Solar Technical Specification

SP-001

9/30/2019

Table of Contents

List of Exhibits

1.0 General

This technical specification defines the minimum requirements acceptable by the Owner governing solar photovoltaic Projects acquired by means of a build transfer agreement. The criteria defined sets the minimum standards of quality for equipment and materials included in the Contractor's design and it is not intended to limit the Contractor to a single design approach. The primary purpose is to ensure safe and reliable operations and maintenance for the lifetime of the facility.

The Contractor shall also comply with the technical requirements contained in other Exhibits to the Agreement.

Prior to a formal contract agreement each solar Project shall develop a conformed version of this specification to detail the specific parameters of the Project.

1.1 Defined Terms

1.1.1 **AC** shall mean – Alternating Current.

1.1.2 **AC Collection** shall mean – All equipment and conductors from the inverter output to the Point of Interconnection.

1.1.3 **Acceptance Test Plan** shall mean – A plan to demonstrate the Project has met all of the requirements within this specification

1.1.4 **Affiliated Transmission Company** shall mean –term as defined in section 2 of 1995 PA 30, MCL 460.562.

1.1.5 **AHJ** shall mean – Authority Having Jurisdiction.

1.1.6 **Capacity Test** shall mean – The demonstrated power generating capability of the Project.

1.1.7 **Commissioning Plan** shall mean – Document(s) that outline the scope, responsibilities, processes and schedules of the commissioning process

1.1.8 The **Contract** shall mean – the pending Contract agreed to between Owner and Contractor for the Contractor to design, construct, and commission the Solar Facility.

1.1.9 The **Contractor** shall mean – the party with whom Owner executes the Contract.

1.1.10 **Control Enclosure** shall mean – A structure that contains electrical control equipment (relay panels, batteries, SCADA system, AC panel, DC panel, etc.).

1.1.11 **DC** shall mean – Direct Current.

1.1.12 **DC Collection** shall mean – All equipment and conductors from the PV module output to the input terminals of the inverter(s).

1.1.13 **Electric Utility** shall mean –term as defined in section 2 of 1995 PA 30, MCL 460.562.

1.1.14 **Extra High Voltage (EHV)** shall mean – RMS AC voltage measured from line to line between 230,001 – 800,000V.

1.1.15 The **Facility** shall mean – the solar PV generating facility and Project substation (if applicable) described in this Specification.

1.1.16 **High Voltage (HV)** shall mean – RMS AC voltage measured from line to line between 69,001 – 230,000V.

1.1.17 **Independent Transmission Company** shall mean –term as defined in section 2 of 1995 PA 30, MCL 460.562.

1.1.18 **Generator Interconnection Agreement** shall mean – The agreement between the Project and the Electric Utility or Independent Transmission Company

1.1.19 **Low Voltage (LV)** shall mean – RMS AC voltage measured from line to line between 0 – 1,000V.

1.1.20 **Medium Voltage (MV)** shall mean – RMS AC voltage measured from line to line between 1,001 – 69,000V.

1.1.21 **OEM** shall mean – Original Equipment Manufacturer.

1.1.22 **Owner** shall mean – Consumers Energy Company.

1.1.23 **Quality Plan** shall mean – Documents that specify quality standards, practices, resources, specifications and the sequence of activity related to the Project.

1.1.24 **RTU** shall mean – Remote Terminal Unit

1.1.25 **SCADA** shall mean – Supervisory Control and Data Acquisition.

1.1.26 **Site** shall mean – Physical location of the Project

1.1.27 **Specification** shall mean – this Technical Specification document.

1.1.28 **Standard Test Conditions (STC)** shall mean –as defined within IEC 61215.

1.1.29 **Submittal** shall mean – Any document related to the Project requiring Owner review and/or approval

1.1.30 **Substantial Completion** shall mean – Sufficiently complete to utilize the Project for the intended purpose.

1.1.31 **System Operator** shall mean – The party responsible for remote site control.

1.1.32 **Transmission Line** shall mean –all structures, equipment, and property necessary to transfer electricity at system bulk supply voltage of 100 kilovolts or above.

1.1.33 **Transmission Provider** shall mean – owner of transmission line that Facility interconnects to.

1.1.34 **Transmission System Operator (TSO)** shall mean – Entity responsible for controlling and operating the electric transmission grid.

1.1.35 **Utility Electric Service Requirements** shall mean – the requirements defined by the distribution service that the Facility interconnects to.

1.1.36 **Vendor** shall mean – Equipment supplier or seller of equipment.

1.2 Applicable Codes and Standards

1.2.1 The design and construction of the solar Project shall be in accordance with all applicable Laws, Permits, Codes, and Standards. Any departure from the referenced codes shall be fully described in writing and submitted for the Owner's review and approval.

1.2.2 Applicable Industry codes and standards include, but are not limited to, the following:

1.2.2.1 ACI - American Concrete Institute

1.2.2.2 AISC - American Institute of Steel Construction

1.2.2.3 AISI - American Iron and Steel Institute

1.2.2.4 ANSI - American National Standards Institute

1.2.2.5 ASCE - American Society of Civil Engineers

1.2.2.6 ASTM - American Society for Testing and Materials

1.2.2.7 AWS - American Welding Society

1.2.2.8 ICC - International Code Council

1.2.2.9 IEEE – Institute of Electrical and Electronic Engineers

1.2.2.10 MBC - Michigan Building Code

1.2.2.11 MIOSHA – Michigan Occupational Safety and Health Administration

1.2.2.12 NEMA - National Electrical Manufacturers Association

1.2.2.13 NERC - North American Electric Reliability Corporation

1.2.2.14 NESC - National Electrical Safety Code

1.2.2.15 NETA - International Electrical Testing Association

1.2.2.16 NFPA 70 - National Electrical Code (NEC)

1.2.2.17 NFPA 70E - Standard for Electrical Safety in the Workplace

1.2.2.18 NFPA 780 - Standard for the Installation of Lightning Protection Systems

1.2.2.19 OSHA - Occupational Safety and Health Administration

1.2.2.20 UL - Underwriters Laboratories

1.2.2.21 Federal, State, County and Local Authorities Having Jurisdiction (AHJ) requirements.

1.2.2.22 United States Code of Federal Regulations (CFR)

1.3 Engineering

1.3.1 Contractor is responsible for all electrical, structural, mechanical, and civil engineering and design. All drawings, studies, and documentation submitted to

any authority having jurisdiction shall be signed and sealed by a professional engineer registered in the State of Michigan.

1.3.2 Contractor shall perform all engineering and design work within the scope defined and in accordance with all applicable building, electrical, safety and fire codes.

1.3.3 Contractor shall provide submittals to Owner pursuant to Section 1.5. Engineering submittals shall be provided at intervals sufficient for Owner to review and comment on design decisions. Submittal milestones include:

1.3.3.1 30% Design Documents

1.3.3.2 90% Design Documents

1.3.3.3 Approved for Construction (AFC) Design Documents

1.3.3.4 As-Built – "For Record" Design Documents

1.3.4 All engineering and design calculations prepared by Contractor during the design of the Project shall be available for Owner to review electronically.

1.3.5 All vendor documents received by Contractor shall be maintained by the Contractor and the final as-built versions submitted to the Owner.

1.3.6 Contractor shall make all engineering documentation available in PDF format for all review submittals.

1.4 Permits

1.4.1 Contractor shall be responsible for obtaining all building, construction, environmental, special land use, and any other permits necessary to complete the work.

1.4.2 Contractor shall comply with all Conditions of Approval and all mitigation measures contained by the Permit Requirements.

1.5 Submittals

1.5.1 General

1.5.1.1 The Contractor shall follow the Owner's submittal requirements to ensure the design, equipment, and materials are in compliance with this specification.

1.5.1.2 Submittal requirements are contained within Exhibit A1.

1.5.1.3 The Universal Required Submittals are summarized within the master deliverables list (MDL), Exhibit-A2. Submittals are also listed within various sections of this specification. The Contractor shall prepare a schedule of all submittals for the specific Project for Owners review and approval.

1.5.1.4 Drawing numbering shall be assigned as referenced in the Drawing and CAD Standards, Exhibit A3.

1.5.2 As-Built Record Documentation

1.5.2.1 During construction the Contractor shall keep on file one set of current as-built drawings with green and red lines reflecting all field deviations from the design drawings.

1.5.2.2 Contractor shall provide to Owner, a complete set of as-built "Record" drawings as indicated on the MDL. Record drawings shall be provided using the English language.

1.5.2.3 Contractor shall provide as-built Record drawings locating all underground utilities dimensioned from permanent identifiable benchmarks or geographic information system (GIS) location controlled information may be substituted.

1.5.2.4 All as-built Record drawings shall be sealed by the Contractor's engineer registered in the State of Michigan. The as-built Record drawings shall be provided to the Owner within eight (8) weeks after Substantial Completion. This shall include all vendor drawings for the project.

1.5.2.5 All as-built Record drawings shall be submitted in electronic format via Owners document control platform, "ProjectWise®. "

1.5.2.6 As-built Record drawings shall be submitted in digital CAD format as identified in Exhibit A3.

1.6 Quality

1.6.1 Quality Control

1.6.1.1 Contractor shall implement a Quality Plan to ensure the necessary measures are taken to support successful execution of the Agreement.

1.6.1.2 Within thirty (30) days following the Notice To Proceed, Contractor shall provide to Owner a Site-specific, detailed Quality Plan. The Quality Plan, at a minimum, shall address all aspects of:

1.6.1.2.1 Procurement of equipment including inspections, testing, shipping, handling, and storage.

1.6.1.2.2 Construction of the Project, including inspection and testing procedures to verify the construction complies with the AHJ-approved design and permit conditions.

1.6.1.2.3 Commissioning and testing of the Project.

1.6.1.2.4 Non-conformance process and corrective action procedures that address defective materials, chain of supply, discrepant system components and field installation issues.

1.6.1.3 Contractor shall have the Quality Plan reviewed by a third party to ensure all testing and inspection procedures satisfy applicable standards and regulations.

1.6.1.4 Contractor shall allow the Owner to visit the site at any point during construction and testing to observe installation and testing activities.

1.6.2 Required Manufacturer's Warranty

1.6.2.1 Original Equipment Manufacturer warranties shall be actionable for the Owner, following commercial operation of the facility.

1.6.2.2 PV modules, at a minimum, shall have a 10-year defects warranty and a 25-year linear output performance warranted degradation not to exceed 0.7% annually and 25th year minimum of 80% of nameplate rating.

1.6.2.3 Contractor shall secure a 3rd party insurance guarantee of the PV module warranty.

1.6.2.4 Main Power step up transformer(s) shall be warranted for a period not less than 5 years.

1.6.2.5 Inverter shall have a minimum 5-year manufacturer's warranty covering defects and workmanship that provides for all shipping costs, parts and labor required to replace or repair warranty-eligible failures.

1.6.2.5.1 Inverter warranty shall allow for unlimited usage at full rated power during the term of the warranty.

1.6.2.6 Single Axis Trackers shall have a minimum manufacturer's warranty of 10 years on the structural components and 5 years on all other parts

1.6.2.7 All other equipment not listed above shall include a minimum one year warranty for all parts and labor by the Contractor.

1.6.3 PV Performance Criteria

1.6.3.1 Every solar facility shall include a solar production estimate modeled to estimate the expected energy production of the site on an hourly basis. The predicted PV system performance must be furnished to the owner for review. The production estimate requirements shall be as follows:

1.6.3.1.1 Utilization of the most recent version of PVSyst®

1.6.3.1.1.1 Native PVSyst data file shall be submitted to the Owner.

1.6.3.1.1.2 Final "as-built" Record version of the PVSyst model shall be submitted to the Owner at the completion of the Project.

1.6.3.1.2 Summary of solar resource dataset used for the model.

1.6.3.1.3 Summary of all model inputs and loss/gain parameters.

1.6.3.1.4 Summary of all auxiliary load losses for daytime and night time.

1.6.3.1.5 Summary of all near shading losses input into the model shall be identified. Assumed tree heights and setbacks shall be listed

1.6.3.1.6 Summary of major equipment and principal design parameters.

1.6.3.1.7 The Project Site near shading scene details .SHD file shall be supplied.

1.6.3.1.8 Summary of key performance metrics including Annual specific yield, DC Capacity Factor, AC Capacity Factor, Performance Ratio, Plane of Array Insolation, and P50/P90 Probability Estimates.

1.6.3.1.9 Summary of annual expected energy production (MWh) and details of any post-processing calculations which may be implemented after the PVsyst modeling software output is calculated.

1.6.3.1.10 An Excel data file containing expected AC energy for every hour for all 8760 hours for year 1.

1.6.3.2 Contractor shall guarantee the year 1 energy performance of the Facility as set forth in the Contract.

1.6.3.3 Contractor shall obtain an independent third party evaluation of the performance model including all input variables. The evaluation shall be provided to the Owner.

1.7 Interconnection Requirements

1.7.1 Contractor shall be responsible for submitting a generator interconnection application to the applicable entity for the Project.

1.7.2 Contractor shall meet all obligations required from the authority governing interconnections for the Project.

1.7.3 Contractor is responsible for all costs associated with fulfilling all interconnection requirements

2.0 Major Equipment

2.1 General Requirements

2.1.1 Contractor shall be responsible for the procurement of all equipment, materials and services, including, without limitation, locating, negotiating, inspecting, expediting, shipping, shipping permits, unloading, receiving, verifying, customs clearance, and claims.

2.1.2 Each solar facility shall be designed for a 25-year operating life based on normal operation, and the performance of maintenance, repairs, and the replacement of parts according to manufacturers' recommendations and standard industry practices.

2.1.3 Unless specifically named in the Specifications, a manufacturer shall have furnished equipment of the similar type for not less than the past 5 years.

2.1.4 Manufacturer's installation and storage instructions shall be carefully followed by Contractor. Electrical equipment insulation shall be protected against moisture and water damage. All equipment having moving parts, such as gears, bearings, and seals, shall be stored fully lubricated with oil, grease, etc., unless otherwise instructed by the manufacturer.

2.1.5 Approved Manufacturers of major equipment shall be used and is defined within Exhibit B1.

2.2 Photovoltaic (PV) Modules

2.2.1.1 PV modules shall be rated and approved by the manufacturer for the method of mounting, location of mounting support and attachment method utilized by the racking design, with no reduction of load capacities. Mounting and attachment method shall not void warranty.

2.2.1.2 Any modifications to the PV module frame must be approved by the manufacturer in writing and shall not void warranty.

2.2.1.3 PV module shall be rated for 1,500 Volts DC.

2.2.1.4 PV modules shall have a power output tolerance rated for -0% of nameplate.

2.2.1.5 PV Modules shall be UL 1703 certified.

2.2.1.6 PV modules shall be IEC 61215 & IEC 61730 certified.

2.2.1.7 PV module grounding method shall be approved by manufacturer.

2.2.1.8 PV modules are to be 100% flash tested, with full results provided to Owner.

2.2.1.9 PV module junction box to be IEC IP67 minimum rated.

2.2.1.10 PV modules are to be rated for Potential Induced Degradation (PID) resistance.

2.2.1.11 PV modules are to include Light Induced Degradation (LID) resistance.

2.2.1.12 All PV modules in each PV system are to be the same manufacturer and same model.

2.2.1.13 PV module manufacturer to be ISO 9001 or better certified.

2.2.1.14 Maximum combined initial LID and first year degradation of 3% of nameplate.

2.2.1.14.1 Thin-film PV modules shall be nameplate power rated for the end of year 1.

2.2.1.14.2 No shading that could cause permanent panel degradation is permitted.

2.2.1.15PV Module shall have an operating temperature range of -40°C to 85°C

2.2.1.16 3rd party validation shall be required for PV module power output, LID, PID resistance, and degradation.

2.2.1.17 PV modules shall be tested to and meet ANSI/CSA-C450-18.

2.2.1.18 PV modules shall have a traceable bill of material for all parts and components.

2.3 PV Mounting Systems

2.3.1 The design specifications for the foundations of the PV module mounting system ("Mounting System") shall be provided by Contractor as part of the Mounting System design specifications.

2.3.2 The Mounting System foundation shall be designed to withstand the soil chemistry of the Site location for a minimum of 25 years without replacement.

2.3.3 The Mounting System including foundation design and support design shall be in compliance with the recommendations of the geotechnical report.

2.3.4 The foundation shall be designed to comply with all of the environmental conditions of the Site, including, but not limited to, corrosion and frost heave.

2.3.5 A minimum height from the module to the ground shall not be less than 3’ at the lowest point of travel for site maintenance in areas where the ground snow load is greater than or equal to 50 pounds per square foot. The minimum height shall be 2’ in other locations.

2.3.6 The mounting system shall be designed for adequate snow buildup/snow shedding clearances to match the region of installation.

2.3.7 The mounting system shall be certified by UL or another approved testing agency to meet the requirements of UL 2703.

2.3.8 Contractor shall provide a detailed structural analysis of the foundations and demonstrate that the design conforms to the applicable standards and codes.

2.3.9 The mounting system and modules shall have provisions to be continuously bonded and grounded to the ground grid system of the array.

2.3.10 Single Axis Tracker (SAT) systems shall meet the following specifications:

2.3.10.1 The SAT system shall withstand wind speeds per Michigan Building Code, Exposure C (Project specific) or the maximums specified by applicable codes, whichever are more conservative, over its specified operating lifetime, without compromising its structural integrity for a minimum of 25 years.

2.3.10.2 The SAT system shall operate normally after high wind conditions have been cleared.

2.3.10.3 The SAT system shall have provisions to be continuously bonded and grounded to the grounding electrode system of the array.

2.3.10.4 The Tracker system shall provide communications and control capabilities that will communicate using a common protocol with the SCADA systems.

2.3.10.5 The control and communications system shall recover automatically (without human intervention) from a loss of power event.

2.3.10.6 The control and communications system shall provide for local manual control at the individual actuator motor level for manual stow and maintenance activities.

2.3.10.7 The control system shall utilize real-time feedback and control algorithm to continuously optimize tracker tilt angle for maximum production.

2.3.10.8The SAT system shall have provisions for operation within the temperature range of -20 degrees Celsius to +40 degrees Celsius.

2.3.11 Dual-axis trackers shall not be permitted.

2.4 Combiner Boxes

2.4.1 The combiner shall be listed to UL 1741 for not less than the maximum DC voltage of the solar PV array, and rated for an operating temperature range of -25°C to +50°C.

2.4.2 The combiner shall be compliant with requirements of the National Electrical Code.

2.4.3 Conduit entries into the combiner shall be from the side or bottom to prevent water ingress. A means to prevent condensation of moisture shall be provided.

2.4.4 The combiner enclosure shall be outdoor-rated and weatherproof.

2.5 Inverters

2.5.1 Inverters shall be UL 1741 SA Certified

2.5.2 Inverter shall be capable of operating with a power factor of 0.90 leading to 0.90 lagging.

2.5.3 Inverter output current harmonics shall contain <3% total harmonic distortion (THD) at rated power output, per IEEE 519.

2.5.4 Inverters shall be equipped with a ground fault detection and protection system that meets the requirements of the applicable version of NFPA 70 (NEC) section 690.

2.5.5 Inverters shall employ a maximum power point tracking (MPPT) scheme to optimize inverter efficiency over the entire range of PV panel output for the given Site design conditions.

2.5.6 Inverters shall be equipped with all hardware for data collection and communication to the SCADA system, including the ability to write to the control registers to reset inverter, power on/off and modify AC output parameters, including power factor and maximum power.

2.5.7 All inverters shall be of identical manufacturer and model number.

2.5.8 Inverters shall have an operating temperature range of -25^0C to $+35^0$C at full rated power.

2.5.9 Inverters shall operate from 25-100% humidity.

2.5.10 Inverters shall not be liquid cooled.

2.5.11 Inverters installed outdoors shall have a minimum environmental rating of NEMA 3R or equivalent.

2.5.12 Enclosure shall have a door interlock system to prohibit the door(s) from being opened while energized.

2.5.13 Inverters shall allow up to at a minimum 1.5:1 DC: AC ratio.

2.5.14 Inverter output shall be protected by an AC output circuit breaker with short and long time adjustable over current protection.

2.5.15 Inverters shall be capable of remote shutdown and curtailment.

2.5.16 Any single inverter shall not exceed 10% of the nameplate capacity of the entire site.

2.5.17 Data collection points shall be integrated into the inverter monitoring and capable to send all to the SCADA system.

2.5.18 Data collection points included shall be (at a minimum):

2.5.18.1 AC Voltage (single phase, 3 phase, and average), DC Voltage, AC Current(single phase, 3 phase, and average), DC current, Real Power (W), Reactive Power (VAr), Apparent Power (VA), Energy (Wh), Alarms, circuit breaker status, and Inverter status and faults (including ground fault interrupts).

2.6 Transformers

2.6.1 The following general design guidance defines the expectation regarding the use of transformers specified between 150 KVA and 150 MVA.

2.6.1.1 Inverter output shall not exceed 1,000 VAC. All interconnecting utility voltages will exceed 1,000 VAC. Transformers shall be required for all solar Projects.

2.6.1.2 The utility interconnection voltage shall determine the appropriate selection of AC collection transformers as follows:

2.6.1.2.1 Interconnection voltage: 1 kV – 45.9 kV --- Padmount Transformer(s) shall be shall be utilized to step up voltage between inverter(s) and interconnecting utility service. High side shall match interconnection voltage. Padmount transformer specifications are contained in this section of the specification.

2.6.1.2.2 Interconnection voltage: 46 kV – 345kV --- Padmount Transformer(s) shall be shall be utilized to step up voltage between inverter(s) and standard AC collection voltage of 34.5 kV. The 34.5 kV AC collection system shall utilize main power step up transformer(s) to match the interconnecting utility service.

2.6.2 The main step up power transformer specification is defined within Exhibit C1.

2.6.3 Contractor shall provide an appropriately sized padmount transformer for the purposes of stepping up inverter output voltage for efficient AC collection and matching of interconnection or collector substation voltage. The padmount transformers shall meet the requirements indicated in Table 1:

Table 1 – Padmount Transformer Specification

Parameter	Value	Units
High Side Voltage	Range - 1 - 34.5	kV
Low Side Voltage	Range - 480 - 1000	V
Impedance	5.75 or per inverter OEM requirements	%
Winding Material	Copper or Aluminum	N/A
High Side BIL	Per interconnection voltage	kV
Low Side BIL	Per voltage class	kV
Taps	2- 2.5% step taps above nominal and 2- 2.5% step taps below nominal. Tap changer to be operated in de-energized condition	N/A
Temperature Rise	65 minimum	C
Cooling Class	Oil-Natural-Air-Natural (ONAN)	N/A
Frequency	60	Hz
Operating Condition	Step Up Operation - PV Use	N/A
Insulating Fluid	Mineral Oil or FR3	N/A
High Side Configuration	Dead Front, Loop Feed (as necessary)	N/A
High Side Switching	Two Position Load Break Switch	N/A
Grounding	Grounding studs furnished for use in providing personnel protection grounds	N/A
Overcurrent Protection	Fused - Bayonet, liquid immersed expulsion type.	N/A

	Back-up current limiting fuses	
Efficiency	N/A	N/A
Sound Level	Compliant with ANSI C57.12.90, NEMA-TR-1 and any local ordinances	N/A
IR Window	Fluke 100 CLKT IR Window	N/A
Accessories	Liquid level gauge with alarm contact, temperature gauge with alarm contact, 1" fill plug and drain valve tamperproof pad lockable cover. Primary and Secondary winding temperature RTD's, top and bottom oil temperature RTDs,	N/A
Specific Standard Compliance	IEEE C57.12, UL	

2.6.4 All standard factory tests required by the ANSI/IEEE C57.12.90 standard shall be performed. Completed test reports shall be provided to Owner.

2.6.5 Dry type transformers shall not be permitted except for low voltage convenience power with a maximum size of 150 KVA.

2.7 Switchgear and Panelboards

2.7.1 Combining AC circuits and safely distributing shall be accomplished by the use of AC panelboards and switchgear for Projects utilizing interconnections below 46 kV per the following requirements defined in this section. Projects interconnecting at 46 kV or above shall utilize an AC collector substation per section 6 of this specification.

2.7.2 All switchgear shall have provisions to achieve an electrically safe working condition and shall have a lockable disconnecting means.

2.7.3 Switchgear shall conform to the applicable standards of the IEEE C37.20 series, ANSI/IEEE C37.100.1, NEMA SG4, SG5, UL, and NEC.

2.7.4 Control Circuits: Battery backed DC control power shall be required for closing coil and trip coil circuits for all switchgear circuit breakers. Closing circuit and trip circuit shall be isolated from each other through 2, 2 pole DC molded case DC circuit breakers with a lockable disconnecting means.

2.7.5 A space heater shall be furnished to prevent condensation of moisture. Space heater capacity shall be as required to maintain the compartment and section internal temperature above the dew point. Space heaters shall be controlled by an adjustable thermostat with a temperature range.

2.7.6 Terminal blocks furnished for control and instrumentation purposes are not to be located in the same compartments as the power connections (above 300V). Terminal blocks shall not be located in a manner that would require a worker to

reach under, over, around, or through the power bus or cable while performing maintenance on the control circuit terminal blocks. Terminal lugs shall be solid barrel non-insulated ring lugs Burndy Type YAV or Owner approved equal.

2.7.7 An uninsulated ground bus shall run through the entire length of the Equipment Assembly with provisions for terminating ground conductors at each feeder point and at each end of the switchgear assembly. Each cubicle shall have 3" ground studs with sleeves provided to cover them while not in use. Utilize ball type ground studs on all rear compartments.

2.7.8 All low voltage control and instrument wiring shall be installed and tested at the factory.

2.7.9 A master nameplate shall be attached to the switchgear giving switchgear designation, voltage and ampere rating, short circuit rating, manufacturer's name, general order number and item number.

2.7.10 Each circuit breaker shall be furnished with a sufficient number of auxiliary contacts and auxiliary switch contacts to provide all necessary interlocks for proper operation of the equipment. Not less than two spare NO and two spare NC auxiliary contacts shall be furnished on each breaker. All auxiliary contacts and auxiliary switch contacts, including spare contacts, shall be wired to terminal blocks for use with control circuits.

2.7.11 For internal switchgear wiring both actual wiring and wiring diagrams shall utilize opposite-end labeling, in which each end of a given wire or cable is labeled with the destination of the opposite end. Labels shall be installed on the wire insulation and not on the terminal lug.

2.7.12 Low voltage panelboards shall meet the following requirements:

2.7.12.1 Panelboards shall be designed and constructed to NEC and NEMA requirements and standards.

2.7.12.2 Panelboards shall be UL listed.

2.7.12.3 Panelboards shall be dead front with molded case circuit breakers of the size and type as required for the design.

2.7.12.4 Panelboards shall have a surface-mounted enclosure.

2.7.12.5 Enclosures shall be NEMA 1 for installations indoors, or NEMA 3R, 4 or 4X for installations outdoors.

2.7.12.6 The enclosure shall have a hinged trim (cover).

2.7.12.7 Breaker operating handles shall be accessible via latched, pad-lockable doors.

2.7.12.8 Circuit breakers shall be thermal magnetic, bolt-on and shall indicate "On," "Off "and" Tripped" positions.

2.8 Meteorological Stations

2.8.1 The Contractor shall supply and install one meteorological station for every 20 MWs of Project AC nameplate capacities, a minimum of one meteorological station is required for every site.

2.8.1.1 Meteorological stations shall be equally spread out across the Project Site providing diversified weather readings

2.8.2 All instruments installed for the meteorological stations shall be new and calibrated within six months of installation.

2.8.3 Each meteorological station shall have a data logger to condition the instruments' signals, record data and communicate to the SCADA system. Data sampling rate shall be at least 4 seconds. The average of these samples shall be recorded at a minimum time interval of 15 minutes.

2.8.4 Each station shall have continuous remote network access.

2.8.5 Instruments and Measurements

2.8.5.1 Each meteorological station shall measure and record global horizontal irradiance Global Horizontal and Insolation over time (GHI), plane-of-array (POA) solar irradiance and insolation over time, ambient temperature, module temperature, and any other required parameters using at least the following instruments:

2.8.5.1.1 One primary POA pyranometer at the same tilt of the array placed adjacent to the secondary POA pyranometer in a location free of shade all year. Pyranometer shall be heated and dried with heater/desiccant attachment.

2.8.5.1.1.1 If bifacial modules are used in the design, in addition to the primary POA pyranometer, a primary Bifacial-plane-of-array (BPOA) pyranometer shall be required

2.8.5.1.2 One secondary POA pyranometer at the same tilt of the array placed adjacent to the primary POA pyranometer in a location free of shade all year. Pyranometer shall be the same model as the primary POA pyranometer and heated and dried with heater/desiccant attachment. Required for the first station, optional thereafter.

2.8.5.1.2.1 If bifacial modules are used in the design, in addition to the secondary POA pyranometer, a secondary Bifacial-plane-of-array (BPOA) pyranometer shall be required. Required for the first station, optional thereafter.

2.8.5.1.3 Three or more module temperature sensors, with accuracy of +/- 1 degree Celsius or better. These sensors shall be of the platinum RTD variety attached to back of modules halfway down a row with a thermally conductive adhesive designed for the purpose and conditions at the base, mid-level and top of a row.

2.8.5.1.4 One ambient temperature sensor enclosed in a naturally aspirated radiation shield and installed at a height similar to the average height of the arrays. Accuracy of this device shall be +/- 1 degree Celsius or better. Required for the first station, optional thereafter.

2.8.5.1.5 One anemometer and one wind vane, installed at the average array height in a location that does not shade the array at any time of the year that is also an open and high area that minimizes the impact of the surrounding obstacles on wind measurement. Anemometer shall be accurate to within +/- 1 m/s or better, and wind vane to within +/- 5° or better. Required for the first station, optional thereafter.

2.8.5.1.6 One barometric pressure sensor, accurate to +/- 1mbar or better. Required for the first station, optional thereafter.

2.8.5.2 A minimum of one soiling loss station shall be installed and meet the following requirements:

2.8.5.2.1 Soiling station shall include provisions to measure snow losses.

2.8.5.2.2 Soiling station shall have communication to the SCADA system.

2.8.5.2.3 Soiling station shall operate on the plane of array of the site.

2.9 Required Spare Parts

2.9.1 Contractor shall turn over at the end of the Project a minimum of 0.1% of the total PV modules used at the site. These modules shall be in good working like new condition and not used as startup/commissioning/construction spares.

2.9.2 For Projects that utilize inverters less than 500kW the Contractor shall supply 10 inverters or 5% of the total quantity used at the array, whichever is greater.

2.9.3 Contractor shall supply a minimum of 1% spare single axis tracker motors, if used.

2.9.4 Contractor shall submit to Owner, not later than 90 days prior to Substantial Completion, a priced list of recommended Operating Spare Parts for the operation of the Project.

2.9.4.1 The recommended Operating Spare Parts list shall incorporate manufacturer-recommended components for all Project equipment.

2.9.4.2 The recommended Operating Spare Parts list shall include at a minimum: manufacturer, part number, price, quantity and source.

2.9.4.3 The recommended Operating Spare Parts list shall incorporate consumable items required to perform the manufacturer-recommended preventative maintenance for Project equipment.

2.9.4.4 If Operating Spare Parts require special storage requirements, special tools, vehicles or other non-standard equipment in order to replace such Operating Spare Parts, these conditions shall be noted on the Operating Spare Parts list.

2.9.4.5 If Operating Spare Parts require calibration while in storage, the calibration requirements shall be noted on the Operating Spare Parts list.

2.9.4.6 Operating Spare Parts quantities shall be based on the quantity required for the first 2 years of operation and based on the quantity of associated equipment installed at the Project.

3.0 Balance of System

3.1 Access & Security

3.1.1.1 Perimeter fencing shall be provided around the entire Site. Perimeter fence shall follow as close as possible the property boundary of the Project Site. Fencing shall be at a height of no less than seven (7) feet, unless otherwise specified by the Authority Having Jurisdiction.

3.1.1.2 Fence design shall also comply with the specifications from the latest version of the National Electric Code and National Electric Safety Code.

3.1.1.3 A separate security fence shall be provided around the substation (if applicable). All access gates to the site or applicable collection substation shall have provisions for a padlock.

3.1.1.4 A minimum of twenty (20) feet clearance from any component to the perimeter fence shall be maintained.

3.1.1.5 At a minimum, one personnel gate and one vehicle gate shall be provided at each Project entrance, with an additional vehicle and personnel gate at the substation, if applicable.

3.1.1.6 The PV array shall include a minimum 3’ wide walkway for any row exceeding 500’. For long rows, the distance between walkways shall not exceed 250’.

3.1.1.7 The PV array shall include a minimum 15’ wide bisecting gravel driveway for any row exceeding 1000’.

3.2 AC Station and Auxiliary Power

3.2.1 For facilities 20 MW AC or larger, station power shall be supplied from two (2) independent sources with an automatic change over switch to switch from one to the other. One source shall be designated primary station power and shall be connected to the inverter output bus. The auxiliary station power feed shall be connected to an independent source via distribution utility service.

3.3 Site Lighting

3.3.1 Site lighting shall be provided at all entrances to the array, at the entry to all buildings, inside all buildings, and inside the collector substation where applicable.

3.3.2 Site lighting shall comply with, at a minimum, the requirements set by OSHA 1926.56.

3.3.3 Any site lighting shall be LED type long lasting UL listed fixtures.

3.3.4 Outdoor lighting shall be equipped with photo-eyes and on/off switches.

3.3.5 Lighting requirements associated with an AC collector substation are defined in section 6 of this specification.

3.4 Grounding

3.4.1 All grounding systems shall be designed and provided as required by NEC, NESC, IEEE, and local code requirements.

3.4.2 Ground loops shall be provided under/around major electrical equipment.

3.4.3 The grounding system shall consist of bare copper conductor or copper-clad steel.

3.4.4 The system shall be designed to protect personnel and equipment at the facility from the hazards that occur during power system faults and lightning strikes.

3.4.5 For ground grids below grade, each junction of the grid shall be bonded with an exothermic weld.

3.4.6 Major items of equipment such as inverters and transformers shall have integral ground buses connected to the grounding electrode system.

3.4.7 Contractor shall route a grounding conductor parallel to all AC power conductors operating above 50 volts.

3.4.8 The module DC system grounding electrode(s) shall be common with, or bonded to, the AC grounding electrode as indicated in NEC Article 690.

3.4.9 All metal framed modules shall be grounded to meet the requirements of applicable codes and UL subject 2703.

3.4.10 Module grounding shall be in compliance with module manufacturer recommendations for grounding.

3.4.11 The conduit and raceway systems are not considered to be a grounding conductor.

3.4.12 Ground rods shall be copper clad manufactured in accordance with UL 467 or approved by owner

3.4.13 Requirements associated with the AC collector substation grounding are contained in section 6 of this specification.

3.5 Lightning Protection

3.5.1 Lightning protection shall be determined in accordance with risk calculations included in NFPA 780.

3.5.2 Lightning protection with traditional air terminals shall be provided atop the following structures, as applicable:

3.5.2.1 Inverter/transformer canopies

3.5.2.2 Inverter walk-in enclosures

3.5.2.3 Control Enclosure

3.5.2.4 Outdoor Switchgear

3.5.2.5 Meteorological Stations.

3.5.3 Lightning protection equipment shall be either Class 1 or Class 2, depending on the height of the structure to be protected in accordance with NFPA 780 or UL 96.

3.5.4 Air terminals or other strike termination devices shall not be secured directly to the PV modules or the module mounting system.

3.5.5 Requirements associated with the AC collector substation are contained in section 6 of this specification.

3.6 Metering

3.6.1 Meters shall be ANSI C12.2 revenue grade meters.

3.6.2 Meters shall support the Modbus TCP and DNP 3.0 communication protocols.

3.7 Instrument Transformers

3.7.1 General

3.7.1.1 This section defines the use of instrument transformers for metering, protection, and control of the solar power system.

3.7.2 Current Transformers

3.7.2.1 Current transformers utilized for protective relaying shall have ANSI standard ranges and accuracy classification of at least C400. Contractor shall be responsible for ensuring classification is suitable for the application. Relaying type current transformers shall have a thermal rating of 2.0 for all ratios. The thermal rating shall be shown on the current transformer nameplate.

3.7.2.2 Current transforms utilized for metering shall have ANSI standard ranges and accuracy classification of 0.3 at a minimum burden of 1.8. For dual ratio metering current transformers, both ratios shall meet the accuracy and burden requirements. Revenue metering type current transformers shall have a minimum rating factor of 2.0 for all ratios. The thermal rating shall be shown on the current transformer nameplate.

3.7.2.3 All current leads shall be wired to the terminal blocks utilizing sold barrel non-insulated ring lugs Burndy Type YAV or Owner approved equal. Terminal blocks shall be States NT type blocks with sliding links. Splices in the current transformer secondary leads are not acceptable. The current transformers shall be shorted and tied to a ground reference at the terminal blocks during shipment.

3.7.2.4 Current transformer sets shall be identified with polarity markings and secondary lead designations as specified by NEMA SG 4.

3.7.2.5 The following shall be provided for current transformers furnished: complete ratio, accuracy, burden, thermal factor, excitation curve and secondary resistance. Certified factory test reports shall be provided for all CT's supplied.

3.7.3 Voltage Transformers

3.7.3.1 The electrical characteristics and mechanical features of the equipment supplied shall be capable of meeting all the requirements specified within the latest revisions of ANSI C57.13. Certified factory test reports shall be provided for all Voltage Transformer's supplied.

3.8 Arc Flash

3.8.1 An Arc Flash Risk Assessment shall be performed per NFPA 70E requirements using the Owner's preferred power system analysis software, ETAP®. The assessment shall determine the Arc Flash Boundary and PPE requirements for all switchgear, panelboards, and control boards. The "As-Built" power system model shall be furnished to the Owner for Record.

3.8.2 Installation shall comply with NFPA 70E Requirements. All equipment/installations shall meet a hazard category 2 or methods to operate equipment outside of the flash boundary shall be provided.

3.8.3 A permanent label shall be furnished for all switchgear, panelboards, and control panels indicating the Arc Flash Boundary, Incident Energy Level, Working Distance, and Hazard Category Rating.

3.9 Signage and Labelling

Strict conformance of system labeling requirements of PV systems and their components are crucial for the safety of operators, service personnel, emergency responders, and others. General PV system labeling requirements as per NEC shall be followed. In addition, the following requirements shall be met.

3.9.1 Cable and Conduit Identification

3.9.1.1 Tags identifying cables with circuit name, number and phase/polarity shall be provided on all cables in all terminal cabinets, panelboards, distribution, control and switchgear, pull boxes and wherever conduit run is broken. Each circuit shall be assigned a unique number as described in Exhibit D2.

3.9.1.2 Unless otherwise specified, identify each conductor of a multi-conductor control cable with a color sequence in accordance with NEMAWC57 (ICEA S-73-532), Appendix E, Method 1, Table E-1.

3.9.1.3 Unless otherwise specified, identify each conductor used for AC or DC power distribution with a color sequence in accordance with Exhibit D2.

3.9.2 Equipment Labeling

3.9.2.1 Nameplates shall be furnished for major equipment, including all operator interfaces, control and electrical panels, cabinets, and instrument racks. The nameplates shall be beveled, laminated black phenolic plastic engraving stock with black core or beveled, two-ply vinyl black with reverse engraved white fill.

3.9.3 Indicating Devices

3.9.3.1 The colors of all indicating devices shall be as shown in Table 2.

Table 2 – Colors of Indicating Devices

Color	Meaning	Explanation
Green	Equipment De-Energized	Normal off condition requiring not action by operator
Red	Equipment Energized	Normal running condition requiring no action by operator
Amber Yellow	Equipment Abnormality	Abnormal condition requiring monitoring and/or intervention by operator
Amber Yellow Flashing	Emergency	Dangerous condition requiring immediate action by operator
White	Permissive	Equipment start permissive; equipment protection relay reset

3.9.4 Facility Signage

3.9.4.1 The Contractor shall make provisions for an Owner furnished permanent facility sign.

3.9.4.2 Perimeter fencing shall have signage to meet all applicable codes and standards including National Electric Code and National Electric Safety Code.

3.10 Glare and Glint Prevention

3.10.1 A glare and glint analysis must be performed if the selected solar array site is within 1 mile of any airport or landing strip, or if within direct sight from motorists on any roadway.

3.10.2 Analysis must include details on areas affected (where glare or glint may have an impact on aircraft pilots or motorists) determination of whether glare or glint is a hazard, and if so, provide a mitigation plan.

3.10.3 If array site is within 1 mile of any airport, glare/glint analysis must be submitted to and approved by the Federal Aviation Administration (FAA).

3.10.4 The Contractor shall conduct glare/glint analysis as necessary for FAA review.

3.10.5 The Contractor shall provide glare and glint study for any residence within 250' of the edge of property and if impacted, provide mitigation measures.

4.0 Civil

Specific requirements associated the collector substation is contained within section 6.

4.1 Geotechnical Requirements

4.1.1 Contractor shall perform all necessary subsurface investigations to establish all soil parameters for design of the Project.

4.1.1.1 Any preliminary geotechnical information provided is for indicative guidance only and shall not be relied upon as the design basis.

4.1.2 The Geotechnical study shall be provided to the Owner and shall address the following:

4.1.2.1 Design parameters and recommendations for proposed foundations, mounting structures, and equipment pads.

4.1.2.2 Corrosion potential (minimum soil resistivity, pH, soluble sulfates, soluble chlorides).

4.1.2.3 Soil electrical resistivity and thermal resistivity tests. Refer to section 6 regarding the specific requirements for the collector substation soil resistivity testing.

4.2 Structural Design Loads

4.2.1 Contractor is responsible to determine all Site data necessary for the design and construction of the Project. This includes, but is not limited to, determination of local design wind speed, ground snow load, seismic design coefficients, flood design criteria, and any areas restricted from construction.

4.2.2 The design loads and other information pertinent to the structural design and code requirements – including, but not limited to, wind design data, earthquake

design data, and snow load data (if applicable) – shall be indicated on the construction documents.

4.2.3 Load combinations shall be determined in accordance with ASCE 7, Design Loads for Buildings and Other Structures, and from appropriate material codes. Load combinations found in the International Building Code that differ from those found in ASCE 7 and material codes shall govern over those found in ASCE 7 and material codes.

4.2.4 Dead loads shall include all gravity loads due to self-weight of permanent structural and nonstructural components, including permanent hung loads.

4.2.5 Snow loads shall be in accordance with the International Building Code as modified by any locally adopted code.

4.2.6 Wind loads shall be in accordance with the International Building Code as modified by the locally adopted code. The Module rack shall be designed in such a way that deflections due to wind will not damage the Modules. Loading due to wind induced vibration shall be incorporated into the design of the racking system.

4.2.6.1 For PV module support structure design only, Risk Category II shall be utilized to determine Basic Wind Speed and related importance factors, unless specified otherwise by the AHJ.

4.2.7 Seismic loads shall be in accordance with ASCE 7 and the International Building Code as modified by any locally adopted code. The Site classification of soil shall be determined by the Contractor based on the results of the subsurface investigation, which shall be performed by the Contractor.

4.2.8 Structural design shall account for thermal loads including thermal expansion, contraction and cycling. Buildings and structures shall be designed for forces and/or displacements resulting from changes in ambient temperature. Induced thermal loads (i.e., thermal loads induced by equipment operating temperatures) shall be considered in design of applicable structural elements.

4.3 Structural Design Calculations

4.3.1 The structural analysis shall conform to applicable standards, the International Building Code, ASCE 7, and local code amendments (including, but not limited to, those listed in Section 1.0.0).

4.3.2 Contractor shall provide a complete and comprehensive report demonstrating structural adequacy of the PV module mounting structure that considers all structural components, hardware, and connections, in a complete load path to the foundation. The structural analysis shall conform to the locally adopted code, using design loads determined according to ASCE 7, and shall be signed and sealed by an appropriately licensed Professional Engineer.

4.3.3 Structural systems and members thereof shall be designed to have adequate stiffness to limit deflections and lateral drift.

4.3.4 Structural analysis shall consider the static and dynamic effects of wind (wind induced vibration). Structural design shall not result in dynamic excitation of the

structural system during wind events. The structure must resist wind loading without damage due to resonance or fatigue.

4.3.5 Contractor shall provide computer modal analysis or physical testing identifying critical mode shapes and natural frequencies of critical mode shapes based on appropriate boundary layer wind tunnel testing of the racking and module system. If lowest natural frequency is not greater than 4 Hz, Contractor shall provide additional analysis with consideration of wind induced vibration, to verify whether the mounting system could experience dynamic amplification of loads.

4.3.6 Wind and other environmental loads must be calculated for individual PV modules as well as all structural components in the system.

4.3.7 Worst-case wind loads on individual modules shall be calculated using an effective wind area of one PV module and must not exceed the wind rating of the PV module.

4.3.8 Structural design calculations shall consider loss of material due to corrosion over the design life of the system.

4.4 Solar Array Foundations

4.4.1 Type of foundations required and allowable bearing values for soil and rock shall be as recommended by Contractor's Geotechnical Engineer based on the subsurface conditions found in the Geotechnical studies.

4.4.2 Contractor shall use a Mounting Structure to mount the PV Modules. Racking design shall be capable of adapting to the Site topography to minimize required earth movement.

4.4.3 The PV Module mounting structure manufacturer shall approve Contractor's design and installation to ensure that the mounting structure warranty remains in effect.

4.4.4 For ground-mounted Projects to be constructed in locations with expansive soil, consideration shall be given to uplift pressures during the wet season as well as increased neglected depth owing to possible loss of soil/foundation contact during the dry season.

4.4.5 For ground-mounted Projects to be constructed in locations with potential for frost heave, full adfreeze uplift loads shall be used in the design unless alternative systems are used to reduce adfreeze uplift pressures. Any reduction in adfreeze uplift pressures shall be substantiated with a detailed engineering analysis.

4.4.6 For steel pile foundations – including driven or vibrated piles, helical piles, or ground screws – field tests shall be performed to determine final capacity. The test program and final report shall be prepared under the responsible charge of an appropriately registered or licensed professional engineer.

4.4.7 Axial tension tests shall be conducted in conformance with ASTM D3689.

4.4.8 Axial compression load tests shall be conducted in conformance with ASTM D1143.

4.4.9 Lateral load tests shall be conducted in conformance with ASTM D3966.

4.4.10 An appropriate Factor of Safety in accordance with industry standards of practice shall be determined by the engineer of record and incorporated into the design of the foundation system.

4.4.11 For cast-in-place concrete foundations, all loose material shall be removed from excavation bottoms.

4.5 Equipment Foundations

4.5.1 Building and equipment foundations shall be of reinforced concrete.

4.5.2 All foundations shall extend a minimum of 6 inches above the adjacent finish grade.

4.5.3 All loose materials shall be removed from excavation bottoms. Unsatisfactory foundation subgrade material shall be removed and replaced with compacted structural fill material, or as directed by the Geotechnical Engineer.

4.5.4 Design of structural concrete shall be in accordance with the latest version of the American Concrete Institute (ACI) 318. All concrete formwork shall conform to ACI 347.

4.5.5 Construction of the concrete shall be in accordance with ACI 301.

4.5.6 Steel reinforcement shall be grade 60 minimum and conform to ASTM A615. Welded steel mesh shall conform to ASTM A185. Plain wire shall conform to ASTM A82. Placement shall be in accordance with Chapters 7 and 12 of ACI 318 and the Manual of Standard Practice of The Concrete Reinforcing Steel Institute.

4.5.7 Concrete shall conform to ASTM C150 with a minimum 28-day compressive strength of 4,000 psi.

4.5.8 Aggregates for normal weight concrete shall conform to ASTM C33.

4.5.9 Concrete mix proportions, including documentation of materials, admixture product information, and compressive strength of mix, shall be submitted and approved by the Owner prior to placing concrete.

4.6 Structural Steel and Fasteners

4.6.1 Steel members of any structural system shall have a specified minimum yield strength of 50 ksi and meet the requirements of the applicable ASTM standard based on the application.

4.6.2 All exterior exposed steel shall be hot-dipped galvanized or coated with an epoxy system with polyurethane topcoat.

4.6.3 All exterior exposed structural fasteners shall be hot-dip galvanized or be formed from stainless steel conforming to ASTM F593.

4.6.4 Structural fasteners used in any structure or support system shall meet the requirements of ASTM F3125 Grade A325 for bolts nominally ½" diameter and larger, or ASTM A449 for bolts smaller than ½" diameter.

4.6.5 Anchor bolts used to secure any structural member to a foundation shall be galvanized and specifically identified by the structural engineer and include installation requirements, minimum projection, material grade, appropriate ASTM standard and torque specification. Anchor bolts shall conform to ASTM A449, ASTM F1554, Grade 36, or A307.

4.6.6 All structural welding shall conform to the requirements of AWS D1.1.

4.6.7 Exposed strut ends shall be covered using vinyl strut caps.

4.6.8 Pipe caps shall be utilized on any open pipes.

4.6.9 Fasteners used for PV racking and module mounting shall be approved for use by the manufacturer and designed to last for a minimum of 25 years without replacements. The fasteners shall attach using the recommended torque from the manufacturer.

4.7 Aluminum

4.7.1 Design of structural and miscellaneous aluminum shall be in accordance with the latest edition of the Aluminum Association – "Aluminum Design Manual" and "Aluminum Standards and Data."

4.7.2 Materials for structural and miscellaneous aluminum, including structural shapes and plate, shall conform to ASTM B209 and ASTM B308.

4.8 Corrosion Prevention

4.8.1 All Project equipment shall be protected from corrosion due to known or expected atmospheric and soil conditions local to the Site. Consideration shall be given to humidity, salinity, acidity, condensation, air particulates and other conditions likely to cause or accelerate corrosion of materials.

4.8.2 Structural design calculations shall be based on the reduction in steel thickness due to corrosion over the 25 year design life of the Project.

4.8.3 All metal components will be designed and specified based on the corrosion recommendations of the geotechnical study.

4.8.4 Contact of dissimilar metals and finishes shall be avoided or intentionally managed to prevent premature galvanic corrosion.

4.8.5 Aluminum shall not be in direct contact with concrete or copper.

4.8.6 Support structure components in contact with soil shall be protected from detrimental subsurface corrosion for the 25 year Design Life of the Project.

4.8.7 Fasteners and hardware shall be stainless steel (300 series, if available with required mechanical strength) or hot-dipped galvanized steel.

4.8.8 Galvanizing of steel products shall conform to the requirements of ASTM A123, ASTM A153 or ASTM F2329, as appropriate.

4.8.9 For any components where the galvanization is disturbed due to factory processing or during installation, those surfaces shall be repaired in accordance with ASTM A780 and A780M-09.

4.9 Site Design and Grading

4.9.1 Contractor shall perform all necessary hydrological and drainage studies of the Site to establish all required design-related parameters related to storm water impacts including, but not limited to flood depths, 100-year flood limits, scour potential and flow velocity.

4.9.2 All Site development areas disturbed during construction shall be stabilized and re-vegetated with an appropriate low growing seed mixture and restored in accordance with the Site Grading Plan and Storm Water Pollution Prevention Plan (SWPPP) prepared by Contractor. All areas occupied by solar modules shall be planted with a grass seed mixture specifically intended for solar facilities and with a maximum growth height of 24 inches. Existing vegetation shall be disked or chemically treated to eliminate regrowth and allow the specified seed mixture to thrive. Minimum vegetation coverage by the specified seed mixture shall be 70% prior to acceptance by the Owner.

4.9.3 Contractor shall develop all necessary design documents and plans and perform all site clearing and grubbing of the Site, including but not limited to grading, excavating, installing drainage and storm water improvements, cutting and backfilling and demolition and removal of existing structures.

4.9.4 Flood water depth and velocity must be accounted for in the structural design and layout of the system, based on applicable laws and regulations. All recommendations from applicable studies must be met.

4.9.5 Areas disturbed or damaged as part of the Project's construction activities that are outside of the primary work area shall be restored, at the Contractor's expense, to the satisfaction of the Owner.

4.9.6 Areas used for installation access, but the topsoil remained undisturbed, shall be graded level to existing grade slope as to allow for proper drainage and remain free of standing water and seeded with a low growing grass seed.

4.9.7 Temporary structures and facilities supplied by the Contractor for use during construction shall be removed. All temporary buildings, structures, concrete slabs and footings, tools, facilities, and other Contractor property shall be removed from the site and the areas involved shall be restored to their original or intended condition.

4.9.8 Contractor shall submit site restoration plan to Owner for approval.

4.10 Roads

4.10.1 Internal access gravel roads shall be constructed such that they are able to support a 32,000 pound axle load to accommodate emergency vehicles and substation maintenance vehicles/equipment.

4.10.2 Subgrade stabilization and/or geo-textile fabrics shall be used as required by design to meet load requirements. Final road sections shall be proof rolled with a 40,000 pound tandem axle truck without rutting or pumping. All roads shall be free draining and not allow water to pond.

4.10.3 Internal access roads shall be constructed of compacted and approved subgrade materials and no less than 6 inches of MDOT 21AA crushed limestone compacted to 95% dry density per ASTM D1557 Modified Proctor. Maximum internal access road width shall be 16 feet; minimum width shall be 12 feet.

4.10.4 Main entrance from a public roadway shall be constructed of compacted and approved subgrade materials and no less than 9 inches of MDOT 22A crushed limestone compacted to 95% dry density per ASTM D1557 Modified Proctor. Installation of non-woven geotextile fabric beneath the compacted crushed limestone is required. Minimum width of road shall be 20 feet with geometric design to accommodate an AASHTO WB-71 design truck for access to the solar array. The main entrance drive shall extend from public roadway edge to the substation fence. Main entrance drive grades shall not exceed 5% and shall be designed to have smooth grade changes and transitions.

4.10.5 Pathways between rows of modules and circuit blocks shall be designed with consideration of procedures required for accessing all modules and array equipment for maintenance and repairs.

4.11 Spill Containment

4.11.1 Contractor shall provide oil containment for all oil-filled transformers meeting all spill prevention, control, and countermeasure (SPCC) regulations.

