHJ) has adopted it, in which case, Seller is obligated to any increased compliance above what is required by the Standards and Codes at the effective date of the Agreement. This risk is borne by Seller.

4 SAFETY

The Substation Designer shall incorporate safe work practices into the design of the collector substation. The Collector Substations design and construction shall allow safe operation and maintenance under all foreseeable operating conditions. The design shall ensure that maintenance can be carried out without a significant effect on the Collector Substations operation and will allow adequate working space to maintain minimum approach distances as specified in the Section 5.2.3, Table 3.

Other aspects such as fire hazard and fire suppression and environmental aspects, such as site drainage and oil containment, shall be considered and incorporated in the design. The Substation Designer is

responsible for ensuring that the Collector Substations are designed in compliance with the National Electrical Safety Code, OSHA, and other regulations. See Section 6 for further details.

5 GENERAL REQUIREMENTS

5.1 Site Environmental Characteristics

Seller shall use the criteria and values set out in "Attachment 2 – Site Environmental Characteristics" and any other criteria and values reasonably determined by Buyer to be necessary or appropriate in the design of the Collector Substation.

5.2 Substation Current, Voltages and Clearances

5.2.1 Current Ratings

The Collector Substation bus systems, jumpers and equipment which is part of the bus shall be designed to serve the maximum equipment ratings. Equipment attached to buses, but not a part of the bus system, shall be designed to service the equipment maximum capabilities.

Any current calculation performed shall take into consideration ambient temperature, temperature rise, conductor maximum operating temperature and coefficient of emissivity. Typical and acceptable ambient temperature value for continuous ampacity shall be 40°C.

Size, variety, and types of conductors used in the Collector Substation shall be kept as minimal as practical.

5.2.2 Voltage Ratings

The Collector Substation equipment and bus systems shall be designed for the voltage ratings in accordance with Table 1. Any project-specific voltage requirements shall be considered, such as high voltage or contamination will dictate increased Basic Impulse levels ("BIL") for a specific design. This shall be coordinated and agreed upon by Seller and Buyer during project planning phases.

Table 1: Equipment Voltage Ratings

Nominal Voltage	Rated Voltage	BIL	BSL	Remarks
13.8 kV	15.5 kV	110 kV		Bus, and Disconnects shall be rated 34.5 kV, 200 kV BIL
24 kV	25.8 kV	150 kV		Bus, and Disconnects shall be rated 34.5 kV
200 kV BIL				
34.5 kV	38 kV	200 kV		
69 kV	72.5 kV	350 kV		
115 kV	121 kV	550 kV		Circuit breakers and instrument current transformers shall be

Nominal Voltage	Rated Voltage	BIL	BSL	Remarks
				rated 145 kV and 650 kV BIL.
138 kV	145 kV	650 kV		
161 kV	169 kV	750 kV		
230 kV	242 kV	900 kV		Instrument current transformers shall be rated 242 kV, and 1050 kV BIL
345 kV	362 kV	1300 kV	825 kV	
500 kV	550 kV	1800 kV	1175 kV	

5.2.3 Clearances and Spacing

All Collector Substation equipment shall be designed to maintain minimum substation clearances and spacing in Table 2, Table 3, Table 4, and Table 7. The below clearances are the minimum allowable clearances for common collector substation HV and MV voltages. Values listed are for altitudes of 1000 meters (3300 feet) or less. See IEEE 1427 for altitude adjustments (if required).

Table 2: Substation Minimum Clearances

Minimum electrical clearances between the conductors, and conductors to ground, shall be as tabulated below.

Nominal Voltage	BIL (BSL)	Minimum Clearance to Ground for Rigid Parts	Minimum Clearance Between Phases (or Live Parts) for Rigid Parts, Metal to Metal
7.5 kV	95 kV	7 inches	8 inches
15 kV	110 kV	8 inches	9 inches
25 kV	150 kV	11 inches	12 inches
34.5 kV	200 kV	15 inches	16 inches
69 kV	350 kV	26 inches	29 inches
115 kV	550 kV	41 inches	45 inches
138 kV	650 kV	49 inches	54 inches
161 kV	750 kV	56 inches	62 inches
230 kV	900 kV	67 inches	74 inches
345 kV	1300 (975) kV	97 (100) inches	105 (140) inches
500 kV	1800 (1300) kV	135 (150) inches	150 (215) inches

Table 3: Substation Minimum Safety Clearances

Minimum horizontal and vertical clearances to live parts for worker safety shall be as tabulated below. These clearances are intended to prevent unintentional encroachment by a worker into the guard zone.

Nominal Voltage	BIL (BSL)	Vertical Clearance	Horizontal Clearance
7.5 kV	95 kV	8 ft 10 in	3 ft 4 in
15 kV	110 kV	9 ft	3 ft 6 in
25 kV	150 kV	9 ft 3 in	3 ft 9 in
34.5 kV	200 kV	9 ft 6 in	4 ft
69 kV	350 kV	10 ft 5 in	4 ft 11 in
115 kV	550 kV	11 ft 7 in	6 ft 1 in
138 kV	650 kV	12 ft 2 in	6 ft 8 in
161 kV	750 kV	12 ft 10 in	7 ft 4 in
230 kV	900 kV	13 ft 9 in	8 ft 3 in
345 kV	1300 (828) kV	18 ft 11 in	13 ft 5 in
500 kV	1800 (1167) kV	27 ft	21 ft 6 in

Table 4: Substation Minimum Vertical Clearances above Ground

Maximum System Voltage	Pedestrian Traffic	Roadways
7.5 kV	14 ft 6 in	18 ft 6 in
15 kV	14 ft 6 in	18 ft 6 in
25 kV	14 ft 6 in	18 ft 6 in
38 kV	14 ft 6 in	18 ft 6 in
72.5 kV	15 ft 2 in	19 ft 2 in
121 kV	16 ft 1 in	20 ft 1 in
145 kV	16 ft 7 in	20 ft 7 in
169 kV	17 ft	21 ft
245 kV	18 ft 6 in	22 ft 6 in
362 kV	20 ft 9 in	24 ft 9 in
550 kV	24 ft 4 in	28 ft 4 in

Note: These clearances shall be maintained under the maximum conductor operating temperatures.

Table 5: Substation Minimum Horizontal Clearance to Fence

Nominal Voltage	BIL	Clearance to Fence
7.5 kV	95 kV	10 ft
15 kV	110 kV	10 ft 1 in
25 kV	150 kV	10 ft 4 in
34.5 kV	200 kV	10 ft 7 in
69 kV	350 kV	11 ft 7 in
115 kV	550 kV	13 ft
138 kV	650 kV	13 ft 8 in
161 kV	750 kV	14 ft 4 in
230 kV	900 kV	15 ft 5 in
345 kV	1300 kV	18 ft 4 in
500 kV	1800 kV	21 ft 6 in

5.3 Substation Equipment

5.3.1 Approved Manufacturers

An Approved Manufacturer List is included in Attachment 1. The Approved Manufacturer List includes a column with applicable Entergy purchase specifications. Approved Manufacturers should already be familiar with the applicable Entergy specifications and be able to provide equipment conforming to these specifications. Seller shall procure items from manufacturers listed in the Approved Manufacturer List in accordance with the applicable Entergy purchase specification and in accordance with this specification.

5.3.2 HV Cables

Seller shall comply with the requirements of the GIA for the design, manufacturing, installation, and testing of all HV cables.

5.3.3 Substation Bus/Conductors

Cable connections between the tube bus and equipment and between equipment shall be ACSR (aluminum conductor steel reinforced), AAAC (all aluminum alloy cable) or AAC (all aluminum cable). Bus connectors shall be aluminum alloy for aluminum-to-aluminum connections and tinned bronze for aluminum-to-copper connections. Hardware connectors shall be welded onto the cable or tube. Aeolian cable shall be installed in the switchyard tubing to limit bus vibration.

5.3.4 Insulators

All insulators for the rigid bus system and disconnect switches shall be porcelain station post and shall be ANSI 70 gray in color. High strength or extra-high strength insulators may be required based on detailed analysis. See Section 5.3.4.1. Polymer station post insulators shall be used for jumper standoff support.

Insulators shall conform to ANSI C29 standards. Insulators shall be specified to satisfy mechanical and electrical requirements including creepage based on the project contamination criteria. If contamination criteria is not available, medium (35mm/kV) shall be used.

5.3.5 Insulator Strength

The determination of the required cantilever strength of the insulator shall be performed in accordance with ANSI/IEEE Standard 605. The determination of the required effective bus span length due to insulator strength shall be determined for the insulator chosen and the external forces applied.

5.3.6 Load Combinations:

Case 1 – Extreme Wind:	2.5 D + 2.5 W IFW + 1.0 SC
Case 2 – Ice with Concurrent Wind:	2.5 D + 2.5 IWIFI + 2.5 WIIFI + 1.0 SC
Case 3 – Seismic:	2.5 D + 2.5 E (or EFS)IFE + 1.0 SC

Refer to ASCE 113 for definitions of the load components within the load cases above. Design values for these load cases shall be as defined in Section 7.1. IEEE 605-2008 recommends a safety factor of 0.4 be applied to insulator strengths for loads other than short circuit loading and 1.0 for short circuit loading. As

detailed in IEEE 605-2008, Section 12.4.2, when different load types are combined, the loads must be calibrated by the appropriate safety factor. As such, the 2.5 Load Factors on loads other than short circuit loading shown above are used to account for the safety factor on the insulator strength.

5.3.7 Surge Arresters

The surge arresters shall be station class, metal-oxide (MOV) type. Surge arresters shall be in accordance with ANSI C62.11. The arrester housing shall be made of polymeric silicone and shall be gray in color. Arresters up to a rated duty cycle voltage of 60 kV shall be of single unit construction, and not more than 2 pieces up through 120 kV.

Arresters shall not be used as rigid bus supports. Arresters shall be installed on all incoming line terminals and at transformer terminals. Arresters shall be installed as close as possible to the equipment being protected. Ratings for surge arresters shall be as shown in Table 5 and dimensions shall be as shown in Table 6.

Table 6: Station Class Surge Arrester Ratings

Nominal System Voltage (kV)	System Type	Rated Duty-Cycle Voltage (kV)	Rated MCOV (kV)
2.4	Effectively Grounded, wye connected system	3	2.55
	Ungrounded or Impedance Grounded, Delta connected system	3	2.55
	Distribution Networks (Note)	3	2.55
4.16	Effectively Grounded, wye connected system	6	5.1
	Ungrounded or Impedance Grounded, Delta connected system	6	5.1
	Distribution Networks (Note)	9	7.65
12.47-14.4	Effectively Grounded, wye connected system	12	10.2
	Ungrounded or Impedance Grounded, Delta connected system	18	15.3
	Distribution Networks (Note)	21	17
23	Effectively Grounded, wye connected system	21	17
	Ungrounded or Impedance Grounded, Delta connected system	36	29
	Distribution Networks (Note)	36	29
34.5	Effectively Grounded, wye connected system	30	24.4
	Ungrounded or Impedance Grounded, Delta connected system	48	39
	Distribution Networks (Note)	48	39
69	Effectively Grounded, wye connected system	60	48
115	Effectively Grounded, wye connected system	96	76
138	Effectively Grounded, wye connected system	120	98
161	Effectively Grounded, wye connected system	132	106
230	Effectively Grounded, wye connected system	192	152
345	Effectively Grounded, wye connected system	276	220

Nominal System Voltage (kV)	System Type	Rated Duty-Cycle Voltage (kV)	Rated MCOV (kV)
500	Effectively Grounded, wye connected system	420	335

Note: Ungrounded Distribution Network and Systems where an accidental ground can exist for long periods of time.

Table 7: Arrester Housing Dimensions by Rating

Rated Duty-Cycle Voltage	Creepage Distance	Height
3 kV	15"	8"
6 kV	20"	10"
12 kV	25"	13"
18 kV	34"	14"
21 kV	38"	16"
30 kV	45"	19"
36 kV	55"	23"
48 kV	55"	23"
60 kV	69"	25"
96 kV	115"	45"
120 kV	138"	50"
132 kV	161"	65"
192 kV	230"	92"
276 kV	345"	110"
420 kV	500"	175"

5.3.8 Disconnect Switches

GSU high-side main disconnect switches are not required when there is only a single transformer configuration. The HV line disconnect shall provide isolation to HV circuit breaker and transformer without compromising safety or operations. When a dual transformer configuration is in place, the high side transformer circuit breaker shall include disconnect switches. The GSU shall include a low side disconnect switch to allow isolation of the entire transformer zone without the need of opening feeder circuit breaker hooksticks.

The disconnect switches shall be three-pole, group operated, single-throw complete with station post insulators, switch blades, contacts, operating mechanisms and include all necessary hardware for the assembly and mounting to steel structures. All disconnect switches shall conform to IEEE Standard C37.30.1 for HV switches. Ratings for disconnect switches shall be as shown in Table 7 and Table 8.

Standard practice is to orient the vertical and side break switches so that the blade shall be dead when the switch is in the open position, i.e., the hinge shall be towards the closest circuit breaker.

All disconnect switches shall be provided with arcing horns which will interrupt charging or magnetizing currents to prevent any arcing at the main switch contacts. Grounding switches will be required for HV line disconnect switches. The line disconnect switch and associated ground switch shall be mechanically

interlocked to avoid mis-operation, i.e. closing the line disconnect switch when the ground switch is closed and vice versa.

Table 8: HV Disconnect Switch Ratings

Nominal Operating Voltage (phase-to-phase)	230kV	161 kV	138kV	115kV	69kV	34.5 kV
Maximum Voltage (phase-to-phase)	See Table 1					
Basic Impulse Level (BIL)						
Maximum Continuous Current (amperes)	To be determined after study results					
Short Time Withstand (symmetrical) Current	To be determined after study results					
Preferred Configuration Type	Vertical Break/Double End Break/Center Break					Vertical Break/Center Break/ Hookstick

Table 9: EHV Disconnect Switch Ratings

Nominal Operating Voltage (phase-to- phase)	345kV	500kV
Rated Voltage	362 kV	550 kV
Lightning Impulse Withstand Voltage	1300 kV	1800 kV
Switching Impulse Withstand Voltage	885 kV to ground 1120 kV across open gap	1150 kV to ground 1450 kV across open gap
Rated Continuous Current:	2000 A, or 3000 A (To be determined after study results)	2000 A, or 3000 A (To be determined after study results)
Rated Short Time Withstand	63 kA rms, 164 kA peak	63 kA rms, 164 kA peak
Short-time Current Withstand Duration	3 seconds	3 seconds

Line switches shall be monitored by the RTU or SCADA system.

All disconnect switches whether motorized or not will have auxiliary contacts for system monitoring. Auxiliary contacts on motorized switches will not be actuated by the motor cam but will be triggered based on the physical switch position.

Electrical interlocks shall be installed to prevent opening of motor operated disconnects and/or grounding switches when the station main breaker is in the closed position.

The complete switch assembly shall have a rated ice breaking ability to open and close with a ¾" thick coating of ice.

Gradient control rings shall be provided for switches at 230kV and higher voltages on both the hinge end and the jaw end to fully shield the live mechanism parts including the terminal pads.

Flexible braids are not acceptable as by-pass shunts. Flexible laminated current carrying components are acceptable only when welded connections are made on each end. Bolted connections are not acceptable on laminated components. All moving contact surfaces for current transfer shall be silver or silver alloy. Aluminum or plated aluminum is not acceptable.

The switches shall be free of visible corona at 110% rated voltage. The Radio Influence Voltage (RIV) shall not exceed 300 microvolts.

All fastenings, nuts, bolts and washers utilized in the non-live parts area shall be of hot-dipped galvanized steel. Plated fastenings are not acceptable.

All bearings shall be heavy duty with stainless steel balls and races. Aluminum or its alloys are not acceptable as a material for bearing raceways or bushing surfaces.

Bearings shall be maintenance free and not located in the current carrying path. Switch bearings shall be lubricated and sealed and shall not require further field lubrication. Dry type, non-lubricated type bearings will be preferred. Lubricant shall be non-deteriorating with a projected shelf life in excess of ten years. All bearing assemblies shall be weatherproofed with corrosion-free seals.

All switches supplied with manual operating mechanism shall be readily convertible to motor operation.

Maintenance ground studs shall be supplied on both hinge and jaw sides of the switch for attachment of portable ground cables. Design of the ground stud attachment shall be such that presence or absence of the ground studs will not change the switch height from its base to the top of the switch terminal pads. Ground studs shall be capable of being added to a switch in the field without undue switch dismantling. The ground studs shall be corona-free and shall be fully shielded where necessary. The ground stud material shall be the same as that of the switch contacts. The ground stud length shall be at least 6" for attaching the portable ground cable clamps and have sufficient strength to support a 50 foot length of a 4/0 copper portable ground cable.

5.3.9 Operating Mechanism

Hookstick operated switches may be used for equipment or circuit isolation, and regulator bypass applications up to 34.5 kV. Hookstick operated disconnect shall be located to provide switch operator space to allow 45 degree switch stick angle, for opening or closing, without operator or switch stick bumping into adjacent equipment, structures or foundations. Escape paths shall be considered in layout to deal with arcing or equipment failure that might occur during switching any switch or local breaker operation.

Switches shall be supplied with a manual three-phase group operated mechanism. The operating mechanism shall be designed such that the complete three phase switch assembly can be operated to fully open and closed positions by one person with a force of not more than 35 lbs applied to the actuating handle.

The vertical operating pipe operation for switches up to and including 145 kV shall be torsion operated by a swing handle. The swing handle shall be galvanized steel pipe not less than 3 feet in length. The switch design, where operation with a swing handle would require a force greater than 35 lbs, shall utilize a worm gear operator.

The vertical operating pipe operation for 170 kV and 230 kV switches shall be torsional operated by a worm gear in lieu of swing handle.

For 363 kV and 550 kV switches, the switch shall be supplied preferably with a three-phase torsional gear drive mechanism with a gearbox for each pole. The operating mechanism shall be designed such that the complete three-phase switch assembly, can be operated to fully open and closed positions with a force of not more than 35 lbs. applied to a manual actuating handle. The worm gear operator, when supplied, shall be in a sealed housing, corrosion and maintenance free. The gear operator shall be self-locking and prevent back driving of the crank handle during operation. The operating crank handle shall be no more than 15 inches in length.

Status indication of operator position is not required for manually operated switches but is required for motor operated switches.

5.3.10 EHV Switches (345 kV & 500 kV) Additional Requirements

The mounting location for the switch operating handle and/or the motor operator shall be the center pole support column.

The switch shall use porcelain station post insulators ANSI TR number 368, rated 1300 kV BIL for 362 kV switches and ANSI TR number 391, rated 1800 kV BIL for 550 kV switches.

5.3.11 Line Tuners

Communication using carrier equipment (line traps and tuners) shall not be used.

5.3.12 Metering Devices

5.3.12.1 General

Metering systems for the Project shall be designed and installed to monitor and record all energy traveling to and from the Project and to permit the evaluation of the functionality and efficiency of the overall Project.

Shorting-type terminal blocks shall be provided for all current transformer circuits to allow meters to be removed without disrupting current transformer circuits.

A set of metering current transformers on the GSU secondary shall be provided. Potential transformers shall be provided on the medium voltage buses for input to the meters. Shorting-type terminal blocks shall be provided to allow meters to be removed without disturbing current transformer circuits.

All permanently installed electrical metering instrumentation, or a combination of temporary test and permanently installed instrumentation, that will be used for the Project Performance Tests shall comply with maximum allowable measurement uncertainties per ASME PTC 22.

Except where more restrictive requirements apply, relaying class accuracy voltage and current transformers are acceptable for panel indication meter applications.

ABB FT-1 type test switches shall be provided for the voltage and current inputs to each meter.