5.0 Collection System

5.1 General

5.1.1 Contractor shall provide sufficient cable length so that the 34.5 kV underground cables and the low voltage cables between padmount transformer and inverter can be re-terminated at least one (1) time after construction.

5.1.2 Field switches, if used to sectionalize the collector system, shall consist of a single self-supporting enclosure, containing three phase gang operated interrupter switches and the necessary accessory components.

5.2 DC Collection

5.2.1 The maximum voltage of the DC collection system shall be 1,500 VDC unless otherwise approved by Owner. All components utilized in the DC collection system shall be rated for a minimum of 1,500 VDC

5.2.2 Wire losses specific to any complete DC circuit from PV modules to inverters shall not exceed a maximum of 2.0% at STC conditions. The average wire loss of all DC circuits shall not exceed 1.50% at STC conditions.

5.2.3 Wire management of PV module lead wires must include adequate strain relief, support and prevention of excessive bends at junction box outlet.

5.2.4 Wiring located above ground and secured to the PV Module mounting structures shall be secured to the mounting structures utilizing UV-resistant devices and secured in a manner such that no exposed wiring can be in direct contact with unfinished metal edges. Wire management means and methods shall be approved by Owner.

5.3 AC Collection

5.3.1 Total wire losses from AC circuits from any inverter to the point of interconnect shall not exceed a maximum of 3.0%. Average wire loss of all AC circuits shall not exceed 2.0%

5.3.2 The 34.5 kV cable shall meet requirements contained within Exhibit D1.

5.3.3 Surge arresters shall be installed on the high side of all unused bushing wells of pad-mount transformers.

5.4 Isolation and Overcurrent Protection

5.4.1 All DC inputs to inverters shall have provisions to achieve an electrically safe working condition and shall have a lockable disconnecting means or method to verify air gap condition.

5.4.2 All AC circuits shall have provisions to achieve an electrically safe working condition and shall have a lockable disconnecting means.

5.4.3 Fuses shall be rated for PV use and comply with IEC 60269-6 and UL-248-19 on both the positive and negative DC connections.

5.4.4 DC circuit breakers shall meet the requirements of UL 489B.

5.5 Power and Control Wiring

5.5.1 Cables shall be selected with an insulation level applicable to the system voltage for which they are used and ampacities suitable for the load being served.

5.5.2 No splices shall be permitted, except with Owner approval.

5.5.3 Conductors shall be stranded aluminum or copper.

5.5.4 DC conductor in grounded and underground systems shall be listed and identified as 1000V or 2000V rated PV wire. The conductors shall meet the requirements of UL4703 and UL 854. The conductor shall be rated for wet or dry locations and be sunlight resistant.

5.5.5 Bends in wires shall not be less than the minimum bend radius rating of the wire.

5.5.6 Analog instrumentation cables shall be twisted shielded pair type.

5.5.7 Contractor shall furnish a cable schedule for all field connected power and control cables containing the following requirements:

5.5.7.1 Unique identifier, “To” and “From” drawing and physical location description, cable type, size, and conductor quantity.

5.6 Conduit

5.6.1 All directly buried conductors shall be protected by conduit from the trench up to the electrical enclosure termination point Conduit shall include a 90^0 conduit sweep or bend in the trench to protect the cable as it enters the trench.

5.6.2 Conduit and cable entry into any electrical enclosure shall be through the bottom or sides only and shall have provisions to prevent water or moisture entry.

5.6.3 AC collection system cabling shall be installed in conduit or duct-bank when crossing under all vehicle roadways and driveways.

5.6.4 Conduits exiting the ground up to 3’ above grade shall be schedule 80 PVC.

5.6.5 Low points in all conduit runs shall have an appropriate drain installed.

5.7 Terminations & Connectors

5.7.1 5 kV and above power cables will be terminated with prefabricated termination kits with stress cones. Lugs will be long barrel copper compression type. Cable shields will be grounded at one end.

5.7.2 Any aluminum to copper connection shall have protection from bi-metallic corrosion.

5.7.3 PV Connectors for any jumpers or home-run wires shall be approved for use by the PV Module manufacturer and factory installed. The use of field installed PV connectors shall only be allowed when specifically approved by Owner.

5.7.4 Current transformer terminations shall be labeled with a red tag on each terminal of the terminal block containing the words “Danger CT Circuit”.

5.8 Direct Buried Conductors

5.8.1 AC, DC, fiber optic, Ethernet, and control cables within the solar array field may be direct buried in cable trenches in suitable soil conditions where cables do not pass under buildings, roadways, concrete slabs, or other permanent structures.

5.8.2 Contractor shall confirm adequate thermal and electrical resistivity of native soils and/or sand bed to ensure proper heat dissipation and cable derating.

5.8.3 Contractor shall provide Professional Engineer's stamped ampacity calculations supporting all direct buried cable applications.

5.8.4 Except for risers to above grade terminations, cable rated 600 volts and less shall be buried in a trench at a minimum depth of two feet below finished grade, and cable rated above 600 volts through 35 kV shall be buried in a trench at a minimum depth of three feet below finished grade.

5.8.5 Backfill of trenches shall be made with clean earth material, or engineered fill, which shall not damage the direct buried cables.

5.8.6 Detectable cable marking tape shall be located 12 inches above underground cable, covering all cable for the entire length of the direct buried cable run.

5.8.7 Cable marking tape shall be six inches wide red metallic strip with the words "CAUTION BURIED ELECTRIC LINE BELOW" printed in black.

5.8.8 Directly buried cables shall not directly cross, rest or touch adjacent cables, except in a single circuit tri-foil arrangement.

5.8.9 The 34.5 kV collector system, if utilized, shall apply the cable specifications defined within Exhibit D1.

5.8.10 Trench shall be backfilled with clean fill material free from aggregate, debris, organic material and stones. An engineered fill shall be used if required based on the cable ampacity calculations.

6.0 AC Collection Substation (If Applicable)

6.1 General

6.1.1 The AC collector substation section shall be applicable for all Projects interconnecting at 46 kV or above. Projects utilizing interconnections below this threshold shall apply switchgear as required per Section 2.7 of this specification.

6.1.2 Contractor shall engineer, procure and construct one (1) 34.5 /XXX kV AC Collector substation including all grading and excavation work, crushed rock surfacing, foundations, ground grid, control enclosure, bus work, bus supports, breakers, switches, station auxiliary transformer, surge arrestors, lightning protection, instrumentation and relays, programming, testing, and commissioning in accordance with this Specification.

6.1.3 The Collection System Substation shall be an outdoor air-insulated conventional utility substation.

6.1.4 The arrangement of the Collection System Substation shall provide access to personnel, equipment, and vehicles as required to operate, inspect, maintain, repair and replace all substation equipment and materials.

6.1.5 Contractor shall provide a noise study for the Collection System Substation demonstrating it meets the noise and tonality requirements of the local ordinance if applicable. Other it shall be less than 45 dBA at the property line.

6.2 Bus Conductors and Fittings

6.2.1 Collection System Substation buses shall be rigid aluminum. Each bus and all equipment connection conductors shall have a rated ampacity at least as great as that of the connected equipment and as required to carry the maximum load over the life of the facility. The physical, mechanical and electrical properties of bus conductors and all equipment connection conductors shall conform to the latest revision of the following standards: ASTM B231, ASTM B232, ASTM B241, and B317.

6.2.2 Hot line taps (aluminum extension studs) shall be installed on a per phase basis for grounding purposes on all exiting bus structures.

6.2.3 Flexible connections for all equipment supplied shall be provided as required, ensuring continuity of service during thermal expansion or contraction, vibration and seismic activities. Contractor shall design the Collection System Substation buses in accordance with IEEE 605, IEEE Guide for Design of Substation Rigid-Bus Structures. Owner shall review the Collection System Substation bus design and calculations.

6.2.4 Fittings shall comply with NEMA CC-1 latest revision and shall be welded type or bolted.

6.3 Main Power Transformer

6.3.1 The main step up power transformer specification is defined within Exhibit C1.

6.4 MV and LV Circuit Breakers

6.4.1 The MV and LV circuit breaker specification is defined within Exhibit E1.

6.5 Disconnect Switches

6.5.1 The disconnect switch specification is defined within Exhibit E2.

6.6 EHV Circuit Breakers

6.6.1 The EHV circuit breaker specification is defined within Exhibit E3.

6.7 Surge Arresters

6.7.1 Surge Arresters shall be station class metal-oxide, polymer housing arresters with appropriate voltage and energy ratings. Contractor to match Surge Arrester ratings and manufacturer as specified in Exhibit F1.

6.8 DC Control Power

6.8.1 Contractor shall provide 125 VDC to all controls, protective relays, and instrumentation fed from battery and charger system.

6.8.2 The duty cycle shall include a minimum of 30 minutes of control power at the end of the 8-hour duty cycle.

6.8.3 Battery chargers shall be sized to fully recharge the batteries from a fully discharged state in not more than twelve (12) hours while supplying normal continuous DC load.

6.8.4 Contractor shall provide 20% spare circuit breakers in all DC panels.

6.8.5 Batteries shall be flooded cell lead-antimony/selenium type for stationary applications. Valve regulated batteries shall not be permitted. Batteries shall be capable of eight (8) hours of operation under normal load without intermittent charging or any supplemental form of station power and shall have sufficient charge remaining after eight (8) hours to operate all breakers' trip coils and any additional tripping loads at least one time. All battery racks shall be accessible from floor level, without use of a ladder, for visual inspection and maintenance activities. The substation shall be equipped with redundant battery charging systems. All chargers supplied under this specification shall be low ripple chargers.

6.8.6 Battery system shall have a monitoring system in compliance with NERC PRC-005-3 Table 1-4(f). This includes but is not limited to voltage monitoring and alarming, electrolyte level monitoring and alarming, unintentional DC ground monitoring and alarming, charger float voltage monitoring and alarming, intercell and/or terminal connection resistance monitoring and alarming, and internal ohmic value or float current monitoring and alarming. Monitoring system must meet any additional requirements as reflected in Brown Book (IEEE 399).

6.8.7 The Battery room shall have temperature and hydrogen monitoring with communications through the substation SCADA system. The battery room shall have an eye wash system as well as ventilation systems that provide external ventilation for gases generated by the lead-acid batteries in accordance with NFPA 70 Article 480. Installation shall comply with all Michigan building codes.

6.8.8 Battery charger output voltage shall be filtered such that the ripple does not exceed 100mV RMS for either of the following conditions: 1. Under steady state conditions with the charger connected to a battery having an 8-hour rating of at least four times the full load current rating of the charger or 2. Over the rated current output range of the charger without the battery being connected.

6.9 Collection Substation Grounding

6.9.1 The ground grid system shall be designed per the latest version of IEEE 80 to limit step and touch potentials to safe levels for personnel both inside and outside the Collection System Substation for the combination of available fault current and fault clearing time which results in the most critical conditions. Use actual calculated clearing times if available at the time of design; otherwise, use the following default clearing times:

6.9.1.1 Collection Substation Voltage of 345/34.5kV - High side clearing time of 25 cycles (0.42 sec) and low side clearing time of 120 cycles (2.0 sec).

6.9.1.2 Collection Substation Voltage of 138/34.5kV - High side clearing time of 45 cycles (0.75 sec) and low side clearing time of 120 cycles (2.0 sec).

6.9.1.3 Collection Substation Voltage of 46/34.5kV - High side clearing time of 120 cycles (2.0 sec) and low side clearing time of 120 cycles (2.0 sec).

6.9.2 The ground grid system shall be 4/0 AWG soft drawn copper conductor and 5/8" diameter copper-clad ground rods. The modified grounding grid at the Collection System Substation shall consist of a number of interconnected, bare conductors buried horizontally at a depth of 18" below rough grade. The grid shall be supplemented by a number of driven ground rods as required. The quantity and depth of driven ground rods shall be determined by a grounding study and site geotechnical conditions. The use of drive on couplers for greater ground rod depths (60' maximum) is acceptable if soil conditions are suitable. The top of the ground rod shall be buried eighteen (18) inches below rough grade at the same elevation as the ground grid conductors. Grounding wells or other ground resistance enhancements may be used where necessary to achieve an acceptable grounding design.

6.9.3 All metal structures, apparatus and equipment which are to remain at ground potential shall be solidly connected to the ground grid by 4/0 AWG copper conductors. Individual galvanized steel ground mats shall be provided at all gang-operated disconnect switch operating mechanism locations and shall be connected to the station ground grid with 4/0 AWG copper conductors. Install ground mats with top surface at finish grade elevation. Below grade connections shall be made with an exothermic welding process except ground rod sections may be connected to each other using drive-on couplers above grade connections may be bolted or compression. Bolted connections shall be used to connect the ground grid to substation galvanized steel structures and equipment. All other connections shall be made in such a manner that the resistance of the connection does not exceed that of the equivalent conductor. Equipment which is to remain at ground potential and is physically mounted on structures or other equipment shall have an appropriately sized grounding conductor(s) installed to provide a continuous path to ground without relying on a path through the structure or equipment.

6.9.4 Communication cables, except for all-dielectric fiber optic, exiting the substation area shall be adequately protected from the ground potential rise during ground faults by provision of suitable protective devices. All-dielectric fiber optic cables do not require any of the foregoing protective devices as they are not subjected to ground potential rise during faults. Any shielded cables shall be grounded as required to control circuit transients and minimize noise.

6.9.5 Connect the substation perimeter fence to the ground grid at intervals not exceeding 50'-0". Ground all gate and corner posts. The ground grid shall be extended 3'-0" beyond the fence line except at gate locations where it shall be extended 3'-0" beyond the swing of any gate leafs. There shall be a ground grid

conductor running parallel to the fence 3'-0" horizontally distant inside the fence as well.

6.9.6 A surface layer of crushed limestone at least 3" deep shall cover all areas within the substation fence and extending 3'-0" outside the fence, except driveway(s).

6.9.7 Grounding grid around structures and equipment shall be located such that they will be buried 1'-6" below rough grade and approximately 3' horizontally distant from any grounded equipment or structure with which personnel by make contact, unless noted on grounding layout or special assembly.

6.9.8 A Grounding Report detailing the design parameters and analysis used to determine the adequacy of the Collector Substation ground grid design shall be provided to Owner.

6.10 Collection Substation Lightning Protection

6.10.1 The Collection System Substation shall be protected from direct stroke lightning strikes by shield wires and/or masts which are connected directly to the ground grid. The lightning protection system shall be designed for an expected failure rate of no more than one (1) per hundred years.

6.10.2 The lightning protection system for the substation shall not have conductor crossings above live power equipment or bus-work. All equipment/structural metallic surfaces shall be bonded at least at two points. However, in all cases the Collection System Substation direct lightning stroke protection shall meet or exceed the level of protection provide by IEEE Standard 998.

6.11 Collection Substation Lighting

6.11.1 Collector Substation shall include permanently installed external lighting capable of illuminating all equipment within the Substation. Collection System Substation lighting shall meet the minimum lighting levels for the appropriate circumstances of indoor, outdoor, and roadway areas given in the latest editions of NFPA 70 and ANSI C2. A substation lighting study and plan shall be submitted for Owner review and approval.

6.12 Collection Substation Civil

6.12.1 General

6.12.1.1 This area of work consists of civil design of the substation with respect to grading, drainage and structural design of structures and foundations for support of the air-insulated bus-work, power transformer, switchgear and related electrical equipment.

6.12.1.2 Tree and vegetation removal, clearing, grubbing, grading, and compacting as necessary shall be performed by the Contractor. All trees within falling range of the substation shall be removed.

6.12.1.3 Contractor shall strip and stockpile topsoil for use during re-vegetation.

6.12.1.4 Clear, grade, and compact the area for the substation foundations. Substation final grade shall be comprised of 3 inches of MDOT 6A Crushed Limestone. Crushed limestone shall extend a minimum of 3 feet outside of the substation fence. Road surfaces internal to the substation fence shall be of the same surface material as the solar array site access roads and be constructed of at least the same structural section thickness as the site access roads.

6.12.1.5 Substations shall be designed with a flat pad (no slope) but if a slope is required to promote proper drainage the slope of the finish grade shall not exceed 0.5%. Substation storm water management shall be completed in accordance to requirements set forth by local jurisdictions having authority and to promote proper drainage on site. The substation shall be designed to not have standing water or subject to flooding from offsite runoff. All fill utilized shall be clean and free of debris and meet the specification of MDOT Class II.

6.12.2 Collector Substation Structures

6.12.2.1 The Contractor will be responsible to design, procure and install all structures related to the substation. All above ground substation structures shall consist of hot dipped galvanized steel. Steel structures can be constructed utilizing: wide flanged, tubular, tapered tubular, and / or Erecticon. Structures will need to be designed and installed to support loads as specified in the codes having jurisdiction and to support all equipment loads.

6.12.2.2 All dead-end structures (line termination structures) shall be designed to loads set forth within the National Electric Safety Code (NESC) and all other applicable codes and standards. Dead-end structures shall be designed to allow for free access to line switches that may or may not be installed on subsequent structure. Loadings from overhead conductors that will be supplied by the transmission or electric provider will need to be coordinated as provided under the generator interconnection agreement. All other structures not considered a dead-end structure shall be designed in accordance to loadings recommended within the Substation Structure Design Guide by ASCE (ASCE No. 113). Additionally, all structures supporting rigid bus shall be designed to withstand loading as specified within IEEE 605.

6.12.2.3 Structures designed to support group operated switches shall be designed to support this equipment and have provisions to mount operators at 3’-1.5” above finish grade.

6.12.2.4 Structures shall be designed to have provisions to connect grounding in accordance to industry standard.

6.12.2.5 Substation structural connections should be completed utilizing bolted connections.

6.12.3 Collector Substation Foundations

6.12.3.1 Contractor will design substation structure foundations in accordance to the soil and rock conditions as determined during the required geotechnical investigation documented previously in this document.

6.12.3.2 Substation foundations shall be designed to limit settlement to 1” and differential to 0.5”.

6.12.3.3 Transformer foundations shall be designed to support any jacking or placement loads during installation of the proposed transformer.

6.12.3.4 Concrete testing and documentation shall follow requirements set forth in section 4.4 and 4.5.

6.12.3.5 Foundation loads shall be determined utilizing load combinations specified in documents specified in 6.14.2 and utilized to size foundations appropriately.

6.12.3.6 All foundations are to be reinforced concrete and designed using requirements set for the in ACI 318 (at a minimum).

6.12.3.7 Foundations shall extend a minimum of 3” above finish grade of the substation and have a uniform elevation across the station.

6.12.3.8 Reinforced concrete foundations shall a minimum compressive strength of 4,500 psi.

6.12.3.9 Anchor bolt design and installation shall follow recommendations set forth in ACI 318.

6.12.3.10 In-situ soil bearing capacity shall be determined in the field at each foundation location by a qualified geotechnical engineer or a designated representative of the qualified engineer.

6.12.4 Collector Substation Fencing

6.12.4.1 Contractor shall fence the entire Collection System Substation in accordance with IEEE and NESC requirements. The fence shall prevent the entrance of unauthorized personnel into the Collection System Substation and be separated from exposed energized parts so as to prevent unsafe contact by objects inserted through or over the fence.

6.12.4.2 The Collection System Substation fence shall be standard galvanized steel chain link security fence with gate and not less than seven (7) feet in height with an additional one (1) foot high barbed wire topping with "V" type extension arms and three (3) strands of barbed wire. In addition, the perimeter fencing shall contain a stiffener bar at the bottom of the mesh to prevent lifting or undermining the mesh for entrance into the station.

6.12.4.3 Perimeter fencing shall be placed in accordance with the requirements of NESC and IEEE Standard 1119. Fence setback from property line shall not be less than three (3) feet to accommodate the installation of a buried perimeter ground wire.

6.12.4.4 Contractor shall install an outward opening, 20 feet wide, and double leaf gates on the perimeter fence for vehicle access to the substation. Perimeter warning signs shall be installed at all gates and at a minimum of fifty (50) feet intervals along the fence. Contractor shall refer to Exhibit G2 for fence, gate and animal barrier details.

6.12.5 Collector Substation Secondary Oil Containment

6.12.5.1 Collector Substation main transformer(s) shall have lined oil containment pit(s). Pit(s) to be sized in accordance with procedures outlined in the current version of IEEE 980.

6.12.5.2 Containment pit(s) shall have a passive system to allow precipitation to drain from pit(s) by gravity flow. The use of pumps and oil sensors for drainage is not acceptable. One of the following methods of draining precipitation from pits shall be used:

6.12.5.2.1 Oil-water separator (See Exhibit G1 for example) properly designed and connected to drainage pipe from transformer pit(s). The separator is designed to float a certain depth of oil on top of a water column. Water will drain from the pits by gravity flow while oil will be contained in the pit and oil-water separator man hole. The example in Exhibit G1 is designed to work in conjunction with a pit that has a bottom elevation 2'-6" below rough grade to match the inlet & outlet invert elevations of the oil-water separator. This example is designed to contain oil in the pit at a depth of 2'-0" which will put the oil-water interface approximately 4' above the bottom of the vertical outlet pipe in the oil-water separator.

6.12.5.2.2 Pit liner system incorporating oil blocking polymers which solidify and prevent oil from leaving the pits while allowing water to drain.

6.13 Collector Substation Control Enclosure

6.13.1 Contractor shall adequately size and configure the Substation Control Enclosure to comply with Owner's standards and requirements and shall be complete with required equipment, foundation, normal and emergency lighting, emergency egress, fire protection, heating and ventilation. The heating and ventilation shall be designed and installed to maintain temperature and humidity within the limitations of the control, communication, and protection equipment. The enclosure shall be 20 x 40 feet in size and designed in accordance with Owner's standard control enclosure layout as included in Exhibit G1.

6.13.2 The control enclosure shall be a free-standing metal enclosure provided complete with framing, or self-framing panels, roofing, siding, insulation, doors, windows, hardware, fasteners, flashing, weather-stripping, caulking, HVAC and other components as required or specified. All materials shall be new, free from defects and fabricated with quality workmanship. The enclosure design as a whole shall

result in a rigid structure that will maintain its shape and alignment against all design loads and shall conform to ASCE 7.

Major equipment to be housed in the Collection Substation Control Enclosure includes:

6.13.2.1 AC Panels, DC Panels, Battery Charger(s), Battery Bank(s), DC Disconnect Switch, SCADA, Relay, protection and controls equipment, HVAC Unit, Exhaust Fan, Fiber Optic Patch Panel

6.14 Collector Substation Protection and Control

6.14.1 General

6.14.1.1 The collector substation protection and control requirements are defined within Exhibit G3.

6.14.1.2 The collector substation monitoring requirements are defined within Exhibit G4.

6.14.1.3 The Contractor shall be responsible for the detailed design and implementation of the protection schemes necessary to satisfy Interconnection Agreement and Owner's requirements.

6.14.1.4 The Contractor shall be responsible for the detailed design and implementation of the Breaker Failure protection schemes necessary to satisfy the Interconnection Agreement and Owner's requirements (i.e. BF detection trip paths, coordinating time delays, etc.). The Contractor shall ensure the design is suitable for the substation and radial line interface to the Transmission Owner according to the Interconnection Agreement.

6.14.1.5 Contractor shall design protection schemes and supply all necessary electrical protection equipment including, but not limited to, (i) primary 1 and primary 2 line protection, (ii) primary 1, primary 2 and back up protection for the main step-up transformer, (iii) feeder protection.

6.14.2 HV Breaker and Main Power Transformer Protection

6.14.2.1 HV breaker protection shall include primary and backup relays, including all Point of Interconnection requirements, phase, ground, and neutral overcurrent protection. Lockout relays for the breaker and breaker failure functions. Lockouts shall trip all appropriate upstream and downstream breakers.

6.14.2.2 Primary protection of the main power transformers shall be provided by a current differential relay. Backup overcurrent protection shall also be provided for the transformer. On transformer trip, a lockout relay shall be asserted which opens all feeder breakers served from that transformer and opens the associated HV breaker(s). Contractor shall design an appropriate protection scheme to be reviewed by the Owner.

6.14.3 MV Bus Protection

6.14.3.1 Primary protection of the MV bus shall be a high impedance differential relay. More detailed MV bus protection and tie-in breaker protection and monitoring requirements are included in Exhibit G3.

6.14.4 MV Collector Circuit Protection

6.14.4.1 The primary protection of additional collector circuits shall, as a minimum, include relaying with the following protection capabilities:

6.14.4.1.1 Phase and ground time-overcurrent

6.14.4.1.2 Directional control

6.14.4.1.3 Voltage supervision and tripping

6.14.4.1.4 Breaker failure logic

6.14.5 MV Capacitor Protection

6.14.5.1 The protection of each capacitor bank, if required, shall include two relays that comply with IEEE 37.99-2000 Guide for Protection of Shunt Capacitor Banks. The protection is dependent on the final capacitor bank design. Unbalance protection shall be included to detect evolving faults and prevent damage to un-faulted capacitor units.

6.14.5.2 The primary protection of each capacitor circuit shall include a single relay with the following protection capabilities:

6.14.5.2.1 Unbalance

6.14.5.2.2 Phase and ground time-overcurrent

6.14.5.2.3 Voltage supervision and tripping

6.14.5.2.4 Breaker failure logic

6.14.6 Capacitor Bank Control

6.14.6.1 Should a capacitor bank be required, the control of each capacitor switch shall be provided by an SEL-2411. At a minimum the control scheme shall include the following capabilities:

6.14.6.1.1 Voltage and pf/Var measurement on the HV or MV bus as appropriate

6.14.6.1.2 An Auto/Manual switch

6.14.6.1.3 Thresholds to accommodate the necessary switching steps

6.14.6.1.4 Switching control to rotate the duty of the capacitor banks evenly

6.14.6.1.5 Time delay logic to accommodate safety time limits before closing and to ride through momentary system fluctuations

6.14.6.1.6 Zero voltage closing control if required due to step size and or duty

6.14.6.1.7 34.5 kV under voltage tripping

6.14.6.1.8 34.5 kV overvoltage tripping

7.0 SCADA, Communication Networks, and Cyber Security

7.1 Supervisory Control and Data Acquisition

7.1.1 Local SCADA System - The Contractor shall provide turn-key design and installation of a complete on-site local SCADA system. The local SCADA shall have the following minimum requirements:

7.1.1.1 The SCADA System hardware and associated equipment shall be located in the AC Collector Substation Control Enclosure, Facility O&M building, Service Rack, or as agreed upon by the Contractor and Owner.

7.1.1.2 SCADA System shall be installed in an environment that meets the manufacturer's recommendations for the equipment and all of its associated sensitive electronic equipment.

7.1.1.3 All SCADA System equipment installed within the substation yard (including the substation control enclosure) shall be compliant with IEEE 1613 requirements, including EMC (i.e., protected by surge suppression equipment that complies with IEEE C37.90.1).

7.1.1.4 The Contractor shall provide all required software and instruction manuals for the operation and maintenance of the provided SCADA system.

7.1.1.5 The SCADA system shall be powered from either the station DC control power bus or a dedicated uninterruptible power supply (UPS) and allow for 8 hours of continuous operation when normal AC station power is not available. The maximum allowable voltage within the SCADA enclosure shall be 150V AC/DC.

7.1.1.6 The SCADA system shall be supplied with a local on-site historian capable of storing, at a minimum, 30 days' worth of data.

7.1.1.7 The SCADA system shall include local human-machine interface (HMI) capability that displays all available site data and perform control functions.

7.1.1.8 SCADA system shall include, at a minimum, 20% spare input and output channels.

7.1.1.9 SCADA system shall be designed that critical data points including, but not limited to faults, alarms, trips and breaker positions are polled at a rate of not longer than 1.0 seconds

7.1.1.10 Non-critical data points shall be polled at no longer than 30 seconds

7.1.1.11 All data point tags and names shall be approved by the Owner.

7.1.1.12 Microsoft Windows® based operating systems shall not be permitted.

7.1.1.13 The local SCADA system shall have provisions for remote access from the Owner. Remote access using external party servers shall not be permitted.

7.1.2 The local SCADA shall have the following minimum remote control functions:

7.1.2.1 Adjustment of real and reactive power output of inverters, on an individual and/or aggregate basis.

7.1.2.2 Power inverters on and off.

7.1.2.3 Acknowledge and reset alarms for inverters and single axis trackers.

7.1.2.4 Trip and close of main Facility circuit breakers.

7.1.3 The local SCADA shall have the following minimum data collection points:

7.1.3.1 Data points for inverters listed within section 10 of IEEE-1547-2018. In addition the inverter alarms, faults, and warnings shall be provided.

7.1.3.2 Data from all weather stations.

7.1.3.3 Data from all transformers.

7.1.3.4 Alarms from DC control bus, battery charger, or UPS system (if used).

7.1.3.5 Alarms and trip indication for any protective relay used.

7.1.3.6 Data from all single axis tracker positions and any alarms, faults, or warnings.

7.1.3.7 Facility main breaker status and position.

7.1.3.8 Data from all metering including: phase voltages, phase currents, power factor, instantaneous power, and accumulated energy.

7.1.4 The Contractor shall be responsible to determine specific equipment required by the distribution or Transmission System Operator, specifically relating to SCADA, metering and telemetering due to the Interconnection Agreement as well as equipment required to complete the indicated control and protection requirements.

7.2 Communication Requirements

7.2.1 Communications facilities shall be furnished by the Contractor for the following purposes:

7.2.1.1 As required by the Generator Interconnection Agreement.

7.2.1.2 To facilitate remote data and control functions to the local SCADA system as described within this specification.

7.2.2 The Contractor shall arrange and manage the delivery of the necessary communication service from a telecom provider to the facility to satisfy the requirements of this specification.

7.2.3 Communication Protocol

7.2.3.1 Inverters and local SCADA shall be capable of utilizing at least one of the communication protocols listed in Table 3.

Table 3 – List of Eligible Protocols

Protocol	Transport	Physical Layer
IEEE 2030.5 (SEP2)	TCP/IP	Ethernet
IEEE 1815 (DNP3)	TCP/IP	Ethernet
	N/A	RS-485, RS-232
Modbus	TCP/IP	Ethernet
	N/A	RS-485
Sun Spec Modbus	TCP/IP	Ethernet
	N/A	RS-485

7.2.4 Component Level Communication

7.2.4.1 Communication between components such as data loggers, meters, Inverters, weather station, and sensor I/O components shall comply with the component manufacture's installation instructions.

7.2.4.2 The cable shield shall be grounded on one end of the cable only.

7.2.4.3 Inverters that have a proprietary communication protocol shall be ordered with conversion devices to connect them to the network.

7.2.4.4 Sensor cabling shall be specified by the component manufacturer or provided with the sensors and shall not exceed manufacturer's recommended maximum length.

7.2.5 Ethernet

7.2.5.1 All Ethernet-based communication networks shall use category 6 or higher cables meeting the following requirements:

7.2.5.1.1 Sunlight, oil, and gas resistant. Rated for underground use or wet locations if used in that manner.

7.2.5.1.2 UL listed.

7.2.5.2 Ports shall be standard Ethernet RJ-45.

7.2.6 Fiber Optic

7.2.6.1 Optical fiber cable networks shall conform to IEEE 802.3 100BASE-FX or 1000BASE-SX or newer requirements.

7.2.6.2 Fiber optic cable shall meet the following requirements:

7.2.6.2.1 Fiber-optic cable shall be 62.5 micron multi-mode, or 50 micron multi-mode.

7.2.6.2.2 Fiber-optic cable shall be installed in inner duct with a minimum diameter of 1.25 inches or double armor (corrugated steel tape), double jacket, when direct buried.

7.2.6.2.3 Single armor (corrugated steel tape), single jacket when installed in conduit.

7.2.6.2.4 Shall include 50% spare fiber for future use.

7.2.6.2.5 Splicing of fiber-optic cables shall not be allowed.

7.2.7 Switches

7.2.7.1 Switch ports shall be capable of both 100 Mbps and gigabit operation, full and half duplex. Switch ports shall be auto sensing so that the correct network bandwidth is applied to the connected equipment. Maximum network segment lengths shall conform to the IEEE 802.3 standard requirements.

7.2.7.2 Switches shall support remote management by the Owner, which is incorporated into the Contractor's network design.

7.2.8 Wireless communication shall not be used unless approved by the Owner. All devices shall be hardwired back to the local SCADA system.

7.3 Cyber Security

7.3.1 The Owner will provide a firewall for the Contractor to install and provide power. The Owner will provide the firewall software configuration.

7.3.2 The Contractor is responsible for bringing communication circuit onto site and into the firewall enclosure.

8.0 Generator Tie Line (if Applicable)

8.1 General

8.1.1 The contractor shall design, furnish, and install a generator tie line to interconnect the output of the solar facility to the transmission system.

8.1.2 The line shall meet all requirements defined within the National Electric Safety Code.

8.1.3 Standard required clearances are as follows:

STANDARD RIGHT OF WAY TREE RIGHTS & NO BUILD ZONE				
	CENTERLINE EASEMENT REQUIREMENTS EACH SIDE OF CENTERLINE FOR 1ST LINE			
STRUCTURE TYPE	NO BUILD ZONE	CLEAR CUT TREES	ADDITIONAL FOR DANGER TREES	HEIGHT OF DANGER TREES
46kV WOOD POLE	20'	40'	40'	35'
46kV TOWER	36'	55'	50'	45'
138kV SWP HORIZONTAL POST	20'	40'	40'	35'
138kV SWP SUSPENSION INSULATOR	36'	45'	45'	40'
138kV H-FRAME AND TOWER	36'	55'	50'	45'
345kV STEEL POLE	75'	75'	40'	50'
345kV TOWER	75'	75'	40'	50'
765kV TOWER	100'	100'	40'	55'

STANDARD SEPARATION BETWEEN ADJACENT LINES BY LINE TYPE & VOLTAGE					
STRUCTURE TYPE	46kV	138kV SWP HORIZONTAL POST	138kV H-F, TOWER & SWP SUSP	345kV	765kV
46kV WOOD POLE	50'	50'	60'	100'	135'
46kV TOWER	60'	60'	60'	100'	135'
138kV SWP HORIZONTAL POST	50'	50'	60'	100'	135'
138kV SWP SUSPENSION INSULATOR	60'	60'	60'	100'	135'
138kV H-FRAME AND TOWER	60'	60'	60'	100'	135'
345kV STEEL POLE	100'	100'	100'	100'	135'
345kV TOWER	100'	100'	100'	100'	135'
765kV TOWER	135'	135'	135'	135'	150'

9.0 Performance Testing

9.1 Commissioning & Acceptance Testing

9.1.1 The Contractor shall develop and provide a detailed Commissioning Plan for the Project.

9.1.2 The Commissioning Plan specifications should define the minimum requirements for field inspection and testing of electrical equipment for the Project (Commissioning Requirements).

9.1.3 The latest edition of codes and standards, in effect at the time the work is executed, shall be used.

9.1.4 The Commissioning Plan shall include all relevant testing required to demonstrate compliance with the Project's interconnection.

9.1.5 In addition to the requirements of the Commissioning Requirements, the Commissioning Plan to be provided by Contractor in accordance with the Agreement, and referenced industry standards, all testing shall be conducted in accordance with any instructions provided by the equipment manufacturer. Any conflict between these requirements shall be brought to the Owner's attention for resolution.

9.1.6 The Contractor shall be responsible for fully commissioning the Project and shall furnish all labor, equipment, tools, and materials required to perform the commissioning testing requirements. The Contractor will not begin commissioning activities until the Owner has performed an inspection and provides approval.

9.1.7 Technicians performing the work shall be qualified by virtue of training and experience for the type of work performed and shall be familiar with the equipment under test. They shall be trained in the nature of the hazards involved and shall be capable of judging the serviceability of the equipment.

9.1.8 Contractor shall provide, for Owner review and approval, a complete set of commissioning test forms at least thirty (30) Business Days prior to commencing the Commissioning Tests.

9.1.9 Functional Test

9.1.9.1 A functional test of 72 hours of uninterrupted operation of the Facility shall be designed to demonstrate and document the items below. Prior to commencement of this test, all Facility equipment shall be operable:

9.1.9.1.1 Facility functionality. The test will demonstrate that the Facility is capable of operating through daily generation cycles.

9.1.9.1.2 Data collection. Facility information will be collected and logged, demonstrating operability of the SCADA system and communication/monitoring systems.

9.1.9.1.3 Reporting. Demonstrate that the SCADA system is capable of producing any operational reports required to document Facility performance.

9.1.9.1.4 Design parameters. Monitoring of the Facility and components will permit verification of Facility operation within expected ranges of design parameters. Contractor shall use data from the 72-hour test to demonstrate that the Facility is producing a minimum of 95% of the energy output expected of the Facility based on input irradiance, temperature and wind speed conditions. Performance results

below 100% shall be accompanied by a written explanation of the deficiency.

9.1.9.1.5 Compliance. The ability of the Facility to comply with all material safety, system reliability, environmental, and other applicable Laws, Governmental Approvals, the EPC Agreement, the Power Purchase Agreement, and the Interconnection Agreement.

9.1.10 A complete report (Commissioning Test Report) of all testing shall be provided. As a minimum, the report shall include all information described in NETA-ATS section 5.4 and copies of all testing records. The Commissioning Test Report shall be submitted within ten (10) Business Days after the last Commissioning Test is completed.

9.1.11 Test results that fall within the guidelines of NETA-ATS are considered acceptable, unless otherwise specified.

9.1.12 The Contractor shall provide an Acceptance Test Plan that includes a capacity test which follows the ASTM-2848-11 test method, “Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance”.

9.1.13 The Acceptance Test Plan shall be used to verify that all components of the Project production capacity meet or exceed the minimum target capacity.

9.1.14 The Contractor shall be fully responsible for testing the completed Project in accordance with the Acceptance Test Plan. The Contractor will not begin acceptance testing until receiving approval from the Owner.

9.1.15 In no more than five (5) Business Days following the end of the capacity test a draft Capacity Test report will be submitted to the Owner by the Contractor. Owner shall have ten (10) Business Days to accept or reject the results of the draft Capacity Test Report and provide in writing any comments of Owner on such draft Capacity Test Report. In the event that Owner rejects all or any part of the draft Capacity Test Report, Contractor shall, within five (5) Business Days thereafter address any comments of Owner and re-submit the draft Capacity Test Report to Owner. This procedure shall continue until Owner accepts the draft Capacity Test Report.

END OF DOCUMENT

Solar Technical Specification

SP-001

Exhibit A1 – Submittal Requirements

9/30/2019

This document details the specifications for communicating information to the Owner following the execution of a purchase and sale agreement. For specifications regarding the submission of a proposal in response to the Owner's solicitation, please see the requirements in such solicitation.

1.0 General

1.1.1 Required Submittals

1.1.1.1 Shall be approved by the Owner prior to Contractor proceeding with design, release for fabrication, manufacture, or construction.

1.1.1.2 Shall be resubmitted on each revision for the number of times required to obtain approval. However, any need for re-submittals in excess of the number set forth in the accepted schedule, or any other delay under Contractor's responsibility, will not be grounds for extension of the Project Schedule.

1.1.2 Miscellaneous Submittals

1.1.2.1 These are comprised of technical reports and administrative submittals which relate to the Work, but do not require Owner approval prior to proceeding with the Work.

1.1.3 Submittal Requirements

1.1.3.1 The Contractor shall prepare for the Owner's concurrence, a schedule for submission of all Submittals specified by the universal master deliverables list, or necessary for the Owner's approval of the use of Equipment and Materials proposed for incorporation in the Work or needed for proper installation, operation, or maintenance. Submit the schedule with the procurement schedule and Work progress schedule. Schedule submission of all Submittals to permit review, fabrication, and delivery in time to not cause a delay in the Work of the Contractor or their Subcontractors or any other contractors as described herein.

1.1.3.2 In establishing schedule for Submittals, allow 15 working days in the Owner's office for reviewing original Submittals and 10 working days in the Owner's office for reviewing re-submittals.

1.1.3.3 Submittals requiring revision shall be resubmitted within 10 working days after receipt of the Owner's review notations.

1.1.3.4 The schedule shall indicate the anticipated dates of original submission for each item and the Owner's approval thereof, and shall be based upon at least one resubmission of each item.

1.1.3.5 Where a Submittal is required by the Contract Documents or the accepted schedule of Submittals, any related Work performed prior to the Owner's review and approval of the pertaining Submittal will be at the sole expense and responsibility of the contractor.

1.1.4 Transmittal of Submittals

The Contractor shall utilize Owner's electronic document management system (ProjectWise®) to facilitate all drawings, submittal reviews, and requests for information (RFIs). Contractor shall procure any necessary software.

All submittals shall be accompanied with a transmittal with the following information:

1.1.4.1 Contractor's file name/drawing number.

1.1.4.2 Contractor's revision number/letter.

1.1.4.3 Description of file/drawing title (individual for each drawing).

1.1.4.4 Supplier/Sub-Supplier's name (if applicable).

1.1.4.5 Supplier/Sub-Supplier's drawing number (if applicable).

1.1.4.6 Supplier/Sub-Supplier's revision number (if applicable).

1.1.5 Owner's Review

1.1.5.1 The Owner will review and take appropriate action on Submittals in accordance with the accepted schedule of Submittals. The Owner's review and approval will be only to determine if the items of Equipment and Materials covered by the Submittals will, after installation or incorporation in the Work, conform to information given in the Contract Documents and be compatible with the design concept of the completed Project as a functioning whole as indicated by the Contract Documents.

1.1.5.2 The Owner's review and approval will not extend to design data reflected in Submittals which is within the special expertise of the Contractor or the Contractor's Subcontractors or Suppliers. Review and approval of a component item as such will not indicate approval of the assembly in which the item functions.

1.1.5.3 The Owner's review and approval of Shop Drawings, product data, or Samples will not relieve the contractor of responsibility for any deviation

from requirements of the Contract Documents unless the contractor has in writing called the Owner's attention to such deviation at the time of submission, and the Owner has given written concurrence in and approval of the specific deviation. Approval by the Owner shall not relieve the contractor from responsibility for errors or omissions in Submittals.

1.1.5.4 The Owner's review action stamp, appropriately completed, will appear on all Submittals of the contractor when returned by the Owner. Review status designations listed on the Owner action stamp are defined as follows:

1.1.5.4.1 AAS – APPROVED AS SUBMITTED: Signifies Equipment or Material represented by the Submittal conforms to the design concept and complies with the intent of the Contract Documents and is approved for incorporation in the Work. The Contractor is to proceed with fabrication or procurement of the items and with related Work.

1.1.5.4.2 AAN – APPROVED AS NOTED: Signifies Equipment and Material represented by the Submittal conforms to the design concept and complies with the intent of the Contract Documents and is approved for incorporation in the Work in accordance with the Owner's notations. The contractor is to proceed with fabrication or procurement of the items and with related Work in accordance with the Owner's notations and is to submit a revised Submittal responsive to notations marked on the returned Submittal or written in the letter of transmittal.

1.1.5.4.3 R&R – REVISE AND RESUBMIT (RESUBMIT): Signifies Equipment and Material represented by the Submittal does not conform to the design concept or comply with the intent of the Contract Documents and is disapproved for use in the

Work. R&R may also signify information is either insufficient in detail or contains discrepancies which prevent the Owner from completing their review. The contractor is to resubmit revised information responsive to the Owner's annotations on the returned Submittal or written in the letter of transmittal. Fabrication or procurement of items represented by the Submittal and related Work is not to proceed until the Submittal is approved. The contractor is to revise and provide Submittals responsive to the Contract Documents.

1.1.5.4.4 IFI – ISSUED FOR INFORMATION – (For Reference, No Approval Required): Signifies Submittals which are for supplementary information only; pamphlets, general information sheets, catalog cuts, standard sheets, bulletins and similar data, all of which are useful to the Owner in design, operation, or maintenance, but which by their nature do not constitute a basis for determining that items represented thereby conform with the design concept or comply with the intent of the Contract Documents. The Owner reviews such Submittals for general content but not for basic details.

Exhibit A2 -- Solar Universal Master Deliverables List -- 9/30/2019

Deliverables	*Release for Fabrication*	*30%*	*90%*	*AFC*	*Record*	*Required*	*Miscellaneous*
Major Equipment Drawings	X				X	X	
Major equipment Factory Acceptance Test Reports				X		X	
Manufacturer field service reports					X		X
Spare parts list					X		X
Equipment Operation and Maintenance manuals					X		X
Equipment Installation manuals					X		X
Letter from manufacturer, if required, – indicating they have inspected the installation, it conforms to their installation guidelines, and the full warranty is in effect.					X		X
Completed warranty cards					X		X
Equipment datasheets			X			X	
Commissioning, normal operation, shutdown and emergency shutdown procedures				X		X	
Permit documentation			X	X	X	X	
Noise-level Study Reports					X		X
Surveys (geotechnical, topographic, recordable easement exhibit, other)			X		X	X	
Plans to identify property easements, if applicable			X		X	X	
Erosion control plans		X	X	X	X	X	
Storm Water Pollution Prevention Plan (SWPPP), if applicable		X	X	X	X	X	
Grading plans			X	X	X	X	
Glare/FAA study			X	X	X	X	
Shading study		X	X	X	X	X	
Solar Production Estimate Model		X	~~X~~	X	X	X	
Drawing Index		X	X	X	X	X	
General notes and symbols		X	X	X	X	X	
Equipment schedule		X	X	X	X	X	
Key plan		X	X	X	X	X	
Site plan drawings.		X	X	X	X	X	
Foundation calculations.			X	X	X	X	
Structural steel design calculations.			X	X	X	X	
Geotechical investigation report & soil boring plan.		X	X	X	X	X	
Topographic property plans		X	X	X	X	X	
Site grading plan.		X	X	X	X	X	
Access road plans and details		X	X	X	X	X	
Site paving & drainage plan.		X	X	X	X	X	

Exhibit A2 -- Solar Universal Master Deliverables List -- 9/30/2019

Deliverables	*Release for Fabrication*	*30%*	*90%*	*AFC*	*Record*	*Required*	*Miscellaneous*
Underground Utility Plans and Details.		X	X	X	X	X	
Soil Erosion & Sedimentation Control (plan and details).		X	X	X	X	X	
Building plans, elevations, sections and details (A&S).		X	X	X	X	X	
Foundation plans, sections & details.		X	X	X	X	X	
Substation Structures and Misc Steel Structures		X	X	X	X	X	
Cable sizing calculations		X	X	X	X	X	
Panel Layouts & Schedules		X	X	X	X	X	
SCADA Network diagram			X	X	X	X	
Grounding Plans, Sections, & Details			X	X	X	X	
Lighting/Illumination plan & Details			X	X	X	X	
Schematic or Loop diagrams			X	X	X	X	
Wiring diagrams			X	X	X	X	
Instrumentation mounting details			X	X	X	X	
Short Circuit Report			X	X	X	X	
Relay Protection Settings			X	X	X	X	
Arc Flash Report			X	X	X	X	
Arc Flash Model			X	X	X	X	
Grounding Study			X	X	X	X	
Circuit and raceway list			X	X	X	X	
Module, inverter, combiner and recombiner location & identification number maps			X	X	X	X	
Inverter plans and details			X	X	X	X	
Module mounting system plans, Details, and Structural Calculations			X	X	X	X	
Substation Control Enclosure plans and details			X	X	X	X	
Fencing, gate, signage, grounding, and label details			X	X	X	X	
Electrical one-line diagrams, both AC and DC, including all voltage.		X	X	X	X	X	
Switchgear plans and elevations, as applicable			X	X	X	X	
Protective relay calibration records			X	X	X	X	
Three-Line system diagrams			X	X	X	X	
Trenching drawings, with both in-plan and cross-section views			X	X	X	X	
Lightning protection plans and details			X	X	X	X	
SCADA communication block diagram			X	X	X	X	
SCADA point list			X	X	X	X	
Project Scope Documents		X	X	X			X
Project Schedule		X	X	X			X
Quality Control Plan			X	X		X	

Solar Technical Specification

SP-001

Exhibit A3 – Drawing and CAD Standard

9/30/2019

1.0 General

1.1.1 New Drawings

1.1.1.1 All new drawings shall be issued in DWG format or DWG/TIF format.

1.1.1.2 The accepted record file format for drawings shall be AutoCAD 2018 or newer unless otherwise stated.

1.1.1.3 Raster files attached to the AutoCAD drawing files shall be in a TIF Group 4 (CCITT Group 4) format and shall utilize Tiled or Stripped style of compression, with bi-tonal color type. Uncompressed raster files are not acceptable.

1.1.1.4 Attached Raster files shall have the same file name as the AutoCAD file. If multiple images are attached, they shall be combined into one image file.

1.1.1.5 PDF files are NOT acceptable as attachments to AutoCAD drawing files.

1.1.2 Reference Files (xrefs)

1.1.2.1 All xrefs (reference files) must be bound to the drawing file prior to turning it over for record.

1.1.2.2 Prior to binding the reference files, they should be purged of all unused components (blocks, layers, linetypes, etc.).

1.1.3 A&E Collection (Other Autodesk Applications)

1.1.3.1 Often other Autodesk applications other than basic AutoCAD are used in developing project drawings. Applications such as Architectural Desktop, Civil 3D, Plant 3D, Advance steel, and others use custom entities and components in the development of 2D and 3D geometry. Many of the components are not supported by or editable by basic AutoCAD. Third party add-ons to AutoCAD also often create custom components that are not even visible in AutoCAD and are represented with basic square blocks. Most of these applications have “Object Enablers” that can be downloaded and installed on individual computers to allow entity manipulation and viewing. However, it is not practical for every computer in the organization to install every possible object enabler.

1.1.3.2 The following rules must be followed when turning over Generation Engineering drawings that have been developed using these packages:

1.1.3.2.1 Prior to turning over Record drawing files use the native application to explode or convert custom components to basic AutoCAD components. Examples of custom components would be application specific linetypes or shapes (.shx components).

1.1.3.2.2 Custom linetypes or shapes (.shx) shall not be used on any drawings.

1.1.3.2.3 Any 3D models or drawings created shall be turned over to the Owner in native format. The 3D drawings shall also be broken into 2D drawings and provided to the Owner

1.1.4 Drawing Types and Sizes

1.1.4.1 The following standard border sizes for drawings shall be used:

1.1.4.1.1 ANSI E (34”x44”) – this is the preferred size for all new drawing unless shown otherwise noted.

1.1.4.1.2 ANSI D (22”x34”)

1.1.4.1.3 ANSI C (17”x22”)

1.1.4.1.4 ANSI B (11”x17”)

1.1.4.1.5 ANSI A Landscape (8½”x11”)

1.1.4.1.6 ANSI A Portrait (8½”x11”)

1.1.4.2 Border templates from the Owner are available for each of the drawing types listed above. These templates have all the necessary settings for text styles, dimension styles, and plot settings. These templates also have the correct title block attributes required to integrate drawing title block information with ProjectWise document management software.

1.1.4.3 It is a requirement that these border templates be used to create all new drawings.

1.1.5 Drawing Naming Convention

1.1.5.1 See table below. “XXX” represents site name or an abbreviation of the site name

1.1.5.2 “???” represents a sheet number for the series

DRAWING NUMBERING	CONTENT
XXX-G100-???	COVER PAGES, GENERAL NOTES
XXX-G200-???	SITE PLANS
XXX-G300-???	BILL OF MATERIALS
XXX-E100-???	AC WIRING DETAILS
XXX-E200-???	DC WIRING DETAILS
XXX-E300-???	COLLECTOR SUBSTATION DETAILS
XXX-E400-???	WEATHER STATION, SCADA AND MISCELLANEOUS ELECTRICAL DETAILS
XXX-E500-???	GROUNDING DETAILS, UNDERGROUND ROUTING DETAILS, CONDUIT DETAILS, LIGHTNING PROTECTION DETAILS, CIRCUIT NUMBERING TABLES
XXX-C100-???	CIVIL DETAILS, SURVEYS, GRADING DETAILS
XXX-C200-???	FOUNDATION DETAILS, MISC STRUCTURAL DETAILS, FENCING
XXX-C300-???	RACKING SYSTEM DETAILS
XXX-WD-???	SINGLE LINE DIAGRAMS

1.1.6 Vendor Drawings

1.1.6.1 Vendor drawings shall be submitted to the Owner in PDF format

1.1.6.2 At the conclusion of the Project all Vendor drawings shall be submitted as as-built Record drawings

Solar Technical Specification

SP-001

Exhibit B1 – Approved Manufacturers List

9/30/2019

1.0 General

The following equipment manufactures shall be approved by the Owner for use:

Solar Facility Acceptable Manufacturers List	
Electrical Enclosures	Hoffmann ,Saginaw Controls Engineering,
High Voltage Group Operated Substation Switches	Cleaveland type V2-CA, Hubbell type AVR, Pascor type TTR-8, Morpac type EA,
High Voltage Substation Hookstick Disconnects	Morpac type STU ,Royal type BT
High Voltage Circuit Breakers	MEPPI, Siemens
Inverters	ABB, SMA, Mitsubishi (TMEIC), Power Electronics, Yaskawa Solectria
Low Voltage Circuit Breakers	Allen-Bradley, Eaton Cutler Hammer, General Electric, Square D
Low Voltage Panel Boards	Eaton, Square D
Main Power Step-Up Transformer	ABB , Delta Star, SPX
Medium Voltage Cable	Anixter, General Cable Corporation, Houston Wires & Cables, Marmon , Okonite, Southwire
Medium Voltage Disconnect Switches	Cleaveland type V2-CA, Emspec type VB1, Hubbell type AVR, Morpac type EA, Pascor type TTR-8, S&C PME, S&C Alduti-rupter, Southern States type TA-OC or EV
Medium Voltage Switchgear	ABB, Eaton, General Electric, Powell, Siemens, Square D
Medium Voltage Transformers	ABB, Eaton , General Electric
Power Supplies	Phoenix QUINT , PULS, SOLA
Protective Relays	Schweitzer Engineering Laboratories (SEL)
PV Modules	Canadian Solar, First Solar Series 6, Hanwah Q-Cells, JA Solar, Jinko Solar, LONGi ,Trina, Yingli
SCADA	Rockwell Automation ,SEL RTAC
Single Axis Trackers	ATI, Game Change , NexTracker, Solar Flex Rack
Weather Instrumentation	ABB VSN800, APRS World, GroundWork Renewables

Solar Technical Specification

SP-001

Exhibit C1 – Main Power Step Up Transformer Specification

9/30/2019

MAIN POWER STEP-UP TRANSFORMERS FOR HV INTERCONNECTION SUBSTATIONS

THREE PHASE, 60 Hz, 65°C RISE, ONAN/ONAF(/ONAF), VARIOUS CAPACITIES

TO BE CONFORMED SPECIFICATION
CONF-SP-001 ITEM 1

CONTENTS

1.0 GENERAL

This specification covers the manufacture, furnishing, delivering and testing, together with technical assistance during installation and initial energization of various, 60Hz, outdoor oil-immersed high voltage station step-up power transformers and accessories for installation and use on the Consumers Energy Company (CEC), "Buyer's", electric system in Michigan, USA. The transformer(s) and accessories shall be in accordance with this specification, associated attachments, the associated purchase contract, the purchase order and latest revisions of ANSI, IEEE, ASTM, NEMA and all other applicable standards (whether expressly identified in this specification or not). At Buyer's discretion, these specifications take precedence over any conflict that may arise between them and ANSI, IEEE, ASTM, NEMA and applicable Standards; it is the Seller's burden to notify the Buyer of any such conflicts in a timely manner. These specifications shall not be considered to be less stringent than the applicable standards referenced within. The Seller shall solicit clarifications from the Buyer for any aspect of the specification that could be considered as ambiguous or incomplete. These clarifications shall be solicited by the Seller prior to Buyer issuance of any purchase order(s).