5.3.12.2 Revenue Metering

The revenue metering system shall be included in the Work except for installation of the revenue meters, which shall be performed by Buyer. Seller shall purchase the revenue meter(s) from [Entity] Transmission during the design phase of the Project. Notwithstanding anything herein to the contrary, all revenue meters, installation and purchases thereof, and revenue metering shall be in accordance with the GIA or other applicable Required Deliverability Arrangement (to the extent applicable).

All meters shall conform to ANSI Standards C12.20, C12.1, and C12.10.

Seller shall provide and install high accuracy 0.15B1.8 extended range CTs and 0.15Z accuracy PTs for GSU high-side revenue metering. Seller shall provide the revenue meter cabinet(s) to Buyer's specifications. Seller shall design and install all wiring needed for revenue metering. Buyer shall install the revenue meters and make the final connections to the meters. Seller's schedule for the Work shall allow a reasonable period of time for Buyer to undertake, complete, and test such installation and final connections, and Seller shall use commercially reasonable efforts to cooperate with Buyer in connection with such installation and final connections.

5.3.12.3 Metering Locations

Other than where included with standard equipment packages (e.g., inverters), indication metering shall be provided in the following locations:

- High side of each GSU (voltage, current, kW, and kVAR)
- Each medium voltage main breaker (voltage, current, kW, and kVAR)

5.3.13 CCVT's & PT's

Voltage transformers and/or CCVTs are required to provide a low voltage supply to protective relays and metering equipment.

Voltage transformers, CVTs and CCVTs are directly connected to the high voltage bus.

Fuses shall not be used on the high side of the Voltage Transformer.

Auxiliary transformers are not permitted.

Refer to Table 10 and Table 11 for required CCVT and PT ratings, respectively.

Table 10: CCVT Ratings

Nominal System Voltage	Maximum Line to Ground Voltage	BIL	Performance Reference Voltage	Nameplate Ratio	Nameplate Secondary Voltage	Accuracy
69 kV	42 kV	350 kV	40.25 kV	350 / 600:1	115 / 67.1 Volts	0.6 WXYZ
115 kV	70 kV	550 kV	69 kV	600 / 1000:1	115 / 69 Volts	0.6 WXYZ
138 kV	84 kV	650 kV	80.5 kV	700 / 1200:1	115 / 67.1 Volts	0.6 WXYZ
161 kV	98 kV	750 kV	92 kV	800 / 1400:1	115 / 65.7 Volts	0.6 WXYZ
230 kV	140 kV	1050 kV	138 kV	1200 / 2000:1	115 / 69 Volts	0.3 WXYZ, ZZ
345 kV	209 kV	1550 kV	209 kV	1800 / 3000:1	115 / 69 Volts	0.3 WXYZ, ZZ
500 kV	318 kV	1800 kV	287.5 kV	2500 / 4500:1	115 / 63.8 Volts	0.3 WXYZ, ZZ

Table 11: PT Ratings

System Voltage	BIL	Primary Voltage	Marked Ratio	Secondary Voltage (each winding)	Accuracy/Burden	Minimum Thermal Burden
15 kV	110kV	7.2 kV/12.47 kV Y	60 : 1	120 V	0.3Z	1000 VA
15 kV	110kV	8.4 kV/14.4 kV Y	70 : 1	120 V	0.3 Z	1000 VA
25 kV	150kV	14.4 kV/24.9 kV Grd Y	120/200 :1:1	120 / 72 V	0.3 Z	1000 VA
34.5 kV	200kV	20.125 kV/34.5 kV Grd Y	175/300:1:1	115 / 67.08 V	0.3 Z	1000 VA
69 kV	350kV	40.25 kV/69 kV Grd Y	350/600:1:1	115 / 67.08 V	0.3 ZZ	2000 VA
115 kV	550kV	69 kV/115 kV Grd Y	600/1000:1:1	115 / 69 V	0.3 ZZ	2000 VA
138 kV	650kV	80.5 kV/138 kV Grd Y	700/1200:1:1	115 / 67.08 V	0.3 ZZ	2000 VA
161 kV	750kV	92 kV/161 kV Grd Y	800/1400:1:1	115 / 65.71 V	0.3 ZZ	2000 VA

230 kV	1050kV	138 kV/230 kV Grd Y	1200/2000:1:1	115 / 69 V	0.3 ZZ	2000 VA
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5.3.13.1 Current Transformers (CT)

All current transformers shall be in accordance with ANSI-C57.13 and shall meet the following requirements.

Relaying: Bushing type, fully distributed winding, five lead multi-ratio, C800 or as specified. (X and Y positions on a breaker bushing 69kV and higher; X position on a breaker bushing 34.5kV only.)

Metering: Bushing type, fully distributed winding, single- or dual-ratio, 0.15% B-0.9 and 0.30% B-1.8 or as specified. To be installed at the Z position on a breaker bushing for 69kV and higher or on the Y position on a breaker bushing at 34.5kV. See Revenue Metering Requirements sections.

Free standing post type current transformers shall be designed to operate at an average ambient temperature of 30°C and with a winding temperature rise not to exceed 55°C. In Buyer's service area, the ambient temperature under full sun can reach as high as 45°C to 50°C.

The minimum thermal rating shall be 2.0.

If continuous load is going to be "X" amps, then the CT shall also be rated "X" amps. Before applying a lower rated CT to benefit from the rating factor the application shall be evaluated thoroughly, and it is generally acceptable only if the peak load is seldom expected and for a very short duration.

Generally, the current transformer rated primary current shall be 10% to 40% above maximum load current when peak load information is unknown. Consideration shall also be given to short circuit levels. The maximum CT ratio shall be selected so that the maximum fault current is less than 20 times the maximum current tap, and so that the maximum secondary CT current is less than 100 amps under maximum fault conditions. An additional rating margin of not less than 25% shall be provided to accommodate future increased fault levels.

Refer to Table 12 and Table 13 for required minimum CT ratios and CT accuracy, respectively.

Table 12: CT Ratios

Fault Current	Minimum CT Ratio
48 – 64kA	4000/5
32 – 48kA	3000/5
20 – 32kA	2000/5
0 - 20kA	1200/5

Table 13: CT Accuracy

	Accuracy
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Metering Accuracy Class	At RF *100% Rated Current	At 10% Rated Current	At 5% Rated Current	At ≤ 1% Rated Current (Note)
0.3	0.3%	0.6%		
0.3S	0.3%		0.3%	
0.15	0.15%	0.3%		
0.15S	0.15%		0.15%	0.15%

The CT shall have the following primary current and minimum short-time thermal current rating, rms for one second. For bushing and slip-over CTs these ratings apply to the secondary winding only.

Table 14: CT Short-Time Thermal Current

Maximum System Voltage	Primary Current	Short – time Thermal Current
15.5 kV	1200 A	25 kA
	2000 A	31.5 kA
	3000 A	40 kA
25.5 kV	1200 kA	25 kA
	2000 A	31.5 kA
36.5 kV	1200 A	25 kA
	2000 A	31.5 kA
	3000 A	40 kA
72.5 kV	2000 A	40 kA
	3000 A	63 kA
123 kV	2000 A	40 kA
	3000 A	63 kA
145 kV	2000 A	40 kA
	3000 A	63 kA
170 kV	2000 A, 3000 A	40 kA
245 kV	2000 A	40 kA
	3000 A	63 kA, 80 kA
362 kV	2000 A	40 kA
550 kV	3000 A	40 kA

5.3.13.2 CT/PT Combo Units

CT/PT Combo units are not allowed. Exceptions must be approved by Buyer in writing.

5.3.14 Circuit Breakers

Circuit breakers shall be three phase dead tank design with current transformers (CTs) on each bushing. A sufficient number of CTs will be supplied to support the system protection and metering requirements. Circuit breakers shall use SF6 or vacuum interrupters.

DC power for the circuit breaker operation and protection will be 125VDC.

Bushings shall comply with the requirements of IEEE Std C37.017. Voltage class and the current rating of the bushings and insulators shall not be less than that of the circuit breaker.

Continuous current rating factor (RF) shall be 2.0 in accordance with IEEE Std. C57.13.

HV and MV breakers shall not have internal 43 Local/Remote switches. If the breakers do come with a 43 device, the device shall be jumpered out. The only 43 Local/Remote switch shall be in the relay panel in the control house, near the 52 CS. The relay panel 43 switch associated with each breaker shall be a three-position switch, with Local, Remote, and Maintenance positions only (i.e., no "Off" position).

HV and MV breakers shall permit local tripping (i.e., tripping via the control switch in the breaker cabinet OR the 52 CS in the relay panel) regardless of the position of the relay panel 43 switch associated with that breaker. HV and MV breakers shall permit local closing ONLY when the relay panel 43 switch associated with that breaker is in the "Local" position. HV and MV breakers shall permit remote closing ONLY when the relay panel 43 switch associated with that breaker is in the "Remote" position. The Maintenance position will be used when working on the circuit and shall initiate a different set of relay settings.

All circuit breakers shall have dual trip coils. Trip coil 1 and the close coil shall be on the same 125 VDC circuit. Trip coil 2 shall be on a separate 125 VDC circuit. Trip circuits shall be in separate cables.

A platform shall be installed for maintenance access if operators will not or would not reasonably be expected to be able to reach all breaker equipment while standing at grade (cabinet access 60" or higher). Seller shall perform a detailed review of breaker manufacturer drawings to ensure that operability concerns, such as proper cabinet heights or the need for a platform, are addressed.

5.3.14.1 High Voltage Circuit Breaker:

HV power circuit breakers shall be SF6 gas insulated, dead-tank, "puffer" type design with a spring-spring type operating mechanism. Auxiliary contacts for breaker internal control functions shall be provided plus additional form "a" and form "b" field convertible contacts per Table 15. Circuit breakers shall conform to IEEE C37. Circuit breaker ratings shall be as shown in Table 15.

Table 15: HV Circuit Breaker Ratings

Rated Maximum Voltage		72.5 kV	123 kV	145 kV	170 kV	242 kV
Rated Continuous Current (as specified)		1200 A	2000 A	2000 A	2000 A	2000 A
		2000 A	3000 A	3000 A	3000 A	3000 A
Rated Short Circuit Current (to be determined after study results)		40 kA	40 kA 63kA	40 kA 63kA	40 kA	40 kA 63kA
Lightning Impulse Withstand Voltage		350 kV	650 kV	650 kV	750 kV	900 kV
Rated Interrupting Time		5 cycles	3 cycles	3 cycles	3 cycles	3 cycles
Rated shunt Capacitor Switching current		630 A	315 A	315 A	400 A	400 A
Additional Auxiliary Contacts	Form "a"	12				
	Form "b"	12				

The alarm for SF6 gas breakers shall be annunciated at the operations control center. SF6 meter/monitor shall be suitable for the loss of SF6 emissions. All of the available alarms for HV breakers shall be inputs into the substation RTU and made available to the Electric Reliability Coordinating Council (ERCC) via the communications network.

All HV circuit breakers shall have low SF6 pressure alarms and emergency operations for:

Stage 1: Low gas pressure

Stage 2: Auto-trip of the Trip Coil 1 and Trip Coil 2 circuits and block close of the Close Coil circuit.

Stage 3: Block-trip of the Trip Coil 1 and Trip Coil 2 circuits and block close of the Close Coil circuit.

5.3.14.2 EHV Circuit Breakers (345 kV & 500 kV)

Additional specific requirements pertaining to 345 kV & 500 kV circuit breakers will be provided under separate cover where applicable.

5.3.14.3 Medium Voltage: Collector Feeders and Reactive Breakers:

MV Circuit breakers shall be rated for outdoor, three-poles, gang operated, dead tank, frame mounted vacuum type with motor charged operating mechanism in conform to IEEE C37. MV Circuit breaker ratings shall be as shown in Table 16.

Table 16: MV Circuit Breaker Ratings

Nominal Operating Voltage (phase-to-phase)	34.5 kV
Maximum Voltage (phase-to-phase)	See Table 2
Basic Impulse Level (BIL)	See Table 2
Maximum Continuous Current (amperes)	To be determined after study results
Short Circuit Interrupting Current (kA)	40kA with full back to back switching capability; tested and proven*
Interrupting Time (cycles)	3
Independent Pole (Phase) Operators	N/A
Duty Cycle	O-0.3 sec – CO -3 min - CO
Spring Motor Voltage	125VDC
AC Heaters and Receptacle Voltage	120/240VAC
Additional Auxiliary Contacts	Forms “a” and “b”

***40kA analysis - use conservative design/results. The results of final short circuit model shall dictate the final rating.**

5.3.14.4 Generator Step-up Unit (GSU) / Main Power Transformer (MPT)

This section describes requirements for the Main Power Transformer (MPT) within the collector substation. This item is also referred to as the Generator Step-up Unit (GSU). The GSU connects the medium voltage collector system to the high voltage interconnecting transmission system.

The GSU shall be built to ANSI/IEEE C57. The GSU shall be an outdoor, oil-filled power transformer and designed in accordance with the Project Site climactic conditions listed in Attachment 2. The transformer shall be a wye-g/wye-g/delta (internally buried) configuration with a neutral grounding bushing on the high and low sides.

The GSU ratings shall be based on the project expected total generation at all operating power factors, including all applicable derating factors and confirmed through software simulations. A minimum 10% design margin shall be included.

The GSU shall be purchased complete as a two winding with LV & HV bushings, current transformers, tap changers, surge arresters, cooling equipment (such as radiators & fans), and control/monitoring system equipment.

Table 17 below provide some recommended transformer specifications to consider.

Table 17: Transformer Recommended Specifications

Project MW		270	250	200	150	100	20
Transformer MVA	ONAN	180	168	135	102	69	18
	ONAF1	240	224	180	136	92	24
	ONAF2	300	280	225	170	115	
%Z (H-X, Positive Sequence)		9.0%	9.0%	8.5%	8.5%	8.0%	8.0%
X ₀ Neutral Reactor		Yes	Yes	Yes	Yes	No	No
Assumptions: 1. Power factor range required at point of interconnect is +/- 0.95 2. Inverters are capable of +/- 0.9 power factor 3. Substation is not close to synchronous generation switchyard 4. Transformers over 300 MVA not recommended due to 34.5 kV fault current 5. Based on transformer winding configuration: HV (wye-gnd); XV (wye-gnd); XV (delta-buried)							

5.3.14.5 Loss Evaluation

The test system accuracy for measuring losses shall be as specified in IEEE C57.12.00. The calibration and the accuracy of the test equipment shall be traceable to the National Institute of Standards and Technology.

The Manufacturer shall guarantee the following losses for each transformer:

No-Load loss in kilowatts at rated voltage and rated frequency

Total losses (sum of no-load loss and load loss) in kilowatts at ONAN rated output, rated voltage and rated frequency

Auxiliary losses (all cooling in operation)

Load losses shall be evaluated on the ONAN 65°C rating for each transformer.

Transformer losses determined under tests shall be corrected to 85°C. No- Load loss shall not be corrected.

All control components shall be capable of operating in a temperature range of minus 20°C to plus 70°C in the control cabinet(s). The control cabinet design shall ensure that all control components will operate satisfactory when the transformer is loaded beyond its nameplate rating in a 40°C ambient temperature, 90% relative humidity, in full sun with no wind. The control cabinet design shall ensure that damage from condensation inside the cabinet is prevented.

The basic impulse level (BIL) of the transformer windings and bushings shall be as listed below for the specified nominal system voltage. The neutral BIL for all wye-connected windings shall be a minimum of 150 kV.

Table 18: Transformer Winding and Bushing BIL

Nominal System Voltage	Winding Lightning Impulse Level
500kV	1550 kV
345kV	1175 kV
230 kV	825 kV
161 kV	650 kV
138 kV	550 kV
115 kV	450 kV
69 kV	350 kV
34.5 kV	200 kV
24 kV	150 kV
13.8 kV	150 kV

The transformer percent impedance at the self-cooled (ONAN) rating shall be as specified in Table 19 below (for 345 kV and 500 kV, requirements will be provided under separate cover);

Table 19: GSU Impedance

HV Winding Voltage	Impedance %	
	Without LTC	With LTC
230 kV	10.0	10.5
161 kV	9.5	10.0
138kV	9.0	9.5
115kV	8.5	9.0
69 kV	8.0	8.5
34.5 kV	7.25	7.5
24 kV	6.75	7.0
13.8 kV	6.75	7.0

The maximum average winding temperature rise shall be 65°C. The maximum hottest-spot temperature rise of the winding shall not exceed 80°C. The maximum hottest-spot temperature rise of any metal components in the transformer core and tank whether in contact or not in contact with the paper insulation, shall not exceed 80°C at an ambient temperature of 40°C.

The calculated maximum temperature rise of any lead or connection shall not exceed the calculated maximum winding hottest spot temperature rise.

The temperature of any serviceable metal parts, gauges, switch handles, etc., located in the control cabinet that may be touched by an operator under normal operation shall not be affected by the transformer and shall not exceed the ambient temperature by more than 10°C at maximum rated load.

Winding hottest-spot calculations shall be made for each winding using the maximum localized losses including the eddy current losses, the insulation thickness at the points of maximum localized losses, and the oil rise in the winding. If Seller is unable to measure the oil rise in the windings, an allowance will be made for the added rise at the design review. These results shall be used in calibrating the hot-spot temperature indicator.

The use of metal oxide varistor (MOV) or other internal devices to control voltage transients is not preferred and Seller shall obtain approval from Buyer prior to use. When MOVs or other internal arrestors are used, their location shall be shown on the nameplate winding schematic and they must be accessible from the top of the transformer without oil drainage.

The calculated maximum temperature rise of any lead or connection shall not exceed the calculated maximum winding hottest spot temperature rise.

The sound pressure level of transformers with an equivalent two-winding rating of more than 25 MVA (ONAN) shall be 6 dB below the levels specified in the NEMA TR-1.

The inter-winding insulation system for windings shall be designed for a BIL impulse to one minute 60 Hz. withstand level ratio of 2.5 or less, using maximum voltage stress and with a safety margin of 20% for the oil space stresses. Weidmann oil gap curves shall be used to determine the field stresses.

Ancillary equipment such as bushings, tap changer, winding leads, etc., shall not restrict the transformer loading to levels below those permitted by the winding conductor. The transformer shall be capable of carrying loads above its nameplate rating in accordance with IEEE C57.91.

5.4 Short Circuit Capability

The transformer shall be designed and constructed to withstand, without damage, the effects of both three-phase and line-to-ground through-faults at either of the transformer HV, LV, or TV terminals. The windings shall not exceed the IEEE thermal limits for the duration of 2 seconds. The pre-fault operating voltage on the non-faulted terminals shall be 1.05 per unit rated voltage.

All windings shall be designed for an infinite bus condition i.e. system impedance shall not be used in the calculation of the fault currents. The inner windings shall be designed to withstand maximum short circuit forces in an unsupported buckling mode (free buckling), assuming no radial mechanical support from the core. The windings shall also be designed for forced or supported buckling.

The transformer shall be designed according to the requirements of IEEE Std 693 Annex D. The transformer assembly shall be designed to withstand seismic loading as specified in IEEE 693.

High temperature fiberglass or Nomex insulation or other Entergy approved high temperature material shall be used for the insulation between the tie plates and the core.

The iron core shall be designed such that at full load and with 105% rated secondary voltage, the maximum core temperature (hotspot) shall not exceed 120°C (80°C rise at 40°C ambient), and the maximum tie plate or core surface temperature rise shall also not exceed 120°C (80°C rise at an ambient of 40°C).

5.4.1.1 Windings:

All winding conductor material shall be copper and all other current-carrying parts shall be copper or silver, or alloy(s) of copper and/or silver.

The current density in the winding conductor under maximum rated power at 65°C temperature rise shall not exceed 4 A / mm² (2580 amps per square inch).

The winding conductor insulation shall be thermally upgraded paper meeting the life criteria as defined and verified in IEEE C57.100. The minimum nitrogen content of the upgraded paper when tested by ASTM standards shall not be less than 2%.

5.4.2 Tank

All welding shall be in accordance with ANSI/AWS D1.1 / D1.1M, American Welding Society Steel Structural Welding Code.

The transformer tank shall be of welded sheet steel construction, free from distortion.

The transfer tank shall withstand full vacuum and at least 10 psig positive pressure without leakage or distortion.

The transformer tank cover shall be welded on with at least a 20-inch diameter manhole.

The transformer tank cover shall be welded to the tank using flanges to facilitate removal. With the exception of the main tank top and bottom plates, no side plate welding shall be within 6" of the corners. All tank joints shall be welded both on the inside and the outside.

The tank cover shall be peaked or sloped to prevent rainwater accumulation. All oil and gas seal designs shall have grooves for gasket retention and shall have groove-depth controlled compression for maximum seal life. Glue should not be used for the gasket retention.

All gaskets shall be one-piece, oil-resistant nitrile elastomer or Fluoroelastomer, such as Viton, compatible with the transformer operating temperature. All gasket materials shall be verified in accordance with ASTM D3455 to be compatible for the intended use with transformer oil. The gasket material shall also be fully compatible with the fluids used in the bushings. Gaskets shall not be exposed to the weather. Gasket material for the LV bushings shall be viton material or equivalent rating.

The location of the "shipping" and "dressed" center of gravity shall be marked with raised letters and symbols on the transformer tank.

The oil preservation system shall be a sealed-tank system with a constant pressure inert gas-pressure or conservator/diaphragm system.

5.4.3 Bushings and Terminals

All Bushings shall be in accordance with IEEE Std C57.19.01.

The minimum BIL of the bushings shall be as tabulated below.

Table 20: BIL ratings for GSU Bushings and Terminals

Nominal System Voltage	Rated Voltage of Bushing	Rated BIL of Bushing
500 kV		1675 kV
345 kV		1175 kV
230 kV	146 kV	900 kV
161 kV	102 kV	750 kV
138 kV	102 kV	650 kV
115 kV	88 kV	550 kV
69 kV	44 kV	350 kV
34.5 kV	22 kV	200 kV
24 kV	16 kV	150 kV
13.8 kV	10 kV	150 kV

The rated current of the bushing shall be as specified in IEEE Std C57.19.01 but not less than 1.2 times the transformer load current corresponding to its maximum MVA rating with full cooling in operation. The bushing shall not restrict the transformer loading to levels below those permitted by the winding conductor. The rate of loss of life of bushing shall not be more than that for the transformer when the transformer is loaded beyond its nameplate rating in accordance with IEEE Std C57.91

Bushing flange or (flange with adapter) sizes shall be such that the bushings and mountings supplied allow interchangeability with older IEEE standard bushings.

All bushings including the neutral bushing shall be provided with test taps.

All bushings shall be power factor tested. Values of "C1" and "C2" shall be stamped on the bushing nameplates.

The oil sight gauges or sight glass on cover-mounted bushings shall face "outward" so that the oil level sight glass in the bushing can be seen from ground level. All bushing nameplates are to face outward to allow reading of nameplates with spotting scope.

All bushings shall be paper-oil condenser type

Minimum clearance between the live parts of bushings and surge arresters to the components of the transformer that may be serviced (e.g. gas detector relay, valves, gauges, etc.) shall be in accordance with OSHA requirements. Bottom of the bushings shall be minimum 8.5 feet above ground including six inch foundation pad. Vertical clearance between the bushing terminal and the ground shall be in accordance with National Electrical Safety Code IEEE Std C2 requirements.

Bushings shall have the following creepage distance in Table 21

Table 21: GSU Bushing Creepage Distance

System Voltage	Creepage Distance
Up to 69 kV	48"
69 kV	69"
115 kV	138"
138 kV	138"
161 kV	230"
230 kV	230"
345 kV	345"
500 kV	415"

The H2 and X2 bushings shall be located on the same centerline, and where practicable shall be on the main tank centerline.

Minimum metal to metal clearance between the live parts of bushings in air shall be as tabulated below in Table 22

Table 22: GSU Bushing Minimum Clearance Between Live Parts

System Voltage (kV)	Clearance (inches)
Up to 69 kV	48"
115 kV	70"
138 kV	70"
161kV	70"
230 kV	78"
345kV	120"
500kV	160"

5.4.3.1 Bushing Current Transformers

Internal, multi-ratio, bushing-type current transformers (CT) shall be provided with all secondary terminals wired to shorting terminal blocks using ring type lugs without intermediary splices.

Typical CT Ratios are listed below in Table 23. Actual ratios to be confirmed as required to support protection relaying scheme requirements and shall be submitted to Buyer for approval. For 345 kV and 500 kV voltages, requirements will be provided under separate cover.

Table 23: GSU Bushing Typical CT Ratios

BUSHING VOLTAGE (kV L-L)	kV	600:5	1200:5	2000:5	3000:5	5000:5	XFMR WINDING MVA RATING: 3Ph @65C
	13.8	12-14 MVA	19-28 MVA	28-47 MVA	47-71 MVA	71-100 MVA	
	14.4	12-14 MVA	19-29 MVA	29-49 MVA	49-74 MVA	74-100 MVA	

	24	12-24 MVA	33-49 MVA	49-83 MVA	83-100 MVA		
	34.5	12-35 MVA	48-71 MVA	71-100 MVA			
	69	12-71 MVA	95-100 MVA				
	115	12-100 MVA					
	138	12-100 MVA					
	161	12-100 MVA					
	230	12-100 MVA					

The continuous thermal current-rating factor RF for the bushing current transformers shall be 2.0 based on temperature rise in accordance with IEEE Std C57.13 unless specified otherwise elsewhere in this Attachment.

All current transformers shall be multi-ratio with ratios in accordance with IEEE Std C57.13.

Provision shall be made to remove and replace the CTs without removing the tank cover.

Seller shall ensure that the manufacturer provides and includes on or as part of the transformer(s) for the Project:

Magnetic liquid level indicator with alarm contacts and threaded conduit hub, with two set points and two sets of alarm contacts per set point

Liquid filling and filter press connection in the top and bottom of the tank

Combination drain and bottom filter valve with sampler

Dial-type liquid thermometer and temperature-indicating switch with alarm contacts, maximum read pointer, and threaded conduit hub, with two set points and two sets of alarm contacts per set point

Vacuum pressure gauge with bleeder

Lifting hooks on the tank, lifting eyes on the cover and provisions for jacking

Stops shall be provided to prevent over-compression of gaskets; gaskets below oil level will be eliminated unless isolating valves are provided

Pressure relief device with alarm contacts and threaded conduit hub

A hot spot dial-type winding temperature indicator with alarm contacts shall be provided for each high voltage and low voltage winding, with a minimum of two (2) per transformer; each winding temperature indicator shall have two set points and two sets of alarm contacts per set point.

De-energized tap changer (DETC). A DETC is preferred, as follows:

Conform to IEEE C57.12.10, Article 5.1.1.

Steps at +5%, +2.5%, 0%, -2.5%, and -5%.

Operable from ground level, with a single external lockable operating handle not more than five feet above ground level.

The tap setting indicator shall be visible from ground level.

Capable of withstanding without damage the short-circuit duty specified for the transformer.

Load Tap Changer (LTC): If an LTC is determined to be required due to system and equipment requirements, then the following requires apply: A high-speed motor operated load tap changer with vacuum or resistance switching conforming to IEEE C57.12.10. Furnish as follows:

Range: plus-or-minus 10% in 32 - 5/8% steps with full MVA capacity on all taps above neutral position, and reduced MVA capacity on taps below neutral position. Preventive autotransformer (PA) if used shall be rated to maintain full capacity with the unequal steps.

Rated Current: not less than the maximum winding current at its rated maximum load (2 stages of supplemental cooling) even if provision only for cooling is initially supplied.

Tap position indicator: located where it can be readable and re-settable from the ground level and visible when manually operating the LTC. The position indicator shall have markings 16L – N - 16R to signify the Normal and the range extremes, and be in accordance with IEEE Std C57.12.10.

Each tap position indication shall provide a digital or analog output for indication in the substation control room and for SCADA indication.

Operation capability: Each contact shall be capable of 500,000 electrical and mechanical operations at the top MVA rating of the transformer before requiring contact replacement. The contacts shall be easily accessible.

The load tap changing equipment shall be contained in segment 2 in a compartment separate from the core and coils to prevent mixing of oil.

The hand crank for manual operation of the drive mechanism shall be operable while standing at the base of the transformer.

The automatic or manual operation of the LTC shall be blocked if the vacuum interrupter fails to interrupt and transfer the load current during a tap change operation.

LTC control relay. Wire to provide sequential or non-sequential operation.

LTC backup control relay

Latching relay for supervisory selection of AUTO or MANUAL REMOTE operation.

LTC Control devices: housed in the transformer control cabinet.

Switch for Manual-Off-Test-Auto control functions. A contact CLOSED when the selector switch is in either the "OFF" or "MANUAL" position shall be provided for the Buyer's supervisory indication.

Switch for Local-Remote control.

Tap Position Indicator with Drag Hands.

Tap position indication sending unit

Operations Counter.

Raise/Lower Switch.

Automatic voltage control equipment.

Terminal blocks for cable connection.

Heaters for anti-condensation

Stainless steel nameplates and tap changer warning/instruction plates; nameplates shall not be attached to the radiators

5.4.3.2 Cooling Fans:

Three-phase and wired to an auxiliary cooling equipment control panel for power connection, individually fused or otherwise thermally protected, controlled by the winding hot spot temperature.

Shall not be located on top of the radiators nor directly mounted on radiator fins. Separate, removable mounting support for fans shall be supplied and bolted to the transformer tank.

Fan guards shall be hot-dipped galvanized, totally enclose the fan blades, and meet OSHA safety requirements.

The radiators shall be equipped with bolted flanges and valves to permit the removal of any radiator without draining the oil from the transformer or any other radiator; lifting eyes shall be provided on each radiator/cooler group

Connection provisions shall be made in the cooling equipment controls circuit to allow external interlocking with the transformer protective relaying scheme, such that operation of normally closed

contacts of the transformer protection lockout relay (86T) will shut down the cooling equipment in the event of an internal transformer fault

Copper grounding pads shall be provided at opposite corners of the tank base. A NEMA 4-hole compression type lug for connection of a 500 kcmil ground cable to the station ground grid shall be provided for each ground pad and for the transformer neutral bushing ground connection which shall be bussed to the tank base.

Insulating Oil: Seller shall ensure the manufacturer fills the tank with oil and the transformer shall be provided with the necessary amount of high-grade insulating oil that contains no detectable PCBs; the oil shall be manufactured and tested in accordance with the requirements of ASTM D3487; identification of non-PCB liquid shall be placed on outside of tank.

Bushing mounted, station-type lightning arresters. Arrester ratings shall be as follows:

Table 24: GSU Arrester Ratings

System Voltage	Surge Arrester Rated Voltage	Surge Arrester MCOV
500 kV	420 kV	335 kV
345 kV	276 kV	220 kV
230 kV	192 kV	152 kV
161 kV	132 kV	106 kV
138kV	120 kV	98 kV
115kV	96 kV	76 kV
69 kV	60 kV	48 kV
34.5 kV	30 kV	24.4 kV
24 kV	21 kV	17 kV
14.4 kV	12 kV	10.2 kV
13.8 kV	12 kV	10.2 kV
13.2 kV	12 kV	10.2 kV
4.16 kV	6 kV	5.1 kV
2.4 kV	3 kV	2.55 kV

The height, from base to the terminal, of the arresters up to 34.5 kV shall be the same as that of the associated LV bushing to reduce probability of flash cause by wildlife. Spacers should be added at the base of the arresters if necessary.

All control wiring shall be 600-volt, 90 degrees C, and XLPE insulation, with stranded copper wire, No. 12 AWG (minimum) for power, No. 14 AWG (minimum) for controls, and No. 10 AWG (minimum) for current transformers

Terminal blocks shall be rated for 600 volts and accept conductors sized #18 through # 8 AWG; an additional 20% spare or extra terminal blocks shall be provided; heat shrink wire markers are required

A core grounding strap shall be provided and accessible from a tank top man-way.

5.4.3.3 Radiators

Radiators shall be detachable from the main tank and preferably shall be interchangeable. The radiators shall be equipped with bolted flanges and valves to permit the removal of any radiator without draining the oil from the transformer or any other radiator and without the loss of cooling from other radiator banks. Lifting eyes shall be provided on each radiator/cooler group.

Studs welded to the tank or headers for mounting of the radiators are not acceptable.

Radiator shut-off valves (butterfly type) shall be provided for each detachable radiator or header, at both top and bottom openings to the main transformer tank. It shall be possible to remove individual radiators for maintenance without the loss of cooling from other radiator banks. The open and closed positions on the radiator shut-off valves shall be clearly and marked

Radiators shall be heavy hot-dip galvanized in accordance with ASTM A123. As measured in accordance with ASTM A386, minimum zinc-coating thickness shall be 3 mils or 1.8 oz/ft². If any repair of the galvanizing coating is necessary, Supplier shall make such repairs in accordance with ASTM 780.

Radiator banks shall have lifting eyes.

Cooling Equipment Control

Winding temperature indicators/sensors shall be calibrated to simulate the winding(s) actual hottest spot temperature and shall actuate automatic control of the fans.

An alarm relay shall be provided for each stage for cooling failure.

A two-position "Fan Transfer Switch" shall be provided to allow selection of either bank of cooling equipment to operate on either stage of cooling.

A three position switch shall be provided to allow manual or automatic operation of cooling equipment. Switch positions shall be marked Auto-Off-Manual.

Each bank of cooling equipment shall be fed separately from and protected by a two pole breaker of adequate rating, 20 kA interrupting capacity minimum.

Means shall be provided to turn off the cooling system with a remote contact.

The first cooler group shall turn ON as soon as the transformer is energized.

The second cooler group shall be temperature-controlled and turn ON when the top oil reaches a pre-determined temperature – typically 65C.

5.4.4 Control Cabinets

Shall comply with the requirements of IEEE C37.21.

The inside pocket on the door shall contain one copy of the instruction manual. Cabinets wider than four (4) feet shall have two approximately equal sized doors.

All control, power, CT, cooling system and alarm wiring shall be terminated in the control cabinet. The control cabinet shall be insulated from transformer so that the “vibrations and heat” are not transmitted to devices within the cabinet.

Sufficient space and clearances shall be provided at the bottom of the cabinet to facilitate cable entry and termination.

Heaters: The heaters shall be rated to operate at 120 V ac and each heater shall be on its own circuit, protected by an appropriate 20 kA interrupting capacity circuit breaker. The heaters shall be PTC (Positive Temperature Coefficient for temperature limiting) heater(s) of sufficient size to prevent moisture condensation. Fan-less PTC heaters, where used, shall be oriented to facilitate convective air flow over their fins to maximize heat transfer.

A 120 volt 15 Amp weatherproof convenience duplex receptacle with ground fault protection shall be provided on the exterior of the control cabinet. A circuit breaker for this receptacle shall be provided inside the cabinet.

Lighting: Shall have a switched convenience light. Large cabinets shall have two switched convenience lights.

The cabinet shall be provided with a grounding bar for individually grounding current transformers, control cable shields, etc.

Provisions for a fall protection system

All standard accessories and maintenance devices as applicable and described in IEEE Std C57.12.10

The oil preservation system of transformer with a conservator shall be equipped with an automatically self-regenerating, maintenance-free dehydrating breather to prevent outside air from having direct contact with the desiccant. A separate unit shall be supplied for the LTC gas space (if applicable). Separate tap-changer compartments shall be equipped with separate dehydrating breathers. Top of the breathers shall be within approximately five feet of the transformer base.

See Section 11.11.5 for additional requirements for integral protective devices.

5.4.4.1 Transformer Monitoring

Transformer On line Monitoring Systems

The transformer shall be provided with an on-line monitoring system to continuously monitor the condition of LV and HV bushings, transformer dissolved gases and temperatures and other transformer parameters, including loss of insulation life. The on-line monitoring system shall be capable of controlling the coolers'/radiators' operation in parallel with the conventional cooler controls. Buyer currently uses Dynamic Ratings Monitoring Control Communication (DRMCC) on-line monitoring with a bushing monitoring system. The latest DRMCC monitoring system or better system

approved by Buyer shall be provided with the transformer. The type and model of the on-line monitoring system and multi-gas monitoring for the transformer shall be specified in the bid proposal. The on-line monitoring system shall have communications protocols built in to monitor all parameters in Buyer's DCS and PI data server. The transformer shall be provided with the latest model of a Vaisala multi-gas monitor (or better), to be specified by Seller and approved by Buyer, for continuously monitoring and detecting fault gasses in the transformer oil. The system shall be complete with necessary hardware, software, and interfaces. This gas monitor shall perform the following functions or as specified by Buyer: Detect, analyze, and correlate quantity of all dissolved fault gasses, including hydrogen (H₂), carbon monoxide (CO), carbon dioxide (CO₂), methane (CH₄), ethylene (C₂H₄), ethane (C₂H₆), acetylene (C₂H₂) moisture-in-oil, and oil temperature.

Annunciator/Data Logger and Alarms

The transformer shall include an annunciator/data logger panel in the transformer control cabinet. The type of annunciator/data logger shall be Rochester Instrument Systems Inc. (RIS) or equivalent approved by Buyer. The annunciator shall monitor the system's health and indicate occurrences of alarms, trips, and other general signaling messages.

The annunciator shall be mounted on a hinged weather-tight panel, for easy access to rear wiring, in a cabinet of dead-front construction arranged so that water cannot enter the wiring area of the cabinet when resetting the annunciator in rainy or inclement weather. A plexiglass panel shall be provided for external viewing of the annunciator. The panel door shall be equipped with a handle mechanism to allow easy access to the annunciator.

The following is a typical list of alarms generated by the monitoring devices that the annunciator system shall be required to monitor and display. All alarms will be discussed and approved during the design review meeting with Buyer.

- Loss of Normal AC Power
- Loss of Standby AC Power
- Power Supply Auto Transfer
- Loss of AC Control Power
- Group 1 Cooler Fail
- Group 1 Cooler Oil Flow Stop
- Group 2 Cooler Fail
- Group 2 Cooler Oil Flow Stop
- Oil Level Low
- Oil Level Low-Low
- Sudden Pressure Seal-in Relay
- Top Oil Temp. 100° C
- Top Oil Temp. 110° C
- Winding Temp. 110° C
- Winding Temp. 120° C
- Gas Detector Relay
- Monitoring Devices Fail
- Control Cabinet Temp. High

Alarm contacts shall be Form C type, and shall be wired independently to terminal blocks in the control cabinet to make possible any grouping of alarms by Buyer for remote indications. The contacts shall be rated 125 volts dc, 5 Amps continuous and 0.2 Amps dc non-inductive tripping.

Protection and Monitoring Devices

The transformers shall be equipped with the following devices for monitoring, control, and protection of the transformer (all of which shall have independent alarm contacts wired to the terminal blocks in the control cabinet):

Oil Level Gauge

A magnetic oil level gauge, Qualitrol or Buyer-approved equivalent, with a 6-inch dial, visible from the ground level shall be provided on the transformer tank and conservator.

The oil level gauge shall be a two-stage oil level monitor. Each stage shall be provided with two normally open contacts for alarm and trip functions. Contacts of the second stage shall close when the oil level in the transformer tank falls to a critical level and will result in an internal flashover of the unit.

Top Oil Temperature Gauge

A conventional oil temperature indicator, Qualitrol or Buyer-approved equivalent, with a minimum six (6)-inch dial, with drag hands, shall be supplied to indicate the temperature of the top oil. The instrument shall be mounted at eye level. The indicator shall be vibration-insulated from the transformer. The temperature indicator shall have two adjustable normally open contacts. Top oil alarm contacts shall be set at 105°C and used to turn on all of the cooling equipment.