1.1 CONFORMANCE

1.1.1 This specification was developed with the understanding that it will be used in a Request for Proposal (RFP) process that that may result in many different possible transformer configuration/capacity proposals. In that light the specification will be conformed prior to being used in a purchase contract with specific focus on the particulars of the application to the extent known and revisions to requirements as deemed appropriate by the Buyer. The focus of the conformance is not for the allowance of exceptions. REMOVE THIS SECTION DURING CONFORMANCE.

1.2 SCOPE

1.2.1 ITEMS INCLUDED IN SCOPE

1.2.1.1 Seller to provide a quantity of TBD Item 1 transformer(s) in accordance with the Substation Transformer Specifications

1.2.1.1.1 Electrical and Mechanical Requirements transformer(s)
1.2.1.1.2 Insulating Oil
1.2.1.1.3 Current Transformers
1.2.1.1.4 Bushings
1.2.1.1.5 Lightning Arrester Brackets
1.2.1.1.6 Accessories and Auxiliary Equipment
1.2.1.1.7 Test
1.2.1.1.8 Loading
1.2.1.1.9 Shipping
1.2.1.1.10 Necessary Drawings and Instructions
1.2.1.1.11 Furnish special tools necessary for installation and testing of furnished equipment.
1.2.1.1.12 Provide technical oversight or supervision to the degree required by Seller for warranty affirmation (and at the Buyer's discretion an interpreter for technical supervisor(s)) at destination jobsite
1.2.1.1.13 Transformer to be shipped oil-filled without radiators attached TBD.
1.2.1.1.14 Transformer to be delivered to the destination by TBD
1.2.1.1.15 Transformer windings and final assembly to be manufactured at the Seller's facility in TBD.
1.2.1.1.16 A complete Fiber Optic Temperature Measurement System (FOTMS) is required for units with ONAN ratings greater or equal to 30 MVA.
1.2.1.1.17 An Online Dissolved Gas Analysis (DGAS) System is required required for units with ONAN ratings greater or equal to 30 MVA.
1.2.1.1.18 The Seller shall perform the reassembly, oil-filling and processing, testing and witnessing commissioning and start-up, acceptance testing as well as the pre-offload activities.

1.2.1.1.18.1 It is the Seller's responsibility to accurately determine its crew sizes, working hours, daily costs, etc. and include these data and associated total costs in its proposal.

1.2.1.1.18.2 Seller's personnel who provide services at the Delivery Point shall be fluent in English.

1.2.2 WORK NOT INCLUDED IN THE SCOPE OF THIS SPECIFICATION:

1.2.2.1 Provide foundations/temporary cribbing

1.2.2.2 Offloading labor and heavy hauler/crane lifting equipment to be provided by Buyer/Others/TBD at FOB destination jobsite - delivery point loaded vehicle.
1.2.2.3 Storage of equipment and materials
1.2.2.4 Surge arresters

1.3 SCHEDULE

1.3.1 A complete set of approval drawings shall be submitted by Seller to Buyer no later than TBD (default 60) calendar days after the Buyer's issuance of Purchase Order. The definition of a "complete" set of drawings is described elsewhere herein these specifications.
1.3.2 Seller shall provide the Milestones schedule within 15 calendar days after Buyer's Purchase Order issuance and then at least once during the 2nd week of every calendar month thereafter until delivery. Seller shall provide more frequent updates when requested by the Buyer for travel planning purposes.

1.3.3 MILESTONES SCHEDULE

1.3.3.1 A milestone schedule of the following Witness and Hold points is to be provided
1.3.3.1.1 H - Design review Data Availability
1.3.3.1.2 H – Design review completion
1.3.3.1.3 H - Design released for manufacturing
1.3.3.1.4 W - All NCR's
1.3.3.1.5 W - Major material delivered to factory
1.3.3.1.6 W - Completed Coils Inspection
1.3.3.1.7 W - Core stacking
1.3.3.1.8 W - Coil Landing Witnessing
1.3.3.1.9 W - Post Oven/Vapor-phase and Pre-tanking Inspection Date
1.3.3.1.10 W - Installion of core and coil assembly into the tank
1.3.3.1.11 H - Internal inspection after connections complete, before oil fill
1.3.3.1.12 H - Wiring check and functional check of cooling and all devices before Factory Acceptance Test (FAT)
1.3.3.1.13 W – Dielectric Factory Acceptance Testing
1.3.3.1.14 W - Site receipt inspection
1.3.3.1.15 W - Torque of bolted connections at site
1.3.3.1.16 H - At site internal inspection after connections complete, before oil fill
1.3.3.1.17 W - Pressure and vacuum decay test before oil fill
1.3.3.1.18 H - Testing after final assembly at site
1.3.3.1.19 H – Shipment date
1.3.3.1.20 H - Final acceptance at site

1.4 COST

1.4.1 The price of the equipment is expressly defined or included in the overall purchase contract price.
1.4.1.1 The price shall be adjusted by the Buyer for failure to meet the Guaranteed Loss parameters as described in the GUARANTEED LOSSES paragraphs below.

1.5 PROJECT CONTACT

1.5.1 The "Buyer" assigned to this procurement will be defined in the purchase agreement contract document
1.5.2 The Buyer's email and physical address to be used for all correspondence and document transmittals, respectively, as needed and described herein, will be documented in the purchase order contract document.
1.5.3 The Buyer's phone contact information will be documented in the purchase order contract document.
1.5.4 All technical related correspondence and contact between the Seller and the Buyer for the duration of the project shall be with, or arranged through, the Buyer's, who (or any replacements of whom) will be identified in writing by the Buyer.

1.6 DESIGN REVIEW

1.6.1 DESIGN REVIEW CONSULTANT

1.6.1.1 The Buyer intends to contract a Transformer Consultant to review the Seller's proposed design.

1.6.1.2 Any communication between the Transformer Consultant and the Seller or any representatives of the Seller shall be through, or explicitly arranged by, the Buyer.

1.6.2 DESIGN REVIEW MEETING(S)

1.6.2.1 The Buyer, the Buyer's Transformer Consultant and the Seller (including the Seller's Sale Representative) shall meet at the Buyer's Parnall Road offices in Jackson, Michigan for a transformer design review meeting. Alternately, at the Buyer's discretion, the design review meeting(s) and associated requirements may be addressed through conference calls and written correspondence. In any case, all Seller costs associated with design review activities shall be borne by the Seller.

1.6.2.2 The Seller shall provide employees for the meeting who are suitable for an in-depth technical review of the proposed equipment.

1.6.2.3 The agenda of the meeting(s) shall be primarily defined by the Buyer (in consultation, as the Buyer deems appropriate, with the Buyer's Transformer Consultant). It is anticipated that the following topics will be discussed in the meeting and therefore it is critical that the Seller provide review documents to the Buyer addressing these topics at least two calendar weeks prior to the scheduled Design Review Meeting:

- 1.6.2.3.1 Winding Layout
- 1.6.2.3.2 Insulation Clearances and Configuration (Electric Field Analysis)
- 1.6.2.3.3 Coil Conductor Sizes and Load Losses
- 1.6.2.3.4 Core Configuration and Materials
- 1.6.2.3.5 Leakage Flux Considerations (Magnetic Field Analysis)
- 1.6.2.3.6 Internal Leads, Connections and tap changers/terminal boards
- 1.6.2.3.7 Short Circuit Design including sequence network fault schematic review
- 1.6.2.3.8 Cooling (Thermal Analysis)
- 1.6.2.3.9 Tank Design and Oil Preservation
- 1.6.2.3.10 Instrumentation issues related to static flow electrification, back-feeding, etc.
- 1.6.2.3.11 Temperature measurement system and sensor placement.
- 1.6.2.3.12 System and Operating Related Aspects (e.g., step-up, arithmetic loading, etc.)
- 1.6.2.3.13 Review of Proposed Layout of Transformer and Accessories
- 1.6.2.3.14 Preparation for Shipment, Field Installation and Processing
- 1.6.2.3.15 Seller's failure statistics and related definitions
- 1.6.2.3.16 Special Design Issues (GIC Calculations, any unique design considerations associated with solar installations)
- 1.6.2.3.17 Sound requirements
- 1.6.2.3.18 Quality Assurance Program
- 1.6.2.3.19 Summary of all details necessary for computer analysis of the design. Typically, this involves the data necessary for the Anderson Program, which is partly summarized in the Anderson Program Input Form.

1.6.2.4 The date of the Design Review Meeting will be by agreement amongst the parties and such that it is as early as possible so as to not impact the equipment delivery date.

1.6.2.5 All issues discussed at the meeting that are material to the equipment design and review shall be documented in the minutes of the meeting, which will be developed through the course of the meeting and agreed to by all parties at the conclusion of the meeting. Audio recordings of the meetings and conference calls may be made.

1.6.2.6 Documents required in response to action items identified in the Design Review Meeting Minutes will be withheld by the Seller until all action items are addressed. This is to prevent a slow trickle of feedback from the Seller. Where dependencies among action items exist, an organized transmittal of uniquely identified and dated documents may be submitted by the Seller to address the action items in sequence.

1.6.3 DESIGN REVIEW COMPLETION NOTICE

The Buyer will, when appropriate, provide a written "Notice of Design Review Completion" to the Seller. The notice does not relieve the Seller from meeting the requirements of the purchase contract and related

documents.

1.6.3.1 The Seller shall not order equipment or materials (e.g., bushings, copper for windings, or electrical steel) prior to receiving the written Notice of Design Review Completion from the Buyer.

1.7 APPROVAL DRAWINGS

1.7.1 Three (3) hardcopy sets and one set of digital drawings shall be sent to the Buyer for approval. Refer to the REQUIREMENTS FOR ELECTRONIC DRAWING FILES section in the Appendix.

1.7.2 All drawings shall be of high quality and accuracy. Outlines and physical detail drawings shall be to scale.

1.7.3 Units on all documents shall be per the United States Customary System (or American System) of Units (e.g., inches, lbs., gallons, etc.). SI units may also be provided in addition to the American System units.

1.7.4 Drawings shall provide all the design information necessary to properly install, operate and maintain the equipment.

1.7.5 The drawings shall include:

1.7.5.1 Outline and physical detail drawing with the following:

1.7.5.1.1 Location of the center of gravity

1.7.5.1.2 Dimensions (including all dimensioning required to confirm live-part to live-part, live-part to ground, and live-part to base clearances)

1.7.5.1.3 Weights (i.e., total, shipping, core and coils, and oil)

1.7.5.1.4 A bill of material shall be provided listing all device manufacturer's model numbers, valve dimensions, and the Seller's part number for each gasket.

1.7.5.1.5 Total number of cooling fans and grouping information

1.7.5.1.6 Fans: CFM, voltage, number of phases, horsepower, inrush current, and running current rating data.

1.7.5.1.7 Detail of base showing bearing areas and support requirements

1.7.5.1.8 CT secondary, forced cooling equipment, and other equipment terminal box/enclosure details

1.7.5.1.9 All auxiliary devices shall be shown to scale within the accuracy of 25mm. The dimension from the center of each device in relation to the side and bottom of the tank shall be shown.

1.7.5.1.10 Detail of internal lead connections, including a bill of material listing all connection hardware.

1.7.5.1.11 Detail of the physical layout of the temperature probe leads from coil to tank wall penetration, including treatment of excess lead length, how to secure the leads, and the matchup of the lead serial number to the penetration number.

1.7.5.1.12 Tank and piping manufacture drawings showing the location and the size of all welds.

1.7.5.1.13 Site installation drawing showing minimum requirements for where to support transformer, tolerance for level, and minimum clearance around radiators.

1.7.5.1.14 Detail of gaskets showing dimensions, material, and Seller's part number.

1.7.5.1.15 The total number of: oil pumps, cooling fans, along with the pump gpm.

1.7.5.2 Nameplate (final drawing to include as-stamped impedances)

1.7.5.3 Schematic wiring diagrams

1.7.5.4 Detail wiring diagrams

1.7.5.4.1 Refer to DETAIL WIRING DRAWING EXAMPLES section in Appendix for examples of detail wiring drawing expectations.

1.7.5.4.2 Detail wiring diagrams of the "wireless" type shall be supplied.

1.7.5.4.3 "Wireless" diagrams shall be drawn so that written next to each terminal will be all other terminals that wiring is routed to.

1.7.5.4.4 Detail wiring diagrams that do not show wiring but have separate tables to list terminal connections instead of writing the routing information next to the terminals will not be accepted.

1.7.5.4.5 Buyer will provide, upon request, additional examples and/or clarifications if required.

1.7.5.4.6 Equipment on the detail wiring diagrams shall be in the relative physical position as the actual equipment.

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1.7.5.5 CT connection and RCF curves

1.7.5.6 CT excitation and RCF curves

1.7.5.7 Bushing details
1.7.5.8 Winding development and temperature measurement system probe locations

1.7.6 Within 30 calandar days after receipt of Approval Drawings, one (l) print of each drawing, marked with appropriate comment or approval, will be returned to the Seller electronically.

1.7.7 The Seller shall then make corrections or comments, if required. For those drawings returned "Not Approved" two (2) prints of the revised drawings shall be resubmitted for final approval within 20 business days. Iterations in the approval drawing cycle will not be grounds for failure of the Seller to meet the delivery date requirements.

1.7.8 The Seller shall make no changes to the drawings other than those requested by the Buyer on the approval drawings.

1.7.9 The final drawings shall conform to the marked-up approval drawings.

1.7.10 If comments made by the Buyer on the approval drawings cause a conflict or are considered unnecessary or undesirable by the Seller, the Seller shall immediately call this to the attention of the Buyer, so the matter may be quickly resolved.

1.7.11 Approval by the Buyer shall not relieve the Seller of the responsibility for the accuracy of the drawings furnished by the Seller nor for their compliance with the purchase contract and related documents (e.g., conformed specification).

1.8 CONSTRUCTION DRAWINGS

Within 30 calendar days after receiving drawing approval, four (4) sets of construction drawings (three sets of “hard copy” prints and one set on CD-ROM), one set on (USB), and one (1) copy of a preliminary instruction book shall be sent to the Buyer to facilitate completion of the project design by the Buyer. All non-conformances shall be provided to the Buyer in real time. This includes every Non-Conformance Report (NCR), , engineering waiver, deviation from specification, modification of procedure, exception to standard, product change, revised work package, process change, revision to manufacturing instruction or anything similar to a non-conformance. At the initiation of an NCR, the Buyer shall be provided a draft with sufficient description and/or pictures to describe the issue. All NCR's shall be considered a Witness point, where the Buyer is given the opportunity to comment, which may include indication as to how this NCR could affect final acceptance of the transformer. Final versions of NCR's documenting corrective action completed shall be provided to the Buyer prior to acceptance for shipment.

1.9 FACTORY INSPECTION AND WITNESSING TESTS

1.9.1 The Buyer reserves the right to inspect materials and workmanship at any state of manufacture and to witness any or all tests including, but not limited to: dielectric tests, temperature rise tests, Doble tests, preliminary tests, and control wiring scheme checks/tests according to control schematics.

1.9.2 The Seller shall furnish periodic construction progress reports to the Buyer so that the Buyer can inspect at progress points if desired. The "Inspector" may be the Buyer Engineer or another designee of the Buyer.

1.9.3 No approval or acceptance by the Inspector shall in any event or in any manner relieve the Seller of any of its obligations or otherwise limit any of the Seller’s obligations or constitute a waiver of or otherwise limit any of the Buyer’s rights or remedies.

1.9.4 The Seller is responsible for all aspects of the transformer design and manufacture although an Inspector may have performed inspections of some parts.

1.9.5 Seller shall provide the Buyer a written “Notice of Opportunity to Inspect Sized Coil Assemblies” no later than two weeks prior to the completed sized coil assemblies being landed on the core so that an Inspector may be sent to the factory, at the Buyer’s discretion, to inspect the completed sized coil assemblies. The Seller shall include with this notice a firm date for the opportunity to allow for Buyer to make firm travel arrangements.

1.9.6 Seller shall provide the Buyer a written “Notice of Opportunity to Inspect Completed Core and Coil Assemblies” no later than two weeks prior to tanking so that an Inspector may be sent to the factory, at the Buyer’s discretion, to inspect the completed core and coil assembly before tanking. The Seller shall include with this notice a firm date for the opportunity to allow for Buyer to make firm travel arrangements.

1.9.6.1 A Sample coil shall be provided for Buyer inspection.

1.9.7 Seller shall provide the Buyer a written “Notice of Intent to Conduct Dielectric Testing” no later than three weeks prior to the Impulse, Applied, Induced Voltage, and Partial Discharge testing. Along with this notice, Seller shall provide a detailed test schedule for review.

1.9.7.1 The detailed test schedule shall include the sequence of, and schedule for, all post-tanking tests.

1.9.7.2 The test plan shall be detailed to include the testing sequence of windings, phases, and associated/involved taps.

1.9.7.3 The Seller shall include with this notice a firm date for the opportunity to allow for Buyer to make firm travel arrangements.

1.9.8 The Buyer (or another designee of the Buyer) shall have access to the work location. He/she shall have authority to, at any time, “refuse release for shipment or further manufacture" if he/she has determined, in his/her opinion, that the requirements of this specification, applicable drawings, procedures, codes and standards have not been fulfilled, likely will not be fulfilled, or if certified copies of all required inspections and test reports are not available for review and delivery to the Buyer.

1.9.9 Draft copies of test reports and all attachments shall be given to the Buyer’s agent witnessing the tests so that enough opportunities are available to verify the accuracy and completeness of all tests and documentation before the transformer(s) are drained and dismantled for shipment. If a Buyer’s inspector/witness is not present, the test report document(s) shall be provided to the Buyer for review.

1.9.10 If the Seller changes an inspection, testing, or similar opportunity date(s) after the Seller has provided the required Notice with firm date(s) to the Buyer, the Buyer will reduce the final cost of the equipment to the Buyer at the time of invoice payment(s) by the total of any realized, reasonable, costs incurred by the Buyer as a result of the related travel plan changes.

1.10 INSTRUCTION MANUALS, DRAWINGS, PHOTOGRAPHS, AND SIMILAR FINAL DOCUMENTATION

1.10.1 At least 15 calendar days prior to the shipping date of each transformer, seven (7) certified hard copies of installation, operating and maintenance manuals, spare parts lists and all final drawings shall be sent to the Buyer. All drawings and other documents provided shall be of such quality to allow the Buyer to produce legible electronic scans, copies or prints.

1.10.2 High resolution (i.e., greater than 12 Mega-pixel), digital, color photographs of the completed core and coil assembly shall be taken prior to tanking. A common (e.g., TIFF, JPEG) format electronic image file of each view is required and shall be sent to the Buyer prior to transformer shipment for review. Hardcopies shall be included with the Instruction Manuals.

1.10.3 One CD-ROM and one USB drive shall be provided with electronic files that are duplicates and individually “all inclusive” in that they will be contain any and all documentation (in electronic form) related to the equipment including, but not limited to: certified test reports, final drawings (CAD and Adobe “.pdf” formats), native Doble formatted test files (sfra and dtax formats), SEL configuration file(s), manuals, image files, OEM component tests/files, impact recorder digital files, and contract documents (e.g., Purchase Order, specifications, appendix items).

1.11 DELIVERY

1.11.1 The required delivery date and terms shall be as defined in the purchase contract.

1.11.2 Seller shall provide Buyer a written “Notice of Intent to Ship Equipment” at least (7) seven calendar days prior to Seller’s anticipated date of shipment from the factory.

1.11.3 The time of day of the delivery (or deliveries) to the destination point shall be at the Buyer’s sole discretion.

1.11.4 No equipment shall be shipped to the Buyer until the Buyer provides the Seller with a written “Notice of Approval to Ship Equipment", which shall include the allowable time or range of times that the Buyer will be ready to take delivery.

1.11.5 Offloading at the destination point site shall be by the Buyer or another contractor of the Buyer; however, the Seller shall be responsible for positioning the transport vehicle in the proper location and orientation at the destination position for such unloading.

1.11.6 The jobsite destination point shall be in TBD, MI.

1.12 SHIPPING AND PACKAGING REQUIREMENTS

1.12.1 Equipment and materials shall be loaded and transported in such a manner that delivery will be made without damage. The procedures for shipment to be followed by the Seller shall meet all requirements of the Seller’s Instruction Manual for the equipment and all requirements of this specification.

1.12.2 Equipment shall be packaged for long-term, outdoor, storage.

1.12.3 The equipment, packages, etc., shall be marked for shipment as follows:

1.12.3.1 Buyer Project and Location
1.12.3.2 Buyer Purchase Order number
1.12.3.3 Buyer item numbers, RXXXXX TBD
1.12.3.4 Seller shop order number
1.12.3.5 Weight

1.12.4 The Seller shall forward to the Buyer complete bills of material for equipment to be shipped at the same time or prior to the Seller’s “Notice of Intent to Ship Equipment” described herein. The bill(s) of material shall include items to be shipped, weights, number of pieces and complete descriptions including item numbers. Included with this data, the Seller shall also provide the details regarding the number and type(s) of delivery vehicles that will be involved in the shipment(s).

1.12.5 At least two three-axis impact recorders shall be provided on each transformer.

1.12.6 One recorder shall be digital and have GPS capability accessible by the Buyer.

1.12.7 For rail shipments, at least one of the recorders shall be mounted to the transformer bank.

1.12.8 Recorders’ impact logging systems (pens or otherwise), multi-day clock, batteries, etc. shall remain operable for the entire trip, which officially begins at the conclusion of the IEEE Standard factory testing.

1.12.9 The chart(s) or data will be inspected upon arrival; then the recording equipment shall be returned to the Seller.

1.12.10 The original paper recordings and/or a copy of the digital file shall be provided to the Seller after the evaluation has been completed and the outcome documented in writing by the Seller.

1.12.11 Without limiting any rights to the Buyer to reject the equipment for any other proper reasons, it is expressly understood that the Buyer shall have the right to reject the equipment if a complete impact recording of the shipment is not available upon delivery, or if there are impact patterns of concern (in the Buyer’s view), or if any particular impact exceeds the acceptable level of impact specified by the Seller and approved by the Buyer in advance as provided below. Any failure of the Buyer to exercise this right shall in not relieve the Seller of any obligations or otherwise limit any of the Buyer’s rights or obligations of the Seller or constitute a waiver of or otherwise limit any of the Buyer’s rights or remedies.

1.12.12 The acceptable levels of impact shall be proposed by the Seller to the Buyer in writing and are subject to the Buyer’s approval. Such levels of impact proposed by the Seller shall in no event be less stringent than those defined by the Seller for the shipping company or companies employed by the Seller for the shipment. The

Buyer's approval of the Seller's proposed acceptable levels of impact shall not relieve the Seller of any obligations for delivering the equipment in good and proper condition or constitute a waiver of any rights or remedies by the Buyer.

1.12.13 The transformers may be shipped (dry air or nitrogen filled) by rail to the nearest rail yard, then by an over the road vehicle to the Delivery Point.

1.12.14 The Seller shall take into consideration the expected range of ambient temperatures on the path to and at the receiving location and ship the transformers with the dry air or nitrogen at a high enough pressure so that upon arrival the gas pressure will be 3 psig minimum.

1.12.15 Prior to shipping, a dew point measurement shall be performed on the dry air or nitrogen in the transformers. Both the dew point and the moisture in ppm shall be recorded, along with the ambient conditions during the test (gas pressure in both the tank and the dew point instrument, barometric pressure, insulation temperature, etc.).

1.12.16 If the dew point indicates an insulation moisture content greater than 0.5%, the transformers must be dried by the Seller until the water content is less than 0.5% prior to shipping the transformer. The results of these tests shall be provided to the Buyer prior to shipment for evaluation. The results shall also be included in the test report and a copy forwarded with each of the transformers in the control cabinet.

1.12.17 The Seller shall furnish all the necessary insulating oil for each of the transformers.

1.12.18 A copy of the operating instructions, along with the packing slip, shall be forwarded with each of the transformers (in the control cabinet, preferably). Any revisions to the instruction book after execution of the purchase contract shall require approval by the Buyer, at the Buyer's discretion.

1.12.19 The shipment of all parts, oil and accessories shall be coordinated by the Seller to ensure that the assembly, tests and installation by the Buyer can proceed without delay.

1.12.20 Assembly instructions with supporting "match mark" drawings shall be provided to facilitate an orderly, correct, and unambiguous assembly of the transformer.

1.12.21 All parts shipped independent of transformer tank shall be "match mark" to indicate proper assembled location and orientation.

1.12.22 Any technical assistance deemed necessary by the Buyer due to evidence of possible hidden damage during shipment shall be provided at the Seller's cost.

1.12.23 Seller shall provide detailed storage requirements prior to shipment.

2.0 EQUIPMENT REQUIREMENTS

2.1 STANDARDS

2.1.1 The transformer furnished shall be designed, fabricated, tested and delivered in accordance with the latest revision in effect at the time quotations are submitted of the applicable ANSI, ASTM, IEEE, NFPA and NEMA Standards, specifically including, but not limited to, the following standards.

2.1.2 In the event discrepancies exist between this Specification and a reference, this Specification, at the Buyer's discretion, shall govern.

2.1.3 Buyer recognizes ANSI, IEEE, ASTM, and NEMA and other standards noted below for this type of equipment.

2.1.4 Any design issues not specifically addressed by these standards will be resolved in a fashion satisfactory to Buyer and its agents without additional cost to Buyer.

2.1.5 IEC standards, at Buyer sole discretion, are specifically not recognized by Buyer for this equipment.

2.1.6 Buyer may employ a Consultant to review the proposed design. Buyer typically uses a Consultant whose primary experience has been in the US transformer supplier market designing for the US transformer market.

With this foreknowledge the Supplier shall describe in its quotation any design issues that would likely be of contention during the Design Review. This requirement should not be viewed as a negative, rather it can be an opportunity to educate Buyer on the quality and possible superiority of the Supplier's proposed design.

2.1.7 Specific Standards, Guides, Etc. (active or otherwise)

2.1.7.1 American National Standards Institute (ANSI)/ International Association of Electrical and Electronics Engineers (IEEE), and ANSI/IEEE:

2.1.7.1.1 C2, National Electric Safety Code
2.1.7.1.2 C57.98, Guide for Transformer Impulse Tests (IEEE Std 93-1968)
2.1.7.1.3 C57.106, IEEE Guide for Acceptance and Maintenance of Insulating Oil in Equipment
2.1.7.1.4 C57.12.00, General Requirements for Distribution, Power and Regulating Transformers
2.1.7.1.5 C57.12.10, Safety Requirements 230kV and Below, 833/958 Through 8333/10417 KVA, Single-Phase, and 750/862 Through 60000/80000/100000 KVA, Three-Phase Without Load Tap Changing; and 3750/4687 Through 60000/80000/100000 KVA With Load Tap Changing
2.1.7.1.6 C57.12.11, Guide for the Installation of Oil-Immersed Transformers (10 MVA and Larger, 69-287kV Rating).
2.1.7.1.7 C57.12.70, Terminal Markings and Connections for Distribution and Power Transformers
2.1.7.1.8 C57.12.80, Terminology for Power and Distribution Transformers
2.1.7.1.9 C57.12.90, Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short-Circuit Testing of Distribution and Power Transformers
2.1.7.1.10 C57.12.91, IEEE Guide For Loading Mineral-Oil-Immersed Power Transformers Up To and Including 100MVA with 55°C or 65°C Winding Rise.
2.1.7.1.11 C57.13, Requirements for Instrument Transformers
2.1.7.1.12 24 - IEEE Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
2.1.7.1.13 C57.19.00, IEEE Standard General Requirements and Test Procedure for Power Apparatus Bushings
2.1.7.1.14 C57.19.01, Standard Performance Characteristics and Dimensions for Outdoor Apparatus Bushings
2.1.7.1.15 C59.2, Methods of Testing Electrical Insulating Oils
2.1.7.1.16 C76.1, Standard Requirements and Test Code for Outdoor Apparatus Bushings
2.1.7.1.17 S1.2, Methods for the Physical Measurement of Sound

2.1.7.2 National Electric Manufacturers Association (NEMA):

2.1.7.2.1 TR1, Transformers, Regulators and Reactors

2.1.7.3 American Society for Testing and Materials (ASTM)

2.1.7.3.1 ASTM D117, Standard Guide for Sampling, Test Methods, and Specifications for Electrical Insulating Oils of Petroleum Origin
2.1.7.3.2 ASTM D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes
2.1.7.3.3 ASTM D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids
2.1.7.3.4 ASTM D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method
2.1.7.3.5 ASTM D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration
2.1.7.3.6 ASTM D1275, Standard Test Method for Corrosive Sulfur in Electrical Insulating Oils
2.1.7.3.7 ASTM D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
2.1.7.3.8 ASTM D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
2.1.7.3.9 ASTM D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field
2.1.7.3.10 ASTM D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration
2.1.7.3.11 ASTM D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes
2.1.7.3.12 ASTM D3487, Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus
2.1.7.3.13 ASTM D4059, Standard Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography.

2.2 SERVICE CONDITIONS

2.2.1 The transformers shall be suitable for operation at usual service conditions as described in ANSI C57.12.00, except as follows:

- 2.2.1.1 Ambient temperature
  - 2.2.1.1.1 The ambient temperature range for designing the transformer and its associated accessories is -40°C to +40°C.
- 2.2.1.2 Step-up and Step-down Operation
  - 2.2.1.2.1 Transformer will be applied in a substation as a generation step-up transformer (i.e., real power flow from XV to HV). However, the transformer shall be capable and warranted for step-up and step-down operation.
- 2.2.1.3 Loading Capabilities and Unique Applications
  - 2.2.1.3.1 Design margins shall be such that neither lead nor stray flux heating related issues shall be the first limiting constraint for loading beyond nameplate ratings.
- 2.2.1.4 Seismic requirements
  - 2.2.1.4.1 The as-designed and as-built transformer shall be designed for use in Michigan, USA and in accordance with ASCE 7 and the International Building Code as modified by or replaced by any locally adoptied code.
- 2.2.1.5 Short Circuit Conditions
  - 2.2.1.5.1 The transformer shall be designed to withstand fault currents as described herein under SHORT CIRCUIT STRENGTH. These requirements are believed to be more stringent than “Usual” IEEE Short Circuit Condition requirements.
- 2.2.1.6 Harmonics
  - 2.2.1.6.1 The transformers will be applied with in a solar farm application where inverters are expected to be used. Transformer design shall be appropriate for the application.

2.3 RATINGS

2.3.1 The capacity (KVA) rating shall be based on a 65°C maximum average winding temperature rise above ambient, and an 80°C maximum winding hottest spot temperature rise above ambient.

2.3.2 The maximum top oil rise at any rating shall be 65°C.

2.3.3 Phase: 3

2.3.4 Frequency: 60 Hz

2.3.5 The conformed specification may isolate many of the ratings requirements into a ratings requirement table. See “RATINGS REQUIREMENTS” Appendix Item. Absent project specific information guidance for the ratings is as follows:

2.3.6 Cooling Stages: TBD either ONAN/ONAF or ONAN/ONAF/ONAF

2.3.7 High Voltage (HV) - 345 kV NOMINAL

- 2.3.7.1 Rated Voltage (kV, L-L): 370,875/362,250/353,625/345,000/336,375 (345,000; 3 X +2.5%, 1 X -2.5%)
- 2.3.7.2 Rated kVA: Per Project Specific Requirements
- 2.3.7.3 Connection: TBD pending interconnection requirements
- 2.3.7.4 BIL, Line End (kV): 1050
- 2.3.7.5 BIL, Neutral End (kV): 200

2.3.8 High Voltage (HV) - 138 kV NOMINAL

- 2.3.8.1 Rated Voltage (kV, L-L): 145,000/142,500/140,000/137,500/135,000 (140,000; 2 X +2.5%, 2 X -

	2.5%)	
2.3.8.2	Rated kVA:	Per Project Specific Requirements
2.3.8.3	Connection:	TBD pending interconnection requirements
2.3.8.4	BIL, Line End (kV):	650
2.3.8.5	BIL, Neutral End (kV):	200

2.3.9 High Voltage (HV) - 69 kV NOMINAL

2.3.9.1	Rated Voltage (kV, L-L):	TBD, (69,000;2 X +2.5%, 2 X -2.5%)
2.3.9.2	Rated kVA:	Per Project Specific Requirements
2.3.9.3	Connection:	TBD pending interconnection requirements
2.3.9.4	BIL, Line End (kV):	350
2.3.9.5	BIL, Neutral End (kV):	TBD/

2.3.1 High Voltage (HV) - 46 kV NOMINAL

2.3.1.1	Rated Voltage (kV, L-L):	TBD, (45,000;2 X +2.5%, 2 X -2.5%)
2.3.1.2	Rated kVA:	Per Project Specific Requirements
2.3.1.3	Connection:	TBD pending interconnection requirements
2.3.1.4	BIL, Line End (kV):	250
2.3.1.5	BIL, Neutral End (kV):	TBD

2.3.2 Low Voltage (XV) - 34.5 kV NOMINAL

2.3.2.1	Rated Voltages (kV, L-L):	34.5
2.3.2.2	Rated kVA:	Per Project Specific Requirements
2.3.2.3	Connection:	Y (Buyer to ground via reactor)
2.3.2.4	BIL, Line End (kV):	200
2.3.2.5	BIL, Neutral End (kV):	TBD

2.3.3 Low Voltage (XV) - INVERTER VOLTAGE NOMINAL

2.3.3.1	Rated Voltages (kV, L-L):	TBD
2.3.3.2	Rated kVA:	Per Project Specific Requirements
2.3.3.3	Connection:	TBD
2.3.3.4	BIL, Line End (kV):	TBD
2.3.3.5	BIL, Neutral End (kV):	TBD

2.3.4 Tertiary Voltage (YV)

2.3.4.1	Rated Voltage (kV, L-L):	7.2
2.3.4.2	Rated kVA:	Per Project Specific Requirements
2.3.4.3	Connection:	Delta, “buried”, except with one corner brought out.
2.3.4.4	BIL (kV):	110

2.3.5 The tertiary (YV) winding shall be appropriate to suppress third harmonic voltages and stabilize the neutral.

2.3.6 Tertiary winding shall be designed with sufficient mechanical strength to withstand the short circuit forces defined elsewhere within these specifications and the winding shall be subjected to the same clamping structures as the non-YV windings.

2.3.7 One corner of the tertiary voltage winding shall be brought outside the tank for the purposes of grounding and insulation testing. The bushing shall be equipped with a removable cover at Buyer sole discretion; expected to be fully resolved during design review.

2.4 IMPEDANCE

2.4.1 The positive sequence impedance shall, for all tap combinations, be:

2.4.1.1 HV to XV, guaranteed at all DETC tap positions, Z=TBD% on ONAN MVA base, reference temperature 85º C.

2.4.1.2 The impedances as tested shall be within ± 10% of guaranteed value as allowed by IEEE Std. C57.

2.5 DIELECTRIC REQUIREMENTS

2.5.1 The complete transformer shall have dielectric strength in accordance with the latest ANSI Standards C57 and NEMA Standards with test parameters as described in the test section of these specifications.

2.5.2 Oscillograms of all voltage and neutral current tests performed shall be furnished with the test report for each transformer shall show that the applicable transformer successfully withstood all tests.

2.6 EXCITATION AND VOLTS/HZ REQUIREMENTS

2.6.1 Appropriate and suitable for the Project specific application, and:

2.6.1.1 The maximum continuous voltage on the 345 kV HV system will be TBD kV RMS (line-line).
2.6.1.2 The maximum continuous voltage on the 138 kV HV system will be TBD kV RMS (line-line).
2.6.1.3 The maximum continuous voltage on the 69 kV HV system will be TBD kV RMS (line-line).
2.6.1.4 The maximum continuous voltage on the 46 kV HV system will be TBD kV RMS (line-line).
2.6.1.5 The maximum continuous voltage on the 34.5 kV System t will be TBD kV RMS (line-line).
2.6.1.6 The maximum continuous voltage on the high voltage side of the inverter system will be TBD kV RMS (line-line).

2.7 ANGULAR DISPLACEMENT

2.7.1 The HV and the XV voltages shall lead the YV by 30° for wye autotransformers or wye-wye transformers with delta tertiaries.

2.7.2 The HV and XV voltages shall be in phase for delta-delta, wye-wye, or wye auto configurations.

2.8 SHORT CIRCUIT STRENGTH

2.8.1 The Seller shall solicit all necessary information from the Buyer to ensure that the transformers have the necessary short circuit strength to withstand the mechanical and electrical forces caused by faults on the Buyer's systems (connected to HV and XV).

2.8.2 For all types of faults, the transformers shall be capable of withstanding forces caused by faults on any one set of terminals with the system fault capacities and voltages described below maintained on the other terminals.

2.8.3 HV SYSTEM FAULT CAPACITY

2.8.3.1 The HV system shall be modeled as an infinite source.
2.8.3.2 HV system pre-fault voltage shall be 1.10 per unit per each HV DETC tap position.
2.8.3.3 For fault calculations requiring the use of an external HV system X_0/X_1 ratio, a ratio of 3:1 shall be used or that which will require the highest transformer fault withstand capabilities (as interpreted by the Buyer).

2.8.4 XV SYSTEM FAULT CAPACITY

2.8.4.1 The XV system shall be modeled as an infinite source.
2.8.4.2 XV system pre-fault voltage shall be 1.11 per unit, based on TBD/34.5 kV line-line nominal system voltage.

2.8.4.3 For fault calculations requiring the use of an external XV system X_0/X_1 ratio, a ratio of 3:1 shall be used or that ratio which will require the highest transformer fault withstand capabilities (as interpreted by the Buyer) shall be used.

2.8.5 SELF PROTECTING: GENERAL STATEMENT

Ultimately, the transformers, as designed and built, shall be absolutely and completely self-protecting under all fault scenarios with all external source impedances equal to zero ohms. The transformer design shall not require any external impedances to reduce its short circuit requirements.

2.9 LOADING CAPABILITY

2.9.1 Transformer shall be designed for loading beyond the nameplate MVA under the following conditions:

2.9.1.1 Continuous loading at 125% of ONAF top rating for 24 hours
2.9.1.2 Average Ambient: 35 °C
2.9.1.3 Top oil maximum temperature: 110 °C
2.9.1.4 Winding hottest spot maximum temperature: 130 °C
2.9.1.5 Load Power Factor: 0.8%
2.9.1.6 Frequency: 95% of rated value
2.9.1.7 HV DETC tap position: worst case
2.9.1.8 LV OLTC tap position (where present): worst case
2.9.1.9 No oil shall be expulsed.

2.9.2 Every effort shall be made to coordinate the ancillary equipment (bushings, de-energized tap changer, BCT's, etc.) so that they sustain no more loss of life than the winding insulation will for the above nameplate loading condition.

2.9.3 The Seller shall conduct all needed design studies and related calculations with respect to such things as winding hot spots, cable and lead hot spots, top oil rise, oil expansion, leakage flux, shunt capability for stray flux shieldings, static plate heating, tank wall heating, tap changer capacity, bushing capacities, current transformer thermal capacity, and bubble formation risk at elevated hot spot temperatures (>140°C), to ensure that the above nameplate loading can be sustained.

2.9.4 The calculated temperature data shall be submitted with the Test Report.

2.9.5 The loading of the transformer under the beyond nameplate loading conditions shall be limited by the winding temperature and/or the top oil maximum temperature limits and not by temperatures of leads, switches, bushings, or any other ancillary device.

2.9.6 The temperature of lead exits from the insulation structure shall be controlled to be less than or equal to 3°C higher than the conductor in the winding under the beyond nameplate loading conditions.

2.10 GUARANTEED LOSSES

2.10.1 Independent maximum Guaranteed Load and No Load Losses shall be provided at the ONAN MVA rating and the 345 kV or 138 kV HV tap.

2.10.2 Transformer losses will be evaluated over a 20-year period using the following loss cost values:

2.10.2.1 The Present Value of Load Losses will be calculated at: $680/kW.
2.10.2.2 The Present Value of No-Load Losses will be calculated at: $6160/kW.

2.10.3 Failure of the built equipment to meet the guaranteed loss values provided herein shall warrant rejection. This Buyer warrant for rejection supersedes the related statement in IEEE C57.12.00 - 2015, Clause 9.3, which states that “Failure to meet the loss tolerances shall not warrant immediate rejection…”. If the Buyer waives the right to rejection in this case, twice the above loss cost factors shall be used to determine a discount to be applied at the time of invoice to the invoice.

2.10.4 The no-load and the load loss guaranteed values will be treated as independent guaranteed design requirements and any subsequent discounts for failure to reach these targets will be calculated independently.

2.10.5 Credit for losses lower than the guaranteed values will not be considered.

2.11 NAMEPLATE

2.11.1 The nameplate shall have provisions for attaching a meter seal to show the connections and taps being used.

2.11.2 All text shall be no less than 4.5mm in height.

2.11.3 The nameplate is to be mounted on each of the transformers prior to shipment.

2.11.3.1 Nameplate diagram to be made facing same side of transformer as nameplate is located.

2.11.4 Information on the nameplate shall include all data as called for in ANSI Standard C57. In addition to ANSI Standards, the nameplate shall show/indicate:

2.11.4.1 Impedance data at each tap combination
2.11.4.2 PCB level/disposition
2.11.4.3 Suitability for step-up or step-down operation
2.11.4.4 A statement addressing the transportability of such transformer while fully assembled and oil-filled.
2.11.4.5 The date and place of manufacture
2.11.4.6 Insulation type if other than cellulose
2.11.4.7 Arithmetic loading statement
2.11.4.8 Ratios of current transformers, qualities/accuracy class of all supplied CTs (including auxiliary, temperature indicator supporting CTs, etc.), continuous thermal rating factor,
2.11.4.9 Guaranteed sound levels
2.11.4.10 All through impedances
2.11.4.11 Self-cooled and forced-air-cooled kilovolt-ampere ratings for the various taps
2.11.4.12 Provide a Piping & Valve Diagram Nameplate per “PIPING & VALVE DIAGRAM NAMEPLATE” Appendix Item.

2.12 CURRENT TRANSFORMERS

2.12.1 General

2.12.1.1 Approximate CT requirements are noted below. Final CT requirements (e.g., ratio) to be provided by Buyer prior to design review completion.

2.12.2 HV Phase Bushing CTs

2.12.2.1 Provide quantity TBD (typical two), TBD (typical 600:5A), multi-ratio, C800, 2.0 (or greater) continuous thermal rating factor, current transformers per bushing.

2.12.2.2 The outermost set of CTs shall be metering accuracy class 0.3 B-1.8. Certified test reports shall be provided by Seller.

2.12.3 HV Neutral Bushing CT

2.12.3.1 Provide quantity TBD (typical one), TBD (typical 600:5A), multi-ratio, C800, 2.0 (or greater) continuous thermal rating factor, current transformers on the neutral bushing.

2.12.4 XV Phase Bushing CTs

2.12.4.1 Provide quantity TBD (typical three), TBD , multi-ratio, C800, 2.0 (or greater) continuous thermal rating factor, current transformers per bushing.

2.12.5 XV Neutral Bushing CT

2.12.5.1 Provide quantity TBD (typical one) TBD, multi-ratio, C800, 2.0 (or greater) continuous thermal rating factor, current transformers on the neutral bushing.

2.12.6 YV Buried CT

2.12.6.1 No CT required.

2.13 TERMINAL CONFIGURATION

Transformer terminals shall be arranged per C57.12.10.

2.14 TRANSPORTABILITY AT JOBSITE WHILE FULLY ASSEMBLED AND OIL-FILLED

The transformers shall be transportable while fully assembled, including oil, all bushings, fans, oil reservoirs, and other parts of the transformers. The transformers shall be capable of being placed in service immediately after such moving. These requirements/abilities shall be noted on the outline drawing.

2.15 CORE AND COILS

2.15.1 Transformers shall be of a circular disk or helical coil design except as described below:

2.15.1.1.1 Preventative Auto transformer coil design, where present, may be of a layered design except where alternate designs may be needed to achieve sound pressure guaranteed levels.

2.15.1.1.2 Regulating/tap winding designs, where present, may be of a layered design with alternating winding pitches on different layers provided the resulting design minimizes axial short circuit forces and the field/electrical center is unaffected by the LTC tap position in operation/selected; with fully distributed windings.

2.15.1.2 Rectangular core designs are not acceptable except for the preventative auto where present.

2.15.2 Step-lap core construction is required for main unit cores. All main unit cores shall use a mitered-core design. "Scrapless" core designs are not acceptable.

2.15.3 The top and bottom core yokes shall be continuous, except for building joints.

2.15.4 Every top, bottom, and end core step shall be supported from the core clamps and core clamp cross members by inserting a non-conductive material.

2.15.5 If taps are located in the top and bottom half of a winding, they shall have the same turn distribution in each half of the winding for all tap positions (i.e. balanced ampere-turns).

2.15.6 Internal metal oxide arresters (e.g., to protect tap windings) are not acceptable.

2.15.7 The impulse ratio used to convert impulse voltages to power frequency voltages shall be no greater than 2.5.

2.15.8 Oil gap and creep stresses on pressboard will be a design review item.

2.15.9 Full circle pressure rings are required for the top and bottom coil clamping. The rings shall be either one piece of uniform thickness or if less than full uniform thickness is used, then ring deflection calculations shall reflect only the uniform thickness in the calculation.

2.15.9.1 Metal pressure rings are not acceptable for designs with ONAN ratings above 5 MVA.

2.15.10 Seller shall have demonstrated experience with the proposed winding arrangement.

2.15.11 The Seller's normal design methods and withstand criteria are expected to have been based on modeling and full size transformer tests for the applications in the USA.

2.15.12 Winding conductor materials shall be copper.

2.15.12.1 All HV winding conductors shall be at least coated copper.

2.15.12.2 All LV winding conductors shall be at least coated copper.

2.15.13 The inner windings shall be designed and constructed to withstand free or unsupported buckling as well as forced or supported buckling. No exceptions will be allowed.

2.15.14 Conductor bending stress to be calculated consistent with the Anderson Program(s) (e.g., ½ spacer method).

2.15.15 For 65°C guaranteed average rise winding designs the paper on the winding conductors must be thermally upgraded paper appropriate for 65°C (or higher) average winding rise operation, minimum required high-temperature solid insulation thermal class of 120° C.

2.15.16 High density Kraft paper tape, Dennison grade 22HCC or the equivalent, is required for all layers of the taping of joints, termination ends, and similar.

2.15.17 It is required that Dennison grade 22HCC paper tape or the equivalent be used for the (minimum) outer two layers on all paper taped conductor.

2.15.18 Where continuously transposed conductors with paper insulation are used the radial duct spacing shall be appropriate to the design and a minimum of 0.1575 inches.

2.15.19 The maximum temperature of "other metallic hot-spot temperature rise (in contact and non in contact with insulation)" shall be 100 °C.

2.15.20 The insulation power factor of any winding at the time of shipment and receipt shall not exceed 0.5% at 25°C.

2.15.21 The maximum allowed water content of the paper insulation upon receipt at the site shall not exceed 0.5% moisture by dry weight (mdw). Upon arrival, where not delivered oil-filled, at the delivery point, a dew point measurement will be made. If the dew point indicates an insulation moisture content greater than 0.5% mdw, per Buyer discretion, the transformer will be dried in accordance with procedures approved by the Seller until the water content is less than 0.5% mdw as judged by Buyer. The cost of this drying shall be applied against the unit purchase price at invoice approval time. Alternately, at Buyer discretion, arrangements may be made

by the Seller to dry the unit with their own resources prior to Buyer receipt.

2.15.22 Leads in the superstructure of the active part shall be adequately supported to withstand the forces generated during short circuit events.

2.15.22.1 Leads may not be fastened to the superstructure (cleats) with fabric tie material or polymeric cable ties.

2.15.22.2 Leads are to be fastened with pressboard clamps, hardwood cleats, or Buyer reviewed/approved alternative means/materials.

2.15.23 Electrical clearances between windings and ground shall be selected for long-term reliable operation for the U.S. power system environment.

2.15.24 The coil and insulation assembly shall be designed to prevent the formation of partial discharge during normal operation and during any test condition.

2.15.25 All under load tap windings shall be the fully distributed configuration.

2.15.26 The mechanical structure of the active part shall be capable of withstanding the accelerations and vibrations imposed by transportation forces, including but not limited to transportation by ship and rail. The minimum design accelerations are as follows:

2.15.26.1 Rail – 5g longitudinal, 3g vertical, and 2g transverse.

2.15.26.2 Truck – 3g longitudinal, 2g vertical, and 2g transverse.

2.15.26.3 The manufacturer shall design for greater values if indicated by the mode of transportation.

2.15.27 Insulating materials built into and adjacent to the core shall be rated with a thermal class to operate without accelerated aging for the temperatures in the center of the core and on the surface of the core.

2.15.28 Externally accessible grounding points shall be provided for the core.

2.15.28.1 The ground connection shall be brought through an external spark plug-like porcelain bushing on the top or side of the transformer case, protected with an enclosure (with weep hole(s) for the drainage of any moisture present if the box is not sealed).

2.15.28.2 If auxiliary transformers such as series transformers or preventive autotransformers are placed within the main tank, separate core grounds shall be bought out for each auxiliary transformer.

2.15.29 All portions of the core shall be compressed and remain compressed for its service life.

2.16 LEAKAGE MAGNETIC FLUX

2.16.1 Leakage flux analysis shall be performed to verify the control of temperature of metallic parts including core, tie plates, core frames, tank panels, shielding materials, etc.

2.16.2 If magnetic shields are provided, the flux density in the shields shall be less than saturation for material at rated load and at any stated load in excess of nameplate rating.

2.16.3 The leakage flux analysis shall include the heating effect in leads, cables, connectors, etc. in the cleats and leads structure.

2.16.4 The design of the regulating voltage winding or coils used to change the voltage of the transformer shall be designed to mitigate the number of leakage magnetic fields. The mechanical stresses in the regulating voltage portion of the winding are to be calculated and available during the design review.

2.17 TANK

2.17.1 Provide tank construction with a sealed (bladder) type conservator or positive pressure inert gas oil preservation system and suitable alarms wired to terminal blocks.

2.17.2 Where a positive pressure inert gas system is provided:

2.17.2.1 Two, full, DOT Certified gas cylinders shall be provided.

2.17.2.2 Cylinders shall be sized to hold approximately 200 cubic feet of Nitrogen.

2.17.2.3 Gas grade shall be “high purity” or higher grade quality.

2.17.2.4 The gas cylinders shall be appropriately secured and stored outside of the regulator system enclosure.

2.17.2.5 The gas cylinders shall rest/stand on a solid bracket suitable for two cylinders attached to the tank wall.

2.17.2.6 The solid bracket shall be removable and attached to the tank wall via bolts into blind threaded holes.

2.17.2.7 The elevation of the bracket shall be 6” above the tank base, but allow adjust to +/- 6” from base elevation.

2.17.2.8 The system shall be piped to only one of the gas cylinders. Manual changeover of TFE lined, stainless steel braided cover hose required to use second cylinder. Hose length shall allow for reconnection to the second cylinder as needed without physically maneuvering or swapping cylinder positions.

2.17.3 Where a conservator tank is provided the following shall also be provided:

2.17.3.1 Suitable drain

2.17.3.2 Filter press

2.17.3.3 Sampling valves

2.17.3.4 Reinhausen MTrab Maintenance-free Dehydrating Breather: of suitable type, 230 VAC/DC, ANSI 70 grey, American/English dimensional cable glands, 4-20 mA output, US appropriate flange, with test button, filter heating, insect protection, protection grid, lateral fixing, and US market appropriate. Alternate Qualitrol model may be substituted with prior Buyer approval.

2.17.3.5 Conservator/expansion tanks shall have a synthetic bladder.

2.17.4 Where neither an inert gas system with cylinder(s), nor a conservator system is provided:

2.17.4.1 1/4 " NPT piping to a main shutoff 1/4 turn ball valve followed by a tee

2.17.4.2 Tee (take-off) feeds pressure-vacuum bleeder with (+/-10 PSIG) pressure-vacuum gauge. Tee feed-thru path feeds 1/4 turn shut-off/fill ball valve with a 1/4 NPT to 1/8" taper barb fitting.

2.17.5 Tank shall be able to withstand full vacuum and one atmosphere pressure without permanent distortion.

2.17.6 Seller shall provide complete instructions for oil handling and filling in the field.

2.17.7 Tank cover shall be welded in place.

2.17.8 Vertical corners shall be constructed from continuous plate with a smooth radius. Tank seams shall be a minimum of four inches in either direction from the corners.