Pressure Relief Devices

A spring-loaded diaphragm-type pressure relief device, Qualitrol Type XRPD or Buyer-approved equivalent, complete with animal intrusion screen P/N SCN-600-1 and a DPDT alarm contact shall be mounted on the transformer tank cover or the tank wall near the top. Transformer tanks containing more than 10,000 gallons of oil shall be provided with two pressure relief devices mounted on diagonally opposite corners of the transformer tank. The device(s) shall be located remote from the control cabinet(s) and equipped with directional shield to direct oil flow downward. Pressure relief value shall be stamped on the device.

Sudden Pressure Rise Relays

A transformer with conservator tank shall be equipped with two sudden pressure rise relays, Qualitrol Type 900-014-02, to detect rapid pressure increase in the transformer tank. The relays shall be located on diagonally opposite corners of the transformer and shall be flange-mounted with gate-type shut-off valves located between three (3) and six (6) feet above the base of the transformer.

Sealed tank transformers shall be supplied with two sudden pressure rise relays, Qualitrol Type 910, to detect rapid pressure increase in the transformer tank. The relays shall be flange-mounted with gate-type shut-off valves in the gas space on the tank wall.

The sudden pressure relays shall be provided with Qualitrol type 909-200-01 seal-in relays set up for 125 volts dc and reset feature. A target relay shall be provided to give visual indication of sudden

pressure relay operation. The target relay shall also have a reset feature. The alarm and trip contacts of the relays shall be wired to the terminal blocks in the control cabinet.

Actuation of each relay will result in an alarm. Actuation of both relays will result in a unit trip.

Gas Accumulation Detecting Relay

The transformers with a conservator tank shall be equipped with a gas accumulation detection device for detecting the presence of combustible gas within the tank and auxiliary oil-filled compartments. The device shall be Qualitrol type 038-003-01 complete with a sampling valve and alarm contacts. Sample test valves shall be located a maximum of five (5) feet above the transformer base.

The design of the gas detecting system, showing the location of the gas detection device and the gas accumulation system, shall be submitted for Buyer's approval before manufacture. Seller shall also submit a complete written description of operation as applied to the particular transformer with above submittal that will later become part of the Instruction Book.

A buchholz gas monitor relay shall be installed based on the transformer design with the COPs tank.

Dehydrating Breather(s)

The oil preservation system of transformer with a conservator shall be equipped with a Waukesha/HVS, or Reinhausen or other Buyer-approved, automatically self-regenerating, maintenance-free dehydrating breather containing an oil bath to prevent outside air from having direct contact with the desiccant.

Top of the breathers shall be within approximately five feet of the transformer base.

Temperature Monitoring System

Transformer shall be provided with an electronic temperature monitoring system (ETMS) in which the temperature rise of the winding hottest spot over the top oil temperature is added digitally by calculation. The traditional simulated Winding Hotspot Measuring System consisting of winding temperature CTs, heater circuit, and analog dial type thermometers is to be supplied only when specifically requested in the purchase order.

The transformer shall be provided with sufficient number of winding temperature CTs, thermo wells, sensors, dual element RTDs (Pt100Ω or Cu10Ω), probes, etc., to monitor the transformer oil and winding temperatures using a digital temperature monitoring system. The transformer shall be equipped with an APT TTC-1000 from Advanced Power Technologies or Buyer-approved temperature monitoring system with digital displays easily readable in daylight.

The sensors, probes, thermowells, etc., shall be located on the transformer tank sidewall (not the tank cover), and capable of being installed or replaced without de-energizing the transformer, opening the transformer, or lowering the oil in the transformer.

The ETMS shall have the digital displays for the following:

- HV winding hottest spot temperature, each phase
- LV winding hottest spot temperature, each phase

- Transformer tank top oil
- Transformer tank bottom oil
- Ambient temperature
- Control cabinet temperature

The temperature monitor shall have large LED displays for easy readability in any lighting condition. The monitor shall operate with a solid state LED light source that will under normal operating conditions last for the life of the transformer without the need to replace the light source.

The monitor shall cover a temperature range from -30 0C to +150 0C, and shall have a display resolution of ± 1 0C and a 0.7% accuracy at full scale. The device should display the future temperature gradient projection and the load current. The monitor shall be complete with 4–20 mA analog outputs for oil temperature and winding temperature and have contacts to control cooling, for alarms, and for trips.

The monitoring system with digital display gauges shall be mounted in the control cabinet five (5) feet above the base of the transformer. The temperature monitor shall be installed in a manner such that all controls are visible and adjustable from the front, and such that adjustments may be made without interference to other devices. The monitor shall be labeled as TMS.

The transformer shall be provided with sufficient number of winding embedded fiber optic sensors at least three (3) fibers per phase per winding (HV & LV) for winding temperature monitoring and three fibers for top oil temperature monitoring. The fiber shall be terminated into Luma Sense digital temperature monitor or Buyer-approved equivalent located inside the control cabinet. The temperature monitor shall have outputs to connect to other plant devices, DCS, and monitors, including the transformer on-line monitoring system.

5.5 Generator Step-Up Transformer Warranty

The GSU transformer(s) shall be provided with an original equipment manufacturer's warranty that the GSU transformer(s) shall be free from defects in material, manufacture, workmanship, and design for a minimum period of five (5) years from the date of such GSU transformer's energization; provided that, if such GSU transformer has not been energized within six (6) months after delivery thereof to the Project Site, the warranty period shall be at least five (5) years commencing six (6) months after the date of delivery to the Project Site. The GSU transformer manufacturer shall be required to repair or replace at its cost any GSU transformer (or component thereof) in breach of such warranty. The warranty shall cover the cost of removal from the Project Site, transportation to and from the repair facility, reinstallation after repairs, and any and all other "in and out" work.

Seller shall notify Buyer of any procedure, activity, or other Work that may void a manufacturer warranty or violate any law or applicable permit reasonably in advance of the performance of such procedure, activity, or Work. Seller shall provide to Buyer all original equipment manufacturer warranty documents.

The original equipment manufacturer's warranty shall cover the equipment is free from defects in material, manufacture, workmanship, and design.

5.6 Neutral Grounding Reactor (NGR)

The neutral grounding reactor shall be used to limit the fault current magnitude on the 34.5kV.

The rating of the NGR shall be based on underground collection design, short circuit analysis and ampacity calculation design criteria. Table 9 shows typical MPT MVA where the X0 Neutral Grounding Reactor is required. The requirement of the NGR shall be evaluated during planning phases.

5.7 Station Service Transformer (Auxiliary Loads)

All HV substations, and other major and strategic substations, shall be provided with two independent AC station service sources with automatic transfer from one source to the other for redundancy.

Recommended station service ac voltage ratings is as follow:

- 240/120 V AC 60Hz, single phase, 3 wire.

The AC station service capacity shall be sufficient to supply all loads for the following as applicable:

- Control house lighting, heating, and air conditioning,
- Power transformer cooling fans, pumps, LTC and control cabinet space heaters,
- Circuit breaker control cabinet heaters, and operating mechanism charging motors,
- Substation lighting,
- Battery chargers.
- Maintenance equipment, including gas cart, and oil filter truck if feasible
- Future Loads

Approved sources of ac station service include the following:

- Distribution line(s) area feeder
- Distribution transformer connected to a substation bus
- Station Service voltage transformers (SSVT) up to 230 kV (suitably rated for this service, but not less than 50 kVA)

SSVTs are used as the primary station service source in critical substations or in substations up to 230 kV without a MV source. The backup station service in such substations shall be from a nearby area distribution feeder based on economics and station importance. If a distribution feeder is not available, then a second SSVT shall be used as a backup. The SSVTs shall have sufficient kVA rating to be able to supply all substation loads including maintenance equipment.

SSVTs are typically connected to the substation bus or a transmission line and are within the associated primary protection zones. Surge protection shall be required on the HV side of the SSVT unless arresters protecting other equipment are close enough to protect the SSVT.

Alternate sources of AC station service, including but not limited to the following, are to be used only in special circumstances and require Buyer approval.

- Inverter system
- Solar panels
- Autotransformer tertiary
- SSVTs above 230kV

An engine generator shall not be acceptable for providing AC station service source.

See IEEE Std. 1818; Guide for the Design of Low-Voltage Auxiliary Systems for Electric Power Substations for additional guidance.

5.8 Reactive Equipment

Reactive equipment used to provide power quality and reliability to the electrical system (where required) shall be done through capacitor banks and reactors at the 34.5 kV level. To protect and control the reactive equipment, a circuit/reactor switcher shall be used. The MV circuit breaker (See Section 5.3.13.3) shall be used to protect for external faults of the reactive zone of protection (bus differential, etc.)

5.8.1 Circuit Switcher

Fully rated dead tank circuit breakers shall be used for the switching of power transformers and shunt capacitor banks; however, circuit switchers may be used with Buyer approval. For switching of the shunt capacitor banks rated up to and including 170 kV, the circuit switchers shall be equipped with pre-insertion resistors for suppression of transients.

Each application where a fully rated dead tank circuit breaker is not justifiable and circuit switcher with a desired fault interrupting rating is not available, a live tank circuit breaker without post type instrument current transformers may be considered in lieu of circuit switcher with Buyer approval.

Circuit switchers are typically rated to interrupt lower fault currents than circuit breakers. As the circuit switchers are normally installed to protect shunt capacitor banks, they are designed to be rated to the expected capacitive switching current as mentioned in the IEEE standards. The circuit switcher application shall ensure that these ratings are not exceeded.

5.8.2 Shunt Reactors

Air core reactors present unique design and safety considerations because they produce very high magnetic fields during normal operation. The distance from adjacent iron and steel structures and apparatus must be sufficient to prevent induction heating. Safety fencing with reactor safety signage shall be provided as needed to prevent personnel from getting too close to a set of reactors. A worker approaching too close could experience overheating of ferrous items he is carrying. There is a danger that implanted medical electronic devices such as pacemakers, insulin pumps, or hearing aids will malfunction or fail, causing injury or death. The manufacturer's documentation shall include minimum phase spacing and magnetic clearance requirements for perimeter fencing and these requirements shall be adhered to in the design of the substation.

The Substation Designer shall consult with the manufacturer of the reactors with any additional questions including clear instructions for reactor grounding. To protect personnel working near the reactors the

Substation Designer shall also request the manufacturer to supply magnetic field plots, needed to determine the perimeter fence spacing.

The ratings of the shunt reactors shall be provided during detail analysis (project specific not required in all projects).

5.8.2.1 Shunt Capacitor Banks

Shunt capacitor banks may be installed in ungrounded wye configuration up to 115 kV, and shall be grounded wye for 138 kV and above. Fuseless capacitor units shall be installed in capacitor banks. Seller must obtain Buyer approval for any exception.

The ratings of the shunt capacitor banks shall be provided during detail analysis (project specific not required in all projects).

5.9 Control House

5.9.1 General

There shall be no wood framing or trim. Eave height is to be manufacturer's standard to accommodate a clear interior height of 10'-0" (minimum) including specified insulation.

See Section 8 for control house structural design information.

5.9.2 Roof

All roof panels in all locations shall have a U.L. wind uplift classification of class 90 (minimum).

5.9.3 Ceiling

Insulation shall be R-19 minimum and shall have a U.L. Flame Spread Rating of 25 (minimum).

5.9.4 Walls

For metal buildings, the exterior building walls shall be constructed with a minimum of 16-gauge aluminized steel (or a zinc-aluminum finish), flat or corrugated surface, with a factory baked on light reflecting finish including a minimum ten-year guarantee.

For concrete buildings, the exterior building walls shall be solid concrete design with 6" walls and steel rebar reinforced high strength concrete.

The building walls shall be insulated with a non-combustible blanket type insulator with a glued-on vapor barrier facing material rated at R-11 (minimum) and a U.L. Flame Spread Rating of 25 (minimum).

5.9.5 Doors

Substation control house doors shall be level 3 full flush doors (Level 3 - 16 gauge per ANSI/SDI A250.8-2003) with weather stripping. All doors are to be equipped with metal, weather-tight thresholds.

The main room (relay room) exit door shall be 6' wide (double leaves, 3' each). The battery room entrance and exit doors shall be 3' wide.

All doors shall be 8' in height. All exit doors shall open outwards and be equipped with panic bars and lighted or photo luminescent exit signs.

The battery room outside exit door shall have no outside handle and shall only be capable of being opened from the inside. All battery room doors (entrance and exit) shall have an emergency push bar. In the battery room, the floor and all interior wall panels shall be acid resistant.

5.9.6 Paint

If steel building, steel shall be coated with either aluminum or aluminum-zinc mix (containing at least 4% aluminum) and shall conform to the proper thickness as specified by ASTM. All structural steel is to have two shop coats of red oxide paint which meets or exceeds Federal Specification TT-P686.

5.9.6.1 Color Schedule

Exterior wall panels:	Light Gray unless specified otherwise by Entergy
All trim:	As specified by Entergy (specified during planning phases)
Interior wall panels:	White
Ceiling panels:	White
Partition door:	White
Exit doors:	to match exterior trim
Interior partition wall:	White

5.9.7 Cable Tray

The tray shall be Aluminum, ladder type, two side rails, with six inch rung spacing.

All cable tray entrances into the house shall be 36 inches wide and reducers shall be utilized to connect to 24 inch cable tray inside of the control house when required. A minimum four (4) cable tray entrances is required.

A solid flanged aluminum tray cover (.040 inches thick) with heavy duty cover clamps and stainless-steel mounting hardware shall be installed over all cable trays located on the outside wall of the control house.

Separate cable tray for communication cables shall be provided.

5.9.8 Lighting

Interior lighting shall be LED (Light Emitting Diode) light fixtures that provide 40 foot-candles of light at a level of three feet above the floor.

External lighting shall be supplied above the exterior doors using weatherproof fixtures.

Exit Lighting (OSHA-approved) shall be an LED (Light-Emitting Diode) illumination or self-illuminating device.

5.9.9 Air Handling

The battery room exhaust fan shall be rated for 90 cfm. Battery room exhaust fan(s) shall be equipped with animal deterrent and mounted 8 feet above the floor for security purposes. Exhaust fan(s) shall be controlled and operated with an electro-mechanical timer. Operation intervals of exhaust fan shall be a minimum of four twenty-minute cycles every twenty-four hours.

The air conditioner shall be controlled by a remote low voltage heating/cooling control thermostat, such as Accustat Energy Guard or equivalent, with design set points of 78°F for cooling and 68°F for heating.

5.9.10 Warranty

Building finish: minimum twenty (20) year non-prorated warranty.

The walls, including all wall openings for doors and louvered openings, are to be warranted weather-tight for a period of five years from the date of completion of the building.

Ceiling: minimum ten (10) year warranty.

Roof: minimum twenty (20) year non-prorated warranty.

A full five-year warranty on the control house including equipment with parts and service is to be included.

5.10 Substation Civil/Structural Design Criteria

Seller shall complete all civil works to furnish a collector substation site design, access road(s), and any other outdoor civil works required inside the Project Site or as needed for interconnection of the Project to the Buyer's Transmission System. The design shall meet all applicable federal, state, and local Laws and regulations and requirements of the Agreement, including the Scope Book and this Appendix 1, and provide a relatively maintenance-free design (e.g., provide adequately-sized culverts to limit the possibility of clogging, provide erosion control means on slopes to eliminate maintenance re-grading, design access road cross-section to minimize rutting, etc.).

5.10.1 Siting and Civil

5.10.1.1 Floodplain

5.10.1.2 Flood Risk Evaluation

Flood risk shall be evaluated, and an Elevation Basis selected. This includes evaluation of the flood risk to the substation from rain, river elevation, storm surge, or other causes. It also includes the placement of structures within known Federal Emergency Management Agency (FEMA) special flood hazard areas (SFHA) or other flood prone areas.

The substation location flood evaluation and decisions made with respect to site and equipment elevations shall be documented on the applicable substation site and foundation drawings.

The process to establish the Elevation Basis shall be as follows:

1. Determine if the site location is located within or near a FEMA SFHA.
2. If published information is available, determine the Base Flood Elevation (BFE, 100-year flood) of the proposed site and if the location is within or adjacent to a mapped floodplain.
3. Evaluate the FEMA Flood Insurance Rate Map (FIRM) to determine the most recent revision to the map (including Letters of Map Revision).
4. Determine the date of the underlying Flood Insurance Study (FIS), if the FIS is available, and if the FIS method can be determined.
5. Evaluate local development and the potential impacts to flooding since the publication of the FIS.
6. Obtain written documentation about local ordinances regarding development in a SFHA, including any local requirements for development.

For locations outside of a mapped SFHA, but that are suspected to be at an elevated flood risk, document the known information and attempt to quantify the risk in relation to the site. An example of this type of risk evaluation is floodway extents or floodplain extents ending in a straight line in the vicinity of the site. This occurrence might indicate a road or railway embankment but may be indicative of an arbitrary study limit.

Determine planned access routes to the site for construction, operation, and maintenance and if such routes could be adversely affected by surface water flooding. The evaluation should consider the probability of surface water flooding at critical elevation points such as control houses, equipment cabinets, and access roads for the expected life cycle of the facility.

If the site is located within a FEMA SFHA, the underlying FIS was conducted within the previous 10 years, and the 100 year BFE is available, the 100-year BFI shall be used as the Elevation Basis.

If the site location is not located in a FEMA SFHA, the FIS was conducted more than 10 years ago, or the BFE is not otherwise available, engineering judgement and input from the Project Team shall be utilized to determine if local knowledge will be used as a basis for the site and equipment elevations or if a Hydrologic and Hydraulic study by a suitably experienced individual or company would need to be performed to determine an Elevation Basis. If it is deemed a study is needed to determine a proper Elevation Basis, a study should be ordered along with a site topographic survey. If applicable, the study shall be used to determine the Elevation Basis.

5.10.1.3 Flood Design Requirements

The Finished Grade of the site shall be at or above the Elevation Basis. Equipment foundation top of concrete (TOC) elevations shall be a minimum of one (1) foot above the Elevation Basis and a minimum of six (6) inches above the Final Grade. The final TOC elevations shall be chosen to keep all equipment control cabinets a minimum two (2) feet and if possible four (4) feet above the Elevation Basis. The Project Team will determine the Elevation Basis, make the final TOC elevation determination, and document those determinations. The TOC elevations shall be recorded on the station foundation plan and foundation details.

When establishing the TOC elevation for the control house foundation, the relative elevations of the control house and equipment control cabinets shall be evaluated. In all stations the control house floor shall be a

minimum of six (6) inches above the Final Grade to prevent rainwater from entering the house. If the control house has trenches in the floor, then the bottom of the trenches shall be a minimum of six (6) inches above final grade. In stations within a FEMA SFHA or otherwise determined to be prone to flooding, the control house floor should be at or above the elevation of the bottom of the lowest equipment control cabinet. A higher control house elevation may be selected to allow for easy maintenance access under the house. In existing substations where the control house is raised due to flooding concerns, the ability to raise equipment cabinets to the same elevation as the control house floor should be evaluated for feasibility.

5.10.1.4 Earthwork

The existing site shall be cleared, grubbed/stripped to a depth sufficient to remove organic material, leveled, filled, compacted, and sloped to drain. The substation yard shall be graded to accommodate drainage. The preferred substation site shall be graded with a slope of no less than 0.5% - 1.5% to facilitate water drainage from the site, storm sewers, catch basins, and/or manholes may be used if required for proper drainage.

A soil drainage analysis may be performed at the same time as soil boring investigation to determine the site's characteristics for water infiltration and retention for sites with aggregate implications larger than 1 acre where AHJs may require additional site permitting.

The drawings shall note the control points on the site, and which coordinate system is to be used.

5.10.1.5 Erosion Control

The design shall comply with the Storm Water Pollution Prevention Plan (SWPPP) and Environmental Management Plan (EMP).

5.10.1.6 Wetland Delineation and Mitigation

Seller shall comply with all wetland requirements specified by Laws and applicable Permits. Wetlands shall be confirmed by a qualified third party.

5.10.1.7 Stormwater Management

Seller shall design the Project Site stormwater management plan. Seller shall complete and submit all necessary permitting applications, including stormwater discharge NPDES Permit applications, to the appropriate Governmental Authorities. The design shall provide quality control of stormwater prior to discharge.

Seller's design for stormwater management on the Project Site shall meet stormwater quality and quantity requirements of local, state, and, if applicable, federal Governmental Authorities. The design shall consist of the following, as a minimum:

Size and design details of stormwater, oil containment, run-off basin, and outfall

Location and size of stormwater piping, inlets and manholes as needed

Location and size of stormwater ditches or channels

Project Site relative grades and slope including the drainage area to each stormwater feature

5.10.1.8 Site Surfacing

Thickness: The Project Site shall be graded to drain and then be surfaced with a minimum of six inches of compacted crushed stone.

Aggregate shall meet the following:

If the Collector Substation is not in Arkansas or Louisiana: Material designation - #610- Crushed limestone, primarily used in the Entergy system.

If the Collector Substation is in Arkansas: Material designation: Arkansas Department of Transportation Class 7 Base - Crushed granite or limestone, primarily used in Arkansas. Class 7 Base is a new designation that replaces the old designation (SB2). The materials in Class 7 and SB2 have the same gradation.

If the Collector Substation is in Louisiana: Material designation - Grade D Base (DGA) Dense Grade Aggregate m-crushed limestone.

Compaction: The crushed stone shall be compacted to a minimum density equal to 95% of the maximum density obtained by a Modified Proctor Test (ASTM D-1557). Do not grade ruts down; fill with additional aggregate and compact.

Sterilant: after sub grade preparation and prior to applying the crushed rock, a non-toxic vegetation eradicant (sterilant) shall be applied. Sterilant shall be applied from a minimum of five feet to a maximum of ten feet outside the fence.

5.10.1.9 Drive Access and Road Design

Substation ingress/egress points are to be compliant with all State and local permitting requirements. A permanent all-weather twenty (20) feet wide roadway shall be provided for access and egress to the substation site directly from a public street or road. Access Road shall be adequate for construction and maintenance activities including hauling heavy equipment such as the collector substation GSU. Access Road shall have no less than 50 ft. centerline turn radii.

Roadways within the substation shall be provided, along the fence if possible, for personnel and equipment movement. All roadways within the substation shall be at least twenty (20) feet wide with at least a fifty (50) feet centerline minimum turn radius. A reduced turn radius inside the substation is acceptable provided that an 18-wheeled low-bed vehicle loaded with equipment can easily negotiate all roads and turns within the substation fence enclosure. Road crossings over cable trenches, and culverts, shall be designed to withstand heavy traffic. Substation shall have only two point of entry in and out of the yard. The yard shall allow for vehicles to turn around or back out of the yard.

Note that new substations designated as CODE (see Section 13) shall include a vehicle access corridor around the exterior of the perimeter to allow drive-around access by security or law enforcement personnel.

5.10.2 Oil Containment

5.10.2.1 Federal Regulatory Requirements

Design and construction shall conform to Code of Federal Regulations, Title 40, (40CFR), Parts 110 and 112.

Oil spill containment shall be provided for the main transformer. Oil spill containment shall be provided for other equipment when required by authority having jurisdiction.

5.10.2.2 State and Local Regulatory Requirements

Oil containment shall comply with state and local requirements which are contained in 40 CFR Part 109. State and local governments have generally adopted the existing federal regulations prohibiting discharges of oil.

5.10.2.3 Containment System

Secondary oil containment type shall be an above grade containment pit.

Minimum containment volume is to be 100% of oil contained within protected equipment in addition to the volume of rainwater retained during a 24 hour 25 year recurrent interval storm event.

All designed water removal systems shall incorporate a method of monitoring discharged water quality. Monitors shall be connected to alarm systems.

In designing (sizing) a stone filled collection pit, the final oil level elevation shall be situated approximately 12 inches below the top elevation of the stone. This provides a fire extinguishing capability designed to quench flames if a piece of oil filled equipment catches fire. The use of 1.5 inch or larger stone (washed and uniformly sized) is recommended to permit quicker penetration to avoid a pool fire. Void Volume Ratio for stone filled devices shall be between 30 to 40 percent.

Pits using drainpipes shall assure that the drainpipe material shall be capable of withstanding the higher temperatures associated with an oil fire.

5.10.2.4 Oil Filled Equipment Separation

Oil-filled equipment shall be separated from other equipment and buildings to prevent potential fire hazards that may impede restoring or maintaining electric service. The following minimum separations from NFPA 850 Section 5.1.4 are suggested:

Power transformers containing between 500 and 5,000 gallons of oil shall be located a minimum of 25 feet from any building unless the exposed walls consist of or are protected by a wall or barrier having a two-hour fire rating. The barrier shall extend horizontally and vertically such that any exposed part of the building is a minimum of 25 feet from the transformer. Transformers shall also be spaced an adequate distance from a fire-rated building wall to ensure that this 25 foot minimum is maintained to any other parts of the building that do not have a two-hour fire rating.

For outdoor transformers with an oil capacity of greater than 5,000 gallons, maintain clear separation of 50 feet from other structures or provide a 2-hour fire rated barrier

A minimum distance of 8 feet shall exist between the transformer and any building or wall to ensure there is adequate space for normal operating and maintenance work. Cable trenches shall not be routed adjacent to oil immersed equipment.

Barriers that are required due to inadequate separation to equipment or buildings shall be constructed of non-combustible, heat-resistant, fire-rated material. The barrier height shall extend a minimum of 1 foot above the top of any oil filled equipment and any of their components. Barriers shall also extend horizontally a minimum of 2 feet beyond the line of sight of the subject building or equipment.

For transformers with less than 500 gallons of oil and where a firewall is not provided, the edge of the postulated oil spill (i.e., containment basin, if provided) should be separated by a minimum of 5 feet from the exposed structure to prevent direct flame impingement on the structure.

Any transformer for the Project using a listed “less flammable” insulating oil (e.g., Envirotemp FR3) shall be installed with and maintain a separation distance and barriers as provided above. If Seller seeks a modification of a separation distance or a barrier requirement for a transformer on the basis that the transformer will use a listed less flammable insulating oil, Seller shall perform and provide to Buyer a detailed hazard evaluation of such transformer with the proposed less flammable insulating oil. Buyer will consider such evaluation in its review of the modification request.

6 EQUIPMENT SUPPORT STRUCTURE LOADING

6.1 Load Cases

The load cases specified shall include the following environmental requirements:

Dead Load: The weight of equipment and support structures shall be included with appropriate increases for all equipment accessories and structure connections.

NESC District Loading (Rule 250B) - NESC District Loading shall be selected from Table 25, Table 26, Table 27, or Table 28 based on project location (Note that these districts may not match the district depicted in NESC for a given county). The ambient air temperature shall be taken as 0°F. Note that the load factors specified in NESC Table 253-1 shall only be used for this condition.

Extreme Wind: An Extreme Wind Speed shall be selected from Table 25, Table 26, Table 27, or Table 28 based on project location (Note that the values in the tables may not match the maps depicted in NESC or ASCE 113 for a given county). Wind pressure shall be developed using ASCE 113. The importance factor (IFW) for Extreme Wind loading shall be 1.0 corresponding to a 50 year mean recurrence interval per ASCE 113, Table 3-3. The ambient air temperature shall be taken as 60°F.

Concurrent Ice and Wind: A wind speed of 30 mph from any direction and a radial ice thickness selected from Table 25, Table 26, Table 27, or Table 28: Load Districts by County – Texas based on project location applied on the equipment or structure. The importance factor (IFI) for Concurrent Ice and Wind loads shall be 1.0 corresponding to a 50 year mean recurrence interval per ASCE 113, Table 3-11. The ambient air temperature shall be taken as 15°F.

Short Circuit Loading: Determined in accordance with ASCE 113 and IEEE 605-2008 using electrical parameters determined from a site-specific analysis.

Seismic: Seismic design parameters (accelerations, site class, etc.) will be provided in the geotechnical report for each site. The seismic loads shall be calculated in accordance with ASCE MOP 113. Unless larger values are provided in the geotechnical report, the following minimum values shall be used for the

mapped ground motion spectral response accelerations: $S_s = 0.140$ and $S_1 = 0.051$. The ambient air temperature shall be taken as 60°F.

Other: For equipment mounted on structures, the same design weather conditions shall apply. Loads associated with operation of the equipment shall be added to applicable load combinations.

Table 25: Load Districts by County – Arkansas and Missouri

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
AR	Arkansas	100		M		1
AR	Ashley	100		M		1
AR	Baxter	100			H	1
AR	Benton	100			H	1
AR	Boone	100			H	1
AR	Bradley	100		M		1
AR	Calhoun	100		M		1
AR	Carroll	100			H	1
AR	Chicot	100		M		1
AR	Clark	100			H	1
AR	Clay	100			H	1
AR	Cleburne	100			H	1
AR	Cleveland	100		M		1
AR	Columbia	100		M		1
AR	Conway	100			H	1
AR	Craighead	100		M		1
AR	Crawford	100			H	1
AR	Crittenden	100		M		1
AR	Cross	100		M		1
AR	Dallas	100		M		1
AR	Desha	100		M		1
AR	Drew	100		M		1
AR	Faulkner	100			H	1
AR	Franklin	100			H	1
AR	Fulton	100			H	1
AR	Garland	100			H	1
AR	Grant	100		M		1
AR	Greene	100			H	1
AR	Hempstead	100			H	1
AR	Hot Spring	100			H	1
AR	Howard	100			H	1
AR	Independence	100			H	1
AR	Izard	100			H	1
AR	Jackson	100			H	1

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
AR	Jefferson	100		M		1
AR	Johnson	100			H	1
AR	Lafayette	100		M		1
AR	Lawrence	100			H	1
AR	Lee	100		M		1
AR	Lincoln	100		M		1
AR	Little River	100			H	1
AR	Logan	100			H	1
AR	Lonoke	100		M		1
AR	Madison	100			H	1
AR	Marion	100			H	1
AR	Miller	100		M		1
AR	Mississippi	100		M		1
AR	Monroe	100		M		1
AR	Montgomery	100			H	1
AR	Nevada	100		M		1
AR	Newton	100			H	1
AR	Ouachita	100		M		1
AR	Perry	100			H	1
AR	Phillips	100		M		1
AR	Pike	100			H	1
AR	Poinsett	100		M		1
AR	Polk	100			H	1
AR	Pope	100			H	1
AR	Prairie	100		M		1
AR	Pulaski	100			H	1
AR	Randolph	100			H	1
AR	St. Francis	100		M		1
AR	Saline	100			H	1
AR	Scott	100			H	1
AR	Searcy	100			H	1
AR	Sebastian	100			H	1
AR	Sevier	100			H	1
AR	Sharp	100			H	1
AR	Stone	100			H	1
AR	Union	100		M		1
AR	Van Buren	100			H	1
AR	Washington	100			H	1
AR	White	100			H	1
AR	Woodruff	100		M		1
AR	Yell	100			H	1
MO	Dunklin	100			H	1

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
MO	New Madrid	100			H	1
MO	Oregon	100			H	1
MO	Pemiscot	100			H	1
MO	Stoddard	100			H	1
MO	Taney	100			H	1

Table 25: Load Districts by Parish – Louisiana

State	Parish	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
LA	Acadia	150	L			0.5
LA	Allen	125	L			0.5
LA	Ascension	150	L			0.5
LA	Assumption	150	L			0.5
LA	Avoyelles	110	L			0.5
LA	Beauregard	125	L			0.5
LA	Bienville	100		M		0.75
LA	Bossier	100		M		0.75
LA	Calcasieu	150	L			0.5
LA	Caldwell	100		M		0.75
LA	Cameron	150	L			0.5
LA	Catahoula	100	L			0.5
LA	Claiborne	100		M		0.75
LA	Concordia	100	L			0.5
LA	Desoto	100		M		0.75
LA	East Baton Rouge	150	L			0.5
LA	East Carrol	100		M		0.75
LA	East Feliciana	125	L			0.5
LA	Evangeline	125	L			0.5
LA	Franklin	100		M		0.75
LA	Grant	100	L			0.75
LA	Iberia	150	L			0.5
LA	Iberville	150	L			0.5
LA	Jackson	100		M		0.75
LA	Jefferson	150	L			0.5
LA	Jefferson Davis	150	L			0.5
LA	Lafayette	150	L			0.5

State	Parish	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
LA	Lafourche	150	L			0.5
LA	Lasalle	100	L			0.75
LA	Lincoln	100		M		0.75
LA	Livingston	150	L			0.5
LA	Madison	100	L			0.75
LA	Morehouse	100		M		0.75
LA	Natchitoches	100		M		0.75
LA	Orleans	150	L			0.5
LA	Ouachita	100		M		0.75
LA	Plaquemines	150	L			0.5
LA	Point Coupee	125	L			0.5
LA	Rapides	100	L			0.5
LA	Red River	100		M		0.75
LA	Richland	100		M		0.75
LA	Sabine	100		M		0.75
LA	St. Bernard	150	L			0.5
LA	St. Charles	150	L			0.5
LA	St. Helena	125	L			0.5
LA	St. James	150	L			0.5
LA	St. John the Baptist	150	L			0.5
LA	St. Landry	125	L			0.5
LA	St. Martin, North	150	L			0.5
LA	St. Martin, South	150	L			0.5
LA	St. Mary	150	L			0.5
LA	St. Tammany	150	L			0.5
LA	Tangipahoa	150	L			0.5
LA	Tensas	100	L			0.5
LA	Terrebonne	150	L			0.5
LA	Union	100		M		0.75
LA	Vermillion	150	L			0.5
LA	Vernon	100	L			0.5
LA	Washington	125	L			0.5
LA	Webster	100		M		0.75
LA	West Baton Rouge	150	L			0.5
LA	West Carrol	100		M		0.75

State	Parish	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
LA	West Feliciana	125	L			0.5
LA	Winn	100		M		0.75

Table 26: Load Districts by County – Mississippi

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
MS	Adams	100	L			0.5
MS	Amite	110	L			0.5
MS	Attala	100	L			0.5
MS	Benton	100		M		1
MS	Bolivar	100		M		1
MS	Calhoun	100		M		1
MS	Carrol	100		M		1
MS	Chickasaw	100		M		1
MS	Choctaw	100		M		1
MS	Claiborne	100	L			0.5
MS	Clay	100		M		1
MS	Coahoma	100		M		1
MS	Copiah	100	L			0.5
MS	Covington	110	L			0.5
MS	Desoto	100		M		1
MS	Franklin	100	L			0.5
MS	Grenada	100		M		1
MS	Hinds	100	L			0.5
MS	Holmes	100		M		1
MS	Humphreys	100		M		1
MS	Issaquena	100	L			1
MS	Jefferson	100	L			0.5
MS	Jefferson Davis	110	L			0.5
MS	Lafayette	100		M		1
MS	Lawrence	110	L			0.5
MS	Leake	100	L			0.5
MS	Leflore	100		M		1
MS	Lincoln	110	L			0.5
MS	Madison	100	L			0.5
MS	Marion	110	L			0.5
MS	Marshall	100		M		1

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
MS	Montgomery	100		M		1
MS	Neshoba	100	L			0.5
MS	Newton	100	L			0.5
MS	Panola	100		M		1
MS	Pike	110	L			0.5
MS	Ponotoc	100		M		1
MS	Quitman	100		M		1
MS	Rankin	100	L			0.5
MS	Scott	100	L			0.5
MS	Sharkey	100	L			0.75
MS	Simpson	100	L			0.5
MS	Smith	110	L			0.5
MS	Sunflower	100		M		1
MS	Tallahatchie	100		M		1
MS	Tate	100		M		1
MS	Tippah	100		M		1
MS	Tunica	100		M		1
MS	Union	100		M		1
MS	Walthall	110	L			0.5
MS	Warren	100	L			0.5
MS	Washington	100		M		1
MS	Webster	100		M		1
MS	Wilkinson	110	L			0.5
MS	Winston	100	L			0.5
MS	Yalobusha	100		M		1
MS	Yazoo	100	L			0.75

Table 27: Load Districts by County – Texas

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
TX	Angelina	100		M		0.75
TX	Brazos	100		M		0.75
TX	Burleson	100		M		0.5
TX	Chambers	150	L			0.5
TX	Galveston	150	L			0.5
TX	Grimes	100		M		0.75
TX	Hardin	125	L			0.5
TX	Harris	125	L			0.5
TX	Houston	100		M		0.75

State	County	Extreme Wind mph	NESC District			Concurrent Ice & Wind Case Ice Thickness inches
			Light	Medium	Heavy	
TX	Jasper	125		M		0.5
TX	Jefferson	150	L			0.5
TX	Leon	100		M		0.75
TX	Liberty	125	L			0.5
TX	Limestone	100		M		0.75
TX	Madison	100		M		0.75
TX	Montgomery	110		M		0.5
TX	Nacogdoches	100		M		0.75
TX	Newton	125		M		0.5
TX	Orange	150	L			0.5
TX	Polk	110		M		0.75
TX	Robertson	100		M		0.75
TX	Sabine	100		M		0.75
TX	San Augustine	100		M		0.75
TX	San Jacinto	100		M		0.75
TX	Trinity	100		M		0.75
TX	Tyler	110		M		0.75
TX	Walker	100		M		0.75
TX	Waller	110	L			0.5
TX	Washington	100	L			0.5

6.2 Load Combinations

All substation equipment support structures shall be designed using the load cases in Section 7 and using the provisions and load combinations of ASCE 113. Wire- supporting structures shall be additionally be designed per the National Electric Safety Code (NESC), Construction Grade B.

6.3 Structural Analysis

Computer aided analysis and design shall include secondary moments from non-linear effects (p-delta) for structure stresses. Analysis procedures shall be based on the applicable design document (AISC 360 for steel structural shapes, ASCE 48 for tubular steel structures, ACI 318 for concrete structures, ASCE 10 for lattice structures, the Aluminum Design Manual for aluminum structures, etc.).

6.4 Equipment Support Structure Design

Transmission line dead ends shall be located outside the substation, with a slack span inside the substation.

Structural supports for bus work, switches, and all other equipment shall be designed in compliance with ASCE MOP 113, and IEEE 605.

All substation structures, except dead-end structures, shall be designed and constructed using hot-rolled, structural steel square, rectangular, or tapered polygonal tubes. The dead-end structures shall be designed using tapered tubular polygonal shapes.

Per ASCE 113, polygonal tube structures shall be designed in accordance with ASCE 48. Per ASCE 113, structures designed with other structural shapes shall be designed in accordance with AISC 360.

6.5 Structure Deflection

For deflection Load Combinations, the deflection extreme wind shall not be determined by using a reduced return period per ASCE 113, Table 3-14. For the Ice with Wind load Combination, the deflection ice thickness shall not be determined by reducing the ice thickness per ASCE 113, Table 3-15.

Structure deflections shall be checked for loading combinations with all load factors equal to 1.1.

The calculated deflections shall not exceed the values listed below.

Wire-Supporting Structures and Shield Poles

Horizontal deflection of vertical members: 1/100 of height

Horizontal deflection of horizontal members: 1/200 of span

Vertical deflection of horizontal members: 1/200 of span

All other Equipment Support Structures

Horizontal deflection of vertical members: 1/200 of height

Horizontal deflection of horizontal members: 1/300 of span

Vertical deflection of horizontal members: 1/300 of span

7 CONTROL HOUSE STRUCTURAL DESIGN

The control house shall be designed using the applicable building code as required by the Authority Having Jurisdiction (AHJ). If no AHJ oversight is required, the International Building Code 2015 edition shall be used for design.

Design, fabrication, and erection of structural steel shall meet the requirements of the IBC, AISC Steel Construction Manual (AISC specification and AISC code of standard practice). Structural design shall comply with seismic design and detailing requirements of the IBC, ASCE 7, and AISC 341. It is preferred to have an Engineered/prefabricated and delivered to site precast concrete building. Steel, concrete, and CMU buildings are all acceptable options.