2.17.9 Welds shall be made on inside and outside of tank joints.

2.17.10 All openings are to be raised to prevent the entrance of moisture.

2.17.11 A shipping cover, if provided, shall be bolted in place.

2.17.12 Base:

2.17.12.1 Continuous welding shall be utilized throughout on bases that are welded to tank bottom.

2.17.12.2 Base shall be suitable for rolling or skidding transformer in any direction with the transformer fully assembled without a plate being necessary under the bottom of the base.

2.17.12.3 Transformer will normally be installed on two (2) parallel piers which run the length of the transformer. In some cases where the piers already exist and are spaced farther apart than the transformer base width, rails spanning the piers will be added to support the transformer at each end. If additional support is required, the Seller shall so note on where further support is required on the outline drawing; a base detail with dimensioning and clear annotations of sufficient support areas is preferred.

2.17.13 Transformers which require installation on a full size concrete slab are unacceptable.

2.17.14 Jacking Facilities: The distance from the underside of the jack pad to base floor line of transformer shall be not less than 15 inches and not more than 24 inches, and shall be adequate for lifting the transformer oil-filled and fully assembled. Outline legend to included full statement of jacking facility adequacy for jacking oil-filled and fully assembled.

2.17.15 Pulling Eyes: Adequate for pulling transformer in any direction with the transformer oil-filled and fully assembled with reasonable skidding provisions. Outline legend to included full statement of pulling eyes adequacy for pulling oil-filled and fully assembled.

2.17.16 Lifting Facilities: ANSI Standard, including lifting eyes for cover only, for core and coils (core form designs only), and lifting hooks for lifting complete transformer. Outline legend to included full statement of lifting facility adequacy for lifting oil-filled and fully assembled.

2.17.17 The tank shall be provided with lifting attachments for fully assembled vertical lifts.

2.17.17.1 The attachments shall be capable of accepting a cable loop without requiring clevises.

2.17.17.2 A hole must be included in the attachments for lifting with cable and for tie downs.

2.17.18 Manholes:

2.17.18.1 Provide two or more hand holes or manholes in the tank cover.

2.17.18.2 There shall be at least one circular manhole with minimum diameter clear openings of 18 inches in the tank cover.

2.17.18.3 Bolted construction is to be used on manhole covers.

2.17.18.4 The manhole flanges shall be raised on the tank cover to prevent entrance of moisture.

2.17.18.5 At least one 18 inch manhole shall be provided that will allow for the inspection of lower active parts of the transformer on the HV side.

2.17.18.6 At least one 18 inch manhole shall be provided that will allow for the inspection of lower active parts of the transformer on the LV side.

2.17.18.7 An additional 18 inch manhole shall also be provided to inspect/repair/replace the DETC if it is below the top of the core and coils or inaccessible through a cover port. The location of the manhole shall be along-side the DETC.

2.17.18.8 The manholes located on the sides shall have the cover secured by bolting into blind threaded holes in the tank. Alternately, subject to Buyer discretion during the approval drawing cycle, a raised flange/lip approach with pass-through hardware may be used in lieu of a blind threaded hole approach provided the lip is raised at least 3” to allow for adequate fastener/tool/working access.

2.17.18.9 Manholes greater than 16”, but less than 18” may be acceptable for other than those required on the

cover subject to approval by Buyer during approval drawing cycle; drawing shall indicate there is an exception to the 18" requirement to facilitate review.

2.17.19 Gaskets:

2.17.19.1 Only O-ring type or continuous gaskets are allowed.

2.17.19.2 Synthetic rubber nitrile gaskets shall be used throughout. If Seller has experience with and recommends "Viton" for bushing gaskets, then Viton will be considered.

2.17.19.3 All oil or gas seals shall have retaining gasket groove construction.

2.17.19.4 Grooves shall be filled at least ninety percent when the O-ring/gasket is compressed or as documented by ring/gasket Original Equipment Manufacturer.

2.17.20 Fasteners:

2.17.20.1 All fasteners, adapters, and similar items exposed to the atmosphere shall be stainless steel, bronze, or otherwise galvanically appropriate and non-corrosive materials and suitable for their purpose.

2.17.20.2 Torque specifications for all fasteners (internal and external) shall be documented as part of the approval drawing set or be supplied in the installation, operating, and maintenance manual(s).

2.17.21 Ground Connections:

2.17.21.1 Provide a minimum of two copper-faced ground pads per ANSI Standards located on diagonally opposite corners near bottom of transformer, but still on the transformer tank.

2.17.21.2 Provide one ground pad on transformer cover near neutral bushing(s).

2.17.21.3 Provide ground pad next to core ground bushing and if present preventative auto/series core ground bushing(s).

2.17.21.4 Provide ground pad next to surge arrester brackets; one per arrester location.

2.17.21.5 Provide a ground pad for each core ground bushing appropriately located within enclosure for core ground bushing(s) as described elsewhere herein.

2.17.21.6 On the front and back of the transformer, provide one ground pad on each end of the transformer support brace.

2.17.22 Provide Flanges and Shutoff Valves with position indicators on radiators, pumps (where present) and radiator headers to permit removal of the radiators and/or the pumps without requiring drainage of the oil from the transformer. Radiator cover plates shall also be shipped with all transformers.

2.17.23 Radiators may be shipped attached only with transformers having an ONAN rating less than 5 MVA and with prior approval. All other sizes shall have radiators shipped separately.

2.17.24 Radiators shall be spaced symmetrically on the tank where possible if alternate dimensional or placement requirements are not defined elsewhere herein.

2.17.25 Radiator model shall be Menk, Trantech, or manufactured by the Seller.

2.17.26 Radiators shall be (preferably ASTM A123) hot dipped galvanized and/or suitably painted with Zinc rich primer (See FINISH).

2.17.27 Provide Oil Flow Indication with ungrounded alarm contacts for each oil circulating pump (if pumps are utilized). Seller shall specify type being furnished. Differential pressure indication will be acceptable. Direction of oil flow shall be indicated. Seller to ensure tank vibration shall not affect this device.

2.17.28 Valves: All valves greater than ¾" shall be flange mounted and shall come without sampling ports.

2.17.29 The upper fill valve shall be 2-inch globe or ball valve type, flanged on the tank side and 2 inch NPT on the outlet side with a plug.

2.17.29.1 Provide an oil deflection plate to prevent oil from pouring directly onto the windings and insulation structure during filling of the transformer via the upper fill valve.

2.17.29.1.1 The transformer outline drawing shall have a bubble identifying the location of the deflection plate and have a corresponding line item with description in the legend.

2.17.30 An "Auxiliary Cooler valve" shall be provided; and be a 2-inch globe or ball type valve. The tank wall penetration should be above the oil. On the inside of the tank a downpipe shall be added to extend 8" below the oil level. On the outside of the tank a down pipe should result in the connection point on the valve being in the vertical plane to allow stress relief for externally connected auxiliary cooler hosing. The valve should be located at an elevation that will allow a worker to make connections to the valve and operate the valve while generously maintaining a Minimum Approach Distance clearance to live parts as described elsewhere herein these specifications. The mounting flange of the HV bushing and the HV arrester mounting bracket elevations are typical reference points for the closest live part(s) of concern. The valve should be located on the H3 side of the tank.

2.17.31 The lower drain valve shall be 2-inch globe or ball valves, flanged on the tank side and 2 inch NPT on the outlet side with a plug. Valve shall come without sampling port. Valve to be located on the LV side near the bottom/base.

2.17.32 Provide a 4-inch opening for vacuum connections on a diagonally opposite corner from the filling valve on the

tank cover.

2.17.32.1 Opening shall have a flat flange welded to the tank top or a throat with blind tapped holes arranged to accept a standard 4-inch flanged valve.

2.17.32.2 The flange of each opening shall be grooved and sealed with an O-ring gasket and a cover plate.

2.17.33 Provide two valves for the future addition of an oil-circulating online gas monitor. One valve shall be located approximately 18 inches from the bottom of the tank and the other shall be located near the top of the tank below the minimum oil level low enough to prevent cavitation.

2.17.33.1 The valves shall be ¾" globe or ball valves with ¾" NPT on the outlet side with pipe plug.

2.17.34 All items mounted on cover shall be raised and shall not be gasketed directly to the cover. Any flanges shall be a minimum of 1/2" above the tank top. The cover shall be crowned or have pitch(es) suitable to prevent standing water accumulation (e.g. at least ¼" rise in one foot).

2.17.35 Where required per the instrumentation requirements a sudden pressure relay shall be provided with 2" valve and plug approximately 60" above the transformer base; includes shutoff valve and test pressure connections.

2.17.36 Provisions shall be made for future addition of bushing current transformers to each bushing, without cutting, welding or drilling the tank. The maximum number of CT's (initial plus future) shall be two per bushing where two or more current transformers are not originally required.

2.17.37 Fall restraint attachment devices to be installed as described elsewhere herein.

2.17.37.1 Placement and quantities of devices subject to approval cycle discussions and Buyer discretion.

2.17.37.2 Locations and orientations of devices shall be compatible with installation and removal of the portable safety equipment/post including base pin insertion.

2.17.38 Where a Fiber Optic Temperature Measurement System is required provide an opening for the fiber optic system "transformer tank wall feedthrough plate".

2.17.38.1 The opening shall have a flat flange welded to the tank top with blind tapped holes arranged to accept the bolt pattern of the tank wall plate.

2.17.38.2 The plate will be approximately 12" in diameter and be located near a man hole.

2.17.38.3 The location of the feedthrough plate shall be subject to CEC approval during the approval drawing review cycle; alternately the locations may be addressed earlier in the event of a formal design review.

2.17.38.4 More than one tank wall feedthrough plate may be required depending on the total number of fibers being required for this design (defined elsewhere herein).

2.17.39 Refer to the FINISH section of these specifications regarding painting of the inside of the main tank.

2.18 FALL RESTRAINT

2.18.1 General

2.18.1.1 This specification covers the proper preparation, techniques and locations for installing Buyer approved base plates and D-bolt anchor channels on Seller's transformers.

2.18.1.2 The installation of Buyer approved base plates and D-bolt anchor channels shall be done in accordance with this specification and attached detailed drawings.

2.18.1.3 This specification provides detailed guidelines that shall be applied by the Seller.

2.18.1.3.1 Additionally, base plate supplier's (OEM's) specifications for installation must also be met.

2.18.1.3.2 Any conflicts that arise between this specification and the base plate supplier's instructions for installation shall be brought forward to the Buyer for resolution.

2.18.2 Location Requirements and Application

2.18.2.1 Base plates and D-bolt anchor channels are used as the primary attachment points for Buyer's field personnel applied fall restraint devices/tools/equipment.

2.18.2.2 Location of base plates and D-bolt anchor channels are a function of the transformer's overall tank cover length.

2.18.2.2.1 For transformers with tank cover lengths less than 10 feet, only one base plate is required.

2.18.2.2.1.1 Base plate shall be located in the center of the transformer tank cover.
2.18.2.2.1.2 Base plate may be moved off centerline to provide better mounting clearances.
2.18.2.2.1.3 Base plate is required to have 12 inches of clearance on either side of its ears. This requirement is to ensure easy insertion of the post locking pin without interference to nearby devices; keeping in mind Buyer's pins may have somewhat different clearance requirements than Seller's pin (if used) at the Seller's factory.
2.18.2.2.1.4 D-bolt anchor channels shall be located on the top of the transformer tank cover.
2.18.2.2.1.5 D-bolt anchor channels shall be located 5 inches from the edge of the transformer tank cover.
2.18.2.2.1.6 Transformers shall have 2 anchor channels installed on the tank cover at ladder accessible locations.
2.18.2.2.1.7 The purpose of the anchor channel is to be the first attachment point for a worker climbing on to the cover of the transformer.
2.18.2.2.1.8 Refer to the Appendix Item "FALL RESTRAINT DOCUMENTS" for sketch showing mounting and location requirements for transformers with covers less than or equal to 10 feet in length.
2.18.2.2.2 For transformers with tank cover length 10 feet or more, a minimum of 2 base plates are required.
2.18.2.2.2.1 Base plates shall be located 10 inches from the edge of the transformer tank cover.
2.18.2.2.2.2 Location of the base plate shall be on opposite ends of the transformer tank cover.
2.18.2.2.2.3 Base plate may be moved slightly if alternate location provides better mounting clearances.
2.18.2.2.2.4 Placement of base plates shall be such that a horizontal life line can be attached from one location to the other and be free of obstructions.
2.18.2.2.2.5 Base plate shall be oriented such that the tie-off ring faces out towards the edge of the tank.
2.18.2.2.2.6 Base plate is required to have 12 inches of clearance on either side of its ears.
2.18.2.2.2.7 The above requirement is to ensure easy insertion of the post locking pin and clearance from other nearby devices.
2.18.2.2.2.8 D-bolt anchor channels shall be located on the top of the transformer tank cover.
2.18.2.2.2.9 D-bolt anchor channels shall be located 5 inches from the edge of the transformer tank cover.
2.18.2.2.2.10 Transformers shall have 2 anchor channels installed on the tank cover at ladder accessible locations.
2.18.2.2.2.11 If a ladder accessible location is near a base plate installment, base plate can be considered an acceptable tie-off.
2.18.2.2.2.12 The purpose of the anchor channel is to be the first attachment point for a worker climbing on to the top of the transformer.
2.18.2.2.2.13 An additional D-bolt anchor channel is required in the center of transformer's tank cover.
2.18.2.2.2.14 Purpose of the above D-bolt channel location is to allow field personnel to install a life line while still remaining tied-off continuously.
2.18.2.2.2.15 Refer to the Appendix Item "FALL RESTRAINT DOCUMENTS" for sketch showing mounting and location requirements for transformers with covers greater than 10 feet in length.

2.18.3 Installation and Welding Procedure Requirements
2.18.3.1 Clean and prepare the surface for welding by removing all oils, grease etc.
2.18.3.2 If existing surface coatings exist such as paints or plating, grind and clean the surfaces exposing a bare steel area (approximately the size of the mounting plate).
2.18.3.3 Lightly grind the edges of the mounting plate on the sleeve before welding to expose a bare steel surface.
2.18.3.4 Weld the mounting plate on using a ¼" fillet weld around the perimeter of the mounting plate and ensuring a seal is created to prevent surface rusting underneath.
2.18.3.5 A surface coating shall be applied to prevent against rust and pitting.
2.18.3.6 All fall protection equipment shall be painted high visible safety green.
2.18.3.7 Proper care shall be taken to ensure paint build-up does not interfere with pin hole dimensions.

2.18.4 Factory Inspection
2.18.4.1 Buyer reserves the right to inspect workmanship at the time of installation to ensure base plate is properly mounted.

2.18.5 Equipment Description
2.18.5.1 Base Plate
2.18.5.1.1 Base plate tie-off anchor shall be DBI/Sala's Part Number 8517422.
2.18.5.1.1.1 The bare steel uni-anchor base plate shall come equipped with the tie off anchor.
2.18.5.1.2 Buyers will not accept any alternative manufacturers' plate base offerings.
2.18.5.2 D-Bolt Anchor Channel
2.18.5.2.1 D-bolt anchor channel shall be designed and built according to detail drawing in Appendix.

2.18.6 Welding Standards
2.18.6.1 All welding associated with the base plates and anchor channel shall be done in accordance with the American Welding Society Standards.

2.18.7 Refer to the Appendix Item “FALL RESTRAINT DOCUMENTS” for Buyer’s Fabrication of Structural Steel for Electric Substations requirements.

2.19 DE-ENERGIZED TAP CHANGER

2.19.1 Provide a suitable high-voltage tap changer for de-energized operation with operating handle brought through the tank sidewall; preferably above the core and coil assembly.

2.19.1.1 The preferred location of the tap changer is on the top of the core and coils.

2.19.2 Provide a position indicator and facilities for padlocking the tap changer's handle in any position.

2.19.3 Tap changing contacts and mechanism shall be accessible for inspection and repair without untanking the transformer or doing major disassembly/re-assembly.

2.19.4 The operation handle shall be directly connected to the tap changer shaft.

2.19.5 The tap changes shall require a maximum of 20 ft-lbs torque at the handle to operate.

2.19.6 The tap changing locking contacts shall be silver-to-silver or Buyer approved equivalent and shall be designed to wipe contact surface when operated.

2.19.7 A tap changer design that requires movement to wipe the contacts to prevent coking in periods of less than seven years is not acceptable.

2.19.8 The tap changer shall be designed to require only one pair of contacts per connection per phase. Dual or multiple type taps changers requiring more than one pair of contacts per connection phase are unacceptable.

2.19.9 If there are any shear couplings on the tap changer acting as safety devices, provide at least one spare unit per coupling. If the shear device is located inside the tank, then the shearing material must be non-conductive. Shear device replacement must be possible through the required access hole.

2.20 TERMINAL BOARDS (WHERE REQUIRED)

2.20.1 LV delta-wye and series-parallel terminal boards shall be provided as needed per specification item and shall be easily accessible through a hand hole in the cover.

2.20.1.1 It shall be possible to change winding connections without draining the oil.

2.20.1.2 Provisions shall prevent terminal board fasteners from being able to fall into or to the side of the core and coil assembly (e.g. captive hardware or box).

2.21 FINISH

2.21.1 The tank and bushings shall be ANSI No. 70 Gray in color.

2.21.2 All surfaces including the tank, radiators, manholes, control cabinets, enclosures, etc. shall be painted.

2.21.2.1 The paint and primer combined, shall be a minimum of 0.002” primer and 0.003” finish coat in thickness. The finish shall have a durability to provide at least 25 years of service.

2.21.2.2 Radiators are required to be painted if not hot dipped galvanized. Where hot-dipped galvanized the radiator zinc dip surface may also be suitably prepped and painted with zinc compatible paint/systems.

2.21.3 All transformers must have a skid resistant paint applied to all surfaces on top of the tank.

2.21.4 The inside of the tank shall be completely painted white with primer and finish coat suitable for long term exposure to oil and internal components. Photos of painted inside of tank prior to active assembly tanking are required for each unit built.

2.21.5 Seller shall submit for tank and piping:

2.21.5.1 Record of surface preparation for painting, including surface profile and cleanliness verification.

2.21.5.2 Record of primer thickness (all sides of tank, internal and external).

2.21.5.3 Record of finish primer thickness (all sides, internal and external).

2.21.6 Radiators and fan assemblies shall be galvanized. Manufacturing drawings for the radiators and fans shall include required galvanizing thickness. Documentation certifying the required thickness of galvanizing shall be provided to the Buyer.

2.22 SOUND LEVEL

2.22.1 The transformer shall have a guaranteed sound pressure level not to exceed TBD dBA at the TBD ratings as measured by IEEE C57.12.90 – 2015, Section 13.5.5. Levels to be appropriate to meet overall governing project sound level restrictions, ordinances, laws, codes, permitting, etc.

2.22.2 The sound level guarantee shall apply to the loudest tap position.

2.22.3 The one-third octave band spectrum of the transformer shall not contain a prominent discrete tone as defined in ANSI Standard S12.9-2005/Part 4 Annex C, which states a prominent discrete tone exists if the one-third octave band sound pressure level in the band exceeds the arithmetic average of the sound pressure levels of the

two continuous one-third octave bands by 5 dB for center frequencies at or between 500 Hz and 10,000 Hz, by 8 dB for center frequencies at or between 160 and 400 Hz, and by 15 dB for center frequencies at or between 25 Hz and 125 Hz.

2.23 INSULATING OIL

2.23.1 OIL REQUIREMENTS

2.23.1.1 All necessary insulating oil shall be provided with the transformer and meet ANSI/ASTM D3487.

2.23.1.2 It is the Buyers intention to purchase transformers which can be placed in service (and later moved, if need be) with a reasonable amount of time and expense for oil handling.

2.23.1.2.1 The Seller shall provide Buyer with their oil filling requirements at time of quotation.

2.23.1.2.2 The oil handling requirements will be taken into consideration in evaluating transformer quotations.

2.23.1.3 The insulating oil shall be Type II inhibited with 0.3 percent by weight of (2, 6-ditertiary-butyl paracresol).

2.23.1.4 Manufacturers trade name of oil and oil specification are required for the Buyer’s approval; included shall be concentrations of chemicals listed on EPA's toxicity list.

2.23.1.5 A Material Safety Data Sheet (MSDS) shall be included with each copy of instruction books. The MSDS contains information on the chemical make-up of the transformer oil and it gives employee handling information and environmental protection information.

2.23.1.6 The insulating oil shall be one of the following brands and types:

2.23.1.6.1	Cross:	Cross Trans Grade 206
2.23.1.6.2	Ergon:	Hyvolt II (NG or Not NG subject to Buyer review)
2.23.1.6.3	Calumet:	Caltran 60-30
2.23.1.6.4	Nynas:	Nytro 11GBX-US
2.23.1.6.5	Exxon/Mobile:	Univolt N 61B

2.23.2 NON-PCB REQUIREMENT

2.23.2.1 Insulating oil that is used in the factory and insulation impregnation, delivered in the transformer, or used in the bushings shall have a non-detectable PCB content.

2.23.2.2 The PCB content of the oil in ppm shall be certified in the test report. Insulating oil sample and test procedures at the factory shall conform to the requirements of ASTM D117.

2.23.2.3 The testing shall confirm and the nameplate shall state that “At the time of manufacture the oil and equipment contain <1PPM, mg/kg (PCB)”.

2.23.3 CORROSIVE SULFUR TESTING

2.23.3.1 Insulating oil intended for use in the transformers shall be tested for corrosive sulfur using ASTM D1275, Method B prior to shipment or use in the factory for transformer testing. Exposure of the transformer insulation to oil that fails the ASTM D1275, Method B test shall be Rejected and be replaced with a sufficient amount of oil that passes this test for flushing and refilling the unit.

2.23.4 CERTIFIED OIL TEST REPORT RESULTS

2.23.4.1 Certified test reports shall be furnished for the oil supplied. The samples for the tests must be taken from the bottom of the shipping containers used to transport the oil to the destination point site. The report shall contain results of the following tests and shall be provided to the Buyer’s before shipment:

2.23.4.2 Dielectric strength, ASTM D1816, 1 mm gap; 20 kV minimum
2.23.4.3 Dielectric strength, ASTM D1816, 2 mm gap; 35 kV minimum
2.23.4.4 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05 % maximum
2.23.4.5 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.30 % maximum
2.23.4.6 Interfacial Tension, ASTM D971; 40 mN/m minimum
2.23.4.7 Color, ASTM D1500; 0.5 ASTM units maximum
2.23.4.8 Visual Examination, ASTM D1524; “Bright and Clear”
2.23.4.9 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum

2.23.4.10 Water content, ASTM D1533; 25 maximum ppm
2.23.4.11 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum
2.23.4.12 Corrosive Sulfur, ASTM D1275, Method B; result “Not corrosive”
2.23.4.13 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum
2.23.4.14 PCB content; Per all governing laws, etc. and PCB shall not be detectable at 1 PPM, mg/kg

2.23.5 OIL SHIPMENT

2.23.5.1 Transformers shipped without oil, but with air or inert gas blanket.

2.23.5.1.1 For transformers shipped not oil-filled, the necessary insulating oil shall be sent by tank truck.
2.23.5.1.2 Oil supply via barrels is not acceptable; including makeup oil.
2.23.5.1.3 No oil shall be shipped without first receiving approval of the delivery schedule by the Buyer’s.
2.23.5.1.4 Oil that fails to meet the specifications contained herein shall be rejected and it shall be the Seller's responsibility to correct the deficiency.
2.23.5.1.5 Oil that fails to meet the oil refiner’s/Seller’s specifications shall be rejected and it shall be the Seller's responsibility to correct the deficiency.
2.23.5.1.6 Oil filling activities per Buyer standard methods typically take 48 hours.
2.23.5.1.6.1 Demurrage charges for oil shipment activities shall be borne by the Seller for the first 48 hours after the pre-approved and realized delivery date and time.
2.23.5.1.6.2 After that, Buyer will be responsible for demurrage charges at the rate(s) denoted in the Seller’s proposal.
2.23.5.1.7 All oil requirements extend to makeup oil also; including rejection costs being borne by the Seller related to rejections.
2.23.5.1.8 The Seller shall notify the Buyer’s forty-eight hours prior to delivery of the insulating oil insulating oil to provide unloading crew sufficient time to prepare for delivery.
2.23.5.1.9 A certified report of tests made on a sample from the shipping container shall be provided by Seller to Buyer’s.
2.23.5.1.10 The oil will also be tested for PCB content 90 days after being placed in service. Oil that fails to meet the Seller’s oil specifications or is found to contain PCB levels in excess of 1 PPM (mg/kg) shall be rejected and it shall be the Seller’s responsibility to correct the deficiency at its cost.
2.23.5.1.11 The oil, prior to shipment, shall be given the following tests and shall be subject to the associated acceptance parameters; results are to be provided to Buyer prior to shipment for review. These same tests and constraints will be applied to samples taken at the delivery point from the tanker(s) prior to any oil transfer into the transformer:
2.23.5.1.11.1 Dielectric strength, ASTM D1816, 1 mm gap; 20 kV minimum
2.23.5.1.11.2 Dielectric strength, ASTM D1816, 2 mm gap; 35 kV minimum
2.23.5.1.11.3 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05 % maximum
2.23.5.1.11.4 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.30 % maximum
2.23.5.1.11.5 Interfacial Tension, ASTM D971; 40 mN/m minimum
2.23.5.1.11.6 Color, ASTM D1500; 0.5 ASTM units maximum
2.23.5.1.11.7 Visual Examination, ASTM D1524; “Bright and Clear”
2.23.5.1.11.8 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum
2.23.5.1.11.9 Water content, ASTM D1533; 25 maximum ppm
2.23.5.1.11.10 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum
2.23.5.1.11.11 Corrosive Sulfur, D1275, Method B; result “Not corrosive”
2.23.5.1.11.12 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum
2.23.5.2 Transformers with HV <= 69 kV delivered oil-filled or after oil-filled and processed, prior to energization:
2.23.5.2.1 The oil in the main tank shall be given the following tests and subject to the associated acceptance parameter:

2.23.5.2.1.1 Dielectric strength, ASTM D1816, 1 mm gap; 25 kV minimum
2.23.5.2.1.2 Dielectric strength, ASTM D1816, 2 mm gap; 45 kV minimum
2.23.5.2.1.3 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05% maximum
2.23.5.2.1.4 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.40 % maximum
2.23.5.2.1.5 Interfacial Tension, ASTM D971; 38 mN/m minimum
2.23.5.2.1.6 Color, ASTM D1500; 1.0 ASTM units maximum
2.23.5.2.1.7 Visual Examination, ASTM D1524; "Bright and Clear"
2.23.5.2.1.8 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum
2.23.5.2.1.9 Water content, ASTM D1533, 20 ppm maximum
2.23.5.2.1.10 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum
2.23.5.2.1.11 Corrosive Sulfur, D1275, Method B; result "not corrosive"
2.23.5.2.1.12 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum

2.23.5.3 Transformers with HV >=69 kV and <230 kV delivered oil-filled or after oil-filled and processed, prior to energization:

2.23.5.3.1 The oil in the main tank shall be given the following tests and subject to the associated acceptance parameter:

2.23.5.3.1.1 Dielectric strength, ASTM D1816, 1 mm gap; 30 kV minimum
2.23.5.3.1.2 Dielectric strength, ASTM D1816, 2 mm gap; 52 kV minimum
2.23.5.3.1.3 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05% maximum
2.23.5.3.1.4 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.40 % maximum
2.23.5.3.1.5 Interfacial Tension, ASTM D971; 38 mN/m minimum
2.23.5.3.1.6 Color, ASTM D1500; 1.0 ASTM units maximum
2.23.5.3.1.7 Visual Examination, ASTM D1524; "Bright and Clear"
2.23.5.3.1.8 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum
2.23.5.3.1.9 Water content, ASTM D1533, 20 ppm maximum
2.23.5.3.1.10 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum
2.23.5.3.1.11 Corrosive Sulfur, D1275, Method B; result "not corrosive"
2.23.5.3.1.12 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum

2.23.5.4 Transformers with HV >=345 kV delivered oil-filled or after oil-filled and processed, prior to energization:

2.23.5.4.1 The oil shall in the main tank shall be given the following tests and subject to the associated acceptance parameter:

2.23.5.4.1.1 Dielectric strength, ASTM D1816, 1 mm gap; 35 kV minimum
2.23.5.4.1.2 Dielectric strength, ASTM D1816, 2 mm gap; 60 kV minimum
2.23.5.4.1.3 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05% maximum
2.23.5.4.1.4 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.30 % maximum
2.23.5.4.1.5 Interfacial Tension, ASTM D971; 38 mN/m minimum
2.23.5.4.1.6 Color, ASTM D1500; 0.5 ASTM units maximum
2.23.5.4.1.7 Visual Examination, ASTM D1524; "Bright and Clear"
2.23.5.4.1.8 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum
2.23.5.4.1.9 Water content, ASTM D1533, neutral ppm maximum
2.23.5.4.1.10 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum
2.23.5.4.1.11 Corrosive Sulfur, D1275, Method B; result "not corrosive"
2.23.5.4.1.12 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum
2.23.5.4.1.13 Total Dissolved Gas, ASTM D2945; 0.5% maximum. Sample to be collected 24h to 48h after transformer is filled and only applied to transformers with conservator systems.

2.23.5.5 For each of the transformers, two hundred (200) additional gallons of oil beyond those required for the applicable transformer shall be provided for the Buyer's oil processing equipment and activities.

2.24 BUSHING REQUIREMENTS

2.24.1 The HV, XV, YV, H0, and X0 bushings shall be cover mounted and installed in the transformer so as to fully develop the specified electrical requirements. Gasketing of the bushings shall be done in such a way as to prevent oil leaks over the life of the transformers. The construction must be such that the bushings can operate at a continuous ambient temperature of 30°C in alignment with the IEEE bushing standard, without damage,

leaks, or deterioration to the gasket.

2.24.2 The HV and XV bushings shall be condenser type with a Type A capacitance tap. The H0, X0, YV bushings may be condenser type with a Type A capacitance tap.

2.24.3 The bushings' outer rain shed shall be made of porcelain for bushings for 345 kV system.

2.24.4 The high voltage winding bushings shall have ANSI Standard threaded studs.

2.24.5 The Seller shall provide NEMA four-hole terminal lugs which are suitable for either copper or aluminum connections. The lugs shall be of a one piece design or expressly submitted for approval with their own outline drawing.

2.24.5.1 The lug manufacturer and part numbers, dimensions and ampacities shall be noted on the transformer Outline drawing including where appropriate whether they are 3-inch or 4-inch for 4-hole patterns.

2.24.6 HV bushing bottom end shields shall be epoxy coated by the bushing Seller. Bare metal is not acceptable.

2.24.7 The bushings should be draw lead connected when current ratings permit; subject to Buyer discretion during approval cycle.

2.24.8 Bushings shall be manufactured by PCORE Electric.

2.24.9 Approval drawings are required for all bushings.

2.24.10 BUSHING RATINGS

Bushings shall be capable of meeting the specific requirements as follows:

2.24.10.1 345 kV HV PHASE (PCORE # POC1675G800S)

2.24.10.1.1 BIL (kV): 1675
2.24.10.1.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.1.3 Minimum live part to ground, straight line, distance: 115 in.
2.24.10.1.4 Minimum Current Rating (A): 800

2.24.10.2 138 kV HV PHASE (PCORE # POC650G1216RS)

2.24.10.2.1 BIL (kV): 650
2.24.10.2.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.2.3 Minimum live part to ground, straight line, distance: 115 in.
2.24.10.2.4 Minimum Current Rating (A): 1200

2.24.10.3 69 kV HV PHASE (PCORE # TBD)

2.24.10.3.1 BIL (kV): 350
2.24.10.3.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.3.3 Minimum live part to ground, straight line, distance: TBD in.
2.24.10.3.4 Minimum Current Rating (A): TBD

2.24.10.4 46 kV HV PHASE (PCORE # POC650G1216RS)

2.24.10.4.1 BIL (kV): 250
2.24.10.4.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.4.3 Minimum live part to ground, straight line, distance: 115 in.
2.24.10.4.4 Minimum Current Rating (A): TBD

2.24.10.5 H0 (PCORE # B-89593-70)

2.24.10.5.1 BIL (kV): 250
2.24.10.5.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.5.3 Minimum live part to ground, straight line, distance: 22 in.
2.24.10.5.4 Minimum Current Rating (A): 400/1200 (draw lead/bottom connected)

2.24.10.6 XV PHASE (PCORE # B-88943-8-9)

2.24.10.6.1 BIL (kV): 250
2.24.10.6.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.6.3 Minimum live part to ground, straight line, distance: 22 in.
2.24.10.6.4 Minimum Current Rating (A): 4000

2.24.10.7 X0 (PCORE # B-89593-70)

2.24.10.7.1 BIL (kV): 350
2.24.10.7.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.7.3 Minimum live part to ground, straight line, distance: 22 in.
2.24.10.7.4 Minimum Current Rating (A): 400/1200 (draw lead/bottom connected)

2.24.10.8 YV (PCORE # B-89183-70)

2.24.10.8.1 BIL (kV): 110
2.24.10.8.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100
2.24.10.8.3 Minimum live part to ground, straight line, distance: 13 in.
2.24.10.8.4 Minimum Current Rating (A): 600

2.24.11 MINIMUM BUSHING LIVE PART CLEARANCES (METAL TO METAL)

2.24.11.1 Clearances in this section shall include the impacts of appropriate ampacity bushing lug pads with conventional take-off pads.
2.24.11.2 All clearances shall be the greater of those specified herein or those resulting from the Seller's normal design practices.

2.24.11.3 Metallic-metallic live part clearances: ANSI/IEEE except as follows:
2.24.11.3.1 HV-HV, HV-XV, HV-XV, HV-Neutral(s), HV-YV :
2.24.11.3.1.1 345 kV Voltage Class: 95" minimum
2.24.11.3.1.2 138 kV Voltage Class: 50" minimum
2.24.11.3.1.3 69 kV Voltage Class: 50" minimum
2.24.11.3.1.4 46 kV Voltage Class: 22" minimum
2.24.11.3.2 XV-XV, XV-TV, XV-Neutral, XV-YV:
2.24.11.3.2.1 46 kV Voltage Class: 22" minimum
2.24.11.3.2.2 34.5 kV Voltage Class: 20" minimum
2.24.11.3.2.3 25 kV Voltage Class: 14" minimum
2.24.11.3.2.4 15 kV Voltage Class: 11" minimum
2.24.11.3.2.5 8.7 kV Voltage Class: 8" minimum
2.24.11.3.3 TV-TV TV-Neutral (when present): 11" minimum
2.24.11.3.4 The Neutral may or may not be grounded and shall be considered to be connected to a system with nominal system voltage (NSV) equal to the voltage class associated with the Neutral BIL.

2.24.12 MINIMUM BUSHING LIVE PART TO GROUND CLEARANCES (METAL TO METAL)
2.24.12.1 Metallic live part to ground clearances; tank will be grounded:
2.24.12.2 345 kV Voltage Class: TBD" minimum
2.24.12.3 138 kV Voltage Class: 44" minimum

2.24.12.4 69 kV Voltage Class: 44” minimum
2.24.12.5 46 kV Voltage Class: 17” minimum
2.24.12.6 34.5 kV Voltage Class: TBD” minimum
2.24.12.7 25 kV Voltage Class: 14” minimum
2.24.12.8 15 kV Voltage Class and below, but greater than 600V: 11” minimum
2.24.12.9 Where control power or instrument transformers are required, appropriate conductor insulations systems may be provided in lieu of air clearances on 25 kV and 15 kV class applications for leads, subject to Buyer review/approval.
2.24.12.10 600V and lower: Per NESC and NEC.

2.24.13 MINIMUM “STRING DISTANCE” FROM GROUND LEVEL TO ENERGIZED PARTS

2.24.13.1 Allowed use only per NESC, otherwise NESC vertical and horizontal independent clearances apply.
2.24.13.2 Nominal System Voltage, 345 kV: 20’-8”
2.24.13.3 Nominal System Voltage, 138 kV: 12’-6”
2.24.13.4 Nominal System Voltage, 46 kV: 10’-4”
2.24.13.5 Nominal System Voltage, 34.5 kV: 10’-4”
2.24.13.6 Nominal System Voltage, 25 kV: 9’-10”
2.24.13.7 Nominal System Voltage, 15 kV: 9’-4”
2.24.13.8 Nominal System Voltage, 8.7 kV - 601 V: 9’-0”

2.24.1 LIVE PART CLEARANCES TO BASE/GRADE

2.24.1.1 Vertical Clearances from Live Parts to base/grade; NESC/ANSI/IEEE
2.24.1.1.1 345 kV Voltage Class: 12’-6” minimum
2.24.1.1.2 138 kV Voltage Class: 12’-6” minimum
2.24.1.1.3 69 kV Voltage Class: 12’-6” minimum
2.24.1.1.4 46 kV Voltage Class: 10’-4” minimum
2.24.1.1.5 34.5 kV Voltage Class: TBD minimum
2.24.1.1.6 25 kV Voltage Class: 9’-10” minimum
2.24.1.1.7 15 kV Voltage Class: 9’-4” minimum
2.24.1.1.8 8.7 kV Voltage Class, but greater than 600 V: 9’-0” minimum
2.24.1.2 Clearance requirements also apply to auxiliary and control potential transformers when supplied.

2.24.2 MINIMUM APPROACH DISTANCE

2.24.2.1 To support certain activities while the transformer is energized, the following minimum approach distances shall be considered when locating instrumentation, controls, fittings, valves, and similar items below top of tank cover:
2.24.2.1.1 345 kV Nominal Sysem Voltage (NSV), (phase-to-phase, nominal system voltage) class live parts: 18’2”
2.24.2.1.2 345 kV NSV (phase-to-ground, nominal system voltage) class live parts: 11’3”
2.24.2.1.3 138 kV NSV (phase-to-phase, nominal system voltage) class live parts: 5’5”
2.24.2.1.4 138 kV NSV (phase-to-ground, nominal system voltage) class live parts: 4’4”
2.24.2.1.5 69 kV NSV (phase-to-phase, nominal system voltage) class live parts: 4’
2.24.2.1.6 69 kV NSV(phase-to-ground, nominal system voltage) class live parts: 3’4”
2.24.2.1.7 46 kV NSV (phase-to-phase, nominal system voltage) class live parts: 3’3”
2.24.2.1.8 46 kV NSV (phase-to-ground, nominal system voltage) class live parts: 3’0”
2.24.2.1.9 0.75 to 36 kV NSV(phase-to-phase, nominal system voltage) class live parts: 3’0”
2.24.2.1.10 0.75 to 36 kV NSV(phase-to-ground, nominal system voltage) class live parts: 3’0”
2.24.2.1.11 0.301 to 0.750 kV NSV(phase-to-phase, nominal system voltage) class live parts: 1’1”
2.24.2.1.12 0.301 to 0.750 kV NSV (phase-to-ground, nominal system voltage) class live parts: 1’1”

2.24.3 LIGHTNING ARRESTERS

2.24.3.1 HV ARRESTERS BRACKETS

Provide lightning arrester brackets mounted on the tank for HV winding protection, including a bracket for H0. No lightning arresters shall be provided.

2.24.3.1.1 Bolt Circle: 10”
2.24.3.1.2 Bolt Holes: 3-9/16”
2.24.3.1.3 Bolt angular spacing = 120°.
2.24.3.1.4 Minimum arrester live line to bushing live part clearance = 30”.
2.24.3.1.5 Minimum arrester spacing center-to-center = 70”.

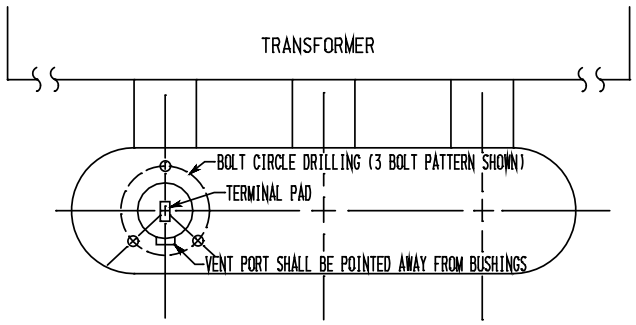
2.24.3.2 XV ARRESTERS BRACKETS

Provide lightning arrester brackets mounted on the tank for XV winding protection, including a bracket for X0. No lightning arresters shall be provided.

2.24.3.2.1 Bolt Circle: Both 8-3/4” and 10” bolt circles to be drilled.
2.24.3.2.2 Bolt Holes: 3-9/16”
2.24.3.2.3 Bolt angular spacing = 120°.
2.24.3.2.4 Minimum arrester live line to bushing live part clearance = 17”.
2.24.3.2.5 Minimum arrester spacing center-to-center = 32”.

2.24.3.3 YV ARRESTER BRACKET

2.24.3.3.1 The requirements, if any, for a tertiary arrester bracket shall be determined prior to design review completion at Buyer’s sole discretion.



LIGHTNING ARRESTER BRACKET LAYOUT

2.24.3.4 ARRESTER GROUND PADS

2.24.3.4.1 In addition to arrester brackets, the Seller shall provide a lightning arrester ground pad mounted near the top of the tank for each set of three arresters. If separation of arresters is such that individual ground pads for grounding each phase arrester represent better design, then individual pads shall be supplied.
2.24.3.4.2 Lightning strike counters are to be installed near arrester ground pads.

2.25 ACCESSORIES AND AUXILIARY EQUIPMENT

2.25.1 AUXILIARY COOLING

2.25.1.1 Fan and pump motors shall be NEMA classed, single phase, 230V, suitable for operation at plus/minus 10% of rated voltage, and shall have sealed, permanently lubricated maintenance free bearings.
2.25.1.2 Fans shall be horizontally mounted.
2.25.1.3 All motors shall be individually protected by an overload reset device.
2.25.1.4 If motors are located in an area where the temperature exceeds the ambient (e.g., in the air discharged from the coolers), the allowable temperature rise should be adjusted accordingly.
2.25.1.5 Under-voltage relays and alarm contacts for the AC supply to the cooling stages, and for the AC supply to the cooling stage controls, shall be provided. These, in turn, will provide a common loss of cooling equipment alarm for an external circuit to the annunciator.

2.25.1.6 Facilities for testing each stage of force cooling shall be provided.
2.25.1.7 A selector switch shall be provided so that the cooling banks can be alternated between Stage 1 and Stage 2 cooling to equalize the running time on the fans and pumps. Runtime hour counters shall be provided for each cooling stage.
2.25.1.8 A method for manually forcing the fans on shall be provided.
2.25.1.9 Motor maintenance intervals shall not be less than 10 years.
2.25.1.10 All motor contactors shall have suitable ampacity ratings with a minimum of 20A.
2.25.1.11 The number of fans shall be increased to provide at least a 15% CFM margin above and beyond the CFM that the Seller's normal design and as-built practices would have required. The Seller's calculations documenting its normal cooling design and the additional cooling margins shall be a design review item. The fans required to accomplish the additional CFM shall be provide, connected, and tested by the seller. These fans shall also be in service during the temperature rise testing of the highest cooling mode.
2.25.1.12 The source for the ancillary equipment will be provided by the Buyer.
2.25.1.13 Molded case circuit breakers shall be used (not fuses).
2.25.1.14 Overloads shall be adjustable, solid state, manual reset, not bimetallic

2.25.2 Cooling fan model shall be one of the following unless approved by Buyer in advance of transformer manufacturing; these are common models used in Buyer's exisiting transformer fleet. Alternate Krenz and Company or California Turbo models may be allowed subject to Seller discretion for meeting sound requirements.
2.25.2.1 Krenz and Company model F24-A8180 with ACC-A8984 kit
2.25.2.1.1 Transformer cooling fan: 24" blade diameter, 1/2 HP; 230 Volt, 1 Phase, 6790 Minimum CFM rating, with automatic overload protection, weatherproof guard, mounting brackets (#MTB19HD08) and 8 foot cord (# WTF08A16).
2.25.2.2 Krenz and Company model F16-A7839 with ACC-A8984 kit
2.25.2.2.1 Transformer cooling fan: 20.5" Maximum outside fan diameter, 1/4 HP; 230 Volt, 1 Phase; 4,500 Minimum CFM rating; with automatic overload protection, weatherproof guard, mounting brackets (#MTB19HD08) and 8 foot cord (# WTF08A16).
2.25.2.3 California Turbo model CFM16E230B
2.25.2.3.1 Transformer cooling fan: 20.5" Maximum outside fan diameter, 1/4 HP; 230 Volt, 1 Phase; 4,500 Minimum CFM rating; with automatic overload protection, weatherproof guard, mounting brackets, and 8 foot cord.
2.25.2.4 California Turbo model CFM18E230B
2.25.2.4.1 Transformer cooling fan: 20.5" Maximum outside fan diameter, 1/4 HP; 230 Volt, 1 Phase; 4,500 Minimum CFM rating; with automatic overload protection, weatherproof guard, mounting brackets, and 8 foot cord.

2.25.3 Cooling fans may be mounted for horizontal flow or upward flow. Downward flow is not acceptable.
2.25.3.1 The motor housing/case for fans mounted for upward flow shall be no less than 24" in the vertical dimension relative to the transformer base.

2.25.4 AUXILIARY DEVICES

The following auxiliary devices shall be provided with each of the transformers. Unless expressly excluded, all items required/noted in this specification shall also be installed/assembled by the Seller including incidental materials:

2.25.4.1 Liquid level gauge with alarm contacts. Gauge shall be calibrated at the Seller's factory.
2.25.4.2 Dial-type liquid temperature indicator (accuracy ±2°C) equipped with alarm contacts, maximum indicating hand, and manual reset button mounted approximately 60 inches above the base. Gauge shall be calibrated at the Seller's factory.
2.25.4.3 Dial-type hottest winding spot temperature indicator (accuracy ±2°C) for the winding equipped with alarm contacts, maximum indicating hand, and manual reset button mounted approximately 60 inches above the base.
2.25.4.3.1 Gauge and associated simulation circuit shall be calibrated at the Seller's factory.
2.25.4.4 An electronic temperature monitoring (ETM) device with all necessary components is required.
2.25.4.4.1 See ELECTRONIC TEMPERATURE MONITOR Appendix Item for further requirements.
2.25.4.5 The fans shall be controlled by the ETM device. Other instrument inputs may also drive the fan

control logic per Buyer feedback during the approval drawing cycle.

2.25.4.6 Gas accumulation indicator, with a sampling valve mounted approximately 60 inches above the base, and alarm contacts.

2.25.4.7 Messko pressure relief device, self-resetting seal, with semaphore-type indicator and alarm contacts; Model 685-XX-22-N07-01 (pressure per Seller, terminal box w/2 switches, nitrile gasket, light grey oil-directed cover, with bleed screw, with semaphore).

2.25.4.7.1 Oil pressure relief pipe from oil-directing cover to be routed, subject to approval cycle review, per supplier's typical approach.

2.25.4.7.2 Oil pressure relief pipe to have output end protected from insect and animal access with appropriate screening. Screening and pipe length shall be such that functionality of sudden pressure relief system is not compromised.

2.25.4.8 Three rapid pressure rise relays, Qualitrol 900 Series, with test facilities (including a shutoff valve and test pressure connections) located approximately 60 inches above the transformer base or as close to this as possible.

2.25.4.9 One Qualitrol 930-010-01 CS-35551 seal-in relay with seal-in control circuitry shall be supplied which provides for a continuous alarm once triggered (until manually reset) and with a normally closed bypass contact for transient voltages to safeguard against false tripping. The seal-in relay panel shall be shock mounted in an area of the main control cabinet so that it is not susceptible to jarring or movement.

2.25.4.9.1 Any one of the rapid pressure rise relays may independently drive the alarm. However, separate "2 or 3 required to trip" logic shall also be provided.

2.25.4.10 Seekirk Model A1020 10-point annunciator for alarms, mounted in the main control cabinet or in a separate cabinet on tank sidewall. The annunciator shall indicate which alarmed device functioned. The Seller shall supply one common alarm contact for a circuit to the Buyer's control house. Refer to TRANSFORMER ALARM DIAGRAM section of Appendix for scheme.

2.25.4.11 States Type NT sliding link terminal blocks shall be provided for all Buyer interface connections (e.g., any conductor that will leave or enter the control enclosure shall have a States Type NT sliding link terminal block to land on). Certain Weschler models may require additional States Type NT sliding link terminal blocks and visible isolation devices.

2.25.4.12 All coils shall be suitable for 125 VDC and suitable for operation without damage during battery charging procedures at 140 VDC.

2.25.4.13 Minor instrument and control material additions or revisions (e.g., <$25,000 in direct material cost changes) required by the Buyer at approval drawing review time shall not result in additional costs to the Buyer.

2.25.4.14 Schematic changes are customary and anticipated as part of the approval drawing process and shall not result in additional costs to the Buyer.

2.25.4.15 For transformers with conservator tank designs:

2.25.4.15.1 Provide a Messko MSafe Buchholz relay with the following features: RAL 7038 (ANSI 70 light grey), Normally Open S1 and S2 contacts (preferably form C), for mineral oil, with: appropriate US flange, triggering pressure flap, cable "gland", US model and optional inspection glass cover, reset for function test, oil drain screw, and connection for pneumatic test. Model may be adjusted per Buyer discretion due to transformer capacity or size related issues. Seller shall raise related issues for discussion with Buyer.

2.25.4.15.2 Reinhausen MTrab Maintenance-free Dehydrating Breather: of suitable type, 230 VAC/DC, ANSI 70 grey, American/English dimensional cable glands, 4-20 mA output, US appropriate flange, with test button, filter heating, insect protection, protection grid, lateral fixing, and US market appropriate. Model may be adjusted per Buyer discretion due to transformer capacity or size related issues. Seller shall raise related issues for discussion with Buyer.

2.25.4.16 Complete Fiber Optic System

2.25.4.16.1 Refer to FIBER OPTIC TEMPERATURE MEASUREMENT SYSTEM

2.25.4.17 Complete Morgan Schaffer Online Dissolved Gas Analysis System

2.25.4.17.1 Refer to ON-LINE DISSOLVED GAS ANALYSIS (DGA) SYSTEM

2.26 WIRING AND CONDUIT

2.26.1 Externally mounted conduit provided with each transformer shall be metallic, rigid type (not EMT) to

effectively shield the wiring from existing fields. Wiring external to the tank shall be in rigid-type steel or aluminum conduit, except that fans and pumps shall be equipped with short weatherproof leads utilizing plug-in type weatherproof connectors. All weatherproof lead cable grips shall be pointed down to prevent capture of rain water.

2.26.2 Conduit drains shall be installed on vertical installed conduits.

2.26.3 Splices in the control wiring are unacceptable.

2.26.4 Splices (more than one) in the leads to the current transformers are unacceptable.

2.26.5 The bushing CT secondary connections shall be wired according to the CURRENT TRANSFORMER DIAGRAM section in the Appendix.

2.26.6 All current transformer, relay, alarm and control wiring shall be brought to States Co, Type NT, sliding link terminal blocks mounted in suitable weatherproof terminal boxes with slipcover or hinged door, conveniently located for customer's connections. If terminal blocks are mounted horizontally, they shall be mounted so that the links shall not fall closed when in the open position.

2.26.7 A terminal box, separate from the main control cabinet, shall be provided for the current transformer wiring. The BCT wiring may be brought into the main control cabinet as long as all the terminal blocks are located in on area and are used solely for BCT (relay) wiring and have a separate cover or barrier over the blocks.

2.26.8 Current transformer terminals shall be provided with individual red marker tags. All other terminals shall be provided with individual white marker tags. Refer to the DETAIL WIRING DRAWING EXAMPLES section of the Appendix for further required details.

2.26.9 Terminal lugs for terminating the control wiring shall be used and shall be Burndy Type YAV, un-insulated ring type with a seamless barrel.

2.26.10 CT ratios in Amperes shall be shown at the terminal block, or on the transformer nameplate.

2.26.11 CT shorting jumpers shall be installed on terminal blocks after (above/not below) termination of CT secondary leads for easy removal by commissioning technician. Stud nut shall be installed between CT and shorting jumper terminals.

2.26.12 Terminal box and device penetration for conduit/cable shall be thru the side or bottom only.

2.26.13 All wiring shall be pulled through conduit and terminated before the Factory Acceptance Test. Tying wiring to the outside of the conduit temporarily is not acceptable, since this may lead to wiring label damage and wiring length shortage in the field. For shipment, wiring can be pulled from terminals and terminal boxes, but shall remain in conduits.

2.26.14 All terminal boxes shall be rated NEMA 3R and shall have drains installed.

2.27 FIBER OPTIC TEMPERATURE MEASUREMENT SYSTEM

2.27.1 Where a Complete Fiber Optic System is required, the system shall be used to verify conformance of the temperature rise test results to the Standard requirements and these specifications and consist of the following:

- 2.27.1.1 A new “Fiber Optic System” shall be provided and installed.
- 2.27.1.2 The Supplier shall provide conduit and mounting hardware as required to complete the installation.
- 2.27.1.3 The Supplier shall install all required components and insure a minimum of one working temperature probe at each location as listed below.
- 2.27.1.4 A total of 16 internal temperature probes (Qualitrol CAB-699) shall be installed and connected to the “Transformer Tank Feedthrough Plate(s)”.
  - 2.27.1.4.1 HV windings – two temperature probes per phase.
  - 2.27.1.4.2 LV windings – two temperature probes per phase.
  - 2.27.1.4.3 Core - two temperature probes at one location.
  - 2.27.1.4.4 Top oil – one temperature probe.

2.27.1.4.5 Bottom oil duct – one temperature probe.

2.27.1.5 Provide two Qualitrol PLT-201 weld-on tank wall "feedthrough" plates with eight (8) feedthrough holes each or 1 if available with appropriate total hole count

2.27.1.6 Provide 16, Qualitrol CON-159-1, optical feedthrough connectors.

2.27.1.7 Provide two Qualitrol COV-121-1 junction boxes for the wall plates.

2.27.1.8 Installation of all components shall adhere to all of the manufacturer's specifications.

2.27.1.9 The location of the temperature probes and other components shall be a design review item requiring CEC agreement.