7.1 Design Loads

Design Loads shall be determined in accordance with IBC assuming a Risk Category III.

Roof dead load: Weight of built-up roof, roof joists, insulation, structural members, permanent equipment, cable tray fully loaded with cables, lighting, and any other items supported by the roof.

Floor dead load: Weight of AC/DC panels, control/relay panels, batteries, cable termination cabinets, and other electrical equipment supported on the floor.

Roof live load: 40 psf (minimum)

Snow load: Per the applicable building code. 10 psf ground snow load minimum.

Floor live load: 250 psf or a 1,300-pound load concentrated in any 2½ square foot area.

Wind load: Per the applicable building code. 120 mph (minimum)

Seismic: Per the applicable building code.

7.2 Fall Protection

Building shall be constructed to include permanent anchorage points to accommodate personal fall protection systems capable of supporting 5,000 pounds per worker (OSHA defined impact load). For elevated houses, permanent anchorage points shall additionally be included on the walls of the control house adjacent to each exterior door to accommodate personal fall protection systems for use when working on the platform. All anchorage points shall be shown on roof drawings and marked on control house if not easily visible.

7.3 Roof

The roof shall have a minimum slope of ¼" in 12"; designed and constructed as specified by the IBC. Control house shall have a freestanding roof with no interior vertical supports to support the roof ridge beam.

7.4 Cable Tray

Cable tray and other suspended items shall be adequately supported to resist applied loads including, but not limited to, dead load, cable pulling loads, and seismic loads.

The cable tray shall be capable of carrying a uniformly distributed load of 75 lbs/ft in addition to the weight of the cable tray with a safety factor of 2.0 when supported as a simple span.

8 FOUNDATIONS

Foundation design will incorporate the soil capacity determined from the geotechnical study. Foundation design shall conform to ACI 318 and County and State Codes.

Drilled Pier/Shaft and Slab-type foundations shall be used. Alternative foundation systems may be considered if agreed upon between Buyer and Seller.

Ground supported pieces of equipment, such as circuit breakers and transformers, shall be supported by cast-in-place reinforced concrete slabs unless otherwise indicated by the geotechnical report.

Transformers shall be positively anchored to supporting foundations.

Foundations for the equipment support structures (bus supports, switches, etc.) and transmission line dead end structures shall be cast-in-place reinforced concrete drilled piers or spread footings, whichever is appropriate based on the subsurface soil information, unless otherwise indicated by the geotechnical report. Anchor bolts for all structures shall be of sufficient length to allow for the use of leveling nuts. The use of grout between the structure base plate and the top of the structure foundation is not required.

The control house foundation shall be piers or concrete slab. A cable routing and pulling area will be designed to facilitate connection with the conduit or pre-cast concrete cable trench entry from the substation and shall be located beneath the termination cabinet(s).

Foundation designs shall be in accordance with the following general minimum criteria:

- a) Concrete Strength $f_c = 4,500$ psi at 28 days
- b) Grout Auger Cast Piling $f_c = 5,000$ psi at 28 days
- c) Reinforcing Steel (ASTM A615 Gr 60) $f_y = 60,000$ psi
- d) Foundation Loads

Structures From structure design calculations

Equipment From equipment manufacturer shop drawings or product literature

Importance Factor

Structures/Foundations - 1.0 for non-essential facilities

Safety factors (foundation reactions shall be service loads)

Shallow Foundations – Bearing Capacity 3.0

Shallow Foundations – Stability (Overturning, Sliding, and Uplift) 1.5

Drilled Piers Not less than 1.5, preferably 2.0

In general, foundations shall extend below the final grade as required by local or state code and the recommendations in the geotechnical report. The geotechnical report shall clearly state the safety factors needed for each site.

8.1 Foundation Deflection and Rotation

Deflection and rotation of drilled pier foundations shall be limited to 0.5 inch of deflection (vertical and horizontal) and 0.5 degrees of rotation due to unfactored (service) loads.

8.2 Materials

Structural steel shapes, plates, and appurtenances for general use shall conform to ASTM A992 or ASTM A572 grade 50 (wide-flange shape and ASTM A36 (other shapes)). Steel pipes shall conform to ASTM A53 grade B. Structural tubing shall conform to ASTM A500 grade B. Primary connection bolts shall conform to ASTM A325, type 1 or ASTM A490, type 1 with ASTM A194 grade 2H heavy hex nuts and steel washers conforming to ASTM F436 or Compressible-Washer-Type Direct Tension Indicators conforming to ASTM F959. Connection plates shall be ASTM A36 or ASTM A572 grade 50 steel. Steel components for metal wall panels, roof decking, and cold-formed girts and purlins shall conform to the North American specification for design of cold-formed steel structural members (AISI-S100).

Welded connections shall be made with welding electrodes with a minimum tensile strength of 70 ksi. Bolted connections shall be made with minimum 5/8 inch diameter ASTM F3125 Grade A325 high strength bolts, and shall typically be fully pre-tensioned Type N connections with threads included in the shear plane, unless noted otherwise. Connections subject to significant stress reversals or as otherwise required by the AISC shall be designed as slip-critical connections.

Welding procedures and qualifications for welders shall be in accordance with AWS D1.1 structural steel welding code and AWS D1.3 sheet steel welding code. Welding electrodes shall be as specified by AWS.

Preparation of metal surfaces for coating systems shall follow the specifications and standard practices of the SSPC, NACE, and the specific instructions of the coatings manufacturer. All structural steel for exterior use shall be hot dip galvanized steel per ASTM A123 and ASTM 153, unless noted otherwise. All structural bolts shall be galvanized, unless noted otherwise. Steel assemblies shall be safeguarded against embrittlement and warping during hot dip galvanizing per ASTM A143 and ASTM A384. Repair of damaged and uncoated areas of hot-dip galvanized steel shall be per ASTM A780.

8.3 Record documents

Seller shall provide buyer with structure and foundation detail drawings and supporting calculations. The drawings shall note all loading criteria used in the design. Foundation details shall note the structure base reactions used in the design. Drawings shall contain appropriate information (e.g. dimensions, materials, weld data, etc.) to allow reanalysis of the structure under future loading conditions.

9 FENCE & SIGNAGE

All substations shall have a fence at least eight feet high (seven-foot fabric and one foot of barbed wire). Fences shall consist of chain link fabric, with 3 strands of barbed wire on 45 degree extension arms, with no ground gaps greater than two (2) inches and secure. All steel, including pipe, roll-formed sections, and fittings to be first quality, full weight, "hot-dipped galvanized" as per ASTM-F1234 or ASTM-F1083. The fence fabric shall be aluminum coated steel according to ASTM-A491. Safe step and touch potential of the perimeter fence shall be verified by an IEEE 80 compliant grounding study.

9.1 Gates

Drive gates shall be equipped with heavy duty drop bars, drop bar keepers, stops, and flip-over latches (as required) to be locked by standard Entergy lock. Hinges shall be heavy duty and shall allow gates to swing either in, or out, or in and out of all gate leaves.

Gates shall be operational from both sides of gate. Gates shall clear finished grade by not more than 3". Gate locking mechanism shall be installed with 3/8" diameter case hardened bolts. The nuts on the bolts shall be incapable of being removed, either by using lock nuts, splitting the end of the bolts or by welding the nuts on the bolts.

The Collector Substation shall have one motor operated sliding gate and an additional non-motor operated sliding gate or one man gate.

Features of the motor operated sliding gates shall include the following:

- Sliding gate shall be four (4') greater than width of entrance road
- An electric gate operator (Lift Master Elite or newer equivalent or better), including associated items
- A hard-wired continuous power connection (if available)
- A hard-wired keypad gate opener (not wireless) located at the gated entrance (exterior side of the PV Project Site fence)
- A pedestal mount, conduits, and wiring at the gated entrance
- A hard-wired push-button gate opener located at the gated exit (interior side of the PV Project Site fence; exit ground loop not required)
- A pedestal mount, conduits, and wiring for the gated exit
- Sliding gate shall be grounded
- Additional security requirements are found in Section 12.

9.2 Signage

A "Danger – High Voltage – Keep Away" sign shall be placed on the exterior of the fence at a maximum spacing of 50 ft. The signs shall be visible and readable from any angle the substation fence can be approached.

10 SUBSTATION PHYSICAL DESIGN CRITERIA

10.1 Substation Bus System

10.1.1 Bus Systems

The bus system consists of the bus conductor, bus insulators and supporting structures, and jumper conductors to equipment and lines. The bus system shall be designed to meet the voltage and continuous current rating requirement, as well as the mechanical requirements for bus design strength and deflection for all cases and conditions.

Rigid Bus structures shall be designed per IEEE Standard 605, IEEE Standard 1427 and in compliance with the NESC. The bus work must be designed to withstand all required weather conditions appropriate for the location of the station and withstand all forces due to maximum fault current.

Bus dampening shall be accounted for during detailed design and be between 10% and 33% of the bus conductor weight.

10.1.2 Bus Configuration

The layout of the bus design shall minimize the crossing of bus sections and equipment by lines and other station buses. This is to reduce or eliminate possible common mode failures and to permit service work to be performed without having to take additional busses or equipment out of service.

The design shall be of the low-profile type using rigid bus in a horizontal (flat) configuration on vertically mounted station post insulators.

Hookstick-operated disconnect switches shall be provided on both sides of all feeder breakers.

If so directed, the bus configurations of the substation facilities shall take into account future expansion. The physical layout shall be made so that expansion can be accomplished with the least amount of outage time when required.

10.1.3 Bus Fittings

Bus fittings used for rigid bus connections shall consist of welded connectors.

Fittings used for stranded conductor shall consist of either bolted, compression or welded types. For incoming lines to the substation DE structure, the use of quadrant clamps is acceptable. In applications where connection to a line surge arrester is required, the use of bolted connectors is preferred to compression connectors due to the potential chance of incorrect installation and bird caging effect on the incoming conductor. If using compression fittings for the incoming transmission line span, the compression tee and dead-end fittings shall have NEMA 4-hole or 6 hole terminal pads for connection of conductor jumpers.

Fittings used for conductor jumpers shall be of the bolted, compression, or welded type to a bolted pad. Jumpers shall be designed so that they can be unbolted and removed from equipment for maintenance, repair, or replacement.

10.2 Station Layout

The collection system shall be identified and marked. This includes all the phases on pad mount transformers, as well as any time the system transitions from underground to over ground or vice versa. An acceptable method of identification is stickers.

10.3 Phase Orientation

The phasing orientation of the substation shall be A-B-C when facing the low side transformer bushing left to right. If the phasing is different for the interconnecting utility, notation shall be added to the drawings detailing the phase rotation. Additionally, all equipment and busses shall be labeled.

10.4 Grounding System

High voltage equipment and structures will be connected to a ground grid. All metallic equipment, structures, and fencing will be conducted to the grounding grid of buried conductors and ground rods, as required for personnel safety.

10.5 Grounding Design Criteria

Grounding system shall be design using field resistivity values obtained from geotechnical studies. Substation ground grid design shall be based upon IEEE Std. 80 and NESC. Parameters to be used in the design, such as fault current magnitude and duration, will come from various studies, such as the Facility Study and other interconnection studies, and relay and protection system evaluation. Seller shall use fault current split factor calculations that consider OHGW, OPGW and feeder neutral grounding, in order to lower the effective ground fault current. The substation ground grid shall be connected to the overheard transmission line shield wires unless specifically isolated due to other engineering considerations. Clearing time for grounding analysis shall not be shorter than the total time for backup relay operation plus breaker time.

The ground grid analysis shall seek to optimize the cost and complexity of the installation. Multiple design iterations shall be developed, considering varying depths of substation rock, grounding conductor size, grid spacing, ground rod depth, etc., until an optimized, lowest-cost design is achieved.

Grounding analysis shall address seasonal conditions as appropriate, such as seasonally dry soil conditions or frozen earth conditions. The ground grid shall be designed to account for the most-restrictive weather condition.

The grounding system shall be modeled using the SES CDEGS grounding analysis software or equivalent.

10.6 Grounding System Components

10.6.1 Soil Structure:

Grounding analysis software shall be used to determine the number of soil layers present based on field test results input. The soil model results are considered usable if the resultant soil model accurately reflects the measured data.

The original soil model shall be adjusted to minimize the RMS error.

10.6.2 Ground Grid:

Ground grid conductor shall be optimized for cost, considering the fault current magnitude and other parameters. Copper clad steel should be considered where appropriate, but soil corrosivity shall be considered when evaluating the use of copper clad steel.

The ground grid shall be installed at a minimum depth of eighteen (18) inches below finished grade (i.e. grade not including any rock cover).

Ground grid shall extend to cover the swing access for all man and vehicle gate access points as well as any pad mount transformers and other medium or low voltage station service equipment located close to the substation fence. Recommended to go 3ft beyond the fence or overall equipment/gate offset.

10.6.3 Grounding Rods

The standard ground rod shall be 10-foot-long and made of 5/8-inch diameter copper-clad steel rod. It is acceptable for longer lengths to be made by joining multiple rods together with ground rod couplers. Longer ground rods shall be considered before more costly methods (such as ground wells) are implemented.

Ground rods shall be installed at applicable ground grid locations or at locations dictated by design. Applicable locations include substation perimeter, dead-end structures, lightning masts, surge arrestors, control house corners, etc.

10.6.4 Grounding Connections

All underground ground grid cable-to-cable and cable-to-ground rod connections shall be made with exothermic connections (Cadweld or equivalent). All above ground grounding connections shall be made with mechanical, bolted, or compression connections.

10.6.5 Above Grade Grounding Provisions

The perimeter fence shall be connected to the substation ground grid at each gate post, every corner and along the fence at intervals dictated by design. Grounding of the fence shall also include grounding provisions for the fence fabric and barbed wire.

All four corners of the control house shall be connected to the substation ground grid.

Two grounding conductors shall be installed the entire length of all pre-cast concrete cable trench greater than 36 inches wide. For pre-cast concrete cable trench less than 36 inches wide a single grounding

conductor shall be installed. These conductors shall provide a convenient access to the substation ground and shall provide some shielding of control cables from electrostatic interference. They shall be connected to the ground grid at all main grid crossings and sized to match the ground grid conductor size.

Personnel safety mats (galvanized steel grating) shall be installed on top of the crushed rock surfacing at each disconnect switch operator, manual or motor-operated gang switches, and each personnel entrance to the control enclosure if metal steps are used. Safety mats shall be bonded to the station ground system in accordance with IEEE 80.

Equipment and structure grounds, or “stingers,” consisting of bare conductors shall connect each piece of the substation equipment and steel structure to the ground grid. The minimum conductor size shall be calculated but never be smaller than the ground grid conductor size. There will be two (2) ground connections to each structure and piece of equipment.

Ground studs shall be installed on every breaker bushing pad. Provisions for portable safety ground installations, either bus \leq 3-inch diameter, ground studs, or grounding stirrups, shall be included at both sides of all disconnect switches. Grounding studs shall be placed such that there is no interference from other equipment (for example, disconnect switch blades).

10.6.6 Crushed Rock

The site will be covered with a layer of crushed rock as defined in Section 5.10.1.8. The crushed rock shall be installed throughout the entire substation area and extend 5 feet beyond the fence and swing radius of the gates.

Resistivity tests shall be performed on potential material sources early in the design phase, and those results shall be integrated into the overall grounding system design. The IFC grounding design shall use material with a known, tested resistivity; no assumptions should be made as to the availability of rock of a certain resistivity.

10.6.7 Grounding Drawings

The design input from the grounding calculation shall be recorded on the grounding drawing in a concise table. The table shall include all pertinent information, including, but not limited to, final design grid resistivity, depth of crushed rock, rock resistivity, length of ground rods, size of grounding conductor, soil parameters, design fault current, and fault duration. Additionally, it shall be included a field on the grounding drawing for the contractor to record the final fall of potential test results.

10.7 Conduit System

All conduit and raceway systems shall comply with NEC and NESC requirements. The conduit and raceway system design shall accommodate power and control cables, communication circuits, underground feeders, and optical fiber cables.

10.7.1 Conduits

Low voltage cables used for protection and control or station power shall be placed in conduit wherever they connect to oil immersed equipment to reduce the risk of burning oil flowing in raceways and causing severe damage to cables. All conduit systems including wiring size shall be detailed on drawings.

Conduit shall be schedule 40 or greater PVC for below grade or above grade applications. Flexible conduit may be used for transitions where necessary. Galvanized steel conduits shall not be used in below-grade applications. Conduits shall be sized in accordance with the National Electrical Code (NFPA-70). Where applicable, 2" and 4" conduits shall be used.

Designs shall incorporate one spare conduit per transformer (main GSU) and circuit breakers 138 kV and above.

All below-grade conduits shall be buried to a minimum depth of twenty-four (24) inches below the finished grade (approximately six inches below the ground grid). The conduit system for the 34.5 kV collector cables shall extend 10 feet beyond the fence and shall be concrete-encased. Additional coordination shall be made with collector system designer.

10.7.2 Cable Trench

For substations and collector facilities that have more than one main GSU transformer, precast concrete trench systems shall be installed. It shall be identified early in detailed design if the current project will ever be expanded with second or third phase. If additional phases are planned, the initial layout shall be designed such that adding new cable trench can be implemented while minimizing impact to existing facilities.

Precast concrete trench with a pedestrian strength rating shall be specified for the substation yard raceway system. HS-20 rated road crossing cable trench shall be used for all vehicle crossing locations. Each vehicle crossing location will be marked with high visibility bollards extending at minimum three (3) feet above the ground and visible during winter snow conditions. Applications for the use of a barrier internal to the cable trench or multiple trench systems may be utilized where required.

Conduits shall be provided between the concrete trench system and yard mounted equipment

On two transformer stations or an integrated ring bus switchyard, a partial cable trench system is normally required, and provisions shall be provided in detailed design.

10.7.3 Pullboxes

Cables entering the control house from the substation yard shall be routed through a pre-cast cable vault and pulling area into the control house termination cabinet.

10.7.4 Cable Entry and Trays

All conduit and cable entry openings into the control house shall be tightly sealed as a barrier to animals to keep out moisture and to minimize heat loss. Cables entering the control house shall be terminated at the appropriate termination cabinet or AC or DC panel board.

Inside the control house overhead cable tray suspended from the ceiling shall be used to route cables between the termination cabinet, control and relay panels, and other equipment.

10.8 Lightning System

The substation direct lightning stroke shielding design shall be performed in accordance with IEEE Standard 998-2012 “IEEE Guide for Direct Lightning Stroke Shielding of Substations” using the “electro-geometrical model” or the “rolling sphere technique”. For small stations it is acceptable to use the fixed angle method as a means for determining proper shield protection locations.

After the substation layout is completed, the direct stroke shielding shall be analyzed to verify that the equipment within the substation fence is adequately protected. The transmission line static wires shall be connected to the substation ground grid.

The following criteria shall be used for the lightning shielding design:

- Station BIL, Table 2.
- Lightning stroke density shall be that for the project area as reported by the Fault Analysis and Lightning Location System
- A design failure rate of less than one shielding failure in one hundred (100) years.

The shielding design shall utilize a combination of shield wires, shielding masts and/or mast poles. Shield wires over substation buses shall be arranged such that there is no more than a single bus between shield wire supporting structures.

All static wires from the transmission lines shall terminate into the station lightning shielding system.

10.8.1 Lighting System

The primary purpose of substation lighting is to provide sufficient illumination for personnel safety and emergency equipment maintenance. The substation shall be provided sufficient illumination during the night for safe passage of the maintenance crew who might be performing equipment inspection or maintenance. Outdoor lighting is often also intended to deter vandalism; however excessive illumination may attract vandals or result in complaints from the surrounding community. Lighting is also used in certain areas to deter birds from roosting and/or nesting. Yellow color lighting such as sodium vapor does not attract as many bugs, flying bats and birds that in turn attract snakes and climbing animals.

Proper placement of lighting is important. Placement of lighting shall consider the collection of insects on adjacent energized equipment. Large quantities of these bugs can attract animals and increase risk of animal outage.

At least minimum illumination levels recommended by National Electrical Safety Code C2 shall be provided in generating stations and substations. Illumination levels relevant to substations are as follows:

- a) Emergency exit path: 1 foot-candle (11 lux)
- b) Control house (occupied): 15 foot-candles (165 lux)
- c) Control house (unoccupied): 5 foot-candles (55 lux)
- d) Front of switchboards and panels: 15 to 25 foot-candles (165 to 275 lux)

- e) Fence: 0.2 foot-candles (2.2 lux)
- f) Substation general horizontal: 2 foot-candles (22 lux)
- g) Substation vertical (on disconnects etc.) 2 foot-candles (22 lux)
- h) Roadway: 0.5 foot-candles (5.5 lux)
- i) Open yard: 0.2 foot-candles (2.2 lux)

The need for detailed lighting design for each substation shall be individually evaluated

depending upon the substation's location, site area, type of buswork structures, and the equipment installed in it. LED light fixtures shall be installed for all new installations. The following is required as a minimum for typical substation lighting:

- a) The entrance gate into the substation shall be provided with a motion-activated photocell-controlled light.
- b) The substation control house entry doors shall be provided with motion activated photocell-controlled lights.
- c) The substation shall have switched, photocell-controlled lights, preferably with a timer, for safe passage. The control switch shall be in the control house.
- d) A sufficient number of GFCI outlets shall be provided in the substation near the equipment e.g. circuit breakers and power transformers for portable light hookup for night time repairs and maintenance. GFCI outlets provided in the equipment control cabinets shall be used for this function.

10.9 Substation Security/Safety (CODE)

Substation Security shall not apply for substations below 161 kV. However, depending of project interconnection area, additional requirements may exist due to other evolving cyber security concerns. Check with Buyer - Transmission Planning for site specific concerns.

10.10 Animal Deterrents

Means for animal deterrent and mitigation shall be provided in all medium voltage substations, and the MV section of all high voltage substations.

IEEE Std 1264 provides guidance in methods and designs to mitigate animal intrusion and resulting interruptions and equipment damage.

Animal mitigation shall be achieved by applying substation insulators that have a large enough flashover distance to prevent bridging by animals, such as snakes and squirrels, by increasing phase spacing and by providing guards and covers for insulators or adding barriers between phases to prevent phase to phase bridging by birds. Guards and covers shall be installed on all MV equipment bushings listed below regardless of the spacing.

Insulating covers shall be installed on all medium voltage equipment bushings as follows:

- a) Power transformers
- b) Station service transformers
- c) Voltage regulators
- d) Circuit breakers and reclosers
- e) Surge arresters
- f) Capacitors
- g) Instrument current and voltage transformers
- h) UG cable terminations
- i) MV switches and jumpers

Insulators in substations where higher BIL bus and disconnect insulators cannot be applied shall be protected by suitable guards and covers.

MV substation equipment including 34.5 kV equipment shall be provided with guards and covers and each phase shall be covered for a distance of three (3) feet, unless otherwise specified during the constructability review. The center phase shall be fully covered. Depending upon location and known animal intrusion problems, additional mitigation may be required.

10.11 Substation Protection & Control Design Criteria

10.11.1 Protection and Control Requirements

The protective relaying shall:

- a) Preserve the integrity of the Entergy transmission system by being dependable and secure to the appropriate level of required reliability as specified by Entergy Transmission Planning.
- b) Properly coordinate and function with other Entergy relay schemes, and neighboring utilities.

10.11.2 Backup and Transfer Trip

Breaker Failure Backup and/or transfer trip circuits to interface with other stations shall always be provided.

10.11.3 Transmission Line Protection

Transmission line protective relay equipment at the collector substation shall be provided to meet the requirements of Buyer - Transmission (as the host utility).

HV transmission lines shall have a dual primary line protection scheme comprising of dual primary communication assisted tripping relaying scheme. Each primary protection scheme shall utilize separate instrument current transformers, or separate current transformer cores of a free-standing current transformer, separate CVT or PT secondary windings, and separated dc and ac supplies from a common distribution panel. Breaker Control is typically on the same line panel.

10.11.4 Bus Protection

HV and MV bus shall use single low or high impedance protection scheme. Low impedance is preferred. If using high impedance protection, all of the current transformers in the circuit shall have the same ratio and must be tapped at the full ratio.

10.11.5 Transformer Protection

Each power transformer shall be protected by a minimum of one and, preferably, two differential relaying schemes. The transformer differential relay shall be connected to the transformer high side bushing current transformers. Low-side circuit breaker or transformer bushing current transformers shall be positioned to provide a sufficient area of overlap between adjacent protective zones. Protection zones shall be created to prevent through-bus interruption for transformer differential operation.

Back up time overcurrent transformer overload relaying shall be provided.

Generator Step-up Transformers shall be purchased and supplied with the following integral monitoring devices:

- a) Oil level gauge on tank wall or conservator.
- b) Pressure relief device(s). The pressure relief device is used for alarms. Transformer tanks containing more than 10,000 gallons of oil shall be provided with two pressure relief devices mounted on diagonally opposite corners of the transformer tank. The device(s) shall be located remote from the control cabinet(s). Pressure relief value shall be stamped on the device.

Sudden pressure rise relays. Transformers are specified to have two sudden pressure relays used to trip the transformer when both relays have operated. A sudden pressure or Bucholtz relay (Device 63) shall be provided, including seal-in contacts in an enclosure with a threaded conduit hub and "loss of DC indication"

Gas accumulation detecting relay (conservator tank units). Contacts of the gas accumulation detecting relay are used for alarm.

- c) Temperature monitoring system to indicate top oil and winding temperatures.

Seller shall design the system so as not to trip and isolate transformers due to the operation of pressure relief devices, high oil temperature, and high winding temperatures. Main power transformers shall be tripped and isolated when the oil level in the transformer tank falls below the critical level to prevent internal flashovers. GSUs or main power transformers shall have critical oil level as an alarming feature only and no tripping.

10.11.6 Capacitor Bank Protection

See IEEE Std C37.99 Guide for Protection of Shunt Capacitor Banks for detailed guidance on the capacitor bank protection schemes. Seller shall employ Unbalance Detection scheme for the protection of the capacitor bank. The aim of this scheme is to trip the capacitor bank if there are unbalances in the phases that result in voltages 110% or more across the individual capacitor unit.

10.11.7 Shunt Reactor Protection

See IEEE Std C37.109 for guidance on the protection of shunt reactors. Studies shall be conducted to determine if snubbers are required for reactor switching. Surge arresters are recommended for all reactor applications.

10.11.8 HV Breaker Control

Gas insulated circuit breakers are specified to be equipped with two or more stages of gas pressure/density monitoring contacts.

- a) Contact of the first stage closes on falling pressure at approximately 10% loss of pressure, and
- b) Contact of the second stage closes on falling pressure at a further 10% reduction of gas pressure.

Most manufacturers comply with these requirements except that the first stage and second stage contacts may not necessarily close at 10% loss of pressure for all makes and models of the circuit breakers.

A circuit breaker retains its full electrical and mechanical rating at this second stage pressure/density of gas in the circuit breaker. However, the circuit breaker manufacturer will not guarantee any rating below this pressure and, accordingly, the circuit breaker operation shall be disabled below this pressure.

The manufacturers of circuit breakers generally do not offer any specific recommendations for the circuit breaker's continued operation when the second stage contacts of the gas density monitor close. It will be the responsibility of Buyer to determine whether a circuit breaker should be tripped (if it was already closed) or block any close/open operation under these conditions.

Since the system security, substation importance, and the circuit breaker applications within the substation vary throughout the system, a common system wide approach on whether to trip or block operation of all circuit breakers cannot be specified.

The following is a recommended plan of action, keeping in mind that the circuit breaker retains full rated values at the second alarm stage, and it is capable of withstanding normal system voltage with the gas in the interrupters at atmospheric pressure. Under ideal conditions and with a standard 0.5% gas leakage rate it would take more than five years for any alarm stage to be generated for most breakers. A second stage alarm usually signifies a rapid loss of gas.

The circuit breaker control scheme shall address the loss of gas alarms as follows:

1. First Stage Alarm: Effort shall be made to investigate the cause within eight hours (or the next day at the latest).

2. Second Stage Alarm received within one day of receiving the first stage alarm: In locations where the system continuity can be maintained (ring bus, or breaker and half bus substations) the circuit breaker shall be tripped immediately. If the system continuity cannot be maintained, then the circuit breaker operation shall be blocked. In substations with a single bus the circuit breaker operation shall be blocked. It may be necessary to include timers in the relay scheme to achieve this requirement. This should be evaluated during detail design.

3. Second stage alarm received more than one day after receiving the first stage alarm: Block circuit breaker operation

All HV Breaker Control relays shall include LOR (lockout relays).

10.11.9 HV Motor Operated Switch Control

When HV motor operated switches (MOS) are used, if a control building is used, it is preferred that the MOS controls be located on the applicable line protection, transformer protection, or breaker control panel.

If no control house is required, the panel design must be modified to fit in a suitable NEMA type 4X stainless steel outdoor enclosure.

10.11.10 MV Collection Feeder Protection

Primary feeder protection will be provided by an SEL-351S or similar relay at each feeder breaker. Instantaneous and time overcurrent phase and residual ground are typical elements to protect the feeder section. Additional voltage and frequency elements will be enabled to ensure compliance with NERC reliability requirements (e.g., PRC 019, 024, and 026, if applicable).

Breaker failure initiate will be enabled to ensure coordination with MV bus and transformer differential if a breaker fail occurs.

10.12 Relay Calculations and Setting Requirements

For relay settings, refer to TE-SD-AD-007 (Relay Settings Procedure) and PM1804 (Transmission Line Relay Setting Criteria, Design and Operation Guide) for guidance. Relay settings shall meet the requirements of NERC Reliability Standards PRC-019, -023, -024, -025, and -026, as applicable.

Typical Relay Engineering Calculations:

- Battery Bank Sizing & Design: IEEE-485 & NEC – Article 480.
- Battery Charger Sizing: EPRI Stationary Battery Guide (Design, Application, and Maintenance)
- DC Load Center Sizing: Requires building DC loading table (Watts / Amps) for yard and enclosure (panel) equipment – Nameplate information and/or equipment manuals required.
- AC Load Center Sizing: Requires building AC loading table (Watts / Amps) for yard and enclosure (panel) equipment – Nameplate information and/or equipment manuals required.
- Station Service Sizing
- Voltage Drop Calculations (Use as Guide only): NEC: 215.2(A)(4)

- Conductor Ampacity Calculations (Use as Guide only): NEC Table(s) 310.15 (Engineer to select correct table for use)
- Grounding Methods for Electrical Supply: NESC Sec. 9
- Size of Equipment Grounding Conductors (Use as a Guide only): NEC Sec. 250.122 and Table 250.122.
- Cable in Conduit Fill Calculations: NEC Tables 310.15(B)(2)(a) & 310.15(B)(3)(a), Chapter 9, Table 1, Table 4
- Cable Tray Fill Calculations: NEC 392.22, Table 392.22(A).

11 CONTROL HOUSE

The control house shall be designed to comply with the latest version of the IBC, and with local building code requirements. See Section 5.9. It is preferred to have an Engineered/prefabricated and delivered to site precast concrete building. Steel, concrete and CMU buildings are all acceptable options.

The control enclosure shall contain Vendor-provided station services such as primary and backup AC supply disconnects, an automatic AC transfer switch, AC Load Centers, DC power system and storage battery, and air conditioning units.

The Vendor shall be capable of meeting any state-specific certification and/or inspection requirements.

The control enclosure shall be suitable for placement upon both concrete slab and concrete pier foundation types. An indication of design loads for both foundation types shall be supplied with the Vendor's engineering documentation.

All Vendor-supplied equipment within the control enclosure shall use equipment enclosures conformant to at least the NEMA 1 specification. External equipment shall be appropriately rated and weatherproofed for exterior installation.

The control enclosure shall contain space for equipment including:

- a) Control enclosure shall be sized to account for all necessary equipment in the station ultimate configuration. No more than sixteen 27-inch, free-standing relaying and control panels in a single row. All cable access to the panels will be from a cable tray system above the panels.
- b) One wall-mounted termination cabinet having dimensions of up to 72" x 90" x 24".
- c) Communications equipment including fiber-optic, telecommunications, and related interfacing gear.
- d) Separated control room is required to all projects.
- e) The control enclosure shall have a minimum internal ceiling height of 10'-0" to allow for adequate equipment clearance below the cable tray.

Wall space shall be left open to the greatest extent practical. Conduit and raceway provided by Vendor for building services and included equipment shall be placed at or near the ceiling with vertical service

drops. Horizontal raceways and conduits between adjacent equipment such as load centers are acceptable.

The control enclosure shall include one eye-wash system with two saline cartridges when there isn't water brought to the site.

11.1 DC System

One (1) VLA 125 VDC battery system shall be provided along with (2) 130 VDC battery chargers. The batteries and chargers shall be size in accordance of IEEE 485 and considering substation ultimate configuration (if any). The calculation shall consider worst case tripping scenario along with dual trip coil operation. A single charger shall be able to fully charge a completed battery within eight to twelve hours while supplying normal loads.

Dual DC Load Centers shall be provided within the control house. DC load centers shall be designed with enough circuit positions for the substation's ultimate configuration. Each DC load center shall be rated 125 VDC and shall have a main circuit breaker. The DC load centers breaker position and total circuits requirement shall be dictated by final approved DC Calculation considering ultimate substation configuration. DC load centers shall be dead-front design, installed on the control enclosure wall, and provided with conduit access to the cable tray.

Battery chargers shall not have an alarm on/off switch. Each battery charger installed in the station shall alarm on zero current output. Dual charger setups shall be wired for parallel operation. When properly set up each charger shall share half of the battery bank charging current.

Battery banks shall be located in a separate room of the control house. There shall be enough space so field personnel can reach each cell and battery terminals for testing and maintenance. A minimum of 24 inches height separation between battery racks is needed to accomplish this.

Battery DC grounds shall be monitored via indicating lights on the front panel of the battery charger and indication of a DC ground shall be an input to the station RTU. Battery voltage shall be an input to the station RTU.

11.2 AC System

The substation will be equipped with normal and backup AC station service sources supplying 120/240 VAC, 3 wire, single phase power. Station service is preferred to be provided by low- side SSVT, local distribution, or on-site generator in that order. The design shall include two (2) fused disconnect switches for the incoming feeds (secondary feed of the SSVT and emergency feed). The system neutral must be bonded to ground in one and only one of the fused disconnects. These two disconnects shall both be in the control building. The normal station power source also needs to have a fused disconnect switch below the station service transformer. The fuses shall be Type LPN.

Also, the unprotected conductors between the normal or backup station service transformers and the first disconnect cannot be routed in the same conduit with feeders or branch circuits.

There shall be specified an automatic transfer switch (ATS) with microprocessor control. The ATS shall be equipped with alarms for loss of normal service and loss of backup service. The ATS shall be capable of managing a standby generator on the backup source. The ATS shall have neutral bonding provisions.

There shall be specified AC load centers with enough circuit positions for the substation's ultimate configuration. Each AC Load Center shall be 120/240 VAC, three-wire, single phase, having a 100% rated, main breaker. The final AC load center breaker position and total circuits shall be dictated by final approved AC Calculation considering ultimate substation configuration. AC Load Centers shall be dead-front design, installed on the control building wall, and provided with conduit or wireway access to the cable tray for use by Others. The load centers shall use a commonly available circuit breaker type.

11.3 Metering Requirements

The metering panel shall be designed and constructed as specified in GIA or project planning phases.

Multi-conductor cables no smaller than #10 AWG shall be used to connect the instrument transformer secondary windings to the meter location. Under no circumstances shall CT cables contain splices. Larger conductor size may be required depending on the location of instrument transformers in relation to the meters. Seller shall perform burden calculations to determine appropriate conductor size.

Conductor used for grounding the metering instrument transformer tank shall be the same size as that used for the ground grid and in no case be smaller than #4/0 AWG.

Metering CTs and PTs shall be 0.15B1.8 sized so that tapping down is not required and 3% extended range TR=2 respectively.

All meters shall conform to ANSI Standards C12.20, C12.1, and C12.10. Acceptable meters are Landis and Gyr E850 MAXsys Elite, SEL-734 or SEL-735.

11.4 SCADA

A Remote Terminal Unit (RTU) and/or gateway device shall be specified, and installed to provide supervisory control, status indication, alarm monitoring, and to gather accumulated and instantaneous data to be telemetered to Entergy Distribution Operations Center (DOC), Transmission Center (TCC) and Entergy Local Balancing Authority (LBA). The RTU shall comply with all GIA requirements.

While all substations require a TCC / DOC RTU to be present, some existing substations host a "dual-port" RTU design in which data is provided to a TCC and LBA SCADA host. Confirmation of existing substation RTU-SCADA host configuration shall be done by contacting the IT-OT EMCS SCADA teams and/or IT-OT Substation Services. Substations that serve as a generation interconnection or system tie boundary with another utility may also require a dual-port RTU-SCADA host configuration.

Relay Design Personnel shall perform the following activities per TMM TE-SD-AD-006;

RTU/Communication Processor Configuration and Edit Sheet Procedure.

a) Obtain Initial baseline TOC RTU Edit Sheet from IT OP- Tech Personnel of what the SCADA Host has programmed to date of the request, or latest revision if there are revisions being documented.

- b) Provide SOC and/or GMS personnel needed information for them to provide new updated SOC and/or GMS edit sheets.
- c) Issue final approved TCC, SOC, and/or GMS edit sheets with relay design package.

11.5 Communications

The communications media (pilot wire, fiber optic cable, power line carrier or digital microwave) required, and the communications system for supervisory control, telemetering and equipment status indication will generally be known at the project initiation stage. Note that Entergy will usually consider digital microwave as adequate communication media. This will vary depending of the interconnection substation communication capabilities and GIA requirements.

Designers of communication circuits shall consider redundant, dual-purpose paths.

A telephone is required to facilitate voice receipt of switching orders, emergency services, and restoration of service during outages.

For fiber optic cable facilities, two conduits from the substation fence to the fiber optic cable terminal board in the control building shall be furnished and installed. The fiber optic cable between the fence and the terminal board shall be installed in conduit(s).

Multiplexers used for fiber-optic interface for digital relay communications schemes system protection shall be hardened per IEEE Std 1613; Standard Environmental and Testing Requirements for Communications Networking Devices Installed in Electric Power Substations, and compatible with IEEE Std C37.94; Standard for N Times 64 Kilobit Per Second Optical Fiber Interfaces Between Teleprotection and Multiplexer Equipment.

11.6 Digital Fault Recorder (DFR)

If project requires DFR, TESLA 4000 or similar DFR may be used. This shall include enough current and voltage inputs as per project design.

11.7 Low Voltage Cable (Wiring)

The following is a partial list of the requirements for station power, instrumentation and control cabling within the substation.

- The voltage drop for all control cables shall be verified not to exceed 10%.
- All current carrying control cables shall be sized based on the anticipated maximum load currents. Factors that shall be considered to determine the adequate cable size are conductor material, ambient conditions, cable insulation, cable stranding, proximity of parallel current carrying cables and whether the cables are in conduit, in a cable tray or suspended in the air.
- All low voltage power, instrumentation and control cables within the substation shall be insulated for a 600 volt rating.
- Coaxial and instrumentation cable shall be fully shielded both inside and outside the control house.
- All other control cables inside the control house are not required to be shielded.