2.27.1.10 The Supplier shall provide drawings showing temperature probe locations and identification.

2.27.1.11 The Supplier shall install the instrumentation and control signals materials per a specification addendum or comments during the approval drawing cycle.

2.27.1.12 The Supplier shall provide and install conduit from the transformer top mounted feed though plate junction boxes to a ground level control cabinet.

2.27.1.13 Provide a Qualitrol Model 408-16-SP1-M4 fiber optic signal conditioner, with the following features:

2.27.1.13.1 16 channels

2.27.1.13.2 Enhanced Serial Communication Protocols; Modbus, DNP 3.0 and IEC60870-S-101

2.27.1.13.3 4 GigaBytes Memory

2.27.1.13.4 RS-485 to USB Bridge Option; Neoptix part number NXP-325.

2.27.1.14 The Supplier shall install the signal conditioner and supporting power supply, outside extension cables, etc. inside the main control enclosure.

2.27.1.15 Installation of the fibers and fiber optic system components shall be per the Original Equipment Manufacturer's (OEM's) recommended methods, practices, guidelines, etc. reflecting high quality workmanship. For example, fiber routing and securing shall be functional, appropriate and aesthetically neat with excess fiber minimized, minimum bending radius requirements met, and overall installation strategically completed to yield functional fiber probes. If Supplier does not have ability to cut and re-terminate probe fibers then Supplier shall strive to reduce excess fiber looping to reasonable levels through appropriate fiber length ordering. Excessive fiber probe lengths and/or those yielding marginal or nearly marginal signal levels shall be reduced in accordance with fiber system OEM requirements at the Supplier's cost.

2.27.1.16 Appropriate stenciling, labeling or otherwise suitable long term identification means shall be effected on the internal side of the tank feed through plates for each probe/penetration termination to aid in rapid identification of the probe. Probes also to be appropriately labeled.

2.27.1.17 Digital images documenting in full all probe placement and probe routing and securement shall be taken/provided to CEC prior to tanking and again prior to transformer shipment. These images to be of high quality and resolution and to be included with the test report.

2.27.1.18 Periodic measurement from the fiber system to be logged during the temperature rise testing and provided for CEC review prior to shipment and as part of the final test report. The frequency and number of measurements to be defined elsewhere in the specifications or at CEC discretion agreed upon with the Supplier prior to the temperature rise testing. Seller shall not proceed with temperature rise testing prior to discussion of the fiber optic data measurement requirements.

2.27.1.19 Supplier shall strive to yield an installation with all fiber probes functional and producing useable data. In the event there are fiber probes that are damaged or otherwise fail to yield consistent plausible data, Supplier shall refund to CEC 1/16 of the adder cost for the full system for each probe agreed, between CEC and Supplier, to be damaged or otherwise not yielding reasonable data at the time of delivery and through the period of the transformer warranty.

2.28 ON-LINE DISSOLVED GAS ANALYSIS (DGA) SYSTEM

2.28.1 SINGLE GAS ON-LINE DGA SYSTEM

2.28.1.1 Provide one Calisto 2 system including standard package items: 1 x USB cable, 1 x CD Calisto Access interface software, 1 x Installation & Operation Manual, 1 x Quick connect oil sampling tube, 1 x Factory test certificate, 4 x Stainless steel shock mount assembly, 2 x Copper tubing – 3/8" OD x 7.6 m (25 ft), 1 x Thermal cut-off fuse, 2 x Brass elbow – 1/2 " NPT (M) – 3/8" Tube, 4 x brass sleeve -3/8" OD, 1 x "Extra" strong shipping box.

2.28.1.2 Provide precision oil temperature probe (4-20 mA)

2.28.1.3 Provide stainless steel braided flex lines

2.28.1.4 Provide Calisto MultiTrack Software

2.28.1.5 Provide Quick-connect dust plug

2.28.1.6 Provide and install all equipment including any required supplemental incidental materials.
2.28.1.7 Seller to program Calisto 2 device for the application and provide any configuration files as part of final documentation.

3.0 REQUIRED FACTORY TESTING AND REPORTING

3.1 GENERAL

3.1.1 All transformers shall be tested as Class II transformers.
3.1.2 See Appendix Item, “TESTING REQUIREMENTS AND REPORT CHECKLIST ATTACHMENT” for required testing and Certified Test Report content.
3.1.3 Further testing requirements are defined herein this document (e.g., testing unique to two winding transformers and testing unique to autotransformers).
3.1.4 The Seller shall provide the maximum A-weighted sound power level (dBA), the 1/3-octave band sound power levels (dB), and the method by which the sound power levels were determined. Sound level shall be measured during each temperature rise (heat run) test and at no load.

3.2 ADDITIONAL REQUIREMENTS FOR STEP-UP TRANSFORMERS

3.2.1 Positive sequence excitation curves and a V/Hz-time curve for each transformer. The continuous V/Hz-time curve shall have sufficient detail to show the permissible over-excitation capability of the transformers over the range of 10 cycles to at least 24 hours, including the specific points of 10 cycles, 1/2 second, 10 minutes, 1 hour and 24 hours. Curves for both full load and no load shall be provided. Design stage versions of these curves are also to be provided by the Seller to the Buyer prior to the design review. The design short circuit withstand strengths, in rms sym. Amperes, of the all windings.

4.0 DOCUMENTS TO BE PROVIDED TO BUYER

4.1 LIST OF NON-EQUIPMENT DELIVERABLES

4.1.1 Design review meeting minutes
4.1.2 Data sufficient for a complete review of the proposed design; including all detailed design data needed for the Anderson Programs
4.1.3 Drawings submitted for Approval
4.1.4 Approved drawings and preliminary instruction book submitted for Construction
4.1.5 NDE report of tank and piping welds
4.1.6 Tank and piping preparation for painting record
4.1.7 Tank and piping primer paint thickness record
4.1.8 Tank and piping final paint thickness record
4.1.9 Sub-supplier test records for bushings, CT's, pump and auxiliary devices
4.1.10 Protective device calibration records
4.1.11 CT curves with manufacturer's model # and serial #'s
4.1.12 Factory Acceptance Test Sequence and Schedule
4.1.13 Factory Acceptance Test notes and draft datasheets (immediately after test)
4.1.14 Certified Factory Acceptance Test final report
4.1.15 Site installation procedure
4.1.16 Final Operating Instruction Manual - including all sub-supplier instruction manuals
4.1.17 Record of fiber optic serial numbers match-up to penetration number
4.1.18 All NCR's
4.1.19 Spare parts list
4.1.20 Detail schedule (including hold point, document submittal, testing, manufacturing activities, and witness points)
4.1.21 Transformer internal connection drawings
4.1.22 Certified Oil Test Report, provided to Buyer before oil shipment.
4.1.23 Material Certificate for radiator and fan assembly galvanizing thickness.

5.0 PRE-OFFLOAD RECEIPT ACTIVITIES

5.1 GENERAL

5.1.1 For each transformer, the following tests and activities shall be successfully completed by the Seller as determined solely by the Buyer, at the Delivery Point, before offloading from the delivery vehicle:

5.1.1.1 Core to ground insulation meggar test performed at 1000 Volts.

5.1.1.1.1 Core ground resistance shall be greater than 200 megaohms when corrected to 20°C.

5.1.1.2 Dew point measurements.

5.1.1.3 Insulation moisture.

5.1.1.3.1 Seller must provide temperature vs. moisture curve prior to acceptance testing.

5.1.1.3.2 Maximum 0.5% moisture content is acceptable at ambient temperatures greater than or equal to 20°C at the time of transformer internal gas temperature measurement. If the ambient is less than 20°C at the time of transformer internal gas temperature measurement, the Seller will remediate per the Buyer's discretion at the Seller's cost.

5.1.1.4 Impact recorder evaluation.

5.1.1.4.1 Seller must provide a chart stating the acceptable frequency and magnitude of impacts the transformers can withstand prior to shipment.

5.1.1.5 Visual Inspection.

5.1.1.6 Seller's standard SFRA testing.

5.1.1.6.1 SFRA tests shall be performed to replicate the SFRA tests that were done at factory prior to shipping.

5.1.2 TO BE CONFORMED

6.0 POST DELIVERY JOBSITE ACTIVITIES

6.1 FINAL ASSEMBLY AND OIL-FILLING

6.1.1 Assembly and oil filling shall be successfully completed by the Seller as determined solely by the Buyer, at the transformer foundation.

6.1.2 Regardless of ambient temperature/seasonal issues, oil filling shall be completed as agreed to at the time of purchase contract award/Buyer expressly accepted bid item. If hot oil filling and/or additional processing is required to meet Buyer's specification requirements, it is the Seller's responsibility to provide these services and all of the associated costs (e.g., labor and materials) shall be borne/absorbed by the Seller at no additional cost to the Buyer.

6.1.3

6.1.3.1 Assembly and oil filling per the Seller's instruction manual(s) will include, but not be limited to the following items:

6.1.3.1.1 Installation of the radiators

6.1.3.1.2 Installation of the conservator tank

6.1.3.1.3 Installation of the jobsite tested HV, LV, and TV bushings

6.1.3.1.4 Installation of all remaining accessories and gauges

6.1.3.1.5 Internal inspection performed by Buyer's personnel

6.1.3.1.6 Make internal connections as applicable

6.1.3.1.7 Pressure test with Dry Nitrogen at rated pressure (cylinder dew point of the gas – 62°C or lower, certified for each cylinder)

6.1.3.1.8 Hold at rated pressure for 24 hours for internal stabilization, take Dew Point reading and record

6.1.3.1.9 Maximum 0.5% moisture content is acceptable at ambient temperatures greater than or equal to 20°C at the time of transformer internal gas temperature measurement. If the ambient is less than 20°C at the time of transformer internal gas temperature measurement, the Seller will remediate per the Buyer's discretion at the Seller's cost.

6.1.3.1.10 Dry process under vacuum, if results are higher than 0.5%, transformer shall be dried with vacuum processing according to the Seller's instruction manual at Seller's cost.

6.1.3.1.11 Oil filling process under vacuum

6.1.3.1.12 8-hour vacuum decay test.

6.2 OIL TESTING

6.2.1 Transformers with HV >=345 kV delivered oil-filled or after oil-filled and processed, prior to energization. The oil in the main tank shall be given the following tests and subject to the associated acceptance parameter below or (if more stringent) to the Seller's required parameters:

6.2.1.1 Dielectric strength, ASTM D1816, 1 mm gap; 35 kV minimum
6.2.1.2 Dielectric strength, ASTM D1816, 2 mm gap; 60 kV minimum
6.2.1.3 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05% maximum
6.2.1.4 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.30 % maximum
6.2.1.5 Interfacial Tension, ASTM D971; 38 mN/m minimum
6.2.1.6 Color, ASTM D1500; 0.5 ASTM units maximum
6.2.1.7 Visual Examination, ASTM D1524; "Bright and Clear"
6.2.1.8 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum
6.2.1.9 Water content, ASTM D1533, 10 ppm maximum
6.2.1.10 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum
6.2.1.11 Corrosive Sulfur, D1275, Method B; result "not corrosive"
6.2.1.12 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum
6.2.1.13 Total Dissolved Gas, ASTM D2945; 0.5% maximum. Sample to be collected 24h to 48h after transformer is filled and only applied to transformers with conservator systems.

6.3 EQUIPMENT TESTING

6.3.1 For each transformer, the following tests shall also be successfully completed as determined solely by the Buyer, at the transformer foundation after assembly, and oil filling and before Buyer's final acceptance. The anticipated in-service tap to be determined by the Buyer.

6.3.2 Doble equipment testing.

6.3.2.1 Winding power factor at the anticipated in-service DETC tap.
6.3.2.2 Bushing power factor at the anticipated in-service DETC tap.
6.3.2.3 Excitation current test is to be performed at all DETC positions.
6.3.2.4 Hot collar testing of tertiary bushing.
6.3.2.5 Leakage reactance test.
6.3.2.5.1 Three-phase equivalent at 345.00 kV HV, 138.00 kV HV DETC tap, or TBD, or
6.3.2.5.2 Per phase at highest and anticipated in-service tap.
6.3.2.6 SFRA test shall be performed to replicate the fully-assembled oil-filled SFRA tests that were done at factory prior to shipping per the Buyer approved test plan.

6.3.3 Transformer turns ratio.

6.3.3.1 All DETC position.

6.3.4 DC winding resistance test.

6.3.4.1 Performed at the anticipated in-service DETC tap.
6.3.4.2 DC winding resistance all windings including phase to phase for delta connected windings and phase to neutral for wye connected windings.
6.3.4.3 The measurements shall be made with the bushings installed.
6.3.4.4 Winding resistance shall have no more than a +/-2% variation between phases when corrected to 20°C.
6.3.4.5 The variation calculations in terms of percent difference shall be included in the test report comparing all phase differential combinations.

6.3.5 Core to ground insulation Megger test performed at 1000 Volts.

6.3.5.1 Core ground resistance shall be greater than 200 megaohms when corrected to 20°C.

7.0 APPENDIX

7.1 RATINGS REQUIREMENTS

7.1.1 Electronic file: “SP-001 Ratings Requirements 081419.xlsx”

7.2 DRAWING TRANSMITTAL DOCUMENTATION

7.2.1 Transmittal Worksheet, “Equipment Document Transmittal Template sheet 091218.xlsx”

7.2.2 Template provided to guide Seller in providing required information. Some formatting changes are acceptable with this newly developed tool provided the required information is provided. Data may eventually be programmatically extracted from the worksheet so standardization is desired. If additional common information is desirable, please add that data for review.

7.3 CURRENT TRANSFORMER DIAGRAM

7.3.1 Electronic file: “CTARRTRF011 022315 1700.pdf”.

7.4 TRANSFORMER ALARM DIAGRAM

7.4.1 Electronic file: “MD-E6411 Sh. 31 Rev. J - Transformer Bank Alarms without Annunciator.pdf”

7.5 FALL PROTECTION DOCUMENTS

7.5.1 Specification for Installment and Application of Consumers Energy Fall Restraint Devices, Electronic file: “BASE-WELD-2_Dated 06162011.pdf”

7.5.2 Fabrication of Structural Steel for Electric Substations, Electronic file: “SS1925_01012000 Structural Steel for ES.pdf”

7.6 DETAIL WIRING DRAWING EXAMPLES

7.6.1 Electronic file: “DETAIL WIRING SAMPLE 1.pdf”

7.6.2 Electronic file: “DETAIL WIRING SAMPLE 2.pdf”

7.7 ELECTRONIC TEMPERATURE MONITOR

7.7.1 Electronic file: “TRF-SEL2414 ETM Specification 06242019.pdf”

7.7.2 Electronic file: “TBM1B3P2W Rev 0.00 SEL-2414 Functional Description.pdf”

7.7.3 Electronic file: “TBM1B3P2W Rev 0.00 SEL-2414 Settings Guide for DSCADA.pdf”

7.8 TESTING REQUIREMENTS AND REPORT CHECKLIST ATTACHMENT

7.8.1 Electronic file: “Testing Requirements and Test Report Checklist 011519.xlsx”

7.9 PIPING & VALVE DIAGRAM NAMEPLATE

7.9.1 Electronic file: “PIPING & VALVE DIAGRAM NAMEPLATE.pdf”

Solar Technical Specification

SP-001

Exhibit D1 – 35 kV Cable Specification

9/30/2019

1.0 General

This specification covers the use of cross-linked polyethylene insulated, 35 kV rated, single conductor concentric neutral-type jacketed cable for use in solar PV applications. All cable shall conform to the latest edition of AEIC - CS8 and the standards listed under section 1.1.1. All 34.5 kV Solar AC collector systems shall utilize cable that meets the minimum requirements defined by this specification.

1.1.1 Reference Standards

1.1.1.1 ASTM B 3, B 230, B 231, B 400, B609 (current editions)

1.1.1.2 ICEA S-94-649 (current edition)

1.1.1.3 ICEA T-31-610

1.1.1.4 NEMA WC 26-2008/EEMAC 201-2008

1.1.1.5 ANSI C119.4

1.1.2 Material Requirements

1.1.2.1 Conductor temper shall be within 1350-H16 to 1350-H19 aluminum in accordance with ASTM Specification B 230 and Class B stranded, concentric lay, in accordance with ASTM B 231. Conductor stranding shall be as shown in Table 1.

1.1.2.2 Compressed conductor diameters shall not vary more than +1% to -2% of the compressed conductor diameters, as specified in ASTM B 231, are required.

1.1.2.3 Compact round conductor diameters shall be in accordance with ASTM B 400, Table I.

1.1.2.4 Conductor strands shall be filled with a material compatible with the conductor and the conductor shield. Strand filling compound shall not adversely impact the use of connectors or lugs when tested in accordance with ICEA-T-32-645/T-31-610.

1.1.2.5 No joints shall be made in the individual strands of the conductor prior to or during final drawing unless the joint is made with a cold-pressure or electric-butt, cold upset weld. The tensile strength of the joint shall be as specified in ASTM B 230.

1.1.2.6 The conductor shield shall be an extruded semi-conducting thermoset layer. Approved compounds are HFDA 0580, HFDA 0581, HFDA 0800, HFDA 0802, LS 0500, LS 571A, LS 572A, LS 572B, XFB 5502A, XFB 5502B, Borealis LE 0500,Borealis LE 0504, Borealis LE 0594 and Borealis LE 0595.

1.1.2.7 Following extrusion, the shield shall be protected, to the greatest extent practicable, from atmospheric contaminants and other extraneous substances.

1.1.2.8 The insulation shall consist of a single layer of extruded tree retardant cross-linked polyethylene. Approved compounds are HFDC-4202 EC and Borealis LE 4212.

1.1.2.9 The insulation shall be cured using radiant (dry) heat. Steam (wet) heat may be used only with written approval of the Owner.

1.1.2.10 The finished insulation shall not contain:

1.1.2.10.1 Voids larger than 3 mils. The maximum density of voids larger than 2 mills shall not exceed 30 per cubic inch of insulation.

1.1.2.10.2 Foreign materials or contaminants larger than 5 mils in largest dimension. The maximum density of foreign materials or contaminants of sizes between 2 and 5 mils shall not exceed 15 per cubic inch of insulation.

1.1.2.10.3 Ambers larger than 10 mils in largest dimension.

1.1.2.10.4 Protrusions from or irregularities in either the conductor shield or insulation shield larger than 5 mils. The method of examination, frequency of sampling and reporting shall be in accordance with ICEA S-94-649.

1.1.2.11 The insulation shield shall consist of a single layer of a black extruded semiconducting themoset layer applied immediately after extrusion of the insulation and prior to insulation curing. Insulation shield shall meet the requirements of ICEA S-94-649, Part 5 except as noted below. Approved compounds are HFDA-0693 LS, LS-567 Borealis LE 310-44 and LE 0520.

1.1.2.12 Resistivity of this shield shall not exceed 500 ohm-meters after curing, measured at or corrected to 90° C.

1.1.2.13 The shield shall strip from the insulation at tensions between 3 (minimum) and 24(maximum) pounds when tested in accordance with Section 5.4.1.1 of ICEA S-94-649 and Section 10.3 of the latest edition of AEIC Specification CS8.

1.1.2.14ing removal of the insulation shield, the insulation shall be free of damage and essentially free of residual shield material. All residual conductive material must be completely removable with reasonable application of cable cleaner.

1.1.2.15 The specified concentric neutral conductors shown in Table 1 shall be annealed solid bare copper wires in accordance with ASTM B 3.

1.1.2.16 A linear low density polyethylene jacket material shall be extruded over and fill the void spaces between the concentric neutral wires. The jacket shall not bond and shall be readily removable from the underlying insulation shield and concentric neutral wires. The jacket shall meet the requirements of ICEA S-94-649.

1.1.2.17 The polyethylene material shall meet or exceed the requirements of ICEA S-94-649, Section 7.

1.1.2.18 The jacket shall contain three (3) extruded red stripes spaced 120° apart.

1.1.2.19 A sealant shall be incorporated under the jacket, to prevent the longitudinal water penetration into the cable.

1.1.3 Cable Identifications

1.1.3.1 The cable shall be marked in accordance with ICEA S-94-649 and Rule 350G of the National Electrical Safety Code.

1.1.3.2 The cable shall have sequential footage markings every 24 inches.

1.1.4 Test Requirements

1.1.4.1 The Contractor shall furnish the Owner with certified copies of the results of all required tests.

1.1.4.2 The compounds used in the cable shall be shown on the certified test report.

1.1.4.3 Each reel (not slave reel) of completed cable to be shipped shall meet the Partial Discharge Test specified in ICEA S-94-649.

1.1.4.4 The apparent charge-transfer (partial discharge), as measured in Pico coulombs, and the partial discharge extinction voltage shall be determined by an X-Y recording.

1.1.4.5 Insulation shrink back shall not exceed 50 mils for #1/0 cable and 100 mils for 350 and 750 kcmil cable, when tested in accordance with Section 9.10 of ICEA S-94-649.

1.1.4.6 The filled strand shall be tested in accordance with ICEA T-31-610.

1.1.4.7 The certified test report shall include the following data for each shipping length:

1.1.4.7.1 The number of the master or slave reel from which the shipping length was cut.

1.1.4.7.2 The length of cable on the shipping reel.

1.1.4.7.3 The corona factory test data for the shipping reel.

1.1.4.7.4 The minimum and maximum (not average) tension necessary to strip the insulation shield.

1.1.4.7.5 The minimum and maximum thickness of the strand shield.

1.1.4.7.6 The minimum and maximum thickness of the insulation.

1.1.4.7.7 The minimum and maximum thickness of the insulation shield.

1.1.4.7.8 The minimum and maximum thickness of the jacket.

1.1.4.7.9 The overall diameter over the insulation.

1.1.4.7.10 The overall diameter over the insulation shield.

1.1.4.7.11 The overall diameter over the jacket.

Solar Technical Specification

SP-001

Exhibit D2 – Cable Identification

9/30/2019

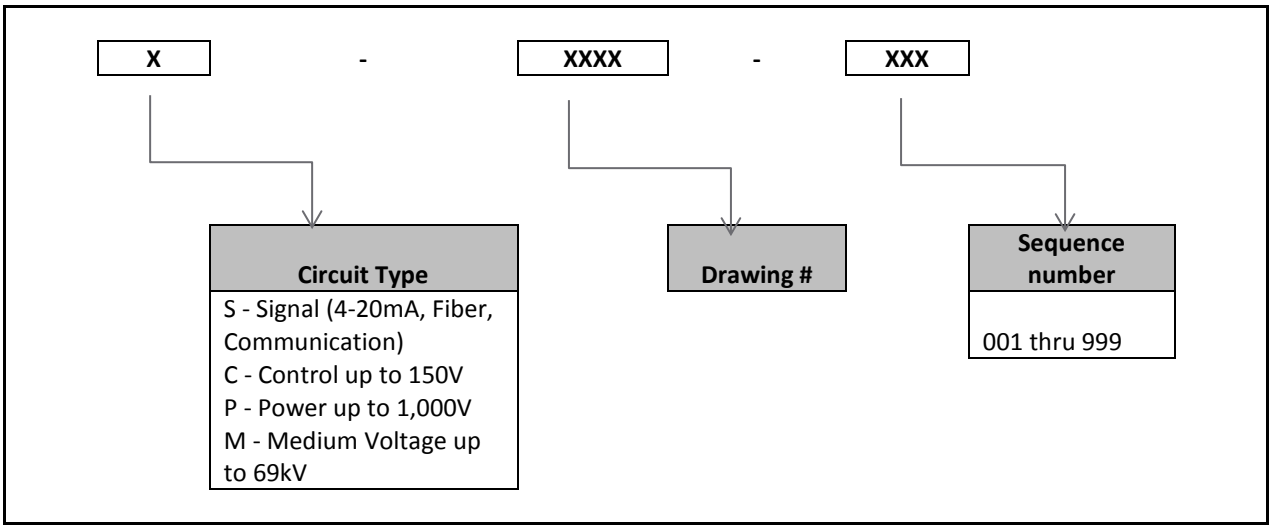
1.0 General

1.1.1 Cable Identification

1.1.1.1 Power cables shall follow the color code sequence indicated:

AC Power Circuits	Color Code
208Y/120 V	Black - Phase A
	Red - Phase B
	Blue - Phase C
	White - Neutral
480Y/277 V	Brown - Phase A
	Orange - Phase B
	Yellow - Phase C
	White/Gray - Neutral
4,160 V and above	Black - Phase A
	Red - Phase B
	Blue - Phase C
DC Circuits	
Negatively Grounded System	Black - DC Positive
	White - DC Negative
Positively Grounded System	White - DC Positive
	Black - DC Negative
Floating/ Non-Grounded System	Red - DC Positive
	Black- DC Negative

1.1.1.2 Circuits shall be permanently identified on the drawings and in the field as follows:



Solar Technical Specification

SP-001

Exhibit D2 – Cable Identification

9/30/2019

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4,160 V and above	Black - Phase A
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	Blue - Phase C
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Negatively Grounded System	Black - DC Positive
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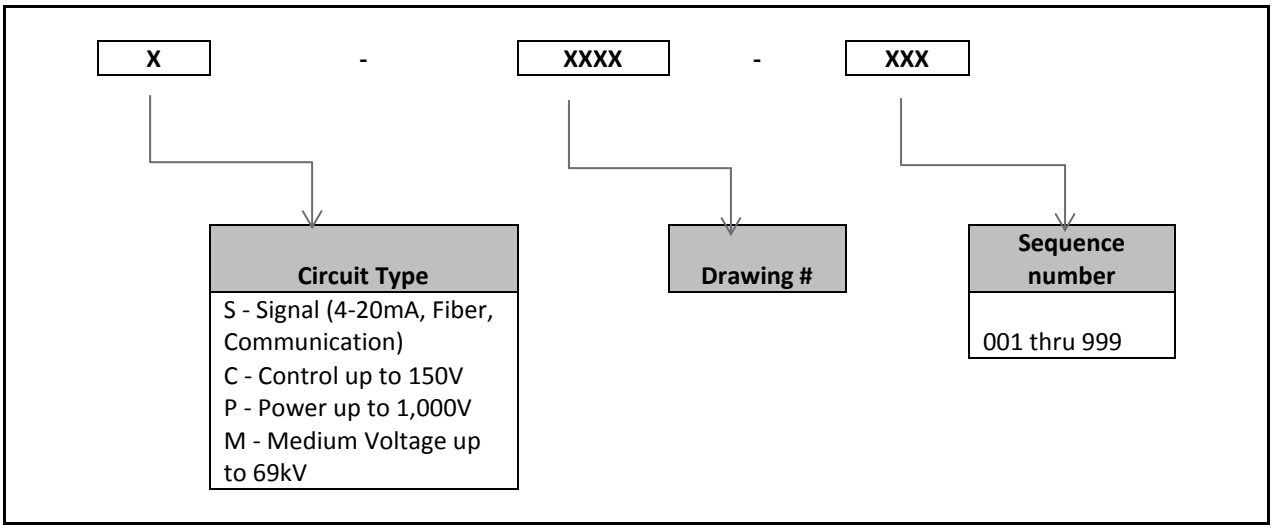


Solar Technical Specification

SP-001

Exhibit E1 – Circuit Breaker Specification

9/30/2019

1.0 Dead Tank AC Circuit Breakers – 48.3 kV, 69 kV, and 145 kV

1.1 General

1.1.1 This specification covers the manufacturing, furnishing, delivering, and testing of both SF6 and Vacuum interrupter type circuit breakers for voltages 48.3 kV, 69 kV and 145 kV dead tank design, and accessories for use in solar AC collector substations. The circuit breakers and accessories shall be in accordance with this specification and latest revisions of ANSI, NEMA, ASTM, and IEEE Standards. The Specifications, at the Owners' discretion, take precedence over any conflicts that may arise between them and ANSI, NEMA, ASTM or IEEE Standards.

1.1.2 These specifications apply to both SF6 Type Circuit Breakers and Vacuum Circuit Breakers (VCBs) unless otherwise noted in section heading.

1.2 Scope

1.2.1 Included in the scope of this specification:

1.2.1.1 Dead Tank Circuit Breaker with SF6 interruption.
1.2.1.2 Dead Tank Circuit Breaker with Vacuum interruption.
1.2.1.3 Bushing type current transformers.
1.2.1.4 Special tools necessary for installation and testing.
1.2.1.5 Necessary drawings, instructions and test reports.

1.3 Service Conditions

1.3.1 The breaker shall be suitable for operation at normal service conditions as described in ANSI C37.04 except the minimum temperature shall be -40°C.

1.4 Factory Inspection

1.4.1 Owner reserves the right to inspect materials and workmanship at all stages of manufacture and of witnessing any or all tests.

1.5 Instruction Books

1.5.1 The Instruction Book for the breaker, as a minimum, shall contain the following items: receiving, installing, operating and maintenance instruction manuals; temperature vs. pressure curve for the breaker showing normal pressure and all pressure switch operating settings; spare parts list; final drawings; detailed drawings of the circuit breaker and mechanism showing internal parts (identified

by the Vendor's part number) of interrupters, valves, etc; catalog data for all devices (auxiliary relays, etc) used in the control of the breaker.

1.6 Electrical Requirements

1.6.1 Ratings

Electrical Requirements Rating	Option 1	Option 2	Option 3	Option 4	Option 5
Rated Power Frequency (Hz)	60	60	60	60	60
Rated Interrupting Time (Maximum Cycles)	3	3	3	3	3
System Voltage (kV rms, nominal)	46	46	69	138	138
Rated Maximum Voltage (kV rms)	48.3	48.3	72.5	145	145
Basic Lightning Impulse Level (kV crest)	250	250	350	650	650
Rated Continuous Current(A rms sym)	2000	2000	2000	2000	3000
Maximum Symmetrical Interrupting Capability (O-15s-CO-3min-CO Duty Cycle), (kA)	31.5	40	31.5	40	63

Refer, respectively, to ANSI C37.06, Tables 2, 2A, 3 and 3A for other related ratings.

1.6.2 Dielectric Requirements

1.6.2.1 The completely assembled breakers shall be capable of withstanding the dielectric test values as given in ANSI C37.06, Table 4, respective to the breaker's Rated Maximum Voltage.

1.7 Mechanical Requirements

1.7.1 Mounting

1.7.1.1 Mounting of the breakers shall be manufacturer's standard subject to the following requirements:

Rated Maximum Voltage (kV rms)	48.3		145	
Dimension	Preferred	Minimum	Preferred	Minimum
Lowest Live Part to Base Height	10’-4”	10'-0"	12’-6”	12'-4"
Live Parts to Live Parts	26"	21"	60"	53"
Live Parts to Ground	22"	17"	48"	42"

1.7.1.2 Manufacturer shall provide height adjustable legs to accommodate up to a 12” decrease in the vertical plane, using 2” or 3” increments.

1.7.2 Color

1.7.2.1 Equipment, ceramic insulators and bushings shall be ANSI 70 light gray.

1.7.2.2 Galvanized surfaces need not be painted; however, if they are painted, they shall be properly prepared with a surface prep primer to remove the oils and etch the galvanizing.

1.7.3 Ground Pads and Tank Grounding

1.7.3.1 Two NEMA 2-hole standard grounding pads shall be provided on diagonally opposite points of the breaker frame.

1.7.3.2 If the breaker frame is painted, the control cabinet and each interrupter tank shall be connected to a ground pad located on the frame using a copper conductor of at least 4/0 in size.

1.7.3.3 The cable that grounds the tank shall be connected directly to the tank.

1.7.3.4 The presence of paint, gaskets, grease or threaded fasteners in the ground fault current path is not acceptable.

1.7.3.5 If the breaker frame is unpainted aluminum or galvanized steel, the ground conductors from the tanks to the frame are not required.

1.7.4 Test Facilities

1.7.4.1 Provide facilities for attachment of a linear resistive transducer for travel recorder attachment.

1.7.4.2 Provide one maintenance closing device per breaker.

1.7.5 Bushing Terminal Pads

1.7.5.1 The bushings shall be provided with 4-hole NEMA drilled terminal pads.

1.7.5.2 Terminal pads that are copper or bronze shall be tin plated.

1.7.6 Ground Pads and Tank Grounding

1.7.6.1 Two NEMA 2-hole standard grounding pads shall be provided on diagonally opposite points of the breaker frame.

1.8 Operating Mechanism

1.8.1 Description and Requirements

1.8.1.1 A spring type operating mechanism shall be provided, and shall be electrically and mechanically trip free.
1.8.1.2 Breakers with a Maximum Rated Voltage of 145 kV shall be provided with two (2) independent trip coils.
1.8.1.2.1 The trip coils shall have separate magnetic and electric circuits.
1.8.1.3 The breaker shall not be damaged when operated at the maximum normal control voltage (refer to 4.3).
1.8.1.4 The breaker shall still be able to trip at a control voltage which is 4 volts below the minimum voltage required to close the breaker.
1.8.1.5 Mounting of the operating mechanism shall be manufacturer's standard arrangement.
1.8.1.6 4.1.6 Provide Westinghouse AB “De-Ion” Type EB, 2-pole, 250V breakers or equivalent for protecting mechanism closing and tripping circuits.
1.8.1.7 An “a” contact which closes upon initiation of the close circuit shall be provided for customer wiring to the automatic reclosing relay.
1.8.1.8 4.1.8 Provide an operating mechanism low operating energy alarm contact.

1.8.2 Spring Charging Motor

1.8.2.1 Breakers with 125 Vdc Control Voltage (Control Option 1 in 4.3) shall have 120 Vac, single phase, spring charging motors with an allowable variation as great as, or in excess of NEMA MG1-12.44.
1.8.2.1.1 The motor shall also be capable of dc operation at 125V dc per 4.3.
1.8.2.2 Breakers having a 120 Vac/125 Vdc spring charging motor (Control Option 1 in 4.3) shall be connected to normally operate from a 120 Vac motor supply circuit.
1.8.2.3 In the event of loss of the 120 Vac supply, the motor shall be automatically transferred to an external 125V dc source, independent of the trip coil source.
1.8.2.4 Provide an under voltage alarm relay to indicate failure of ac voltage on the motor.

1.8.2.5 Provide Westinghouse AB "De-Ion" Type EB, 2 pole, 250V breaker for protecting the motor.

1.8.3 DC Control Voltages

1.8.3.1 The nominal DC control voltage will be 125V with equalizing charging performed periodically at 140V. All dc operating and control devices shall provide satisfactory operation over the range of dc voltages listed below:

1.8.3.1.1 Rated: 125 Vdc
1.8.3.1.2 Control Circuit Components and Closing Coil: 90-140 Vdc
1.8.3.1.3 Trip Coils: 70-140 Vdc

1.9 Control Wire Terminal Blocks, Auxiliary Switches, and Misc. Devices

1.9.1 Terminal Blocks

1.9.1.1 All terminal blocks which interface with CE wiring shall be States Company Type NT sliding link, except for the input for the ac and dc power circuits which shall be Marathon, Bussman or CE approved equivalent capable of accepting terminal lugs for wire sizes ranging from #2 to #14.

1.9.1.2 The sliding link blocks for control circuits and auxiliary switch contacts shall have individual white marker tags and shall be arranged so that terminal links drop open when loosened if the blocks are mounted horizontally.

1.9.1.3 All terminal blocks shall be mounted so they are easily viewed and accessible.

1.9.1.4 Terminal lugs for terminating the wiring shall be used and shall be Burndy Type YAV, un-insulated ring type with a seamless barrel.

1.9.1.5 A spring type operating mechanism shall be provided, and shall be electrically and mechanically trip free.

1.9.1.6 A minimum of six (6) consecutive spare points shall be provided for future Owner use.

1.9.2 Time Delay Relay

1.9.2.1 An adjustable time delay relay shall be provided in the closing circuit such that upon breaker opening there is a closing delay of approximately 20 cycles (adjustable) minimum.

1.9.3 Wiring

1.9.3.1 The manufacturer shall provide all internal control and current transformer wiring and the component wiring materials.
1.9.3.2 All control wire shall be No 14 AWG or larger stranded copper and be in accordance with NEMA Standards.
1.9.3.3 All wiring shall be adequately supported with suitable spacers, cabling and cleats and properly tagged at the terminations.
1.9.3.4 All conduit shall be either rigid metal, or weatherproof coated flexible metal; plastic or EMT is not acceptable.
1.9.3.5 Control wire that has a clear Mylar (or other clear material) binder tape between the conductor and the insulating material shall not be used.

1.9.4 Heaters

1.9.4.1 Control and Mechanism Cabinet
1.9.4.1.1 Provide thermostat and heaters suitable for operation over a range of 190-250 Vac, single phase, in accordance with ANSI Standard C37.06-1979, adequate to prevent condensation of moisture in the control cabinet, and maintain an adequate temperature for correct mechanism operation.
1.9.4.2 Interrupter Housing
1.9.4.2.1 Tank heaters controlled by non-adjustable thermostats shall be provided if required for proper (full rated interrupting capability at rated interrupting time) performance at -40□C.

1.9.5 Trip Counter

1.9.5.1 Provide one trip counter for the operating mechanism.
1.9.5.2 Mechanical counter is preferred, but an electrical counter will be acceptable.
1.9.5.3 The counter shall count trips only.
1.9.5.4 The counter shall be easily viewed by an operator at ground level.

1.9.6 Auxiliary Switches

1.9.6.1 Provide rotary type auxiliary switches having a minimum of 12 stages. Six shall be "a" and six shall be "b" contacts for customer use. Auxiliary switches shall be easily convertible from "a" to "b" and vice versa.
1.9.6.2 Mounting of the auxiliary switches shall be the manufacturer's standard.
1.9.6.3 One "a" contact that operates in two cycles or less shall be provided as part of the multi-contact auxiliary switch, or located at an appropriate location on the breaker, to detect failure of the circuit breaker to operate after a trip signal is given to the circuit breaker.
1.9.6.4 Auxiliary switches shall be wired to States NT sliding link terminal blocks with individual white marker tags.

1.9.6.5 Adjustment information shall be provided in the instruction book.

1.9.7 Control Cabinet

1.9.7.1 Provide one convenience outlet, NEMA, Type 5-15R, mounted in the control cabinet. The convenience outlet shall be Arrow Hart No 6262 or equivalent, 2-pole, 3-wire, 15A, 125V, protected by a 15A ground fault interrupter (GFI).

1.9.7.2 If any conduit hubs are used on the top surface of the cabinet, they shall be the welded type. Bolted types are not acceptable.

1.9.8 System Requirements

1.9.8.1 SF6 GAS SYSTEM AND REQUIREMENTS (Item 1: Applies to Breakers Utilizing an SF6 Gas Interrupter)

1.9.8.1.1 The breaker shall have a guaranteed maximum leak rate of 1% per year.

1.9.8.1.2 Provide a temperature compensated pressure switch to monitor the SF6 gas system.

1.9.8.1.3 This switch shall have the necessary contacts for alarms and to either:

1.9.8.1.4 Paralyze the breaker (block tripping or closing) if the gas pressure reaches the "lockout" level.

1.9.8.1.5 Trip and block closing if the gas pressure reaches the "lockout" level.

1.9.8.1.6 The breaker as supplied from the factory shall be wired to paralyze. However, the wiring shall be easily changeable in the field for the trip and block closing option if so desired by the Owner.

1.9.8.1.7 All pressure switches shall be adjusted and tested in the factory.

1.9.8.1.8 Each switch shall be tagged in the factory with the tested value.

1.9.8.1.9 These factory values will be used as reference points during field checkout.

1.9.8.1.10 Access to both the low SF6 gas pressure alarm and low SF6 gas pressure cutout contacts shall be provided for SCADA system.

1.9.8.1.11 All necessary SF6 for initial filling shall be provided for the breaker and shall conform to the requirements of ASTM D2472-71, "Standard Specification for Sulfur Hexafluoride."

1.9.8.1.12 The moisture content of the SF6 gas supplied separate from the breaker shall not exceed 8.9 ppm by weight or 71 ppm by volume.

1.9.8.1.13 The breaker shall be supplied with an internal desiccant for the absorption of moisture, by-products and or contaminants.

1.9.8.1.14 Dilo fittings shall be used at the connections between the interrupters and the SF6 gas manifold piping.

1.9.8.1.15 The breaker shall have SF6 gas fittings that allow safe sampling of SF6 gas for in-service moisture testing.

1.9.8.1.16 The breaker shall have SF6 gas fittings that allow individual pole units to be isolated with SF6 gas for de-energized maintenance without the need to drain the entire breaker.

1.9.8.1.17 The breaker shall have a ¼" turn, ball valve between the SF6 manifold/tee and the pressure alarm/gauge instruments. The valve handle shall be oriented "in line" with the piping when the valve is open, and perpendicular to the piping when the valve is in the closed position.

1.9.8.2 VACUUM BREAKER SYSTEM AND REQUIREMENTS (Item 2: Applies to Breakers Utilizing a Vacuum Interrupter)

1.9.8.2.1 The breaker shall have a guaranteed maximum leak rate of 1% per year.

1.9.8.2.2 Provide a temperature compensated pressure switch to monitor the gas insulating medium.

1.9.8.2.3 This switch shall have the necessary contacts for alarms and to either:

1.9.8.2.4 Paralyze the breaker (block tripping or closing) if the gas pressure reaches the "lockout" level.

1.9.8.2.5 Trip and block closing if the gas pressure reaches the "lockout" level.

1.9.8.2.6 The breaker as supplied from the factory shall be wired to paralyze. However, the wiring shall be easily changeable in the field for the trip and block closing option if so desired by CE.

1.9.8.2.7 All pressure switches shall be adjusted and tested in the factory.

1.9.8.2.8 Each switch shall be tagged in the factory with the tested value.

1.9.8.2.9 These factory values will be used as reference points during field checkout.

1.9.8.2.10 Access to both the low insulating gas pressure alarm and low vacuum interrupter pressure cutout contacts shall be provided for the SCADA system.

1.9.8.2.11 All necessary gas for initial filling shall be provided for the breaker by the manufacturer. Include detailed filling instructions.

1.9.8.2.12 The moisture content of the gas in the vacuum interrupter shall not exceed manufacturers recommended values to maintain proper operating performance for rated interrupting ability.

1.9.8.2.13 The breaker shall be supplied with an internal desiccant for the absorption of moisture, by-products and or contaminants if required to maintain proper operating performance for rated interrupting ability.

1.9.8.2.14 Dilo fittings shall be used at the connections between the interrupters and the insulating gas manifold piping.

1.9.8.2.15 The breaker shall have dilo fittings that allow safe sampling of insulating gas for in-service moisture testing.

1.9.8.2.16 The breaker shall provide some means that allow individual pole units to be isolated from the insulating gas for de-energized maintenance without the need to drain the entire breaker.

1.9.8.2.17 Provisions should be available that allow field crews the ability to monitor, test, remove and fill the pole enclosure gas.

1.9.9 Current Transformers

1.9.9.1 The Supplier shall provide bushing current transformers (BCTs) installed on the circuit breaker in of the arrangements listed below.

Bushing Current Transformer Arrangements

Arrangement Option No.	Ratio	Quantity and Location
1	1200:5A MR	1/bushing
2	1200:5A MR	2/bushing
3	2000:5A MR	1/bushing
4	2000:5A MR	2/bushing
5	1200:5A MR 2000:5A MR	1/bushing, top (farthest from main contacts) 1/bushing, bottom (nearest main contacts)
6	2000:5A MR 1200:5A MR	1/bushing, top (farthest from main contacts) 1/bushing, bottom (nearest main contacts)
7	3000:5A MR 2000:5A MR	1/bushing, top (farthest from main contacts) 1/bushing, bottom (nearest main contacts)
8	Unique, per Purchase Order	

1.9.9.2 All BCTs shall be multi-ratio type with 5-lead secondaries and an accuracy class of C800 (or better) in accordance with ANSI C57.13.

1.9.9.3 Testing The resistance of the 2000/5A BCTs shall be no greater than 0.0035 ohms/turn.

1.9.9.4 For breakers rated 2000A continuous current, the minimum continuous thermal rating factor shall be 2.0 for BCT rated 1200:5A and 1.25 for BCTs rated 2000:5A.

1.9.9.5 For breakers rated 3000A continuous current, the minimum continuous thermal rating factor shall be 1.5 for BCTs rated 2000:5A.

1.9.9.6 The BCT terminal box should be located on the end of the breaker opposite the mechanism and shall include sliding link terminal blocks wired in accordance with CE Drawing SS-0305.01 or SS-0305.02, per the required arrangement.

1.9.9.7 If space limitations prevent the use of a separate BCT terminal box, the BCT wires can be terminated in a separate area of the mechanism/control cabinet, such as at one end or side of the cabinet, where no other terminal blocks, relays, etc are in close proximity.

1.9.9.8 Terminal block marker tags shall be red color for BCT connections and white for all other connections.

1.9.9.9 Terminal blocks shall be arranged so that terminal links drop open when loosened if blocks are mounted horizontally.

1.9.9.10 All terminal blocks are to be mounted so that they are easily viewed and are accessible.

1.9.9.11 A removable conduit entrance plate in the bottom of the BCT terminal box shall be provided.

1.10 Testing

1.10.1 All tests, design and production shall be made in accordance with ANSI Standards C37.

1.10.2 Tests shall be made with the breaker assembled as it will be used in the field.

1.10.3 Test report shall include temperature rise data for various circuit breaker components at rated amperes in accordance with ANSI C37.

1.10.4 Test report shall include the minimum trip and the maximum close voltages of each breaker measured in the factory.

1.10.5 Test report shall include tripping and closing current (at nominal voltage rating) for each coil.

1.10.6 Test report shall include the thermal rating factor for the current transformer secondaries.

1.10.7 Heat run tests are not required on each circuit breaker. Design information will be sufficient.

1.10.8 In addition to the standard tests, a travel recording of the breaker shall be made and the opening and closing speed calculated from these traces.

Solar Technical Specification

SP-001

Exhibit E2 – Switch Specification

9/30/2019

1.0 Group Operated Air Switches

1.1 General

1.1.1 This section covers the manufacturing, testing, and delivery of outdoor group-operated air switches with rated voltage of 15.5kV through 145kV for use in solar AC collector substations.

1.2 Application

1.2.1 Group-operated air switches shall be used to disconnect equipment or to close and open electric circuits and will be required to interrupt relatively low currents.

1.2.1.1 Arcing horns shall be standard equipment on these switches.

1.2.2 If necssary, an interrupter (quick whip breaks, vacuum, or SF6 bottle) shall be provided with the switch that will meet the specified switching duty.

1.3 Equipment

1.3.1 Each switch pole shall be a 3-insulator, vertical break, resembling typical construction classification A of ANSI C37.32-2002, Annex B, mounted upright unless otherwise specified.

1.4 Standards

1.4.1 The equipment furnished shall be designed, fabricated, tested and delivered in accordance with the latest revision in effect at the time quotations are submitted of the applicable ANSI, NEMA, AISC, and IEEE Standards, specifically including, but not limited to, the following noted ANSI, IEEE, and NEMA Standards.

1.5 Electrical Requirements

1.5.1 Terminal Pads

1.5.1.1 Bronze or copper terminal pads shall be tinned.
1.5.1.2 Switches rated 600A shall have NEMA 2-hole pads.
1.5.1.3 Switches rated 1200A and above shall have NEMA 4-hole pads.

1.5.2 Contacts

1.5.2.1 Hinge, jaw and blade contacts shall be silver-to-silver.

1.5.3 Ratings

1.5.3.1 The voltage and current ratings will be based on the specific design conditions.

1.5.3.2 Refer to Table 1 below and ANSI C37.32 for related ratings and requirements based on the nominal system voltage rating.

TABLE 1

Nominal System Voltage (kV)	Rated Maximum Voltage (kV)	Rated Impulse Withstand Line-to-Ground (kV)	Post Insulators	Switch Open Gap BIL (kV)	Length of Break (min. metal-to-metal inches)
15	15.5	110	TR205	121	10
25	25.8	150	TR208	165	12
46	48.3	250	TR214	275	22
138 (reduced BIL)	145	550	TR286	715	60
138 (full BIL)	145	650	TR288	715	60

1.6 Mechanical Requirements

1.6.1 Base Requirements

1.6.1.1 The switch shall be mounted on galvanized steel bases fabricated as specified.

1.6.1.2 The base shall have sufficient height so that there are no projections below the bottom of the base.

1.6.2 Operating Mechanism Requirements

1.6.2.1 The switch operating mechanism shall have a torsional vertical operating shaft.

1.6.2.2 Unless a motor operator is utilized, a manual gearbox meeting the following requirements shall be supplied:

1.6.2.2.1 Ratio of the gearbox shall not exceed 25:1.

1.6.2.2.2 Maximum force required by an operator to open or close the switch shall not exceed 40 pounds.

1.6.2.2.3 Turning the crank of the gearbox clockwise shall close the switch.

1.6.2.3 The mechanism shall be complete with interphase connections, outboard bearings, intermediate guides, position indication nameplates, operating handle suitable for padlocking in open and closed positions and all mounting brackets and hardware.

1.6.2.4 Universal joints shall be provided whenever the vertical shaft has more than six degree angular displacement.

1.6.2.5 All switch-operating pipe and brackets shall be hot-dipped galvanized steel according to the latest revisions of ASTM A123.

1.6.2.6 All lock washers shall be split type.

1.6.2.7 Bolts, nuts and locknuts shall be hot-dipped galvanized according to the latest revisions of ASTM A123.

1.6.2.8 All switch bearings shall be permanently sealed and require no maintenance.

1.6.2.9 Self-piercing screws shall be furnished for clamps.

1.6.2.10 Either screw clevises or clevises with self-piercing screws shall be furnished.

1.6.2.11 If the operating mechanism has a fixed and an adjustable stop, the operating shaft shall be against the adjustable stop in the closed position.

1.6.2.12 When the switch is in the open position, the blade shall tilt two degrees away from the open gap.

1.6.3 Insulators

1.6.3.1 Solid core station post insulators, ANSI 70 gray in color, shall be provided with the switches.

1.6.3.2 The switch shall be mounted on galvanized steel bases fabricated as specified.

1.7 Testing Requirements

1.7.1 The Contractor shall certify ensure that design and performance tests on all air switches in accordance with the latest revision of ANSI C37.34 and shall furnish certified test data to the Owner.

1.8 Weld and Casting Requirements

1.8.1 Welds

1.8.1.1 All welding associated with the switches and switch base shall be in accordance with the American Welding Society Standards.

1.8.2 Castings

1.8.2.1 All aluminum alloy, sand and permanent mold castings shall conform to the latest revisions of ASTM B26, B108, E94, E155 and NEMA CC1-2.03.

1.8.2.2 Castings used as current carrying parts shall have ampacity ratings equal to or greater than the rating of associated non-cast current carrying components.

1.8.2.3 Castings shall be uniform in composition and free of cracks, cold shunts, mis-runs, core shifts and surface irregularities.

1.8.2.4 If the terminal pad is part of a casting, it shall have a ground or machined finish.

1.8.2.5 Other contact surfaces shall be smooth and provide adequate contact surface for the size of assembly components for which the casting is intended.

1.8.2.6 Castings shall have adequate strength for stresses imposed under maximum design conditions.

1.8.2.7 The maximum stress in the casting shall not exceed the minimum guaranteed yield strength of the alloy used.

1.8.2.8 Maximum design conditions for the casting shall be the combination of dynamic and static loads that may be imposed during the usage which the casting was designed.

2.0 Hook Operated Switches

2.1 General

2.1.1 This specification covers the manufacturing, testing, and delivery of hook-stick operated, single pole, outdoor air switches.

2.2 Application

2.2.1 Disconnect switches are used for changing the connections in a circuit, or for isolating a circuit or equipment from the source of power.

2.2.2 Loadbreak switches shall be equipped with an interrupter (quick whip breaks, vacuum, or SF6 bottle) device for interrupting specific currents under specific conditions.

2.3 Equipment

2.3.1 Disconnect Switch Requirements

2.3.1.1 Disconnect switches shall be two insulator, NEMA Type H, for outdoor use, mounted on inverted station post insulators with 90 degree stops.

2.3.2 Transfer Disconnect Switch Requirements

2.3.2.1 Transfer disconnect switches shall be three insulator, NEMA Type TF-A, except for outdoor use, mounted on inverted station post insulators.

2.3.2.2 The current rating of each blade shall be the same as the current rating of the switch.

2.3.3 Tandem Disconnect Switch Requirements

2.3.3.1 Tandem disconnect switches shall be two insulator, NEMA Type H, for outdoor use, with two switches mounted on a single base, for independent operation, with clip ends facing out.

2.3.3.2 The switch shall have 70 degree stops and be mounted on inverted station post insulators.

2.3.4 Load Interrupter Switch Requirements

2.3.4.1 Load interrupter switches shall be two insulator, NEMA Type H, for outdoor use, with blade and interrupter unit mounted on inverted station post insulators and have 90 degree stops.

2.4 Standards

2.4.1 The equipment furnished shall be designed, fabricated, tested and delivered in accordance with the latest revision in effect at the time quotations are submitted of the applicable ANSI, NEMA, AISC, and IEEE Standards, specifically including, but not limited to, the following noted ANSI, IEEE, and NEMA Standards.

2.5 Electrical Requirements

2.5.1 Terminal Pads

2.5.1.1 Bronze or copper terminal pads shall be tinned.

2.5.1.2 Switches rated 600A shall have NEMA 2-hole pads.

2.5.1.3 Switches rated 1200A and above shall have NEMA 4-hole pads.

2.5.2 Contacts

2.5.2.1 Hinge, jaw and blade contacts shall be silver-to-silver.

2.5.3 Ratings

2.5.3.1 The voltage and current ratings will be based on the specific design conditions.

2.5.3.2 Refer to Table 2 below and ANSI C37.32 for related ratings and requirements based on the nominal system voltage rating.

TABLE 2					
Nominal System Voltage (kV)	Rated Maximum Voltage (kV)	Rated Impulse Withstand Line-to-Ground (kV)	Length of Break (min. metal-to-metal inches)	Post Insulators	
				Reference Number	Height (inches)
15	15.5	110	10	TR205	10
25	25.8	150	12	TR208	14
34.5	38	200	18	TR210	18
46	48.3	250	22	TR214	22
115	121	550	50	TR286	45

2.6 Mechanical Requirements

2.6.1 Operational Requirements

2.6.1.1 Each switch shall be manually operated with a switch stick.

2.6.1.2 The maximum operating force (opening or closing) of the hookstick switch shall not exceed 50lbs.

2.6.1.3 Each switch shall be adjusted or equipped with a device so that it will not be damaged if the blade is accidently dropped during operation.

2.6.1.4 When in the open position, the switch blade shall not move toward the closed position because of its own weight, counterbalances or vibration.

2.6.1.5 The switch shall be provided with a latch that will positively lock the blade when closed.

2.6.1.6 The side pressure of the contacts is not to be relied on for locking.

2.6.1.7 Hookstick switches with a BIL rating of 550kV or higher shall have a counterbalance mechanism to assist in lifting the blade during close operations.

2.6.2 Mounting Posistion Requirements

2.6.2.1 The mounting positions of these switches shall be horizontal under-hung.

2.6.3 Assembly Requirements

2.6.3.1 Switch poles shall be factory assembled with insulators on bases and adjusted for proper operation.

2.6.3.2 115kV tandem switches shall be supplied without insulators.

2.6.4 Base Requirements

2.6.4.1 The switches shall be mounted on galvanized steel bases.

2.6.5 Insulators

2.6.5.1 Solid core station post insulators, ANSI 70 gray in color, shall be provided with the switches.

2.7 Testing Requirements

2.7.1 The Contractor shall certify ensure that design and performance tests on all air switches in accordance with the latest revision of ANSI C37.34 and shall furnish certified test data to the Owner.

2.8 Weld and Casting Requirements

2.8.1 Welds

2.8.1.1 All welding associated with the switches and switch base shall be in accordance with the American Welding Society Standards.

2.8.2 Castings

2.8.2.1 All aluminum alloys, sand and permanent mold castings shall conform to the latest revisions of ASTM B26, B108, E94, E155 and NEMA CC1-2.03.

2.8.2.2 Castings used as current carrying parts shall have ampacity ratings equal to or greater than the rating of associated non-cast current carrying components.

2.8.2.3 Castings shall be uniform in composition and free of cracks, cold shunts, mis-runs, core shifts and surface irregularities.

2.8.2.4 If the terminal pad is part of a casting, it shall have a ground or machined finish.

2.8.2.5 Other contact surfaces shall be smooth and provide adequate contact surface for the size of assembly components for which the casting is intended.

2.8.2.6 Castings shall have adequate strength for stresses imposed under maximum design conditions.

2.8.2.7 The maximum stress in the casting shall not exceed the minimum guaranteed yield strength of the alloy used.
Maximum design conditions for the casting shall be the combination of dynamic and static loads that may be imposed during the usage which the casting was designed.

Solar Technical Specification

SP-001

Exhibit E3 – EHV Circuit Breaker Specification

9/30/2019

1.0 Dead Tank Power Circuit Breakers – 362 kV SF6 Type

1.1 General

1.1.1 This specification covers the manufacture, furnishing, delivering and testing of 362 kV SF6 type dead tank circuit breakers and accessories for for use in solar AC collector substations.. The circuit breakers and accessories shall be in accordance with this specification and latest revisions of ANSI, IEEE, NEMA, NEC, NESC, ASME and ASTM Standards. The Owner's Specifications, at the Owner's discretion, take precedence over any conflicts that may arise between them and ANSI, IEEE, NEMA, NEC, NESC, ASME and ASTM Standards; the Contractor shall notify the Owner of any such conflicts.

1.2 Scope

1.2.1 Included in the scope of this specification:

1.2.1.1 SF6 gas type circuit breakers.
1.2.1.2 SF6 for initial filling.
1.2.1.3 Current transformers.
1.2.1.4 Special tools necessary for installation and testing.
1.2.1.5 Necessary drawings, instructions and test reports.

1.3 Service Conditions

1.3.1 The breaker shall be suitable for operation at normal service conditions as described in ANSI C37.04 except the minimum temperature shall be - 40°C.

1.4 Factory Inspection

1.4.1 Owner reserves the right to inspect materials and workmanship at all stages of manufacture and of witnessing any or all tests.

1.5 Instruction Books

1.5.1 The Instruction Book for the breaker, as a minimum, shall contain the following items: receiving, installing, operating and maintenance instruction manuals; temperature vs. pressure curve for the breaker showing normal pressure and all pressure switch operating settings; spare parts list; final drawings; detailed drawings of the circuit breaker and mechanism showing internal parts (identified

by the Vendor's part number) of interrupters, valves, etc; catalog data for all devices (auxiliary relays, etc) used in the control of the breaker.

1.6 Electrical Requirements

1.6.1 Description

1.6.1.1 Type - Circuit breaker shall be oil-less, utilizing sulphur hexafluoride gas (SF6) dielectric and interrupting medium. All necessary SF6 gas shall be included in order. Compressed air, hydraulic, or spring operating energy shall be used to operate the breaker.
1.6.1.2 Service – Outdoor
1.6.1.3 Phases - Three
1.6.1.4 System Operating Frequency - 60 Hertz
1.6.1.5 Breaker Rated Maximum Voltage - 362 kV (L-L), but suitable for continuous 380 kV (L-L)
1.6.1.6 Continuous Current Rating 2,000 Amperes (rms)
1.6.1.7 Rated Interrupting Capacity on the Basis of a O + 0.3 Sec + CO Duty Cycle: 40 kA (rms)
1.6.1.8 Asymmetrical interrupting ability corresponding to the above symmetrical current value shall be based on an X/R ratio of 17 for three-phase and line-to-ground faults.
1.6.1.9 Rated closing and latching current - 104 kA (peak)
1.6.1.10 Three Second Current-Carrying Ability - 40 kA (rms)
1.6.1.11 Rated Interrupting Time - 2 Cycles
1.6.1.12 Closing Time - 3 to 12 Cycles, Nonadjustable
1.6.1.13 Reclosing Time - 3 to 120 Cycles, Adjustable
1.6.1.14 Maximum Pole Closing Span - 180 Electrical Degrees
1.6.1.15 All breakers shall have provisions for the future addition of pre-insertion (circuit closing) resistors of 400 ohms per phase, subject to individual Vendor's design. The minimum insertion time shall be 120 electrical degrees. Resistors may be required on some breakers, see purchase order for details.
1.6.1.16 Provide voltage grading capacitors as required.
1.6.1.17 Provide opening resistors as required.

1.6.2 Dielectric Requirements

1.6.2.1 The insulation structure shall be designed so that impulse, switching surge or 60 hertz over-voltages not exceeding the test and rated voltages that may be imposed on the circuit breaker during an opening operation or while it is in the open position shall not cause dielectric breakdown across the open contacts or to ground. If voltages exceeding the test and

rated voltages cause dielectric breakdown, the insulation structure shall be designed so that breakdown occurs to ground and not across the open contacts, resistors, capacitors or other insulating parts.

1.6.2.2 The completely assembled (as it will be used in the field) circuit breaker, shall have insulation strength and shall withstand tests as follows:

1.6.2.3 Impulse test (BIL)

1.6.2.3.1 Full Wave 1.2 x 50 Withstand - kV Crest - 1300 (Test)

1.6.2.3.2 Chopped Wave at 2 Microseconds - kV Crest - 1680 (Test)

1.6.2.3.3 Chopped Wave at 3 Microseconds - kV Crest - 1500 (Test)

1.6.2.4 60 Hertz Withstand Test, Dry, One Minute - kV rms - 555

1.6.2.5 60 Hertz Withstand Test, Wet, Ten Seconds - kV rms - 555

1.6.2.6 Switching Surge Withstand, Wet, - kV Crest – 825 Line-Ground.

1.6.2.7 Switching Surge Withstand, Across Open - kV Crest - 900 Plus Contacts 295 Bias

1.7 Mechanical Requirements

1.7.1 Mounting

1.7.1.1 The breaker shall be floor mounted on a factory assembled, rolled section or equivalent structural steel base.

1.7.1.2 Minimum Height of Bushing Terminal Above Base: 17'-2"

1.7.1.3 Pole Spacing:

1.7.1.3.1 15'-0" Minimum (Center Line Spacing)

1.7.1.3.2 20'-0" Maximum (Center Line Spacing)

1.7.1.4 Minimum Creepage Distance to ground (One Phase): 305" (35 mm/kV L-G @ 380 kV L-L)

1.7.1.5 Minimum External Strike Distance to Ground: 104"

1.7.1.6 Minimum Strike Distance Phase to Phase: 125"

1.7.2 Color

1.7.2.1 Equipment, ceramic insulators and bushings shall be ANSI 70 light gray.

1.7.2.2 Galvanized surfaces need not be painted; however, if they are painted, they shall be properly prepared with a surface prep primer to remove the oils and etch the galvanizing.

1.7.3 Ground Pads and Tank Grounding

1.7.3.1 Two NEMA 2-hole standard grounding pads shall be provided on diagonally opposite points of the breaker frame.

1.7.3.2 If the breaker frame is painted, interrupter tank (and any cabinets mounted to the frame) shall be connected to a ground pad located on the frame using a copper conductor of at least 250 kcmil in size. If the breaker frame is unpainted aluminum or galvanized steel separate ground conductors to the frame are not required.

1.7.4 Test Facilities

1.7.4.1 Provide facilities for attachment of a linear resistive transducer for travel recorder attachment.
1.7.4.2 Provide one maintenance closing device per breaker.

1.7.5 Bushing Terminal Pads

1.7.5.1 The bushings shall be provided with 4-hole NEMA drilled terminal pads.
1.7.5.2 Terminal pads that are copper or bronze shall be tin plated.
1.7.5.3 Circuit breaker bushings shall conform to the requirements of IEEE C57.19.01.
1.7.5.4 A tinned, bronze stud connector to NEMA 4-hole flat pad shall be furnished for each bushing terminal.
1.7.5.5 Each bushing shall be identified with a number located near the bushing, but visible from the ground. The location of the number shall be shown on the outline drawing.

1.8 Operating Mechanism

1.8.1 Description and Requirements

1.8.1.1 The breaker shall have a spring, hydraulic or pneumatic operating mechanism with either separate mechanisms for each pole, or one mechanism with the three poles mechanically gang operated.
1.8.1.2 The preferred mechanism is a stored energy, spring-operated device. Pneumatic, or hydraulic mechanisms, may be acceptable.
1.8.1.3 The operating mechanism shall be electrically trip-free. It shall close satisfactorily and latch the breaker against an rms current initially equal to the rated asymmetrical current of the breaker at the minimum service voltage specified.
1.8.1.4 The breaker shall not be damaged when operated at the maximum normal control voltage (defined elsewhere herein).
1.8.1.5 The breaker shall still be able to trip at a control voltage which is 4 volts below the minimum voltage required to close the beaker.

1.8.1.6 The breaker shall not close if the closing operation will leave the breaker with insufficient stored energy to trip.

1.8.1.7 All coils and relays shall be encapsulated or housed in a weather tight cabinet to prevent the entrance of moisture.

1.8.1.8 The operating mechanism shall include all applicable devices listed in ANSI C37.12, Table 1. The following features shall be incorporated into the mechanism regardless of type:

1.8.1.8.1 Trip and close push-buttons.

1.8.1.8.2 Removable maintenance closing device for slow closing.

1.8.1.8.3 Provide equipment to interface with our existing Doble TR3100 time travel analyzer and our Doble TR3160 linear transducer.

1.8.1.8.4 Auxiliary Switch

1.8.1.8.5 A minimum of sixteen (16) single-pole, double throw auxiliary switch contacts (eight 52/a and eight 52/b) wired to terminal blocks

1.8.1.8.6 Contacts shall be rated 20 amperes at 600 V AC. The Vendor shall provide a table on the control schematic diagram, which indicates the position of all “a”, “aa”, “b”, and “bb” contacts relative to the position of the main contacts.

1.8.1.8.7 Mounting of the auxiliary switches shall be per the Vendor's standard.

1.8.1.8.8 Auxiliary switches shall be easily convertible from "a" to "b" and vice versa. Adjustment information shall be provided.

1.8.1.8.9 Wire auxiliary switch to sliding link terminal blocks with individual white marker tags.

1.8.1.8.10 Provide an “aa”contact on each phase that shall operate in one cycle or less included as a part of the multi-contact auxiliary switch, or located at the central control block, or at another appropriate location on the circuit breaker, to detect failure of the circuit breaker to operate after a trip signal is given to the circuit breaker.

1.8.1.8.11 Provide two (2) independent trip coils and trip circuits per pole, one for primary protective relaying and one for backup relaying, to be supplied from two separate supply cables.

1.8.1.8.12 Provide necessary relaying (52X & 52Y relay) to limit the continuous current flow through the closing equipment to 0.1 amp.

1.8.1.8.13 The capacity of a stored energy, spring-operated system shall be sufficient for a minimum of one open-close-open operation at rated short circuit current. The spring charging motor shall be a 120VAC/125VDC universal type, capable of recharging the spring mechanism in less than 10 seconds.

1.8.1.8.14 Spring-operated mechanisms shall include a means to prevent overcharging the spring(s) and prevent insufficiently charged spring(s) from attempting a close operation.

1.8.1.8.15 Pneumatic and hydraulic operating mechanisms rated 145 kV and above shall be capable of a minimum of five close-open operations at rated short circuit current without replenishing the energy storage.

1.8.1.8.16 Compressor motors shall be rated for 120/240V AC single-phase operation.

1.8.1.8.17 Manufacturer shall provide a digital meter to display the accumulated run time of the compressor in hours, and tenths of an hour, up to 9999.9 hours.

1.8.1.8.18 If capacitors and/or surge arresters are required by the Vendor, on the circuit Breaker, for TRV control and/or other purposes, the Vendor shall expressly confirm that these will be the sole responsibility of the Vendor and the Vendor shall provide complete data; including, but not limited to values, mounting and connection details (e.g. phase-to-phase or phase-to-ground, alongside the bushing or perdendicular to the bushings….etc.). The Bidder shall also provide type test reports to confirm that the TRV capability of the breaker or Circuit Breaker Rated TRV Envelope lies above the "standard" TRV envelope or the System TRV. Vendor shall provide, along with the Proposal, complete Type/Design Test Reports substantiating declared rated values.

1.8.1.8.19 For circuit breakers to be used for capacitor bank switching, an adjustable time delay relay (1 – 10 minute range) shall be provided.

1.8.1.8.20 The relay shall be wired to block closing for 5 minutes after the circuit breaker has opened to allow the capacitor bank to completely discharge prior to re-energization.

1.8.2 Motors

1.8.2.1 Pneumatic and Hydraulic Mechanisms

1.8.2.1.1 Motors for air compressors or hydraulic pumps shall be rated 230 Vac, 60 Hz, with an allowable variation as great as, or in excess of that listed in NEMA MG1-12.44. Motors may be single phase or three phase.

1.8.2.1.2 Provide an under-voltage alarm relay to indicate failure of voltage on the motor.

1.8.2.1.3 Provide an elapsed time meter suitable for service in the 207-253 Vac range to operate in parallel with the motor.

1.8.2.1.4 Provide Westinghouse AB □De-Ion Type EB, 2-pole, 250V breaker or Owner approved equivalent for protecting the motor.

1.8.2.2 Spring Operated Mechanisms

1.8.2.3 Spring charging motors shall be rated 120 Vac, single phase, with an allowable variation as great as, or in excess of that listed in NEMA MG1-12.44. The motor shall also be capable of dc operation over the range of 90-140V dc (125V dc nominal rating).

1.8.2.4 Provide automatic transfer of the spring winding motor to an external 125V dc source in the event of loss of the 120 Vac supply. This 125V dc source shall be independent of the source for the trip coils.

1.8.2.5 Provide an under-voltage alarm relay to indicate failure of ac voltage on the motor.

1.8.2.6 Provide Westinghouse AB De-Ion Type EB, 2 pole, 250V breaker or Owner approved equivalent for protecting the motor.

1.8.2.7 Mechanical indicator to show the spring(s) "Charged" and "Discharged" status.

1.8.2.8 Alarm to indicate the spring(s) is not fully charged; this alarm shall include a 30 second time delay to prevent operation during a normal trip and recharge cycle.

1.8.3 DC Control Voltages

1.8.3.1 The nominal DC control voltage will be 125V with equalizing charging performed periodically at 140V. All dc operating and control devices shall provide satisfactory operation over the range of dc voltages listed below:

1.8.3.1.1 Rated: 125 Vdc

1.8.3.1.2 Control Circuit Components and Closing Coil: 90-140 Vdc

1.8.3.1.3 Trip Coils: 70-140 Vdc

1.8.3.2 Provide Westinghouse AB DE-Ion Type EB, 2-pole, 250 V breakers or equivalent for protecting mechanism closing and tripping circuits.

1.8.4 DC Control Voltages

1.8.4.1 Mechanisms that use hydraulic or pneumatic type operating mechanisms shall be provided with a pressure switch, or some other means, for monitoring the status of the pressure system for alarm purposes. For breakers having pressure systems segregated by pole, one pressure switch per pole shall be provided with the alarm contacts for each pole wired in parallel.

1.9 Control Wire Terminal Blocks, Auxiliary Switches, and Misc. Devices

1.9.1 Terminal Blocks

1.9.1.1 All terminal blocks which interface with the Owner's wiring shall be States Company Type NT sliding link, or otherwise require express approval by the Owner, except for the main input for the ac and dc power circuits which shall be Marathon or Bussman capable of accepting terminal lugs for wire sizes ranging from #2 to #14.

1.9.1.2 The sliding link blocks for control circuits and auxiliary switch contacts shall have individual white marker tags and shall be arranged so that terminal links drop open when loosened if the blocks are mounted horizontally.

1.9.1.3 All terminal blocks shall be mounted so they are easily viewed and accessible.

1.9.1.4 Marker tags shall be attached so the tag can be removed without loosening the terminal lug connection.

1.9.1.5 A minimum of six (6) consecutive spare points shall be provided

1.9.2 Time Delay Relay

1.9.2.1 A time delay relay adjustable over a range of 3 to 120 cycles, Agastat or equivalent, shall be provided in the closing circuit such that upon breaker opening the time delay relay coil is energized and causes a reclosing delay.

1.9.2.2 The factory setting for this relay shall be for a 20 cycle delay in reclosing.

1.9.3 Wiring

1.9.3.1 The manufacturer shall provide all internal control and current transformer wiring and the component wiring materials.

1.9.3.2 All control wire shall be No 14 AWG or larger stranded copper and be in accordance with NEMA Standards.

1.9.3.3 All wiring shall be adequately supported with suitable spacers, cabling and cleats and properly tagged at the terminations.

1.9.3.4 All conduit shall be either rigid metal, or weatherproof coated flexible metal; plastic or EMT is not acceptable.

1.9.3.5 Control wire that has a clear Mylar (or other clear material) binder tape between the conductor and the insulating material shall not be used.

1.9.4 Heaters

1.9.4.1 Control and Mechanism Cabinet

1.9.4.1.1 Provide thermostat and heaters suitable for operation over a range of 190-250 Vac, single phase, in accordance with ANSI Standard C37, adequate to prevent condensation of moisture in the control cabinet, and maintain an adequate temperature for correct mechanism operation.

1.9.4.2 Interrupter Housing

1.9.4.2.1 Provide primary and backup thermostatically controlled heaters suitable for operation over a range of 190-250 Vac for the SF6 gas if required to meet the full interrupting capability at -40°C. Each heater system shall be adequate by itself down to -40°C ambient.

1.9.4.2.2 The heaters for each pole shall be wired to separate terminals in the main control cabinet to allow the Owner to rewire them in some configuration other than as a balanced 3-phase load in order to balance the overall station power load. As provided from the Vendor, the heaters shall be connected as a balanced 3-phase 240V load.

1.9.4.2.3 When tank heaters are required, the temperature probe for the heaters shall be located outside the control cabinet.

1.9.4.2.4 The tank heaters shall be monitored by an undercurrent device with two independent “a” contacts to alarm for a loss of tank heater(s).

1.9.5 Trip Counter

1.9.5.1 Provide one trip counter for the operating mechanism.

1.9.5.2 Mechanical counter is preferred, but an electrical counter will be acceptable.

1.9.5.3 The counter shall count trips only.

1.9.5.4 The counter shall be easily viewed by an operator at ground level.

1.9.6 Sensing and Alarms

1.9.6.1 Alarm contacts and associated wiring shall be rated for 125V DC operation.

1.9.6.2 All pressure gauges, monitors, indicators, and running time meters shall be readable from ground level without requiring the use of ladders or stands. All pressure switches shall be temperature compensated.

1.9.6.3 An external position indicator shall be provided to show the circuit breaker "Open" or "Closed" status.

1.9.6.4 The AC & DC circuits shall be monitored by a loss of AC or DC device with two (2) independent “a” contacts to alarm for loss of AC or DC.

1.9.6.5 A Seekirk Model A1010 annunciator shall be provided in the control cabinet for alarms.

1.9.6.6 Pneumatic and hydraulic mechanisms shall be provided with the applicable pressure gauges, alarms, and devices as listed in ANSI C37.12, Table 1.

1.9.7 Control Cabinet

1.9.7.1 Provide a 3-pole, 3 wire, non-grounded, 240V, 50A (NEMA 10-50R) outlet for Owner's SF6 gas cart.

1.9.7.2 Molded case circuit breakers shall be used for protection of the dc and ac circuits.

1.9.7.3 Provide clear plastic barriers for any knife switches or energized terminations located on the front of the control panel.

1.9.7.4 If any conduit hubs are used on the top surface of the cabinet, they shall be the welded type. Bolted types are not acceptable.

1.9.7.5 The control cabinet shall be a NEMA Type 3R cabinet. It shall be painted or galvanized to the same specification as the circuit breaker, and shall be sufficiently sized so that all terminal blocks, wire raceway, and equipment can be mounted on the back panel of the cabinet. Controls may be mounted on a swing panel. At least 50% of the area of the bottom of the cabinet shall be made up of a removable plate that can be field punched to accept conduit.

1.9.7.6 The cabinet shall be mounted so that the top of the cabinet does not exceed 7 ft. from the circuit breaker base and the base of the cabinet shall not be less than 2 ft. from the circuit breaker base.

1.9.7.7 If any individual door exceeds 1080 sq. in., then the cabinet shall be designed to have multiple doors. Wind braces shall be provided to secure doors open at a minimum of 120° from the closed position.

1.9.7.8 One space heater shall be on constantly to prevent condensation in the control cabinet. Space heaters, controlled by an adjustable thermostat, shall be provided, as required, to keep equipment within the cabinet operational to an ambient temperature of -40°C. Heaters shall be located away from and thermally insulated from any devices or painted surfaces.

1.9.7.9 A light, controlled by a door switch, shall be provided to illuminate the cabinet interior. A 120 V, 20 amp, GFI, duplex convenience receptacle shall be mounted within the cabinet or on the exterior. The light and receptacle shall be on a dedicated branch circuit.

1.9.7.10 Control cabinets shall have a minimum of one internal and one external ground pads, which are electrically common. The internal ground pads shall be connected to a suitable copper ground bus bar which shall have tapped holes for (10) 10-32 screws.

1.9.8 Break Test Terminals

1.9.8.1 A separate 6-point sliding link terminal block wired to the No 1 and No 2 trip coils and the closing coil shall be provided in the control cabinet to provide easy testing of the breaker from an external device.

1.9.9 SF6 GAS SYSTEM AND REQUIREMENTS

1.9.9.1 The breaker shall have a guaranteed maximum leak rate of 1% per year.
1.9.9.2 Provide two temperature compensated pressure switches per pole (one for trip coil 1 and the other for trip coil 2) to monitor the SF6 gas system.
1.9.9.3 These switches shall have the necessary contacts for alarms and to either: 1) paralyze the breaker (block tripping or closing) if the gas pressure reaches the "lockout" level; or 2) trip and block closing if the gas pressure reaches the "lockout" level.
1.9.9.4 The breaker as supplied from the factory shall be wired to paralyze.
1.9.9.5 However, the wiring shall be easily changeable in the field for the trip and block closing option if so desired by the Owner.
1.9.9.6 The overall details of the approach will be reviewed during the approval drawing cycle by the Owner and may be subject to change per the Owner’s discretion.
1.9.9.7 Access to both the low SF6 gas pressure alarm and the low SF6 gas pressure cutout contacts shall be provided for the Owner’s SCADA system.
1.9.9.8 All necessary SF6 for initial filling shall be provided for the breaker and shall conform to the requirements of ASTM D2472-71, "Standard Specification for Sulfur Hexafloride."
1.9.9.9 The moisture content of the SF6 gas supplied separate from the breaker shall not exceed 8.9 ppm by weight or 71 ppm by volume.
1.9.9.10 The breaker shall be supplied with an internal desiccant for the absorption of moisture and moisture contaminants.
1.9.9.11 The circuit breaker shall be shipped with a minimal positive pressure of SF6 gas from the factory.
1.9.9.12 Evacuation of the circuit breaker shall not be required to install and gas fill the circuit breaker. Mixing nitrogen with SF6 gas, for any reason, is not acceptable.
1.9.9.13 When practical, the insulating gas system shall be common to all poles. For each gas system, the circuit breaker shall include a shutoff valve between the gas monitoring system and the gas-filled enclosure to provide inspection and replacement of pressure switches and gauges while the enclosure is at rated pressure. A quick disconnect valve may also be considered for isolation of a single phase for maintenance.
1.9.9.14 Gas filling instructions shall be included in the instruction book along with documentation of the required SF6 volume and quality.

1.9.9.15 Vendor shall document the continued operational SF6 quality (i.e., moisture, purity, S02) requirements to maintain the interrupting ratings in the quotation and in the instruction book.
1.9.9.16 Provide a pressure gauge for the gas system.
1.9.9.17 Provide a mechanical relief device for the gas system.
1.9.9.18 The breakers shall be equipped with an electronic gas density monitor that continuously monitors real gas density for all conditions. This monitor shall supplement a separate mechanical monitor. The electronic monitor shall perform the following functions:
1.9.9.19 Monitor shall continuously monitor the gas density in percent.
1.9.9.20 Monitor shall provide three (3) independent contacts for each – low SF6 gas pressure alarm and lockout alarm.
1.9.9.21 Monitor shall indicate gas liquification, real time pressure or vacuum, pressure and vacuum leakage rate
1.9.9.22 Monitor shall datalog the gas characteristics for trending analysis and recording events.
1.9.9.23 Monitor shall measure SF6 gas temperature.

1.9.10 Current Transformers

1.9.10.1 All BCTs shall be multi-ratio type with 5-lead secondaries and an accuracy class of C800 (or better) in accordance with ANSI C57.13.
1.9.10.2 The continuous thermal rating factor of the BCTs shall be 2.0 or higher.
1.9.10.3 The Vendor shall provide two (2) 1200/5A bushing current transformers (BCTs) per bushing on terminals 1,3, and 5 unless otherwise noted in the Purchase Order for a specific circuit breaker.
1.9.10.4 The Vendor shall provide two (2) 3000/5A bushing current transformers (BCTs) per bushing on terminals 2,4, and 6 unless otherwise noted in the Purchase Order for a specific circuit breaker.
1.9.10.5 7.5 The BCT terminal box shall be located on the end of the breaker opposite the mechanism and shall include sliding link terminal blocks.
1.9.10.6 If space limitations prevent the use of a separate BCT terminal box, the BCT wires can be terminated in a separate area of the control cabinet, such as at one end or side of the cabinet, where no other terminal blocks, relays, etc are in close proximity.
1.9.10.7 Terminal block marker tags shall be red color for BCT connections and white for all other connections.
1.9.10.8 All terminal blocks are to be mounted so that they are easily viewed and are accessible. Blocks that are mounted horizontally shall be arranged so that the terminal links drop open when loosened.
1.9.10.9 A removable conduit entrance plate in the bottom of the BCT terminal box shall be provided.
1.9.10.10 Splices in the current transformer secondary leads are not acceptable.

1.9.10.11 The current transformers shall be shorted and tied to a ground reference at the terminal blocks during shipment.

1.9.10.12 Current transformer sets shall be identified with polarity markings and secondary lead designations as specified by NEMA SG 4 as shown on Figure 1.

1.9.10.13 When revenue metering CT's are supplied, metering accuracy tests for each CT unit are required including a ratio and angle correction chart over the normal IEEE meter CT testing range in addition to relay accuracy tests (saturation and ratio) are required. Also when revenue metering CT's are supplied, tracking paperwork that identifies which bushing the CT is in is required.

1.9.10.14 The manufacturer shall supply current transformer housing covers that prevent birds from building nests in or on the current transformer.

1.10 Pressure Switches

1.10.1 All pressure switches shall be adjusted and tested in the factory. The tested values for each switch shall be included in the Test Report. These factory test values will be used as reference points during field checkout.

1.11 Testing

1.11.1 All tests, design and production shall be made in accordance with ANSI Standards C37.

1.11.2 The test report shall include temperature rise data for various circuit breaker components at rated amperes in accordance with ANSI C37.

1.11.3 The minimum trip and the maximum close voltages of each breaker shall be measured in the factory and recorded in the test report.

1.11.4 Tripping and closing current (at nominal voltage rating) shall be recorded for each coil.

1.11.5 The thermal rating factor for the current transformer secondaries shall be included in the test report.

1.11.6 Heat run test shall not be required on each circuit breaker. Design information will be sufficient.

1.11.7 The vendor shall provide complete type/design test reports for the breaker being supplied.

1.11.8 Vendor shall provide a timing diagram showing all elapsed time from initiation of the trip circuit to show start of movement, parting and arc interruption of the main contacts and opening resistor contacts and any delays in the timing sequence.

1.11.9 Vendor shall provide a timing diagram showing all elapsed time from initiation of the closing circuit to show start of movement, arc-over, contact making and any delays in the timing sequence.

1.11.10 Vendor shall provide timing diagrams combining the above opening and closing timing sequences to show the following operations:

1.11.10.1 Open-Reclose

1.11.10.2 Close-Open-Reclose

1.11.10.3 Close-Open

Solar Technical Specification

SP-001

Exhibit F1 – Surge Arrestor Specification

9/30/2019

SUBSTATION SURGE ARRESTERS

1.1. STATION CLASS ARRESTERS

1.1.1. Main Transformer

For all collector substation main transformer banks with a high voltage rating of 46kV and above, station class arresters are required on all bushings/terminals, including the high voltage, low voltage, tertiary voltage and neutral (when required).

1.1.2. Collector Circuit Exits

Station class arresters are required at the line entrance structure for each collector circuit.

1.1.3. Busses

Substation busses normally do not require arresters. For some busses rated 120kV and above, arresters have been installed. For all busses where arresters are installed, station class arresters are required.

1.2. NO ARRESTERS REQUIRED

No arresters are required for the following equipment:

1.2.1. Circuit breakers
1.2.2. Circuit switchers
1.2.3. Reclosers
1.2.4. Station power transformers
1.2.5. Metering transformers

1.3. ADDITIONAL CONSIDERATIONS

1.3.1. ENERGY CAPABILITY

The mininum energy capability ratings required for substation station class arresters in accordance with IEEE standard C62.11-2012, section 8.14.4.1, Table 13 is shown in Table 1-1 below:

Table 1-1

Nominal System Voltage kV	Minimum Energy Class	Capability Ratings Energy Rating (2 shot) kJ/kV MCOV
69 kV and below	E	9
120 kV and 138 kV	F	11
345 kV	Consider F or higher	Per application

1.3.2. POLYMER VS PORCELAIN HOUSING

Both polymer and porcelain housings are available, with polymer being the preferred choice. While porcelain arresters have superior cantilever strength (63,000 to 90,000 in-lb versus 10,000 to 20,000 in-lb for polymer), the advantages of the polymer arrester housing are:

- No internal air space, which removes the chance of moisture ingress
- Vandal proof (from hunters)
- Improved resistance to damage during transportation and handling
- Lower weight, simplifying installation
- High thermal conductivity, which improves heat dissipation
- Hon-explosive failure mode
- Superior pressure relief capabilites (can withstand 80 kA or 100 kA faults versus 65 kA faults for porcelain)

1.3.3. ARRESTER LEAD LENGTH

The arrester lead length from the bus to the top of the arrester, and from the arrester ground terminal to the ground grid should be minimized. During fast front lightning strikes close to the station, the lightning discharge current through the lead wire (typically .4 microhenries/ft of surge impedance inductance) can add as much as 4 kV/ft of additional voltage rise above the arrester clamping voltage, reducing the protective margin to the transformer or other protected equipment significantly. Switching surges and slow rate of rise lightning strokes are not as much of a concern, adding only .5 kV/ft of additional voltage rise above the arrester clamping voltage. For a more detailed calculation of the effect of the arrester lead length, see Annex C of IEEE Standard C62.22-2009.

1.4. METAL OXIDE (MOV) ARRESTER VOLTAGE RATINGS

The MOV arrester voltage ratings for substation applications are shown in Table 1-2 (duty cycle voltage rating) and Table 1-3 (MCOV rating) for various system voltages and circuit conditions.

The selection of the arrester voltage rating is determined by the Maximum Continuous Operating Voltage (MCOV), which is governed by the normal grounding condition of the system. In solidly and effectively grounded systems, the MCOV will not exceed the line-ground voltage. In ungrounded, delta, or high resistance/reactance grounded systems, the MCOV can reach the line-line voltage. The MCOV voltage ratings in Table 1-3 were selected to exceed the expected maximum continuous system operating voltage (1.05 times the nominal system voltage).

Abnormal operating conditions can arise which change the effective grounding of the system. Where abnormal operating conditions are expected, higher MCOV rated arresters may be required. Examples of abnormal operating conditions include:

- load rejection,
- frequent system operation at voltages above the maximum system voltage,
- temporary overvoltage conditions, and

- the possible loss or disconnection of the ground source,such as loss of the separate grounding transformer at some bulk power substations, or islanding at some hydroelectric or distributed generation plants when the system becomes ungrounded with the loss of the bulk power system connection.

Table 1-2		
	Station Class MOV Arrester Rated Voltage (Duty Cycle Rating)	
Nominal System Voltage (kV)	Circuit Conditions Solid & Effectively Grounded Y[1]	Circuit Conditions Ungrounded Y, Delta or High Resistance/Reactance Grounded Y
345	258	-
138	108	-
69	60	72
46	36	48
34.5	27	36

Notes:

1. Effectively Grounded: For HVD voltage classes, a single rating system, the neutral is connected to ground, either solidly or through a resistance or reactance of sufficiently low value to reduce temporary and transient overvoltages and to improve the conditions for selective ground-fault protection. The HVD system is typically “effectively grounded”, such that for all system conditions the ratio of zero-sequence reactance to positive-sequence reactance (X0/X1) is positive and less than 3, and the ratio of zero-sequence resistance to positive-sequence reactance (R0/X1) is positive and less than 1.

Table 1-3		
	Station Class MOV Arrester Rated MCOV	
Nominal System Voltage (kV)	Circuit Conditions Solid & Effectively Grounded Y[1]	Circuit Conditions Ungrounded Y, Delta or High Resistance/Reactance Grounded Y
345	209	-
138	84	-
69	48	57
46	29	39
34.5	22	29

Notes:

1. Effectively Grounded: For HVD voltage classes, a single rating system, the neutral is connected to ground, either solidly or through a resistance or reactance of sufficiently low value to reduce temporary and transient overvoltages and to improve the conditions for selective ground-fault protection. The HVD system is typically “effectively grounded”, such that for all system conditions the ratio of zero-sequence reactance to positive-sequence reactance (X0/X1) is positive and less than 3, and the ratio of zero-sequence resistance to positive-sequence reactance (R0/X1) is positive and less than 1.

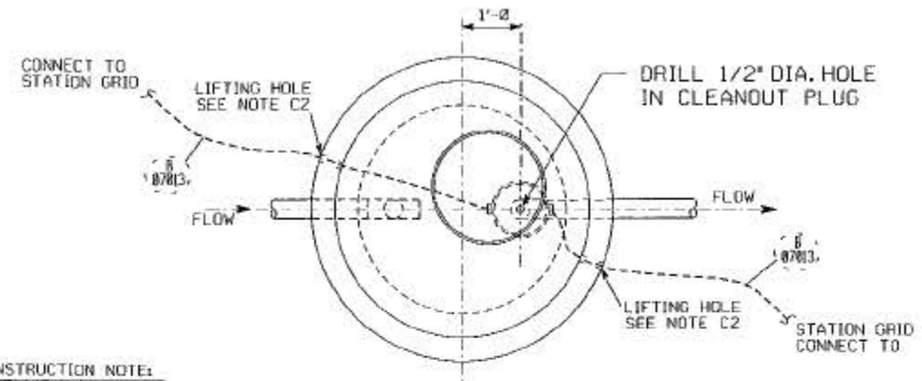
Solar Technical Specification

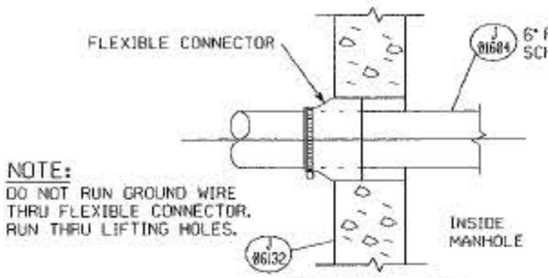
SP-001

Exhibit G1 – Oil Water Seperator Detail

9/30/2019

DWG. NO. _____





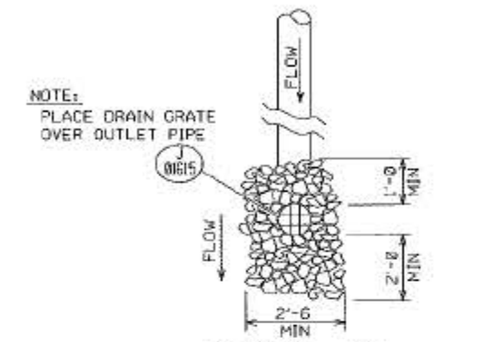
NOTE:
DO NOT RUN GROUND WIRE THRU FLEXIBLE CONNECTOR. RUN THRU LIFTING HOLES.

DETAIL "A"
(MANHOLE WALL PIPE PENETRATION)

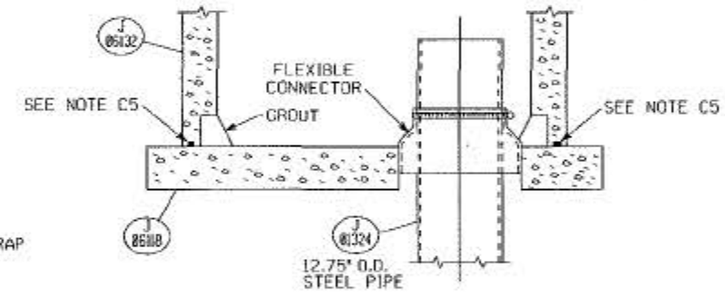
ASSEMBLY * S160A192			(MATERIAL FOR ONE UNIT ONLY)	
COMP/ASSY	QTY	UNIT	DESCRIPTION	SAP Num.
B07013	0	FT	CABLE BARE CU 4/0 SOFT DRAWN	10022758
J01324	1	EA	PIPE ASSEMBLY STEEL 12" DIA.	10084694
J01604	50	FT	PIPE, PVC 6" SCHEDULE 40	10084857
J01615	1	EA	DRAIN GRATE 6" SEWER	10086885
J02813	2	EA	TEE, 6" PVC SCHEDULE 40	10088778
J02836	2	EA	CLEANOUT ASSY, 6" PVC SCH 40	10089232
J02853	4	EA	COUPLING, 6" PVC SCHD 40	10089234
J02860	1	EA	COUPLING, 6"x6"PVC DWV REDUCER	10089236
J06103	1	EA	MANHOLE COVER AND FRAME	10035872
J06118	1	EA	BASE, CONCRETE	10140117
J06132	1	EA	MANHOLE, CONCRETE, 48"	10140128
J06142	1	EA	CONE, CONCRETE	10140129
J06152	4	TB	CAULK, BUTYL RUBBER	10140132
J09169	1	PT	CLEANER, PVC JOINT	10140165
J09170	2	PT	GLUE, PVC JOINT	10140166
M03113	1	CY	RIPRAP	10140568
G170A205	0	EA	OIL-WATER SEPARATOR PIPE	
00616I	4	EA	ANCHOR CONCRETE EXPANSION .625"x4 3/4"	10157360

DESIGNER TO REMOVE THIS NOTE WHEN STATION DRAWING IS DONE

1. ASSEMBLY (INCLUDES ENOUGH 6" PIPE TO EXTEND APPROX. 10' EACH SIDE OF THE M.H. CENTER. (i.e. INLET & OUTLET LENGTHS)
2. NOTIFY ELECTRICAL DESIGNER THAT OIL-WATER SEPARATOR PIPE HAS TO BE GROUNDED & SHOW ON GROUNDING LAYOUT.

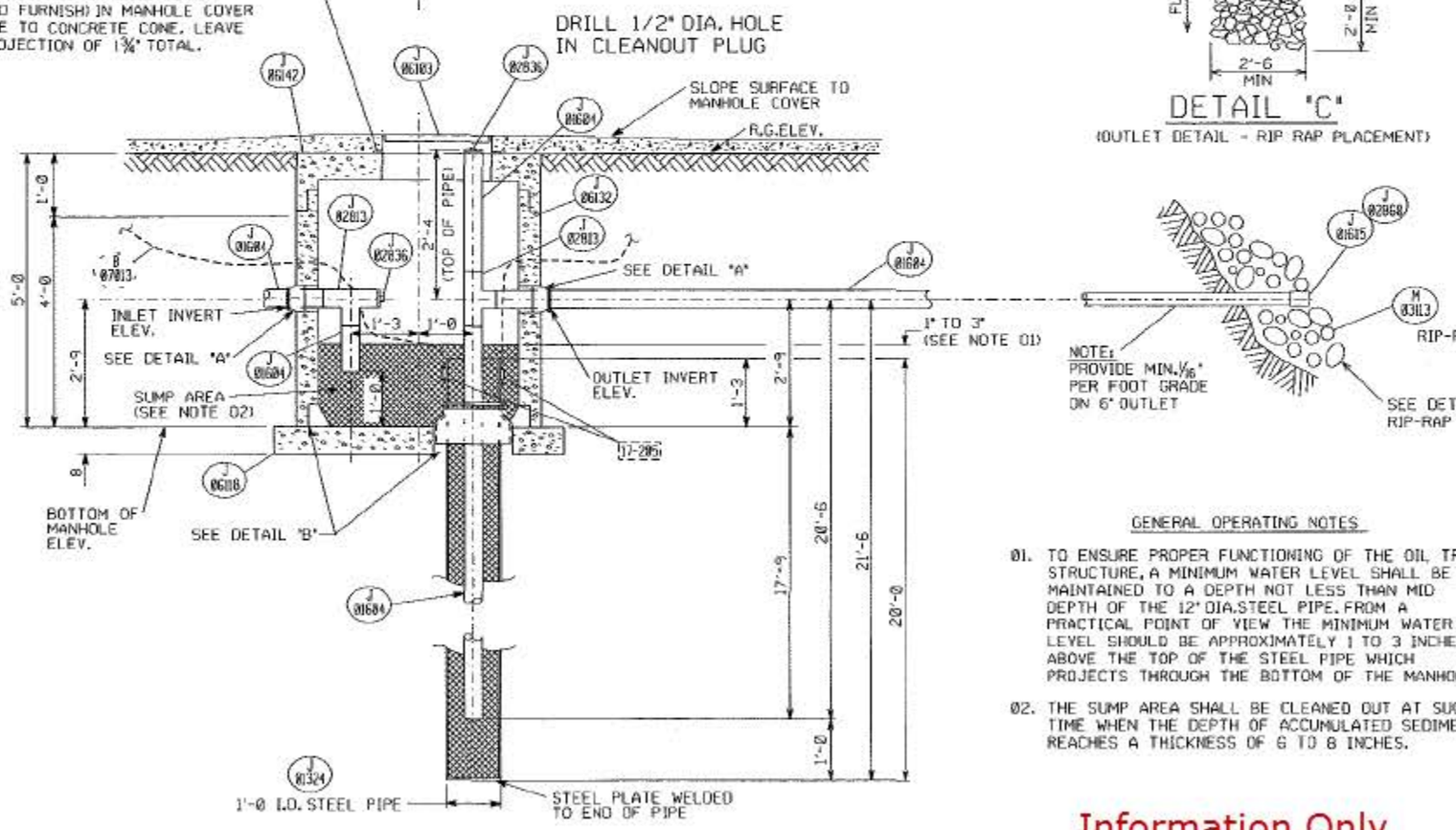


DETAIL "C"
(OUTLET DETAIL - RIP RAP PLACEMENT)



DETAIL "B"
(MANHOLE BASE)

CONSTRUCTION NOTE:
FIELD DRILL & INSTALL (4) 5/8"x4 3/4" KWIK BOLT EXPANSION ANCHORS, HILTI KB3 HDG OR EQUIVALENT (FIELD FURNISH) IN MANHOLE COVER FRAME TO CONCRETE CONE. LEAVE A PROJECTION OF 1 3/4" TOTAL.



GENERAL OPERATING NOTES

01. TO ENSURE PROPER FUNCTIONING OF THE OIL TRAP STRUCTURE, A MINIMUM WATER LEVEL SHALL BE MAINTAINED TO A DEPTH NOT LESS THAN MID DEPTH OF THE 12" DIA. STEEL PIPE. FROM A PRACTICAL POINT OF VIEW THE MINIMUM WATER LEVEL SHOULD BE APPROXIMATELY 1 TO 3 INCHES ABOVE THE TOP OF THE STEEL PIPE WHICH PROJECTS THROUGH THE BOTTOM OF THE MANHOLE.

02. THE SUMP AREA SHALL BE CLEANED OUT AT SUCH TIME WHEN THE DEPTH OF ACCUMULATED SEDIMENT REACHES A THICKNESS OF 6 TO 8 INCHES.

GENERAL CONSTRUCTION NOTES

C1. FOR LOCATION OF OIL TRAP SEE DWG.

C2. USE BUTYL OR SILICON RUBBER CAULKING COMPOUND TO SEAL ANY AND ALL HOLES, CRACKS ETC IN MANHOLE OR BASE TO PREVENT LEAKAGE. INSTALL GROUND WIRES BEFORE SEALING.

C3. PLACE MANHOLE BASE ON A LAYER OF WELL COMPACTED SAND WHERE POOR SOIL CONDITIONS EXIST.

C4. OVERSIZED EXCAVATION FOR INSTALLATION OF 12" STEEL PIPE TO BE BACKFILLED AFTER PIPE IS IN PLACE.

C5. USE NON-SWELLING PREFORMED JOINT SEALANT, (SF302-SYNKO-FLEX WATERSTOP OR EQUAL) SUPPLIED WITH MANHOLE, TO SEAL MANHOLE TO MANHOLE BASE. INSTALL PER MANUFACTURERS STANDARD APPLICATION METHOD. GROUT INSIDE JOINT WITH A NON-SHRINK CEMENT BASED GROUT, (FIVE STAR GROUT OR EQUAL, SUPPLIED BY CONTRACTOR).

Information Only

REF. DWG: DSE7016 SH 189

REV	DATE	DESCRIPTION	BY	APP
E	JAH 03-26-09		RS	

DR. DATE
CK.
SECTION HEAD APP.
DIVISION HEAD APP.
DEPARTMENT HEAD APP.

Consumers Energy

OIL-WATER SEPARATOR DETAIL

SUBSTATION

SCALE	NONE	DRAWING NO.	-E16	SHEET	REV.
JOB	WO				

ASSY MATERIAL NO.	S160A192	ASSY ICON NO.	8005	REV.	E
DRWG	SHT				

S160A192
192
8005
8005

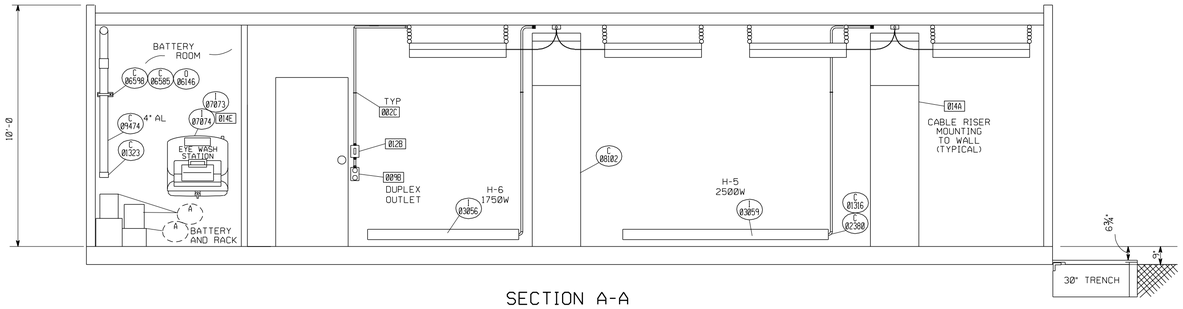
Solar Technical Specification

SP-001

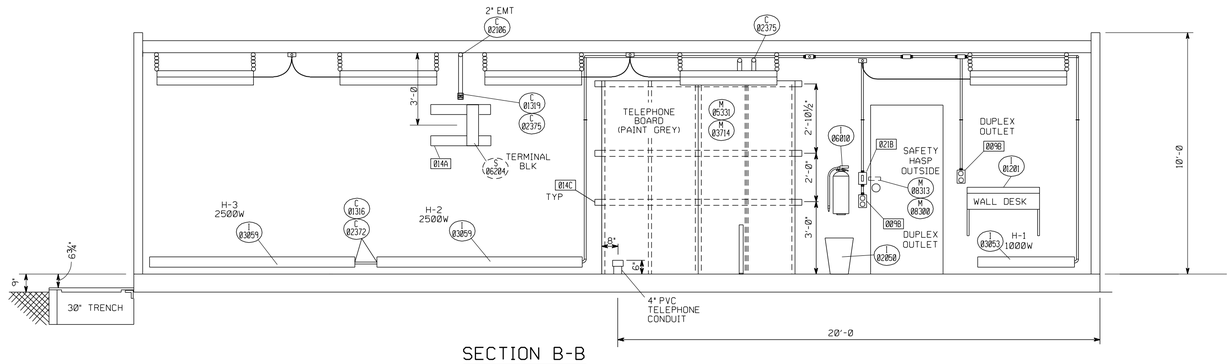
Exhibit G2 – Collector Substation Control Enclosure

9/30/2019

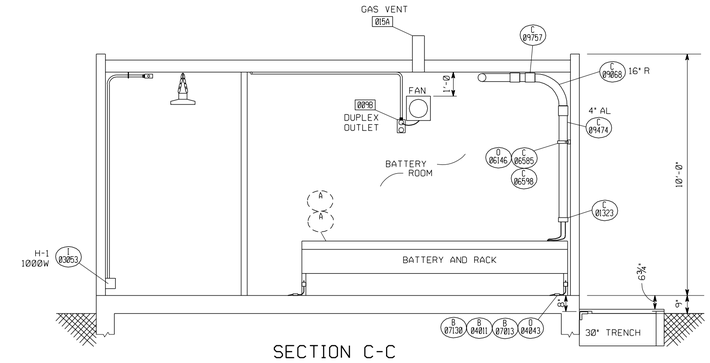
DWG. NO. _____



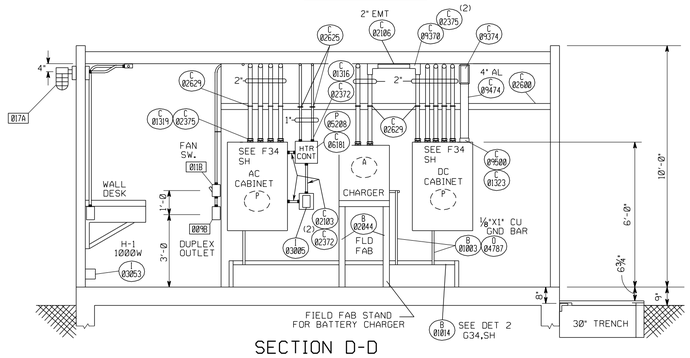
SECTION A-A



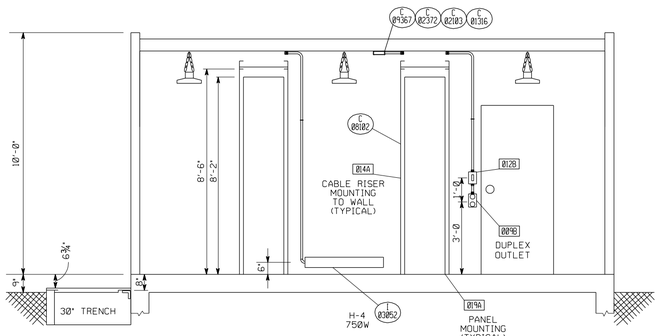
SECTION B-B



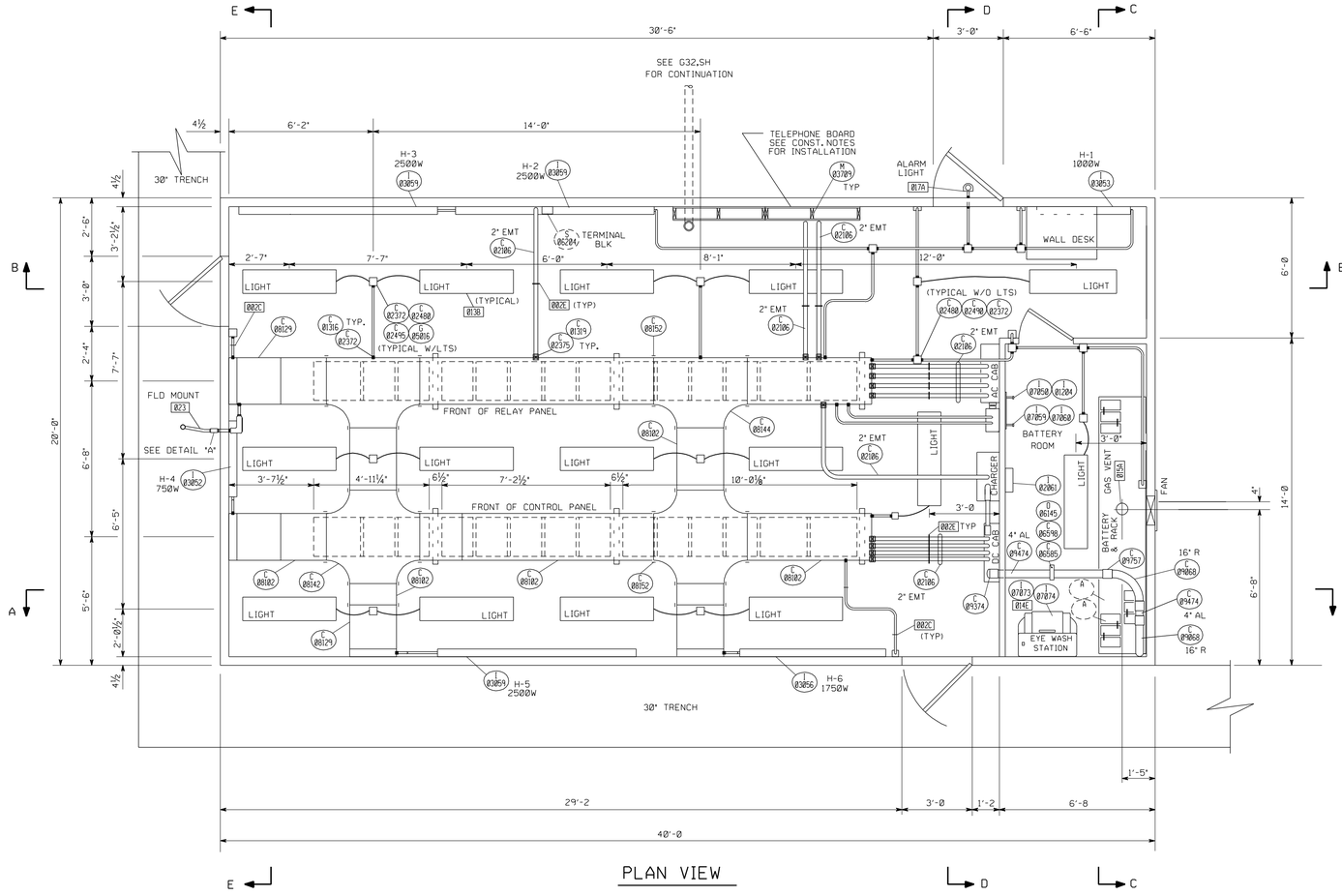
SECTION C-C



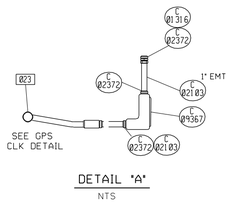
SECTION D-D



SECTION E-E



PLAN VIEW



DETAIL 'A'
NTS

CONSTRUCTION NOTE:

SUGGESTED TELEPHONE BOARD INSTALLATION

1. INSTALL ALUM. BAR AND WALL BACKSIDE PLYWOOD AS SHOWN IN DET 014C. AFTER ATTACHING PLYWOOD TO 2 X 6 IN STUDS. STUDS TO BE PLACED AT APPROX. 2'-0 C/C FOR EACH PIECE OF PLYWOOD. USE GALV. DECKSCREWS (LOCAL PURCHASE) AT 16' C/C.