- Shielded cables shall be required in 345 kV yards and above (CT, Trip and Control Circuits) and in 69 kV and above capacitor banks (grounded and ungrounded). All control and low voltage power cables outside the control house shall have a longitudinally corrugated copper tape shield.
- Returns for power, currents, potentials, controls, analogs and others shall be within the same cable.
- Cable shields and unused conductors are not required to be terminated or grounded for cables within the control house. For shielded field cables, the shield shall be terminated at one end, preferably within the termination cabinet, and unused conductors shall be left ungrounded. The termination cabinet ground bar shall be sized to accommodate shield grounding.
- Analog connections shall be made with 2 pair #18 AWG instrumentation cable, communication connections shall use shielded 4/C #18 AWG control cable, and status point connections shall use shielded 8/C #18 AWG control cable when new cables are required.
- Power line carrier signals shall be shielded via a shielded coaxial type cable.
- Splicing of cables is not permitted.

12 PHYSICAL AND ELECTRONIC SECURITY

Refer to IEEE Std. 1402 Guide for Electric Power Substation Physical and Electronic Security for guidance in providing physical and electronic security for the substation. Additional security design elements may be required by NERC Critical Infrastructure Protection (CIP) standards.

The following NERC CIP standards provide mandatory security requirements:

- a) CIP-002; Cyber Security-BES Cyber System Categorization
- b) CIP-005; Cyber Security-Electronic security Perimeter(s)
- c) CIP-006; Cyber Security-Physical Security of BES Cyber Systems
- d) CIP-014; Physical Security

Critical Substations are designated as Critical or CODE. CODE substations include the Critical Asset and infrastructure but also the larger assets which if destroyed, damaged degraded or otherwise rendered unavailable would have a significant impact on the Bulk Electric System (BES) affecting its stability or ability to transport large loads or would have a detrimental impact on the reliability or operability of the electric grid or would cause significant risk to the public health and safety.

NERC standard CIP-014-1 provides the following criteria for critical designation:

- a) All 500 kV substations
- b) Substations operating at 200 kV to 499 kV with an aggregate weight exceeding 3000 per table below
- c) Substations operating at 200 kV and above and connected to three or more substations with an aggregate weight exceeding 3000 per table below:

Voltage of Line	Weight Value per Line
200 kV to 299 KV	700
300 kV to 499 kV	1300

In general, all 500 kV substations, all substations with four 230 kV lines or all substations with three 230 kV and several 161 kV or lower transmission lines may be considered as CODE. The criteria noted above are the minimum threshold for CODE designation. A substation may also be designated CODE as necessary per the unique risks that justify.

Substations that are designated as Critical or Deemed Essential (CODE) assets require additional physical and electronic security from physical and electronic intrusion, vandalism as required by NERC CIP-002, -005, and -006.

Additional requirements may exist due to other evolving cyber security concerns. Check with Transmission Planning for site specific concerns.

Minimum security requirements are defined in the following table:

Location	Description	Equipment by Seller	Equipment by Buyer
Collector Substation	Minimum two cameras located at opposite corners of substation area	Wiring (power and communications) and required hardware supports	Cameras
	Electrically operated slide gate with keycard reader	Keypad, slide gate, gate operator, wiring (power and communications), grounding loop, exit button and hardware for mounting keycard reader	Keycard reader
Collector Substation Control House	Keycard reader for lock on control house personnel door	Keypad, wiring (power and communications), and required hardware supports for mounting keycard reader	Keycard reader

13 DELIVERABLES

In addition to any submittals and deliverables defined in the contract documents, in accordance with NERC reliability standards, Seller shall provide the following documentation to Buyer thirty (30) days prior to initial synchronization of the Project, along with any other documentation reasonably requested by Buyer or required by NERC:

- BAL-005 – One-line diagram that displays the Electrical Interconnection Point (and includes unique line identifiers/names ensuring that the Project Site and Buyer - Transmission use the same naming convention when referring to the PV Plant (e.g., breakers, lines, etc.) by Seller

- COM-002 – Network diagram of voice and data links by Seller
- FAC-008 – Identification of most limiting equipment factor based on application of Generator Buyers Facility Rating Methodology by Seller
- MOD-032 – Data for Power System and Analysis, as applicable, by Seller.
- VAR-002 - Transformer information, including the following, as applicable, by Seller and Buyer (or its Affiliate), and as obtained by Seller from the Approved Vendor of the GSU:
 - Tap Settings
 - Available fixed tap ranges
 - Impedance data
 - The + / - voltage range with step-change in % for load-tap changing transformers.

ATTACHMENT 1: APPROVED MANUFACTURERS LIST FOR COLLECTOR SUBSTATION*

*Attachment 1 to Appendix 1 (Collector Substation) of this Scope Book provides an Approved Manufacturers List. The Approved Manufacturers List in this Attachment 1 is in addition to the Approved Manufacturers and EPC Contractor List in Appendix 9 of the Scope Book.

Attachment 1: Approved Manufacturers List

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
SA0102	Arresters	Arrester, Surge		(Cooper), Siemens, ABB	Cooper	Substation	
PM0201	Battery	Batteries & Battery Racks		(Energysys)	Nolan Power	Relay	125VDC 58 Cell EC- XM/CC- XM only
PM0301	Battery	Battery Charger		(Hindel)	Nolan Power	Relay	AT-10 Models
PM0303	Battery	Battery Charger Rack		(Energysys)	Nolan Power	Relay	
	Bolts	Bolts Anchor		Valmont, Distran, Threaded Fasteners		Substation	
	Bolts	Anchor bolt cage for foundations		Valmont, Distran, Threaded Fasteners-w/size limit		Substation	
SD0203	Breaker	Breaker, EHV	500 & 345kV (Live Tank)	(MEPPI), ABB	MEPPI	Substation	
SD0203	Breaker	Breaker, EHV	500 & 345kV (Dead Tank)	(MEPPI), ABB	MEPPI	Substation	
SD0202	Breaker	Breaker, HV, IPO	245kV - 145kV	(Siemens), ABB, MEPPI	Siemens	Substation	Per Entergy review

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
SD0202	Breaker	Breaker, HV	245kV - 72.5kV	(Siemens), ABB, MEPPI	Siemens	Substation	See table below
SD0201	Breaker	Breaker, MV	27kV - 15kV	(ABB), MEPPI	ABB	Substation	
SD0201	Breaker	Breaker, MV	34.5 kV	(ABB)	ABB	Substation	
SB0101	Bus	Bus, Aluminum Pipe		(Williams Metals), AFL	(W illiams Metals)	Substation	
PB0401	Cable, Control	Control Cable - Shielded and Non-Shielded		(Southwire), Priority	Southwire	Relay	ICEA Method 1 for color coding
SA0301	Capacitor Bank	Capacitor Banks, Shunt		(Cooper), GE, ABB	Cooper-Eaton	Substation	
	Capswitcher	Capswitcher	170kV - 72.5kV	(Southern States)	Preferred Sales	Substation	
	Carrier Relays	Power line Carrier	UPLC	Pulsar-Ametek	Ametek	Relay	
PN0201	CCVT	CCVT	500kV - 69kV	(GE-Alstom), Trench, ABB	Crescent Power	Relay	Polymer only. Trench required when Line trap to be mounted on CCVT.
SD1801	Circuit Switcher	Circuit Switcher	Series 2000	(S&C)	Curtis Stout	Substation	
	Conductor	Cable, Aluminum	ACSS, ACSR	(General Cable), Southwire	Aertker Co.	Substation	
	Conductor	Copper (Not Control cable)		Copperweld/Alcoa	Stuart Irby	Substation	Grounding conductor
	Conductor	Cable, Fiber	OPT-GW	AFL	Preferred Sales	T-Line	

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
	Conductor	Cable, Fiber	ADSS	AFL	Preferred Sales	T-Line	
	Conduit	Conduit & Accessories		Cantex, Carlon	Stuart Irby	Substation	
	Connector	Connectors, T-Line	ACCR	AFL / 3M	Preferred Sales	T-Line	
	Connector	Connectors, T-Line	ACSS	AFL	Preferred Sales		
	Connector	Connectors line (Fiber, OPGW, ACSR)	Fiber, OPGW, ACSR	AFL	Preferred Sales	T-Line	
	Connector	Connectors, T-Line		Maclean Power Sys	Preferred Sales	T-Line	
	Connectors /Fittings	Connectors/Fittings - Substation		Anderson, AFL, Homac, Travis, Sefcor, Burndy		Substation	
SL0403	Control House	Control House	Drop-In (turnkey)	VFP	VFP	Relay	Concrete only.
SL0403	Control House	Control House		Modular Connections, VFP, Atkinson, Trachte, Oldcastle		Substation	Concrete only.
PN0301	CT	CT	Slipover only	ITEC, ABB, Meramac, Siemens		Relay	
PN0301	CT	CT	34.5kV - 15kV	ABB, GE		Relay	
PN0301	CT	CT	500kV - 69kV	(GE-Alstom), Trench, ABB	Crescent Power	Relay	Polymer only
	DFR	DFR (Digital Fault Recorder)		MehtaTech	Louisiana, Mississippi, Arkansas only	Relay	

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
	DFR	DFR (Digital Fault Recorder)		Qualitrol	Texas only	Relay	
	Fittings	Conductor Fittings Compression		AFL, Secor, Anderson, Hubell	Stuart Irby	Substation	
	Grounds Rods Clamps	Ground Rods, Clamps		Cadweld, Erico, Thermoweld	Stuart Irby	Substation	
TA0504	Insulators	Insulator, Line, Toughened Glass		Sediver		T-Line	
TA0504	Insulators	Insulator, Line, Polymer	(Polymer Insulator Only)	Maclean Power Sys	Preferred Sales	T-Line	
TA0504	Insulators	Insulator, Line, Polymer	(Polymer Insulator Hardware Assembly)	Maclean Power Sys	Preferred Sales	T-Line	
SA0502	Insulators	Insulator, Station Post, Porcelain	500kV-69kV	(Seves), Victor, Lapp, NGK, Newell, Vanguard		Substation	
SA0502	Insulators	Insulator, Station Post, Polymer	230kV-15kV	(Maclean Power Sys)		Substation	
	Junction Box	Junction Boxes		MMR, SEL, Custom Automated, Premier Control		Relay	
	Meter	Meter & Cables	Elite Model	Landis+Gyr		Relay	
CP Approved Panels Appendix S	Panel	Panel - Battery Switching		SEL	Power Connections	Relay	
CP Approved Panels Appendix S	Panel	Panel - AC & DC Stand Alone		Peterson Electric Panel	Peterson	Relay	No AC/DC Combo Panel permitted

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
PM3507	Panel	Panel - Autoxfmr Differential		MMR, SEL, Custom Automated, Premier Control		Relay	
PM3505	Panel	Panel - Power xfmr Differential		MMR, SEL, Custom Automated, Premier Control		Relay	
PM0501	Panel	Panel - Breaker Control		MMR, SEL, Custom Automated, Premier Control		Relay	
PM0602	Panel	Panel - Bus Differential		MMR, SEL, Custom Automated, Premier Control		Relay	
PM1803	Panel	Panel - Line, Line/Breaker		MMR, SEL, Custom Automated, Premier Control		Relay	
MI0200	Panel	Panel - Meter		MMR, SEL, Custom Automated, Premier Control		Relay	
	Poles	Pole Caissons		(Valmont)	Preferred Sales	T-Line	
TC0609	Poles	Pole, Concrete		(Valmont)	Preferred Sales	T-Line	
TC0608	Poles	Pole, Steel		(Valmont)	Preferred Sales	T-Line	
PN0701	PT	PT	34.5kV and below	ABB, GE, Trench		Relay	
PN0701	PT	PT	230kV - 69kV	GE-Alstom, Trench, (ABB)		Relay	Polymer only
SN0903	Reactor	Reactor, Dry Type Shunt	Below 230kV	Alstom Grid, Coil Innovations, Trench		Substation	
SN0902	Reactor	Reactor, Current Limiting		Alstom Grid, Coil Innovations, Trench		Substation	

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
SN0904	Reactor	Reactor, Oil filled Shunt	230kV, 500kV	ABB, Alstom Grid, Mitsubishi, Siemens, SMIT		Substation	
SN1002	Regulators	Regulator		Pennsylvania Transformers	Curtis Stout	Substation	
	Relay	Protective Relays & associated accessories		SEL	Power Connections	Relay	
	RTU		Accessories & Cables	(ACS), GE Grid Solutions	Ruffin & Associates	Relay	
PM3002	RTU	RTU	SEL RTAC	SEL	Power Connections	Relay	
SL1301	Signs	Signs - Entergy Substation Switchyard Placard w/Address		Impco	Impco	Substation	This is the substation name and address sign on the front fence.
SL1301	Signs	Signs - General		Stuart Irby	Stuart Irby	Substation	
SC0401, SL0505	Structure	Steel	Substation, Tubular / Tapered	(Distran), Valmont	Distran	Substation	
SC0401, SL0505	Structure	Steel	Substation, Lattice	(Distran), Industrial Steel	Distran	Substation	
SC0401, SL0505	Structure	Steel Standard and Tapered Tubular	Substation, pre-existing designs w/details	(Distran), Valmont	Distran	Substation	
PM3401	Switch	ATS (Automatic Transfer Switch)		ASCO	Utility and Industrial Supply LLC, WESCO	Relay	

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
	Switch	Switch, T-Line	Switch group operated 245kV and below	SEECO	Southern Utility Sales Agency	T- Line	
SD1502	Switch	Switch, Disconnect	500 & 345kV	(Southern States), Pascor Atlantic	Preferred Sales	Substation	
SD1501	Switch	Switch, Disconnect	230kV - 69kV	(Southern States), USCO, Pascor Atlantic	Preferred Sales	Substation	
SD0601	Switch	Switch, Disconnect	34.5kV - 15kV	(Southern States), USCO	Preferred Sales	Substation	
SD0701	Switch	Switch, Disconnect, Hookstick	34.5kV - 15kV	(Southern States), USCO	Preferred Sales	Substation	
	Switch	Switch, Fuse (SMD style)	34.5kV - 15kV	(S&C)	Curtis Stout	Substation	
SD1601	Switch/Motor Operators	Motor Operator	Southern States	(Southern States)	Preferred Sales	Substation	For Southern States switches
SN1101	Transformer	SSVT; Station Service Voltage Transformer	230kV - 69kV	Alstom Grid, ABB		Substation	Polymer only
SN0103, SN0104	Transformer	Transformer, Auto	230kV and Above 100MVA	ABB, HICO, MEPPI, Siemens, SMIT, SPX-Waukesha Electric		Substation	See chart below
SN0102	Transformer	Transformer, Small Auto	below 230kV and 100MVA	(SPX-Waukesha Electric), ABB, HICO, Howard	Aertker Co.	Substation	See chart below
SN0801	Transformer	Power Transformers	230kV and below	(SPX-Waukesha Electric), ABB, HICO	Aertker Co.		See chart below

Purchase Spec.	Class	Description	Qualifier	Approved Manufacturer(s) - (Preferred)	Preferred Supplier	Type	Notes
PM0802	Trap	Trap, Line Carrier		Trench (No other supplier approved)	Curtis Stout	Relay	See CCVT note above
	Trench	Trench (Cable Trench)		(Concast), Trenway, Old Castle	GHMR	Substation	
PM0804	Tuner	Tuner, Line Carrier		Trench	Curtis Stout	Relay	
	Xfmr Firewall						

ENTERGY APPROVED SUBSTATION TRANSFORMER SUPPLIERS						
TWO-WINDING & AUTO-TRANSFORMERS RATED < 100MVA (3-phase) and HV ≤ 230kV						
Production Facility & Location	Currently qualifying or already qualified	Maximum ratings approved by Entergy		Capabilities reported by facility		
		MVA (3ø)	KV	MVA (3ø)	KV	
ABB / Crystal Springs, MS USA	Qualified	50 (MS)	161 (MS)	~60 (MS)	161 (MS)	
Delta Star / Lynchburg, VA	Qualified	60	230	~200	230	
HICO-Memphis	Qualified	1000	230	1000	230	
Waukesha Electric (SPX), Goldsboro, NC & Waukesha, WI USA	Qualified	80 (NC), 100 (WI)	230 (NC), 230 (WI)	~80 (NC), 800 (WI)	230 (NC), 345 (WI)	
AUTO-TRANSFORMERS RATED ≥ 100MVA (3-phase) or HV > 230kV						
Production Facility & Location	Currently qualifying or already qualified	Maximum ratings approved by Entergy		Capabilities reported by facility		
		MVA (3ø)	KV	MVA (3ø)	KV	

ABB / Varennes, Quebec, Canada; Guarulhos, Brazil; Cordoba, Spain	Qualified	1000 (Can), 500 (Br), 800 (Sp)	500 (Can), 500 (Br), 500 (Sp)	1200 (Can), 600 (Br), 800 (Sp)	765 (Can), 765 (Br), 500 (Sp)	
HICO-Memphis	Qualified	1000	765	1000	765	
Mitsubishi / Ako, Japan	Qualified	~1000	500	~1500	1000+	
Siemens / Linz & Weiz, Austria; Nuremburg, Germany; Jundiai, Brazil; Bogota, Colombia	Qualified	1000 (Aus, Ger), 750 (Br), 200 (Col)	500 (Aus, Ger, Br), 230 (Col)	2000 (Aus), 1100 (Ger), 1000 (Br), 250 (Col)	765 (Aus), 1000+ (Ger), 765 (Br), 345 (Col)	
SMIT / Nijmegen, Netherlands	Qualified	~800	500	~1200	500	
Waukesha Electric (SPX), Waukesha, WI USA	Qualified	400	345	~800	345	
ENTERGY APPROVED HV CIRCUIT BREAKER MODEL NUMBERS						
Voltage	Continuous Current (A)	Interrupting Rating (A)	Siemens Breaker to be ordered	CT Ratio and Accuracy	CT Quantity	
230 KV	3000	50KA	SPS2-245-50- 3000	3000:5 C800	3 per bushing	
	3000	63KA	SPS2-245-63- 3000(reference)	3000:5 C1200	3 per bushing	non-standard
161 KV	3000	40KA	SPS2-170-40- 3000	3000:5 C800	3 per bushing	
	3000	63KA	SPS2-170-63- 3000(reference)	3000:5 C1200	3 per bushing	non-standard
138 KV	3000	40KA	SPS2-145-40- 3000	3000:5 C800	2 per bushing	
	3000	63KA	SPS2-145-63- 3000(reference)	3000:5 C1200	2 per bushing	non-standard

115 KV	3000	40KA	SPS2-145-40-3000	3000:5 C800	2 per bushing	
	3000	63KA	SPS2-145-63-3000(reference)	3000:5 C1200	2 per bushing	non-standard
69 KV	3000	40KA	SPS2-72.5-40-3000	3000:5 C800	2 per bushing	
	3000	63KA	SPS2-145-63-3000(reference)	3000:5 C1200	2 per bushing	non-standard

ATTACHMENT 2: SITE ENVIRONMENTAL CHARACTERISTICS

The Project Site environmental data that Seller shall use for the design of the Collector Substation shall have been determined prior to bid submission. The minimum required Project Site environmental data to be included is shown in Table 2-1 below. This Table 2-1 shall have been completed by Seller and included with the bid. Additional pertinent criteria shall be provided as needed.

Table 2-1. Project Site Environmental Characteristics

Description	Data (Units)
Elevation (substation)	
Contamination Level (light, medium, heavy, extra heavy) *	
Average Annual Temperature	
Average High Temperature	
Extreme High Temperature	
Average Low Temperature	
Extreme Low Temperature	
Average Annual Precipitation	
Maximum 24-hour Rainfall	
Maximum 1-hour Rainfall	
Maximum 24-hour Snowfall	
Ground Snow Load	
Design Ice Load	
Design Wind Speed	
Isokeraunic Level	
Seismic Referenced Code	
Mapped Spectral Response Acceleration at Short Period (0.2-Second) S_s	
Mapped Spectral Response Acceleration at 1-Second Period S_1	

Description	Data (Units)
Site Class	
Seismic Design Category	

***All equipment external bushing creepage distance shall be based on this criterion. If not available, medium (35mm/kV) shall be used. This factor is applied to nominal line to ground voltage.**

***** END OF APPENDIX 1**