2. INSTALL FRONT PIECE OF PLYWOOD WITH GALV. DECK SCREWS AT 16' C/C. CO-ORDINATE LOCATION OF SCREWS WITH DRAWING -G .SH .

3. PAINT FRONT PLYWOOD GREY. STUDS AND BACK PIECE OF PLYWOOD DOES NOT REQUIRE PAINT.

CONTRACTOR NOTE:

LOCKING INSTRUCTIONS FOR CONTROL HOUSE DOORS AFTER CONSTRUCTION IS COMPLETE.

AND DOOR:
TO BE USED AS AN EXIT DOOR ONLY. LOCK DOOR FROM OUTSIDE WITH KEY SUPPLIED WITH DOOR. (NOT A SUB KEY) CROSSBAR PANIC DEVICE WILL ALLOW EMERGENCY EXIT FROM INSIDE.

DOOR:
TO BE USED AS AN ENTRANCE AND EXIT DOOR. CROSSBAR PANIC DEVICE TO BE UNLOCKED PERMANENTLY. INSTALL HASP AND SUBSTATION KEYED PADLOCK ON OUTSIDE OF DOOR. (M 03308)

DESIGNER/DRAFTER FILL IN THE FOLLOWING INFORMATION BEFORE ISSUING DRAWING:

1. BATTERY, BATTERY CHARGER & RACK ITEM NUMBERS.
2. NORTH ARROW.
3. DIRECTIONS ON DOOR LOCKING NOTE.
4. DRAWING NUMBERS FOR AC-DC CABINETS.
5. HOUSE NUMBER, GWO, SUBSTATION, ETC. IN TITLE BLK.

MISCELLANEOUS EQUIPMENT FOR CONTROL HOUSE

I-01103	36X24X42 CABINET
I-01600	WD WALL FRAME
I-02023	2 DRAWER FILE CABINET
I-04000	12 HR WALL CLOCK
I-04010	WALL THERMOMETER
I-07043	FIRST AID KIT
I-09100	3 FT STEP LADDER
I-09102	6 FT PLATFORM LADDER
M-05510	GRANITEX FLOOR HARD (TO BE APPLIED)
M-05500	LIQUID FLOOR WAX (TO BE APPLIED)

NOTES

1. ALL MOUNTING PLATES ARE SHOWN ON DRAWING MD-E6450 SH.1.
2. ALL CONDUIT 1" EMT UNLESS OTHERWISE NOTED.
3. USE MP-7 PLATES (M-04175) AND ¼" X 2½" SHEET METAL SCREWS (O-05535) FOR MOUNTING EQUIPMENT AND CABLE RISERS TO HOUSE WALLS. (014A)
4. MOUNT COPPER GROUNDING BAR TO SWBD PANELS WITH ½"-20 X ¾" SCREWS (S-01540) AND ¼"-20 UNISTRUT NUT (S-00152).
5. MOUNT ALARM LIGHT SO IT IS VISIBLE FROM DRIVE.
6. FOR DETAILS ON SUPPORT FOR CABLE TROUGH SEE G34 SH. & .

LEGEND

- ⬭ = BILL OF MATERIAL ITEM
- ⬭ = NOT PART OF THIS UNIT. TO BE ORDERED BY I&C, MAJOR EQUIPMENT, DESIGNER, OR INCLUDED IN ANOTHER ASS'Y.
- ▭ = SEE ELECTRICAL ASSEMBLY DETAIL PACKAGE OR BLUE BOOK
- ⌜ _ _ ⌝ = DETAIL NOT PART OF THIS UNIT

Exhibit A-14
Page 1 of 4

ASSY D S G 2 5 3 4 0 0 9 ELECTRICAL

-G34 SH.	GROUNDING AND FLOOR CONDUIT LAYOUT													DR.	DATE
-G34 SH.	CABLE TRAY SUPPORT LAYOUT													CK.	
-G34 SH.	BUILDING LAYOUT													APP.	SECTION HEAD
														APP.	DIVISION HEAD
DRAWING NO.	REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	BY	APP	REV	DATE	DESCRIPTION	BY	APP			APP.	DEPARTMENT HEAD

Consumers Energy

20'X40' CONTROL HOUSE - MAXIMUM OF (8) 46KV BAYS
EXPANSION LEFT WITH TELEPHONE BOARD

TYPICAL CONTROL ENCLOSURE LAYOUT

SUBSTATION

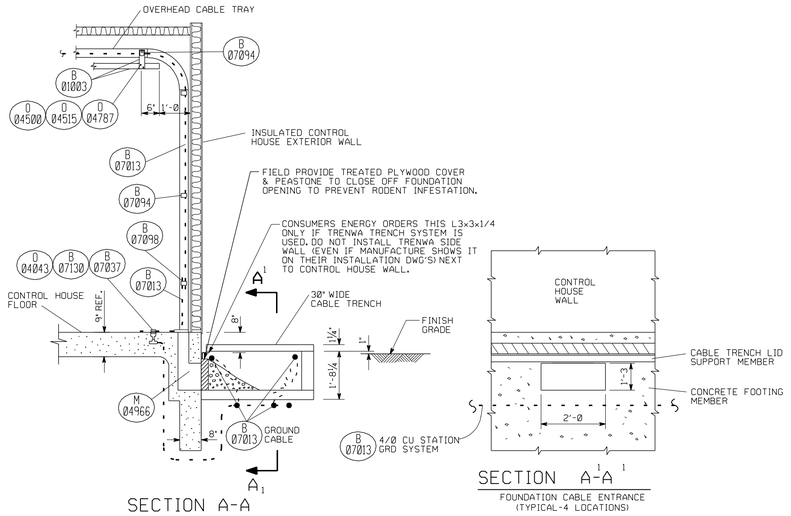
SCALE	DRAWING NO.	SHEET	REV.
¾" = 1'-0"	-G34		
JOB GWO			

F 10/13/09 JAH

2534009 .DGN RS

D S G 2 5 3 4 0 0 9 F

DWG. NO. _____

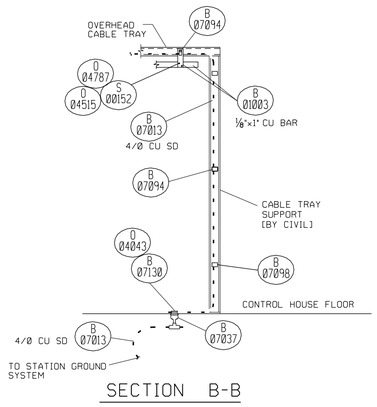


SECTION A-A

VIEW MAY BE OPP. HAND
2 LOCATIONS

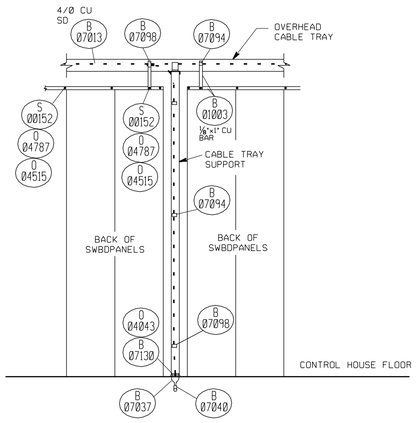
SECTION A-A

FOUNDATION CABLE ENTRANCE
(TYPICAL-4 LOCATIONS)



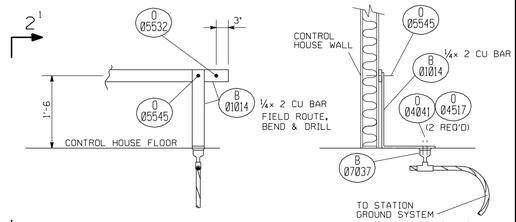
SECTION B-B

CABLE TRAY SUPPORT &
PANEL GROUND (TYPICAL)
2 LOCATIONS



SECTION C-C

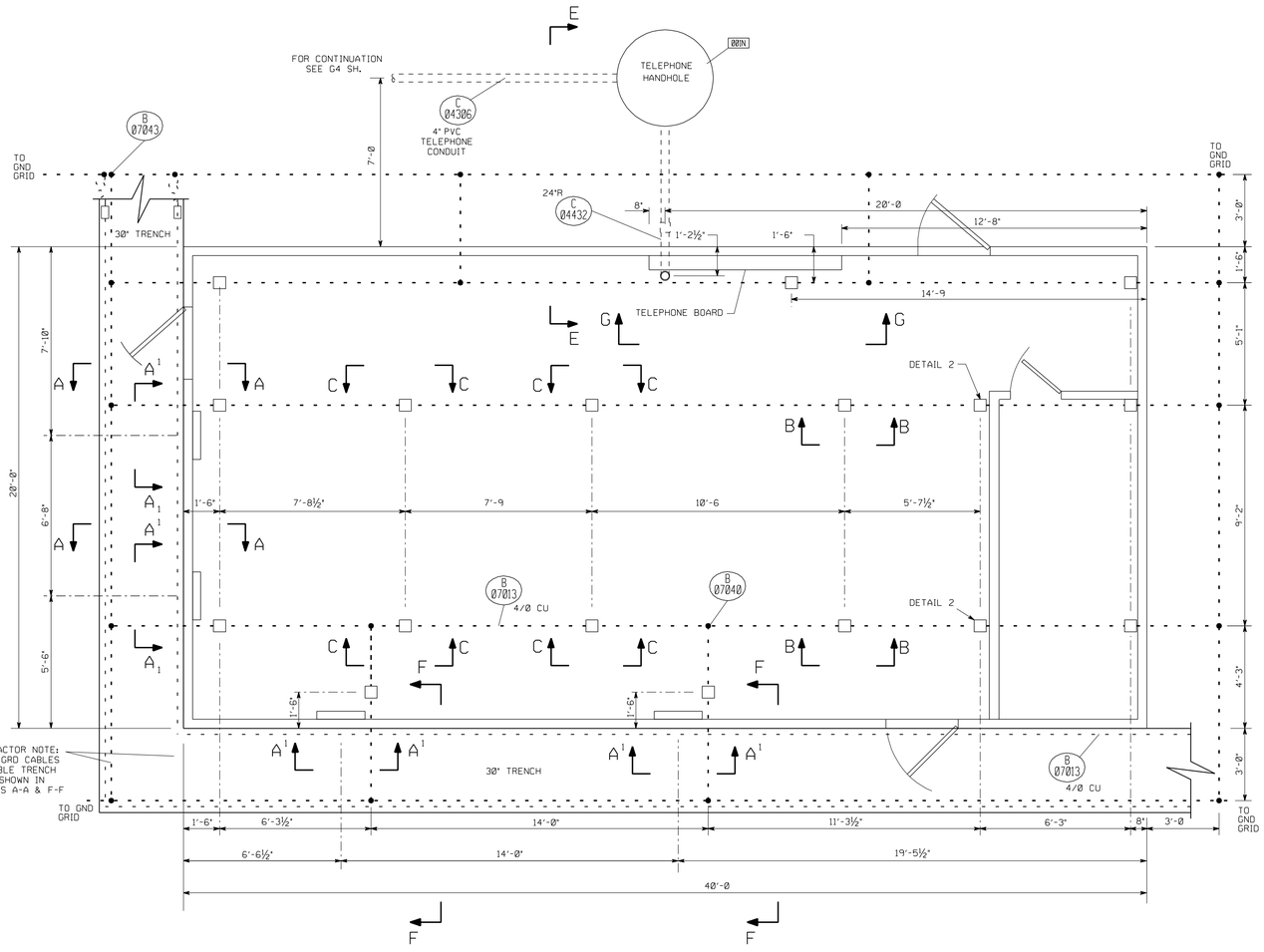
CABLE TRAY SUPPORT &
PANEL GROUND (TYPICAL)
4 LOCATIONS



DETAIL 2

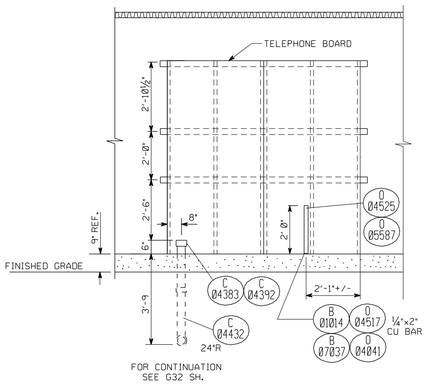
TYP. EQUIP. WALL MOUNTED GRD BUS

SECTION 2-2



FLOOR CONDUIT & GROUNDING LAYOUT

FOR HOUSE FOUNDATION
SEE DETAIL 718A

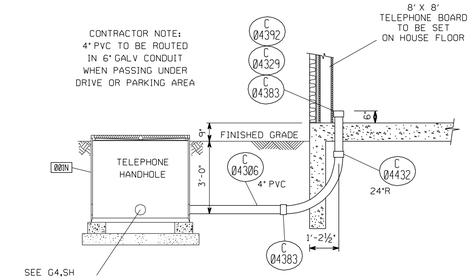


SECTION G-G

TELEPHONE CONDUIT

SECTION F-F

2 LOCATIONS



SECTION E-E

TELEPHONE CONDUIT

LEGEND

- ⬭ = BILL OF MATERIAL ITEM
- ⬭ (dashed) = NOT PART OF THIS UNIT. TO BE ORDERED BY I&C, MAJOR EQUIPMENT, DESIGNER, OR INCLUDED IN ANOTHER ASS'Y.
- ▭ = SEE ELECTRICAL ASSEMBLY DETAIL PACKAGE OR BLUE BOOK
- - - = DETAIL NOT PART OF THIS UNIT

THESE ITEMS ARE VARIABLES AND NEED TO BE ORDERED SEPERATELY
4" PVC TELEPHONE CONDUIT TO OUTSIDE STATION FENCE

DESIGNER/DRAFTER FILL IN THE FOLLOWING INFORMATION BEFORE ISSUING DRAWING:

1. NORTH ARROW
2. HOUSE NUMBER, SUBSTATION, GWO, ETC. IN THE TITLE BLOCK.

Exhibit A-14
Page 2 of 4

20'X40' CONTROL HOUSE - MAXIMUM OF (8) 46KV BAYS
EXPANSION LEFT WITH TELEPHONE BOARD

ASSY DSG25340010 EMBEDDED CONDUIT & GROUNDING

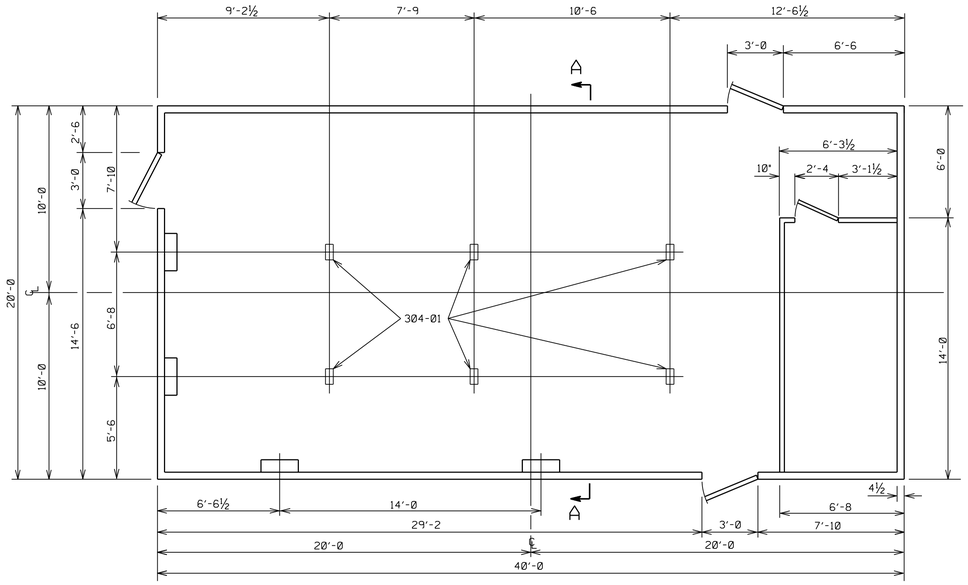
-G34 SH.	ELECTRICAL LAYOUT													DR.	DATE
-G34 SH.	CABLE TRAY SUPPORT LAYOUT													CK.	
-G34 SH.	BUILDING LAYOUT													APP. SECTION HEAD	
														APP. DIVISION HEAD	
DRAWING NO.	REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	BY	APP	REV	DATE	DESCRIPTION	BY	APP			APP. DEPARTMENT HEAD	

Consumers Energy

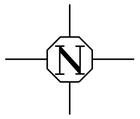
HVD CONTROL HOUSE
GROUNDING & CONDUIT LAYOUT
SUBSTATION

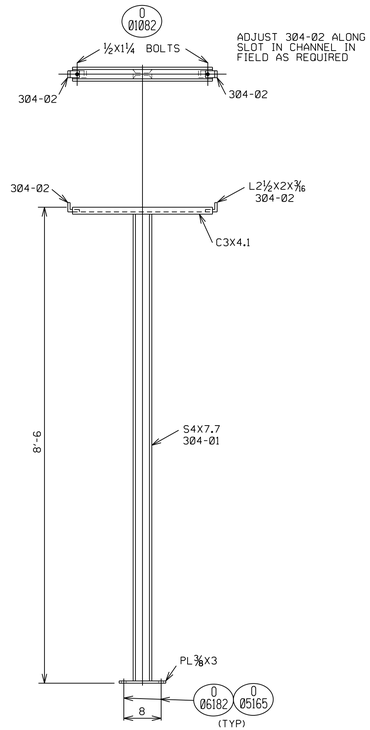
SCALE 3/8" = 1'-0" | DRAWING NO. -G34 | SHEET | REV.
JOB WO

E JAH 10-13-09 | 2534010 | RS* | DSG25340010E

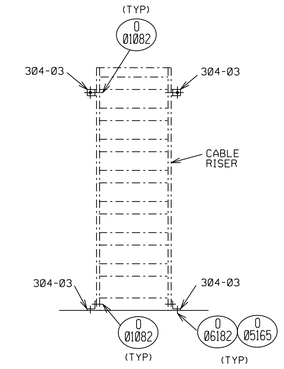


PLAN VIEW

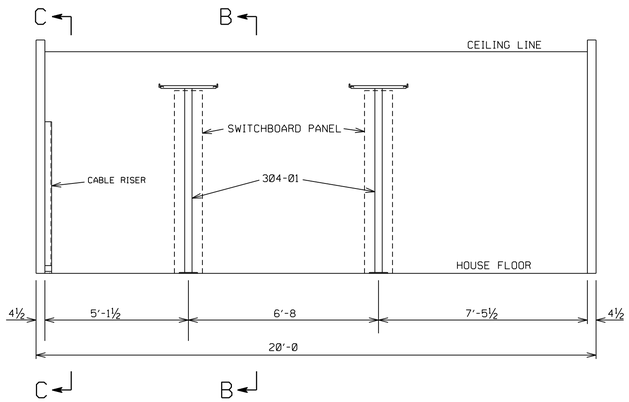




SECTION B-B



SECTION C-C
(TYPICAL)



SECTION A-A
(TYPICAL)

2534007

Exhibit A-14
Page 3 of 4

ASSY CTS2534 007

20'×40' CONTROL HOUSE

DRAWING NO.	REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	BY	APP
	CONTROL HOUSE ELECTRICAL LAYOUT					
	STEEL DETAILS					
	CONTROL HOUSE BUILDING LAYOUT					

DATE
DR.
CK.
SECTION HEAD APP.
DIVISION HEAD APP.
DEPARTMENT HEAD APP.

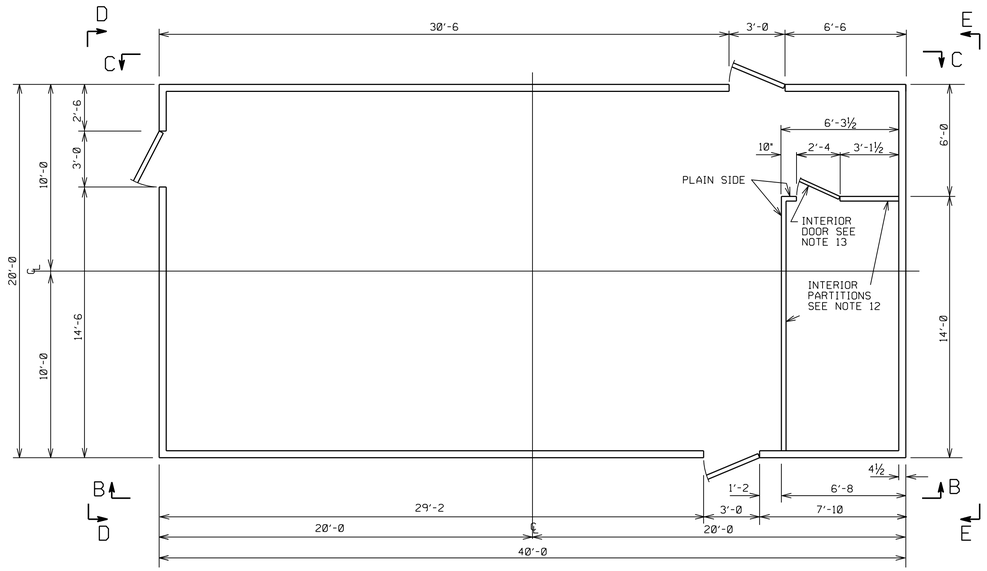
Consumers Energy

CONTROL HOUSE
CABLE TRAY SUPPORT LAYOUT
EXPANSION LEFT
SUBSTATION

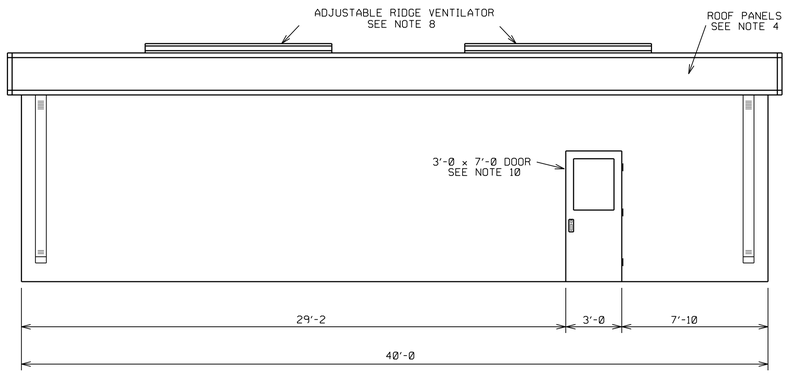
SCALE NONE | DRAWING NO. | SHEET | REV.
JOB WO

JAH 05/06/10

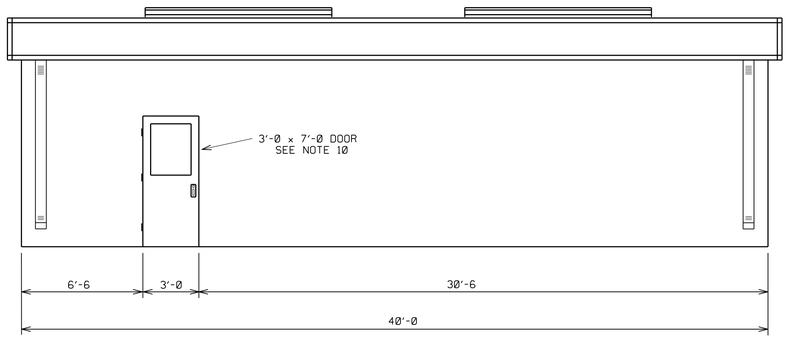
RS # DSF2534 007 I



PLAN "A-A"



ELEV "B-B"



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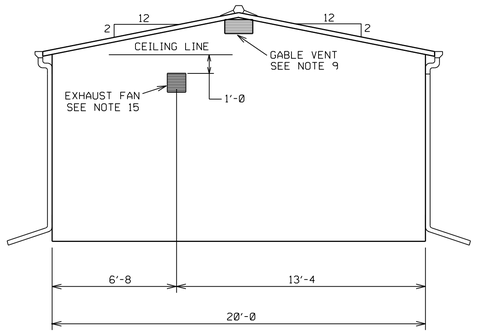
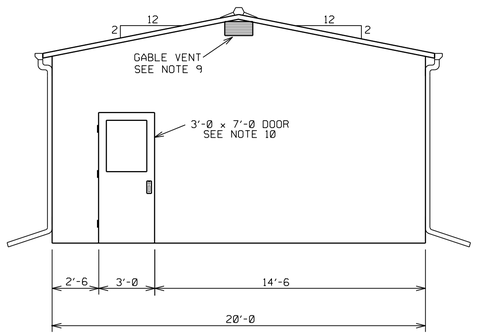


ELEV "E-E"



ELEV "D-D"

SHIPPING NOTE

ALL MATERIAL SHALL BE PACKAGED SUCH THAT DAMAGE IS MINIMIZED DURING LOADING, SHIPPING & UNLOADING OPERATIONS. DUE CONSIDERATION SHOULD BE GIVEN TO THE ADEQUACY OF THE PACKING MATERIAL AND TECHNIQUE WHEN EXPOSED TO NATURAL ELEMENTS OVER AN EXTENDED PERIOD OF TIME

DESIGN SPECIFICATIONS

BUILDING TO BE DESIGNED FOR 20 PSF WIND LOAD AND 40 PSF VERTICAL LIVE LOAD

MATERIAL SPECIFICATIONS

BUILDING TO BE FURNISHED WITH THE FOLLOWING:

1. 16" WIDE PANELS WITH 3" RIBS.
2. PAINTED, GALVANIZED METAL PANEL CEILING COLOR "WHITE".
3. INSULATED, PAINTED METAL INTERIOR LOCK-IN WALL LINER PANELS, COLOR "WHITE".
4. ROOF PANELS TO BE MINIMUM 24 GAGE STEEL COATED ON BOTH SIDES WITH CORROSION RESISTANT ALUMINUM ZINC ALLOY. (GALVALUMA)
5. 3" FRICTION FIBERGLASS INSULATION FOR EXTERIOR WALLS AND 6" FRICTION FIBERGLASS INSULATION FOR CEILING.
6. GUTTERS, DOWNSPOUTS, BOTTOM BOOTS AND RUNOFF EXTENSIONS FOR EACH SIDE OF BUILDING.
7. ANCHOR BOLTS, ⅜" DIA. STD. DRILL IN TYPE OR EQUAL (BY CONSUMERS).
8. TWO (2) 4" THROAT X 10'-0 LONG ADJUSTABLE RIDGE VENTILATORS FIXED IN THE OPEN POSITION.
9. TWO (2) ADJUSTABLE LOUVERED GABLE VENTS OR EQUAL (ONE IN EACH GABLE).
10. THREE (3) 3'-0 WIDE X 7'-0 HIGH X 1¾" #20 GA MINIMUM COMMERCIAL STANDARD CLEAR GLAZED OUTSWING EXTERIOR METAL DOORS. ONE (1) DOOR TO BE RIGHT HAND HINGED AND TWO (2) DOORS TO BE LEFT HAND HINGED AS OBSERVED FROM THE OUTSIDE OF THE BUILDING. (SEE NOTE 16)
11. EXTERIOR DOOR TO BE FURNISHED WITH WEATHERSTRIPPING, THRESHOLD AND RIM TYPE CROSSBAR PANIC DEVICE PER ANSI A156.3 TYPE 1, GRADE 1, FUNCTION 05 AND HYDRAULIC SURFACE APPLIED DOOR CLOSER WITH ADJUSTABLE SPRING FORCE & HYDRAULIC BACK CHECK FOR DOORS TO MEET ACCESSABILITY REQUIREMENTS.
12. APPROXIMATLY 20'-0 OF NON-INSULATED INTERIOR PARTITIONS INCLUDING BASE AND CEILING TRIM.
13. ONE (1) 2'-4 WIDE X 7'-0 HIGH X 1¾" #20 GA MINIMUM COMMERCIAL, OUTSWING, INTERIOR METAL DOOR WITH FIXED LOUVERS IN BOTTOM PANEL AND LEFT HAND HINGES AS OBSERVED FROM PLAIN SIDE OF PARTITION.
14. INTERIOR DOOR TO BE FURNISHED WITH PASSAGE SET WITHOUT KEY, KNOB LOCKS AND THRESHOLD.
15. ONE (1) EXHAUST FAN RATED AT APPROX. 1000 CFM @ 0 STATIC PRESSURE WITH 120V, 60 CYCLE, SINGLE PHASE MOTOR (GREENHECK SE1-10-440-D OR EQUAL) AND AUTOMATIC MOTOR OPERATED WEATHERPROOF LOUVERS. FAN TO BE LOCATED IN WALL APPROX. 1'-0 BELOW CEILING.
16. SHOP PAINT: FOLLOWING COLORS OR EQUAL:
    PARKLINE:
    EXTERIOR SIDEWALLS "LAUREL GREEN". DOORS "ROMAN BRONZE" AND TRIM "ARCTIC WHITE".
    RELIABLE:
    EXTERIOR SIDEWALLS "MIST GREEN". DOORS "TAN" AND TRIM "POLAR WHITE".

Exhibit A-14
Page 4 of 4

ITEM M68930 20'X40' CONTROL HOUSE

ASSY C C H 2 5 3 4 Ø Ø 8

							DATE
	CONTROL HOUSE ELECTRICAL LAYOUT						DR.
	CABLE TRAY SUPPORT LAYOUT						CK.
							SECTION HEAD APP.
F200C718A	FOUNDATION DETAIL						DIVISION HEAD APP.
DRAWING NO.	REFERENCE DRAWINGS		REV	DATE	DESCRIPTION	BY	APP DEPARTMENT HEAD APP.

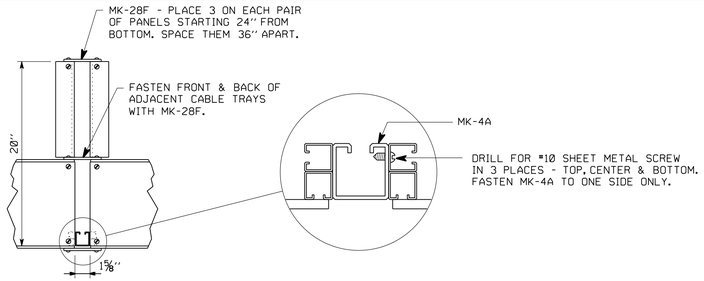
Consumers Energy

CONTROL HOUSE
BUILDING LAYOUT
EXPANSION LEFT
SUBSTATION

SCALE 1/4" = 1'-0	DRAWING NO.	SHEET	REV.
JOB WO			

J - JAH 05-06-10

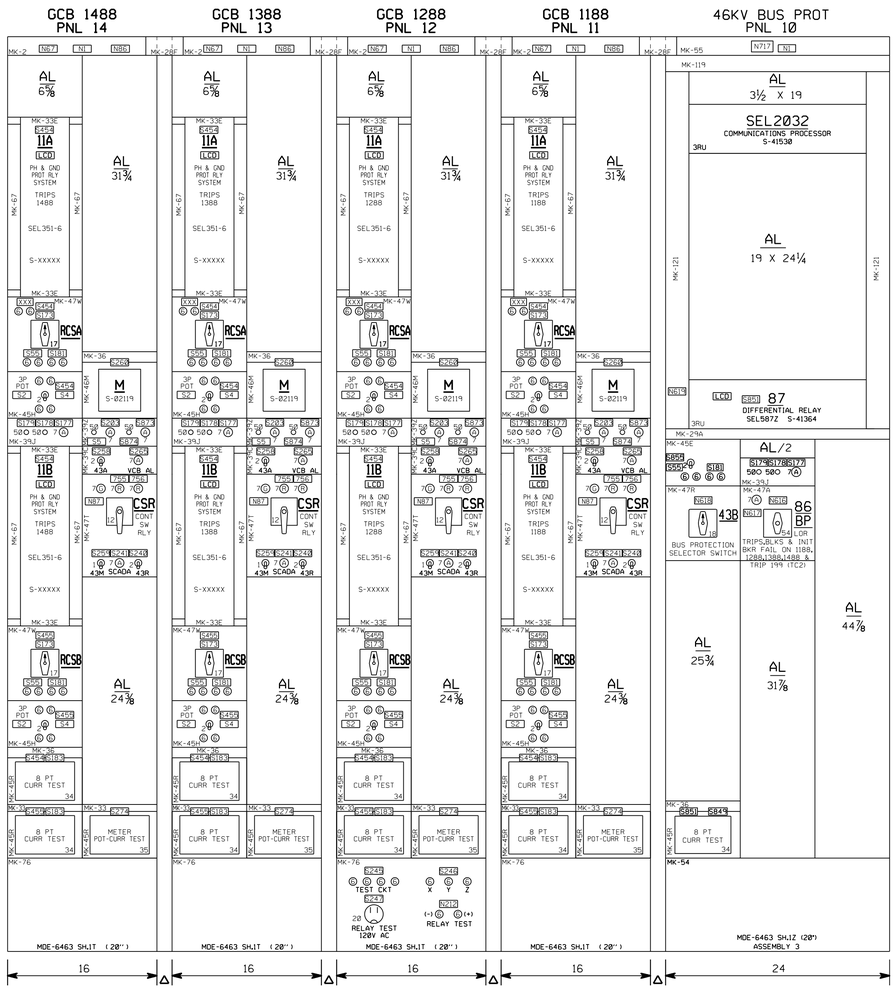
2534008 RS # D S F 2 5 3 4 Ø Ø 8 J



TOP VIEW OF MODULAR PANELS SHOWING 1 5/8" SPACING UNISTRUT MK-4A AT FRONT OF PANEL.

BILL OF MATERIAL LIST - WO 19147639

REF	B/M NO.	DESCRIPTION	PNL 10 QUAN	PNLS 11, 13-14 QUAN	PNL 12 QUAN	PNL 1 QUAN	PNL 2 QUAN	PNL 3 QUAN
1	S-05301	RELAY TEST SW - SINGLE POT.		3	1			
2	S-05302	RELAY TEST SW - DOUBLE POT.	1	18	6	2	2	
6	S-06111	BINDING POST & POT. CAL. TERM.	4	48	25	10	25	8
7A	S-06368	AMBER IND. LAMP 125V DC ET-16	2	3	5	5	2	5
7G	S-06366	GREEN IND. LAMP 125V DC ET-16		3	1	1		
7R	S-06365	RED IND. LAMP 125V DC ET-16		6	2	2		
11	S-05501	SYNC SWITCH				1		
12	S-05107	CONTROL SW RELAY - CSR		3	1	1		
17	S-05919	ELECTRO SW 24210YG SEL SW		6	2		2	2
18	S-05910	ELECTRO SW 24316YD SEL 5W (43B)	1					
19	S-06521	TEST PLUG 8PT JONES S-308-AB				1		
20	S-06511	OUTLET 2P 3W 120V - RLY TEST ONLY			1		1	
33	S-06104	CT RELAY TEST BLOCK 4 POINT						6
34	S-06108	CT RELAY TEST BLOCK 8 POINT	1	3	1	1	1	
35	S-06109	PT-CT RELAY TEST BLOCK 9 POINT		6	2	1		
50	S-05001	PUSHBUTTON SWITCH SQ.D AP-221	2	12	4	5	4	7
54	S-46002	LOR 10 STAGE 125V DC - 7810K				1		2
60	S-06340	SOCKET, PORCELAIN				2		
61	S-06341	LAMP 15W SCREW BASE 120V				2		
	S-99031	SWBD ASSEMBLY	1	3	1	1	1	1
	S-99033	SWBD DELIVERY	1					
43A	S-05901	MODE OF OPERATION SWITCH				1		
SYN	S-02401	SYNC SCOPE/LED				1		
11	S-XXXXX	SCHWEITZER SEL351-6 125V DC				1		
		SEL0351G7A4B54XXI (HORIZ MT.)						
11P1, 11P2	S-XXXXX	SCHWEITZER SEL311L 125V DC					2	
		SEL0311L12DD3254X1XX (VERT MT.)						
87T1,T2	S-41360	SCHWEITZER SEL387 TBI DIFF RLY						2
		SEL0387S04X57XX4XI (HORIZ MT.)						
M	S-41609	SATEC PM130P-PLUS 125V DC		3	1	1		
11A,11B	S-XXXXX	SCHWEITZER SEL351-6 125V DC		6	2			
		SEL0351G8A4B542XI (HORIZ MT.)						
87	S-41364	SCHWEITZER SEL587Z DIFF RLY 125V DC	1					
		SEL0587Z0X325H12XX (HORIZ MT.)						
SEL2032	S-41530	SCHWEITZER SEL2032 RLY COMM PROCESSOR	1					1
		SEL203203X30XXXXX (HORIZ MT.)						



△ 1 5/8" SPACER (MK-4A) S-00004

							DATE		
						DR.	02/13/13		
						CK.	02/13/13		
							SECTION HEAD		
						APP.	02/13/13		
							DIVISION HEAD		
						APP.	02/13/13		
							DEPARTMENT HEAD		
						APP.	02/13/13		
DRAWING NO.	REFERENCE DRAWINGS		REV	DATE	DESCRIPTION	BY	APP		

Consumers Energy

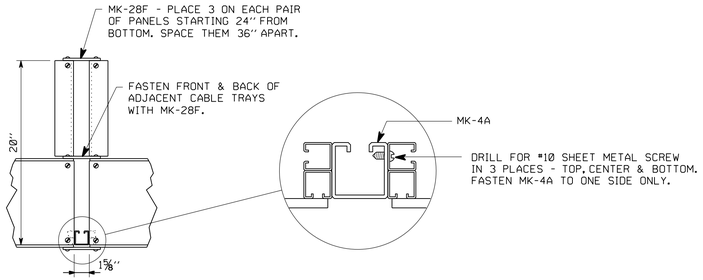
JACKSON, MICHIGAN

34.5KV & 345KV PANELS CCH

FRONT VIEW OF SWITCHBOARDS

CROSS WINDS GENERATION — SUBSTATION

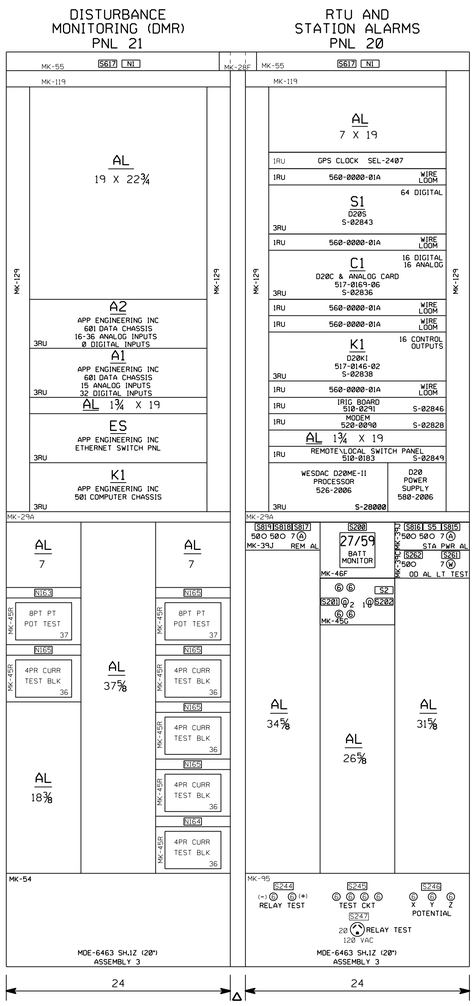
SCALE	1½" = 1'-0"	DRAWING NO.	SHEET	REV.
JOB	WO 19147639	1630-F11	2	

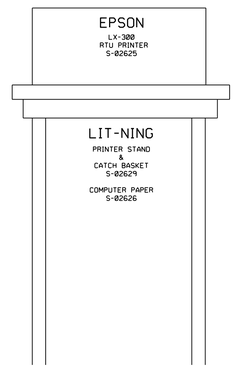


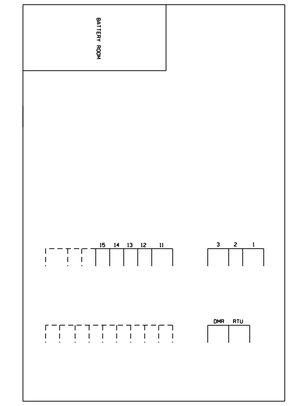
TOP VIEW OF MODULAR PANELS SHOWING 1 5/8'' SPACING UNISTRUT MK-4A AT FRONT OF PANEL.

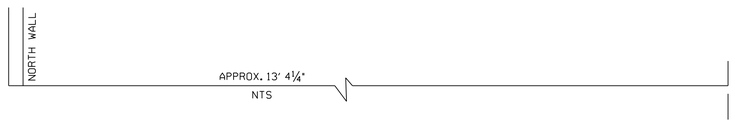
BILL OF MATERIAL LIST - WO 19147639

REF	B/M NO.	DESCRIPTION	PNL 20 QUAN	PNL 21 QUAN
1	S-05301	RELAY TEST SW - SINGLE POT.	1	
2	S-05302	RELAY TEST SW - DOUBLE POT.	1	
6	S-06111	BINDING POST & POT. CAL. TERM.	13	
7A	S-06368	AMBER IND. LAMP 125V DC ET-16	2	
7W	S-06367	WHITE IND. LAMP 125V DC ET-16	1	
20	S-06511	OUTLET 2P 3W 120V - RLY TEST ONLY	1	
36	S-06114	CT TEST BLOCK 4 PAIR		5
37	S-06113	PT TEST BLOCK 8 POINT		2
50	S-05001	PUSHBUTTON SWITCH SQ.D AP-221	5	
54	S-46002	LOR 10 STAGE 125V DC - 7810K	1	
EPSON	S-02625	RTU PRINTER	1	
LIT-NING	S-02629	PRINTER STAND ASSEMBLY	1	
	S-02626	COMPUTER PAPER 9½" X 11"	1	
	S-99031	SWBD ASSEMBLY	1	1
	S-99033	SWBD DELIVERY	1	
	S-02828	WESDAC MODEM 520-0090	1	
C1	S-02836	WESTERM D20C W/OPT ANALOG	1	
K1	S-02838	WESTERM D20KII 517-0146-02	1	
S1	S-02843	WESTERM D20S	1	
	S-02846	IRIG BOARD 510-0291	1	
	S-02849	REM/LOC SWITCH PNL 510-0183	1	
	S-28000	WESDAC D20ME-II 125V DC 526-2006	1	
		D20 POWER SUPPLY 580-2006		
27/59	S-06904	BATTERY MONITOR 125V DC BA31251207A	1	
GPS		SEL 2407 SATELLITE-SYNCHRONIZED CLOCK	1	









△ 1 5/8'' SPACER (MK-4A) S-00004

DRAWING NO.	REFERENCE DRAWINGS		REV	DATE	DESCRIPTION	BY	APP
							DR. DATE 02/13/13
							CK. 02/13/13
							APP. SECTION HEAD 02/13/13
							APP. DIVISION HEAD 02/13/13
							APP. DEPARTMENT HEAD 02/13/13

Consumers Energy
JACKSON, MICHIGAN

RTU & DMR PANELS CCH

FRONT VIEW OF SWITCHBOARDS

CROSS WINDS GENERATION SUBSTATION

SCALE	1½'' = 1'-0''	DRAWING NO.	SHEET	REV.
JOB	WO 19147639	1630-F11	1	

T

SPECIFICATION

FOR

CONSUMERS ENERGY

SWITCHBOARD PANEL FABRICATION

SPECIFICATION NO.: MSPF-04

SPECIFICATION DATE: 04/27/2012

1.0 GENERAL REQUIREMENTS

1.1 SCOPE

1.1.1 This specification covers the material, fabrication, wiring, inspection and delivery requirements for switchboard panels to be installed in substation control houses on the Consumers Energy Company's (CEC) electric system.

1.1.2 Refer to the CEC purchase order for details pertaining to a particular switchboard panel fabrication job.

2.0 MATERIAL

2.1 MK PARTS

2.1.1 Framework and panel material will be shown by MK numbers on the drawings.

2.1.2 This material will be furnished by the fabricator, and will not appear on the panel fabrication bill of material.

2.1.3 The cost of supplying and fabricating the MK parts required for the panel shall be included in the fabricator's bid.

2.1.4 All MK parts will be in accordance with the latest Switchboard Modular Steel & Framework Assembly specification.

2.1.4.1 The fabricator shall refer to the latest revisions of CEC's MD-E6463 series of drawings for details on the MK parts.

2.2 MISCELLANEOUS

2.2.1 A bill of material will be furnished by CEC for each panel fabrication job.

2.2.2 CEC will furnish all equipment listed on the bill of material, including wire terminal lugs, unless otherwise specified.

2.2.3 The fabricator shall furnish all bolts, screws, washers, nuts, aluminum filler plates, wire, wire duct, wire ties, mimic buses, paint and other miscellaneous small items not furnished by CEC.

2.2.4 All fabricator furnished bolts, washers and nuts shall be plated to inhibit rust.

2.2.4.1 The cost of these items is to be estimated and included in the bid price.

2.2.5 Nameplates will be furnished by CEC, and mounted by the fabricator with GE Metallic Silicon Glue (GE# 2564-51DP) adhesive (or equivalent) as located by the drawings.

3.0 FABRICATION

3.1 PANEL SUPPORTS

3.1.1 The supporting framework will be in accordance with the latest Switchboard Modular Steel & Framework Assembly specification.

3.1.1.1 The fabricator shall refer to the latest revisions of CEC's MD-E6463 series of drawings for details on the supporting framework.

3.1.1.2 The sheet number of this drawing, which applies to a particular panel, will be indicated on the front view drawing.

3.2 FINISHING STEEL

3.2.1 Steel parts furnished by the fabricator will be finished before fabrication, unless otherwise stated.

3.2.2 Panel fronts will be given another coat of paint by the fabricator, if necessary, to obtain a good color match between various parts.

3.2.3 All MK parts shall be free of mill scale, cleaned with lacquer thinner, and painted with Sherwin Williams Co. Opex Industrial Spray Lacquer, Pale Gray (No. L61A23) or equivalent.

3.2.3.1 This lacquer may be applied directly on a sand blasted surface without primer or on a suitably cleaned and lacquer-primed coated surface.

3.2.3.2 Do not use a brush to apply the primer or the finish coat.

3.2.4 The "finished" steel must pass the adherence test by not pulling off when Scotch brand filament, pressure sensitive tape (No. 898) is stuck to it and pulled off.

3.3 FINISHING ALUMINUM

3.3.1 The fabricator is to furnish 1/8" thick panels of aluminum to fill panel spaces not occupied by MK parts or other equipment.

3.3.2 All aluminum panels are to be cleaned and coated with a suitable lacquer primer, and painted with Sherwin Williams Co. Opex Industrial Spray Lacquer, Pale Gray (No. L61A23) or equivalent.

3.3.3 The "finished" aluminum must pass the adherence test by not pulling off when Scotch brand filament, pressure sensitive tape (No. 898) is stuck to it and pulled off.

4.0 GROUNDING

4.1.1 To ensure proper grounding of metal panels and metal cases of instruments, relays and other equipment, all panel assembly and equipment mounting bolts shall be installed with multiple internal tooth lock washers.

4.1.2 A lock washer shall be used under the head of each bolt, and another under the nut, if a nut other than a Unistrut-type nut is used.

5.0 AUXILIARIES

5.1.1 Auxiliary transformers, resistors, auxiliary relays, fuse blocks and other miscellaneous equipment mounted in the rear of the panels should be mounted for easy accessibility for maintenance, checking and for making external connections, and so that they do not interfere with access to wire terminal points on the panel.

5.1.2 The auxiliaries should be installed in their relative position, as shown on the wiring diagram, and in accordance with any dimensions and details, if shown.

5.1.3 Auxiliaries are not to be mounted on the backs of relays or other equipment.

5.1.4 Those terminal blocks with sliding links that are mounted horizontally across the back of the panels shall be mounted so that the link will fall open in the event it comes loose.

5.1.5 Those terminal blocks with sliding links that are mounted vertically along the sides of the panel shall be mounted so that the link screw is angled out away from the panel, and slide towards the internal wire when loose.

5.1.6 Those terminal blocks with sliding links that are mounted vertically in the back of the terminal block panel shall be mounted so that the link screw is angled towards the interior of the panel.

6.0 TERMINAL BLOCKS, WIRING AND MISCELLANEOUS

6.1 TERMINAL BLOCKS

6.1.1 States Company Type NT sliding link terminal blocks will be used, unless otherwise indicated on the wiring diagram.

6.1.2 All terminal blocks shall be mounted so that they are easily viewed and accessible.

6.1.3 Terminal blocks must be wired exactly as shown on the wiring diagram, including the number and position of the spare terminals.

6.1.4 States Company Type NT or other approved terminal blocks are to be marked with marker tags, as shown on the latest revision of CEC's drawing MD-E6411, Sheet 33.

6.2 WIRING

6.2.1 Panel wiring must follow the wiring diagram exactly, so that each wire is connected between exactly the same terminals as shown on the wiring diagram.

6.2.2 Substitute wire routings must not be made, without CEC's permission, even if the electrical circuit is the equivalent to that of the wiring diagram.

6.2.3 All control wiring shall utilize stranded wire and be properly tagged at the terminations.

6.2.4 Panels are to be wired with No. 12 AWG, 19 stranded copper, 600 Volt, 90 deg. C THHN machine tool wire, with 0.15" PVC insulation and 0.004" nylon jacket.

6.2.5 Wire must be made by manufacturers approved by CEC.

6.2.6 Control wire that has a clear Mylar (or other clear material) binder tape between the conductor and the insulting material shall not be used.

6.2.7 Required wire colors are red, black, white, green, orange, blue and yellow.

6.2.8 Wire colors used are to match those shown on the wiring diagram.

6.2.9 Wire not color coded on the wiring diagram is to be yellow.

6.2.10 ASEA relays are to be wired with No. 16 AWG, 26 stranded copper, 600 Volt, 90 deg. C THHN machine tool wire with 2/64" PVC insulation.

6.2.11 Selector switches and lockout relays occasionally require wiring changes in the field, so the fabricator should loop the wires to the device in such a way that slack will be available for removing the device from the front of the panel and pulling it into the clear.

6.2.11.1 If there are other devices, such as panel lights, common to the same mounting plate, then also loop their wires.

6.3 MISCELLANEOUS

6.3.1 The wire lugs used for terminating the wiring shall be un-insulated ring type with a solid barrel.

6.3.2 Un-insulated wire lugs for #14-12 wire and #8-10 studs shall be used on the States Company Type NT terminal blocks and on relays, instruments and equipment where adjacent terminals are not likely to become shorted.

6.3.3 Insulated lugs shall be used where closely spaced adjacent terminals without barriers may cause shorts between terminals.

6.3.4 The manufacturer recommended crimping tool must be used to assure proper connection between the wire and lug.

6.3.5 Wire lugs installed on States Company Type NT terminal blocks must be placed in accordance with the latest revision of CEC's drawing MD-E6411, Sheet 33.

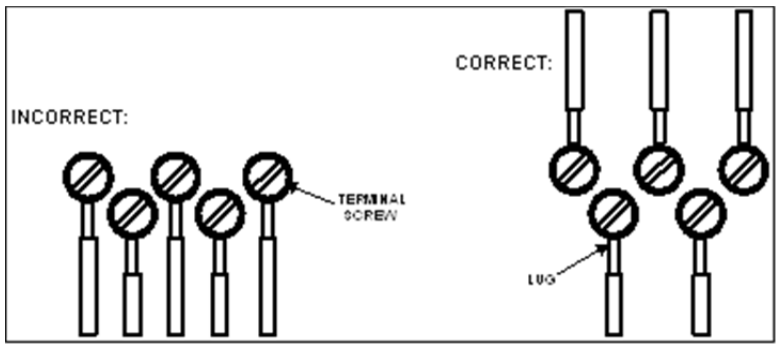
6.3.5.1 The wire lug on the stud closest to the link shall be in direct contact to the link as shown on drawing MD-E6411, Sheet 33.

6.3.6 Spare terminal block marker tags and nuts shall be placed in a bag and attached to the panel.

6.3.7 Do not make sharp (90 degree) bends in the wiring, as a smooth arc is preferred in all cases.

6.3.8 Do not solder Metal Oxide Varistor (MOV) leads into the wire lug. Instead, insert the leads into the lug, along with a length of wire of gauge appropriate to the lug, and crimp them both together.

6.3.9 When wiring devices with two rows of terminals that are close together, such that the lugs may contact one another if out of position, route the wiring to each row from the opposite position as shown below:



6.3.10 In the event that soldered connections are required, use only rosin core solder. Acid core solder or acid flux is not acceptable.

6.3.11 When wiring to devices with adjustment screws or ports, such as transducers, route the wiring to allow easy access.

6.3.12 Potential and current test switches shall be mounted and wired in accordance with the latest revision of CEC's drawings MD-E6411, Sheets 41 and 41A.

6.3.13 Plastic wiring duct shall be used wherever feasible, and shall be white Panduit, open slot type or approved equivalent.

7.0 DRAWINGS

7.1 The bid drawings adequately describe the work required.

7.2 Bids should be prepared from drawings stamped "Approved for Bids."

7.3 Only drawings stamped "Approved for Fabrication" are to be used for panel fabrication.

7.4 The fabrication drawings that are issued to the fabricator awarded the job may contain additional details and changes.

7.4.1 These are not to be considered a basis for initiating adders to the original bid figure, unless they require a major change in the scope of work.

7.5 All drawings supplied to the fabricator are the property of CEC, and contain proprietary and confidential information. It is unlawful to duplicate, use or disclose the drawings in whole or part, in any manner, without the prior written management consent of the CEC document originator. Violators will be prosecuted.

7.6 As-built drawings shall be provided to the CEC panel coordinator at the time of panel inspection.

8.0 PANEL INSPECTION

8.1 At the time the panel is nearing completion, the panel fabricator shall notify the CEC panel coordinator, so that arrangements can be made to inspect the completed panel at the panel fabricator's facility.

9.0 PANEL DELIVERY

9.1 The CEC panel coordinator will coordinate a delivery date with the appropriate CEC field construction representative.

9.2 A delivery date, along with the field contact's name and phone number, will be provided to the panel fabricator for each project requiring panel delivery.

9.3 The panel fabricator shall load and deliver, by their own appropriate enclosed, weather tight conveyance, or conveyance under their control, with unloading supervised by a representative from CEC.

10.0 APPENDIX

10.1 SWITCHBOARD MODULAR STEEL & FRAMEWORK ASSEMBLY DETAILS

10.1.1 Attached file name, “Switchboard Panel Steel Book.pdf”

10.2 TYPICAL DIAGRAM FOR SWITCHBOARD MARKER TAGS ON TERMINAL BLOCKS

10.2.1 Attached file name, “MD-E6411_Sh33.pdf”

10.3 TYPICAL DIAGRAM FOR TOGGLE TEST SWITCHES

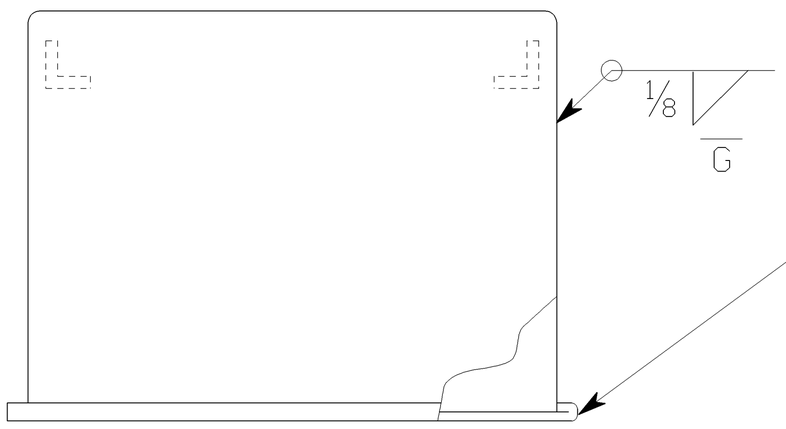
10.3.1 Attached file name, “MD-E6411_Sh41.pdf”

10.4 TYPICAL DIAGRAM FOR PUSH-PULL TEST SWITCHES

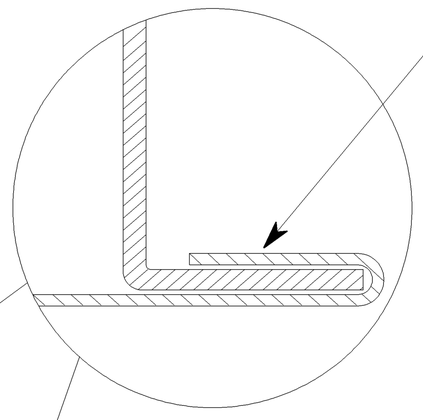
10.4.1 Attached file name, “MD-E6411_Sh41A.pdf”

10.5 OUTDOOR BOXES W/SLIDE COVERS CONSTRUCTION DETAILS

10.5.1 Attached file name, “DSA9033_Sh10.pdf”

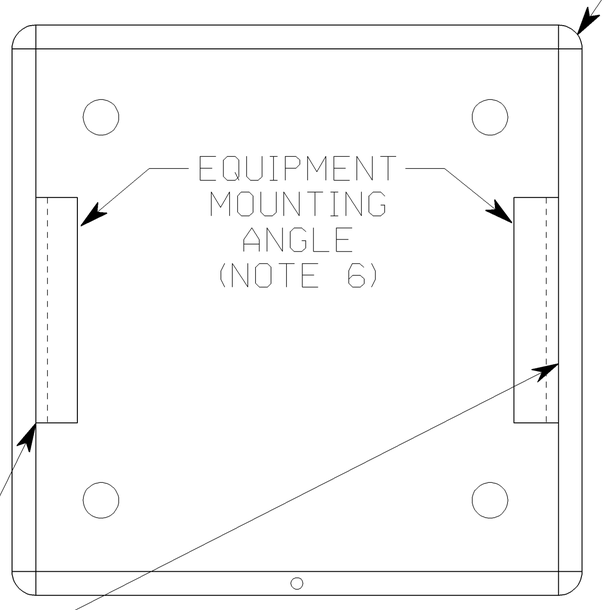


TOP VIEW



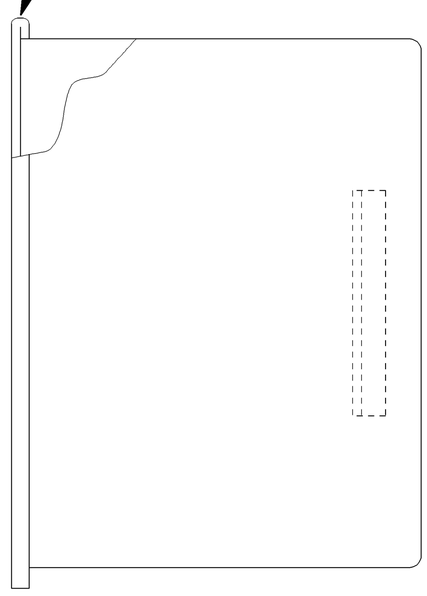
FABRICATE THE COVER WITH SUFFICIENT CLEARANCE SO THAT IT DOES NOT BIND IN ANY POSITION. (REFER TO NOTE 3)

WELD AN 11/16 X 1/8 X 11/16 PIECE IN EACH CORNER. GRIND WELDS SMOOTH AND ROUND CORNERS.

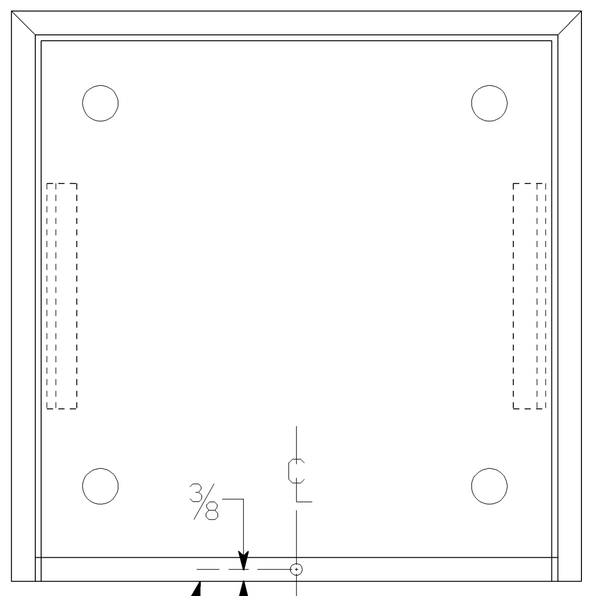


FRONT VIEW

COVER REMOVED



SIDE VIEW

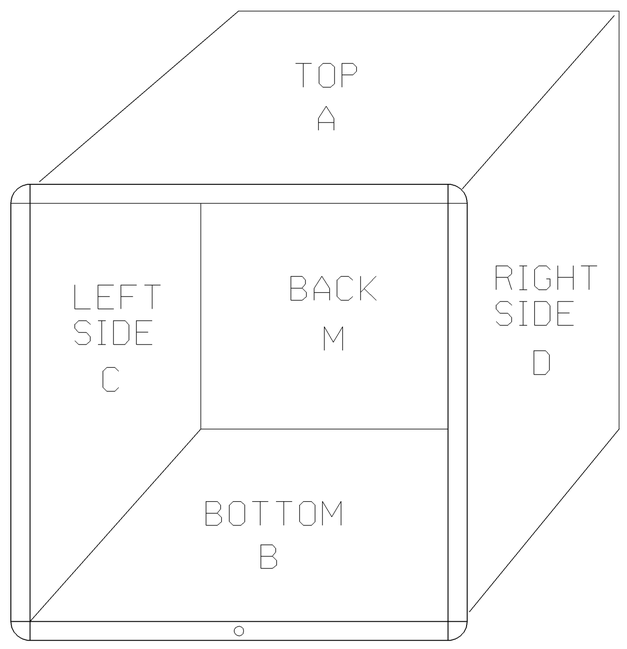


BACK VIEW

7/16" DIA. HOLE THROUGH FLANGE AND COVER

WELD CORNERS OF COVER CLOSED (REFER TO NOTE 3)

BOTTOM VIEW



CONDUIT BOX NOMENCLATURE

NOTES:

1. MATERIAL:

   BOX-0.125-IN SHEET ALUMINUM. ASTM SPECIFICATION 5052-H34. COVER-0.064-IN SHEET ALUMINUM. ASTM SPECIFICATION 5052-H3 CONDUIT HUBS-ONE HALF OF A RIGID ALUMINUM CONDUIT COUPLING AS FOLLOWS:

   1-IN AND UNDER. ASTM SPECIFICATION 3003-H18
   1 1/4 IN. AND LARGER. ASTM SPECIFICATION 6061-T6.

2. GRIND ALL SHARP EDGES SMOOTH.

3. THE COVER SHALL SLIDE FROM TOP TO BOTTOM

4. STAMP THE BOX NUMBER, USING STEEL DIES, ON THE INSIDE AND OUTSIDE OF THE BOTTOM OF THE BOX AND ON THE INSIDE OF THE COVER.

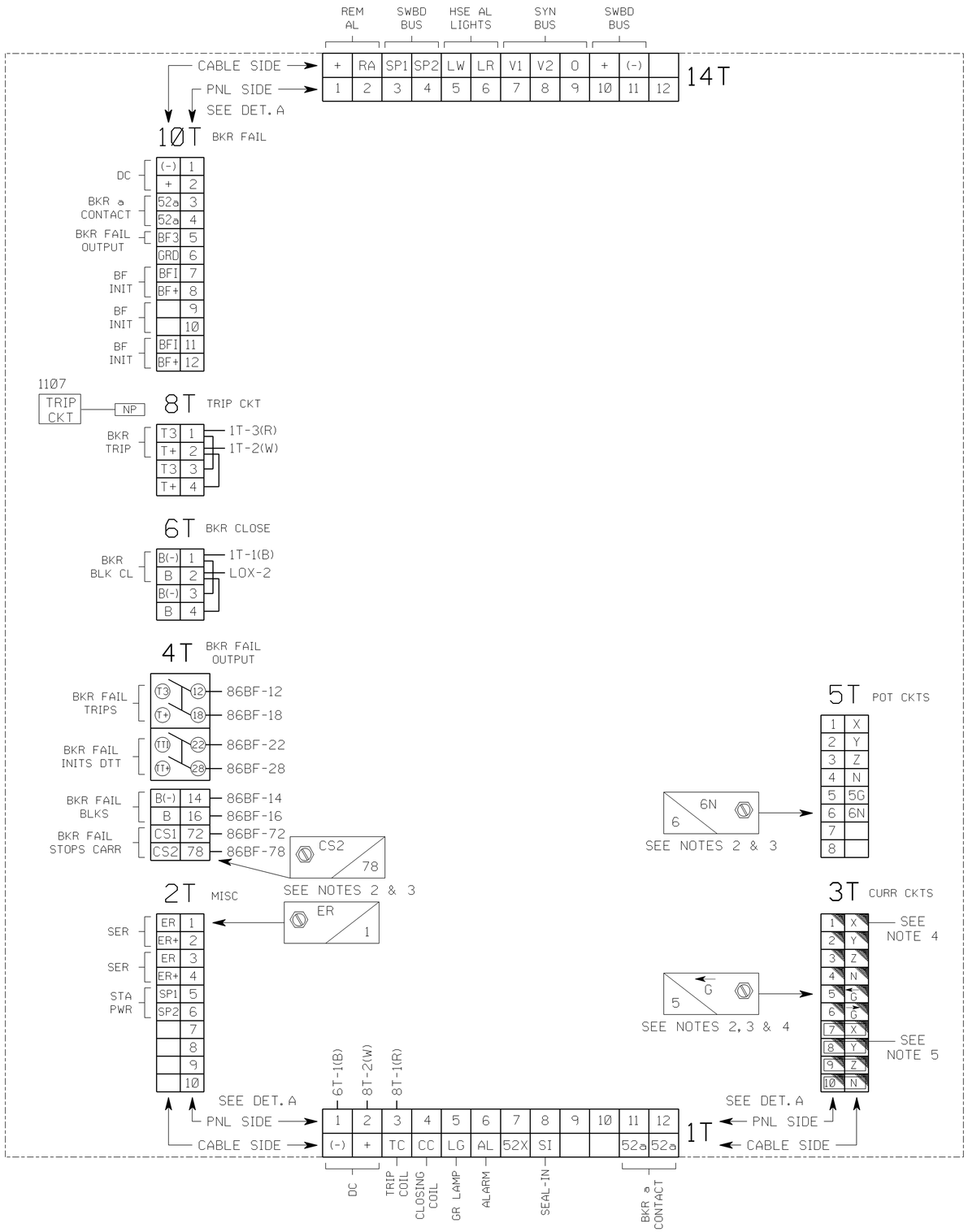
5. THE INERT GAS SHIELDED ARC WELDING PROCESS IS PREFERRED FOR THIS WORK.

6. ALL EQUIPMENT MOUNTING ANGLES SHALL BE 1x1x1/8 ALUMINUM ASTM SPECIFICATION 6061-T6.

TDSEL798.DGN

SECTION HEAD	DATE	DR. JA HYDEN 09/26/97	CK. ME FLICK 09/26/97
APP JG BALAZER	09/26/97		
DIVISION HEAD		Consumers Energy	O.D. BOXS W/SLIDE COVERS CONSTRUCTION DETAILS ©
APP JH SOSINSKI	09/26/97		
DEPARTMENT HEAD			DSA9033 SHEET 010 REV. A
APP J ALZUBAYDI	09/26/97		

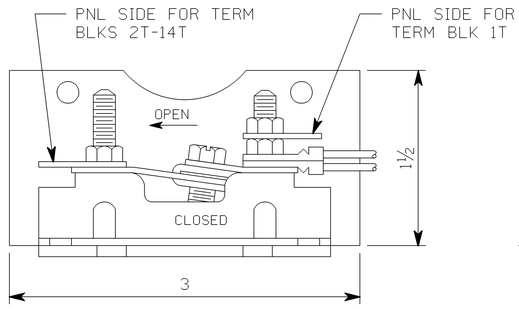
NEW DRAWING CREATED FROM SS-1310.01 PAGE 13-101 BROWN BOOK



CABLE CONDUCTORS COLOR CODE								
COLOR ABBREV	COLOR	CONDUCTOR NUMBER	DC	CURR POL	CURR OR POT	CURR	POT	FUNCTION
B	BLACK	1	(-)	G CURR TO RELAY	X,Y OR Z	Y	Y	(-) OR SP1
W	WHITE	2	+	N CURR FROM RELAY	N	Z	Z	(+) OR SP2
R	RED	3	T			X	X	TRIP
G	GREEN	4				N	N	CLOSE
O	ORANGE	5					5G	GREEN LAMP
BL	BLUE	6					6N	AMBER LAMP (ALARM)
W/B	WHITE-BLACK	7						RECLOSING
R/B	RED-BLACK	8						BKR SEAL-IN
G/B	GREEN-BLACK	9						MISCELLANEOUS OR (+) DC
O/B	ORANGE-BLACK	10						MISCELLANEOUS OR (-) DC
BL/B	BLUE-BLACK	11						MISCELLANEOUS OR AC
B/W	BLACK-WHITE	12						MISCELLANEOUS OR AC

COLOR CODES PER SS-1503.05 DATED 1971

SWITCHBOARD WIRES COLOR CODE		
COLOR	WIRE NUMBER	FUNCTION
BLACK	1	(-) NEGATIVE DC G (IN) POLARIZING CURR Y PHASE (CT OR PT)
WHITE	2	(+) POSITIVE DC G (OUT) POLARIZING CURR Z PHASE (CT OR PT)
RED	3	TRIP X PHASE (PT OR CT)
GREEN	4	CLOSE NEUTRAL (CT OR PT)
ORANGE	5	GREEN LAMP 5G POLARIZING POTENTIAL
BLUE	6	6N POLARIZING POTENTIAL
YELLOW		ALL OTHER WIRES



DETAIL A

STATES NT LINK ASSEMBLY

BLOCK LENGTHS:

4 POLE	3 1/8
8	5 5/8
12	8 1/8
16	10 5/8
20	13 1/8

NOTES

1. TERMINAL BLOCKS ARE EITHER
   a. STATES TYPE NT SLIDE LINK
   b. MTS SW RED HANDLES GANGED IN PAIRS WITH CLEAR PLASTIC COVER.
2. VERTICALLY-MOUNTED TERM BLOCKS WITH HORIZ LINKS SHALL BE INSTALLED SO THAT LINK IS TOWARD PNL WHEN OPEN. HORIZONTALLY-MOUNTED TERM BLOCKS WITH VERT LINKS SHALL BE INSTALLED SO THAT LINK FALLS DOWN WHEN OPEN.
3. EACH LINK WILL HAVE 2 MARKER TAGS, ONE ON THE INSIDE AND ONE ON THE OUTSIDE TERMINAL TO BE INSTALLED BY THE FABRICATOR. THE PANEL SIDE MARKER TAG WILL BE LABELED AS INDICATED. THE CABLE SIDE MARKER TAG WILL BE BLANK FOR USE BY LAB. USE INK MARKER PEN TO MARK TAGS.
4. LINKS LABELED ▨ ARE FOR CURRENT WIRES & WILL HAVE RED MARKER TAGS. ALL OTHER TAGS WILL BE WHITE.
5. ALL TERMINALS MARKED ▭ WITH DOUBLE LINE ARE TO BE PROTECTED BY A CAUTION GUARD AS COVERED IN STANDARD DRAWING SS-1499 SH.1-3.
6. THE CONSTRUCTION DEPARTMENT WILL HAVE TO REMOVE THE OUTSIDE MARKERS TO ADD CONTROL CABLE WIRES, THEN PUT MARKERS BACK IN PLACE.

REV	DATE	DESCRIPTION	BY	APP
E	08-11-95	UPDATED TERM BLOCK FUNCTIONS. REVISED DETAIL A & NOTES.	DTB DMS	REF JAP

	DATE
DR. N MIHLETHALER	04/26/73
CK. RE FRAME	09/10/73
SECTION HEAD APP. RE FRAME	09/19/73
DIVISION HEAD APP. P LOLICH	09/19/73
DEPARTMENT HEAD APP. S GRAND GIRARD	09/19/73

Consumers Energy

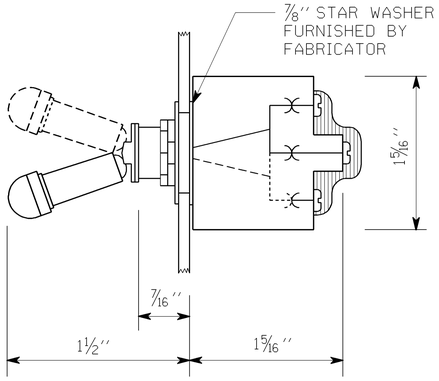
JACKSON, MICHIGAN

TYPICAL DIAGRAM FOR SWITCHBOARD MARKER TAGS ON TERMINAL BLOCKS

SCALE	NONE	DRAWING NO.	SHEET	REV.
JOB		MD-E6411	33	E

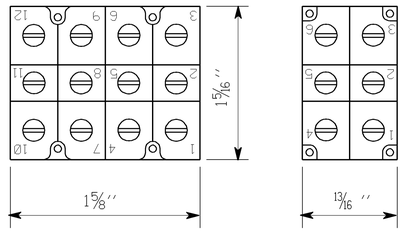
TMD00074

		STOCK NO.	CMS NO.
1	SINGLE POT 2PDT MICRO SW CAT NO 2TL1-3D	17-78844	S-05301
2	DOUBLE POT 4PDT MICRO SW CAT NO 4TL1-3D	17-78869	S-05302
6	TEST STUD MULTI-AMP CAT NO 40091-B	17-79511	S-06111



HANDLE POSITION

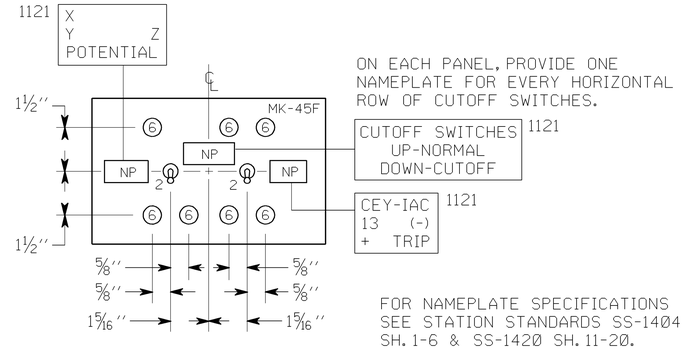
DOWN - NORMAL OR AUTOMATIC OR ON
DOWN - TEST OR NON-AUTOMATIC OR OFF
WITH HANDLE DOWN (TEST) POSITION, PULL TO UNLOCK & CHANGE POSITION
CONTACTS 2-3, 5-6, 8-9, & 11-12 ARE CLOSED.



4 POLE - REAR VIEW - 2 POLE

FABRICATOR NOTE

SWITCHES ARE TO BE MOUNTED SO THE TERMINAL MARKED No 1 IS IN THE LOWER RIGHT POSITION

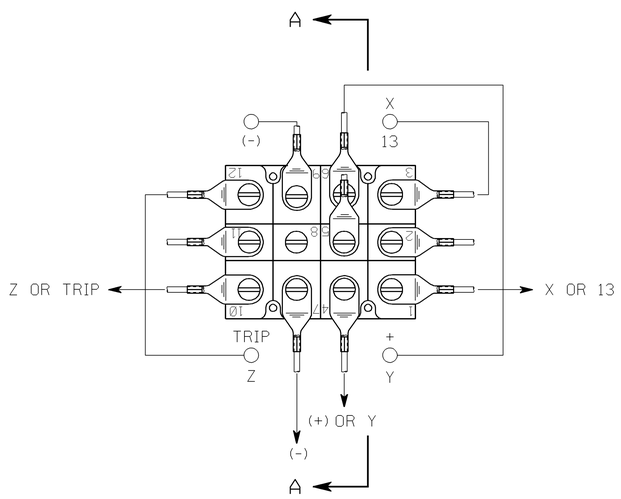


ON EACH PANEL, PROVIDE ONE NAMEPLATE FOR EVERY HORIZONTAL ROW OF CUTOFF SWITCHES.

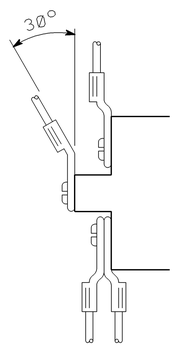
FOR NAMEPLATE SPECIFICATIONS SEE STATION STANDARDS SS-1404 SH. 1-6 & SS-1420 SH. 11-20.

FRONT VIEW

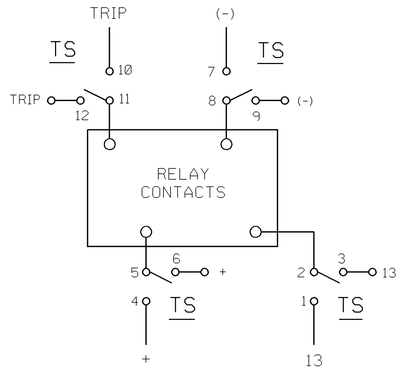
SCALE 3"=1'-0"



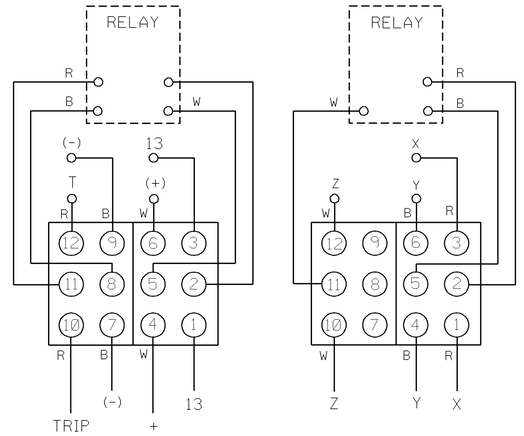
MAXIMUM OF 2 WIRES PER TERMINAL



SECTION A-A



TYPICAL SCHEMATIC



TYPICAL SWBD WIRING

NOTICE

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1/8" THICK PANEL MOUNTING

REV	DATE	DESCRIPTION	BY	APP
F	09-01-95	REVISED AND RELOCATED CUTOFF SWITCHES NAMEPLATE.	DTB CDR	REF JAP
E	06-06-80	ADDED STUDS & NP'S TO FV. REV WIRING TO SW. ADDED NEW SW TO SCHEM & SWBD.	MWS	ERL

	DATE
DR. BK HESSMER	01/24/68
CK. RE FRAME	02/02/68
SECTION HEAD APP. EW WARNOCK	02/02/68
DIVISION HEAD APP. LC ROBISON	02/02/68
DEPARTMENT HEAD APP. MW BALFOUR	02/02/68

Consumers Energy

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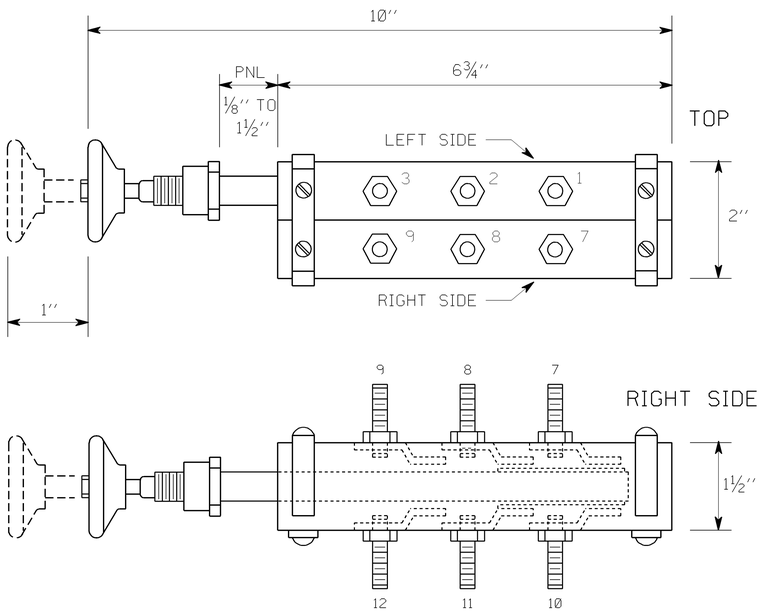
TYPICAL DIAGRAM FOR TOGGLE TEST SWITCHES

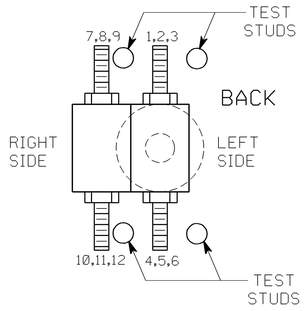
SCALE	NONE	DRAWING NO.	SHEET	REV.
JOB		MD-E6411	41	F

TMD00075



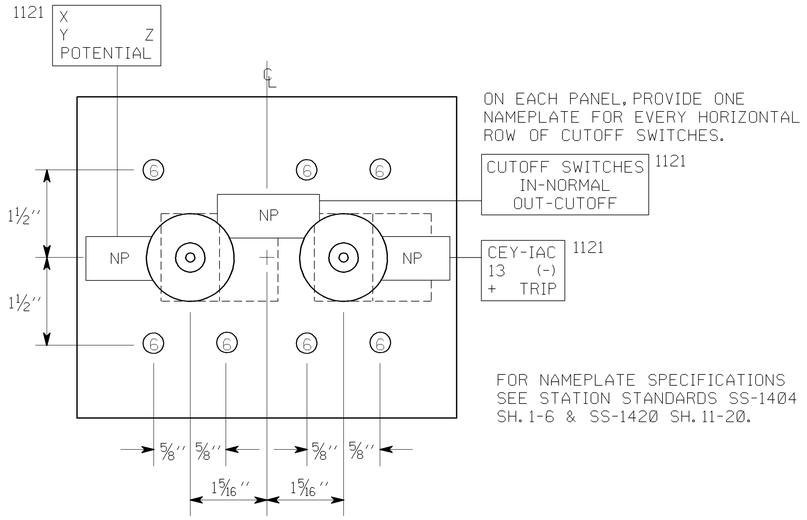
HANDLE POSITION

IN - NORMAL OR AUTOMATIC OR ON
OUT - TEST OR NON-AUTOMATIC OR OFF
WITH HANDLE PULLED OUT (IN CUTOFF POSITION)
CONTACTS 2-3, 5-6, 8-9, & 11-12 ARE CLOSED.

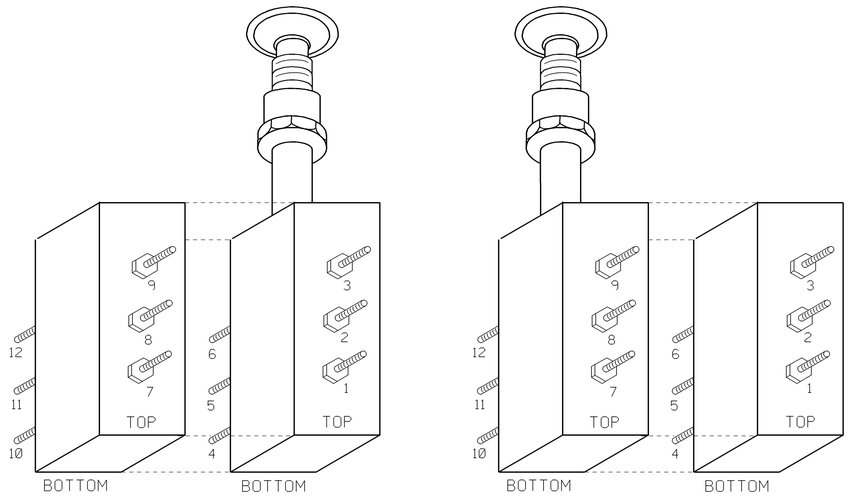


STATES RELAY TEST SWITCH

		STOCK NO.	CMS NO.
1	SINGLE POT 2PDT STATES CAT NO R-26300	17-78992	S-05324
2	DOUBLE POT 4PDT STATES CAT NO R-29302-B	17-79149	S-05325
3	SINGLE CURR 2PDT STATES CAT NO 25300	17-78935	S-05320
	DOUBLE CURR 4PDT W/SHRTG CLIP STATES CAT NO 29302C		
6	TEST STUDS WHSE CAT NO 790118 OR EQUIV		



FRONT VIEW



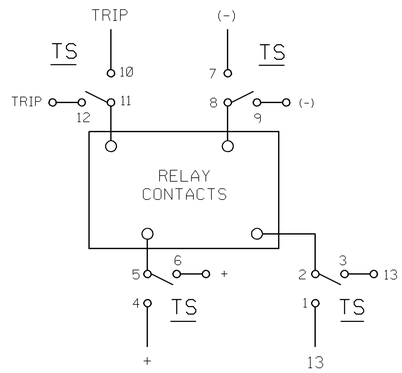
VIEW FROM BACK OF PANEL

MAJORITY OF INSTALLATIONS

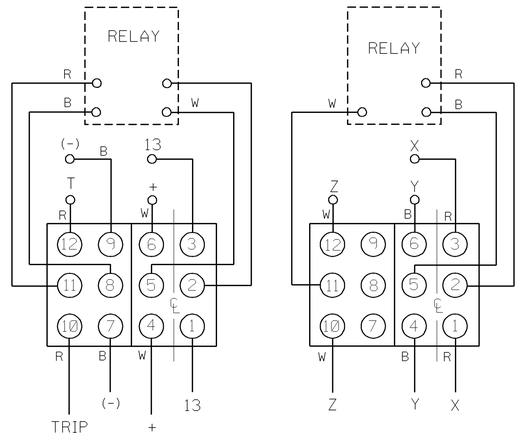
VIEW FROM BACK OF PANEL

MINORITY OF INSTALLATIONS

NOTE - SWITCH TERMINALS ARE NOT NUMBERED BUT ARE ADDED BY CPCO AS A CONVENTION FOR WIRING PURPOSES.



TYPICAL SCHEMATIC



TYPICAL SWBD WIRING

1½'' THICK PANEL MOUNTING

REV	DATE	DESCRIPTION	BY	APP
B	08/10/95	REDRAWN. REVISED SWITCH VIEWS FOR CLARIFICATION.	DIS CDR	DTB JAP
A	12-04-89	ADDED SYMBOLS (-), (+) & T TO TEST STUDS.	DIS CDR	JKM

DATE

DR. DI SURQUE 02/11/87

CK. JK MASON 09/18/87

SECTION HEAD
APP. DC PICKWORTH 10/05/87

DIVISION HEAD
APP. TL KRUMMREY 10/05/87

DEPARTMENT HEAD
APP. DC TARSI 10/05/87

Consumers Energy

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TYPICAL DIAGRAM FOR PUSH-PULL TEST SWITCHES

SCALE	DRAWING NO.	SHEET	REV.
NONE	MD-E6411	41A	B
JOB			

SWITCHBOARD MODULAR STEEL

SWITCHBOARD MODULAR STEEL IS TO BE FABRICATED ACCORDING TO THE DETAILS SHOWN ON THE VARIOUS SHEETS OF CONSUMERS ENERGY DRAWING MD-E6463 (ATTACHED).

MATERIAL

THE MATERIAL IS SPECIFIED ON THE DETAIL DRAWING FOR EACH MK.

ALL STEEL PIECES ARE TO BE MADE OF STANDARD CARBON SHEET STEEL.

FRONT PANELS WHICH CAN BE MADE FROM 6" OR NARROWER STRIPS CAN BE MADE FROM ⅛" THICK DRAWN FLATS. PANELS MUST BE FLAT AND FREE OF BURRS AND SHARP EDGES.

BRACES, MOUNTING STRIPS AND BRACKETS LOCATED BEHIND THE FRONT PANELS, UNLESS OTHERWISE SPECIFIED, ARE TO BE MADE FROM HOT ROLLED STRIPS. PIECES ARE TO BE FREE OF BURRS AND SHARP EDGES.

TOLERANCES

DIMENSIONS OF THE SWITCHBOARD MODULAR STEEL MUST BE WITHIN THE TOLERANCES SHOWN FOR EACK MK NUMBER ON THE DETAIL DRAWING MD-E6463. THE LOCATION OF HOLES WITH RESPECT TO CENTER LINES SHALL BE WITHIN ±.010 OF AN INCH. HOLE DIAMETERS SHALL BE HELD TO ±.015 AND -.000 INCHES. OTHER DIMENSIONS ON WHICH TOLERANCES ARE NOT SPECIFIED SHALL BE WITHIN ± 1/32 INCH.

FINISHING

STEEL PANELS AND OTHER STEEL SWITCHBOARD PARTS SHALL BE FREE OF MILL SCALE, CLEANED WITH LACQUER THINNER, AND (UNLESS OTHERWISE SPECIFIED), PAINTED WITH SHERWIN WILLIAMS CO. OPEX INDUSTRIAL SPRAY LACQUER, PALE GREY, NO. L61A23, OR SHERMAN WILLIAMS CO. METALATEX-INDUS/MARINE COATING NO. B42W102. THE L61A23 LACQUER MAY BE APPLIED DIRECTLY ON A SANDBLASTED SURFACE WITHOUT PRIMER OR ON A SUITABLY CLEANED AND LACQUER-PRIMER COATED SURFACE. THE B42W102 METALATEX MUST BE APPLIED ON A SURFACE THAT HAS BEEN COATED WITH SHERWIN WILLIAMS CO. NO. A41W210 PRIMER. STEEL FINISH MUST BE ABLE TO PASS THE ADHERENCE TEST BY NOT PULLING-OFF WHEN SCOTCH BRAND FILAMENT, PRESSURE SENSITIVE TAPE NO. 898 IS STUCK TO IT THEN PULLED OFF. STEEL FINISH SHOULD BE SMOOTH. DO NOT USE A BRUSH TO APPLY PRIMER OR FINISH COAT.

ALL "UNISTRUT TYPE" PARTS LISTED BELOW SHALL BE PURCHASED WITH A PREGALVANIZED FINISH IN CONFORMANCE WITH ASTM SPECIFICATION A525 (G90). NO OTHER LACQUER OR PAINT SHOULD BE APPLIED.

MARK NO.	UNISTRUT NO.	STOCK NO.
MK-3	P6001C	16-65033
MK-4	P2000	16-65041
MK-4A	P2000	16-65066
MK-5	P6001A	16-65058
MK-16	P6000	16-65173
MK-18	P6001A	16-65181

REFERENCE CONSUMERS ENERGY SPECIFICATION MSS-3 DATED 7/30/91

REV	DATE	DESCRIPTION	BY	APP
A	01-09-02	REVISED PAINT SPEC ADDED LACQUER NO. B42W102 AND PRIMER NO. A41W210.	KDR	TVG KDR

		DATE
DR.	C D RODERICK	01/22/91
CK.	D T BINSACK	01/31/91
APP.	J A POMPEO (SECTION HEAD)	01/31/91
APP.	T L KRUMMREY (DIVISION HEAD)	01/31/91
APP.	D C TARSI (DEPARTMENT HEAD)	01/31/91

Consumers Energy

JACKSON, MICHIGAN

SWITCHBOARD MODULAR STEEL

SUBSTATION

SCALE	NONE	DRAWING NO.	SHEET	REV.
JOB		MD-E6463	1	A

TMD00A52

Solar Technical Specification

SP-001

Exhibit G3 – Collector Substation System Protection Relay Requirements

9/30/2019

Consumers Energy

System Protection

Relay Recommendation Sheet

Subject Generic Solar Facility Collector Substation Station n/a

WO

Made By Will English Date 06/28/2019

References App'd By Date

Field Lab

These are generic relay recommendations for Consumers Energy Solar Facility Collector Substation projects. The high voltage line relaying, when required, will use OPGW fiber installation and must be compatible with interconnecting company relaying. Redundant and separate high voltage line, transformer differential and collector feeder relays will allow for continuous system operation should one relay be temporarily cut out of service. Automatic reclosing will not be used.

Design Notes

With each relay, provide a relay cutoff switch having two positions, one for normal and one for when the relay is cut out of service. Connect the switch to supervise all connected output contacts including the alarm output contact.

When the collector substation has more than one protection zone, relays are to be connected to current transformers such that protection zones overlap. CT ratios should be selected to provide optimal performance.

High Voltage Ground Switch (when required)

A high voltage ground switch is only required when interconnecting at 345 kV.

Operation of the high voltage ground switch while the associated high voltage line side disconnect switch is closed should trip the high voltage breaker.

High Voltage line to Interconnecting Company Substation (when required)

Line protection may not be required when the collector substation is connected at 46 kV.

Install two line current differential relays, Primary 1 (11P1) and Primary 2 (11P2) to protect the high voltage line from the collector substation to the interconnecting company substation.

Primary 1:

Contact the interconnecting company to determine the relay model to be used.

Both channels of the Primary 1 relay in this scheme must be connected via fiber to the Primary 1 relay at the interconnecting company substation.

Connect one set of current transformers located on the main power transformer side of the high voltage breaker to provide three phase current to the relay. Connect a secondary winding of the high voltage CCVTs to provide three-phase, four-wire potential to the relay. When an appropriate current polarizing source is available, connect the current polarizing circuit to the relay.

Inputs and Outputs are to be connected to provide the following functions.

INPUTS:

- Connect test trip studs to an input to enable the operator to test trip the breaker by connecting a jumper across the studs when the breaker is closed.
- Connect high voltage breaker 52 ‘a’ contact(s) to an input to provide breaker status.
- Connect an output contact of the high voltage breaker trip coil 1 TIR to an input. The relay will be programmed to initiate an event report for operation of the TIR.
- Connect high voltage breaker failure lockout (86BF) output contact to an input. Internal relay logic will be used to send direct transfer trip (DTT) to the interconnecting company substation for high voltage breaker failure.
- Connect a high voltage breaker alarm output to an input to enable DNP communication of breaker alarm via the relay.
- Pilot Cutoff - connect a pilot scheme cutoff switch to an input and to light an alarm lamp (amber). When the switch is open, the pilot scheme will be functioning. Closing the switch will energize the relay input and light the lamp. The relay will be set to disable the pilot scheme when the input is energized.

OUTPUTS

- Connect an output contact to test studs to facilitate relay testing.
- Connect an output contact to the breaker failure initiation input (IN105) of the breaker failure and main power transformer high-side backup SEL-351-6 relay.
- Connect an output contact (‘b’) to the relay alarm scheme. The output should operate for relay alarm conditions or failure of the 87 scheme.
- Connect a high-speed output to trip the high voltage breaker (trip coil #1).
- Connect a high-speed output to trip the high voltage breaker (trip coil #2).

Primary 2:

Contact the interconnecting company to determine the relay model to be used.

Both channels of the Primary 2 relay in this scheme must be connected via fiber to the Primary 2 relay at the interconnecting company substation.

Connect another set of current transformers located on the main power transformer side of the high voltage breaker to provide three phase current to the relay. Connect another secondary winding of the high voltage CCVTs to provide three-phase, four-wire potential to the relay. When an appropriate current polarizing source is available, connect the current polarizing circuit to the relay.

Inputs and Outputs are to be connected to provide the following functions.

INPUTS:

- Connect test trip studs to an input to enable the operator to test trip the breaker by connecting a jumper across the studs when the breaker is closed.
- Connect high voltage breaker 52 ‘a’ contact(s) to an input to provide breaker status.
- Connect an output contact of the high voltage breaker trip coil 2 TIR to an input. The relay will be programmed to initiate an event report for operation of the TIR.
- Connect a high voltage breaker failure lockout (86BF) output contact to an input. Internal relay logic will be used to send direct transfer trip (DTT) to the interconnecting company substation for high voltage breaker failure.
- Connect high voltage breaker alarm output to an input to enable DNP communication of breaker alarm via the relay.
- Pilot Cutoff - connect a pilot scheme cutoff switch to an input and to light an alarm lamp (amber). When the switch is open, the pilot scheme will be functioning. Closing the switch will energize the

relay input and light the lamp. The relay will be set to disable the pilot scheme when the input is energized.

OUTPUTS

- Connect an output contact to test studs to facilitate relay testing.
- Connect an output contact to the breaker failure initiation input (IN105) of the breaker failure and main power transformer high-side backup SEL-351-6 relay.
- Connect an output contact ('b') to the relay alarm scheme. The output should operate for relay alarm conditions or failure of the 87 scheme.
- Connect a high-speed output to trip the high voltage breaker (trip coil #1).
- Connect a high-speed output to trip the high voltage breaker (trip coil #2).

The functions for the (11P1) and (11P2) relays are: 21, 67N and 87. Include a DTT operating note on the WD (for example: high voltage breaker failure relay sends DTT to interconnecting company substation via high voltage line relays). See "Additional Information on Fiber Optic Installation" for details on connecting line current differential relays to the indoor fiber-optic splice box.

Breaker Failure and Main Power Transformer Backup:

Install a relay for detecting failure of the high voltage breaker and for Main Power Transformer Bank high-side backup (11HSBU). Install associated lockout relay (86BF).

Install one Schweitzer SEL-351-6 relay (model #03516?C4E544X1). This relay will have with Standard Firmware (includes Mirrored Bits® and Load Profile), Mounting as determined by designer, Standard User Interface including USB, 125/250 Vdc power supply, (2) 10/100Base-T with EIA-485 Communications Interface, 5 Amp phase and 5 Amp neutral Secondary Input Current, 125 Vdc Control Input Voltage, Additional 4 standard outputs and 16 inputs, No Conformal Coat and Standard Communications Protocols.

Connect one set of current transformers located on the line side of the high voltage breaker to provide three phase current to the relay. Connect a secondary winding of the high voltage CCVTs to provide three-phase, four-wire potential to the relay. The synchronizing voltage input (VS) will not be used. When an appropriate current polarizing source is available, connect the current polarizing circuit to the neutral CT input (IN).

Inputs and Outputs are to be connected as follows

IN101	Connect test trip studs to this input to enable the operator to test trip the breaker by connecting a jumper across the studs when the breaker is closed. (Note: When using the test studs for breaker failure testing, they must be programmed to operate the 'Re-trip' output only).
IN102	Connect high voltage breaker 52 'a' contact(s) to this input.
IN103	Connect line side high voltage breaker disconnect "b" contact to this input for position indication.
IN104	Connect transformer side high voltage disconnect "b" contact to this input for position indication.
IN105	Connect line current differential 11P1 output contact, 11P2 output contact, SEL-387 87P1 OUT101, SEL-387 87P2 OUT101, and contacts of the Main Power Transformer Bank lockout relays (86T1, 86T2) to this input. This input will be programmed to initiate breaker failure.
IN106	Connect the high voltage breaker gas pressure monitor to this input to provide low gas pressure alarm via the relay.
IN201	Connect the high voltage breaker pole disagreement output to this input.
IN202	Connect the high voltage breaker alarm output to this input.
IN205	Connect to monitor the high voltage breaker close coil.
IN206	Connect to monitor high voltage breaker trip coil #1 (X-phase)

IN207	Connect to monitor high voltage breaker trip coil #1 (Y-phase)
IN208	Connect to monitor high voltage breaker trip coil #1 (Z-phase)
IN209	Connect to monitor high voltage breaker trip coil #2 (X-phase)
IN210	Connect to monitor high voltage breaker trip coil #2 (Y-phase)
IN211	Connect to monitor high voltage breaker trip coil #2 (Z-phase)
OUT101	Trip high voltage breaker (trip coil #1). For operation of protective elements and breaker failure retrip.
OUT102	Trip high voltage breaker (trip coil #2)
OUT103	Operate breaker failure lockout relay (86BF)
OUT105	Connect to test studs.
OUT106	Trip medium voltage main breaker for breaker failure.
OUT107	Connect to a lamp to provide indication of breaker failure operation.
ALARM	Connect to relay alarm scheme

The SEL-351-6 relay will be used for the following functions: 50, 51, 67N, and BF.

The (86BF) LOR will trip and block closing of the high voltage breaker and the medium voltage main breaker and will initiate direct transfer trip (DTT) to interconnecting company substation by operating the DTT inputs of the line current differential 11P1 and 11P2 relays (when installed).

Main Power Transformer Bank Relaying

Install two transformer differential relays, Primary 1 (87P1) and Primary 2 (87P2) for the Main Transformer Bank protection. Install associated lockout relays (86T1) and (86T2).

Primary 1:

Install one Schweitzer SEL-387 relay (model # 0387504X5?XX4X1). This relay will have Standard Firmware plus integration enhancements with binary SER, No additional I/O Board, 125/250 Vdc or Vac Power Supply, 5 Amp Secondary Input Current, Mounting as determined by designer, 125 V Control Input Voltage and Standard plus DNP Communications Protocol.

Connect one set of wye connected current transformers located on the line side of the high voltage breaker to provide three phase current to the relay winding 1. Connect one set of wye connected current transformers located on the bus side of the medium voltage breaker to provide three phase current to the relay winding 2.

Depending on the type of transformer connection, connect the appropriate transformer tertiary, neutral, or totalized neutral CT circuit to the center phase of the relay winding 4 (IBW4). This will be used to provide backup overcurrent protection for ground faults.

Inputs and Outputs are to be connected as follows

IN101	Connect high voltage breaker 52 ‘a’ contacts to this input.
IN102	Connect an output of the 86T1 LOR to this input to provide LOR status.
IN105	Connect an output of the 86T2 LOR to this input to provide LOR status.
OUT101	Connect to the breaker failure initiation input (IN105) of the breaker failure and main power transformer high-side backup SEL-351-6 relay.
OUT102	Trip 86T1 LOR.
OUT103	Trip high voltage breaker (trip coil #1).
OUT104	Trip high voltage breaker (trip coil #2)
OUT105	Connect to test studs.
OUT106	Trip medium voltage main breaker.
ALARM	Connect to relay alarm scheme

Primary 2:

Install one Schweitzer SEL-387 relay (model # 0387504X5?XX4X1). This relay will have Standard Firmware plus integration enhancements with binary SER, No additional I/O Board, 125/250 Vdc or Vac Power Supply, 5 Amp Secondary Input Current, Mounting as determined by designer, 125 V Control Input Voltage and Standard plus DNP Communications Protocol.

Connect another set of wye connected current transformers located on the line side of the high voltage breaker to provide three phase current to the relay winding 1. Connect another set of wye connected current transformers located on the bus side of the medium voltage breaker to provide three phase current to the relay winding 2.

Depending on the type of transformer connection, connect the appropriate transformer tertiary, neutral, or totalized neutral CT circuit to the center phase of the relay winding 4 (IBW4). This will be used to provide backup overcurrent protection for ground faults.

Inputs and Outputs are to be connected as follows

IN101	Connect high voltage breaker 52 ‘a’ contacts to this input.
IN102	Connect an output of the 86T1 LOR to this input to provide LOR status.
IN105	Connect an output of the 86T2 LOR to this input to provide LOR status.
OUT101	Connect to the breaker failure initiation input (IN105) of the breaker failure and main power transformer high-side backup SEL-351-6 relay.
OUT102	Trip 86T2 LOR.
OUT103	Trip high voltage breaker (trip coil #1).
OUT104	Trip high voltage breaker (trip coil #2)
OUT105	Connect to test studs.
OUT106	Trip medium voltage main breaker.
ALARM	Connect to relay alarm scheme

The functions for the SEL-387 (87P1) and (87P2) relays are: 51N and 87.

Operation of the main power transformer sudden pressure relay (63) should also operate the (86T1) LOR.

The 86T1 LOR will trip, block closing and initiate breaker failure on the high voltage Breaker (TC#1&2) and trip and block the medium voltage main breaker.

The 86T2 LOR will trip, block closing and initiate breaker failure on the high voltage Breaker (TC#1&2) and trip and block the medium voltage main breaker.

Medium Voltage Bus Protection (when required)

Typically required when the medium voltage bus has more than one exit equipped with a breaker.

Install a bus differential relay (87B) for the medium voltage Bus. Install associated lockout relay (86BP).

Install one Schweitzer SEL-587Z relay (model # 0587Z0X325?12XX). This relay will have Standard Firmware, No Conformal Coat, 48/125Vdc or 125Vac Power Supply with 125Vdc Control Input Voltage, 2 MOVs – 5000J, 2000V Energy-Clamping MOVs, 5A Secondary Current Input, Mounting as determined by designer, EIA-232 Front and Rear Communications Port and Standard plus Modbus RTU Communications Protocol.

Connect the line side CTs of each non-main medium voltage breaker and the transformer side CTs of the medium voltage main breaker at the full CT ratio. Totalize all of these CTs and connect the totalized circuit to the relay. Note: All totalized CTs will have the same ratio. Each phase should be connected with the low-impedance current input (IA, IB or IC) in series with the high-impedance current input (87A, 87B or 87C). Connect contacts of the (86BP) lockout relay to short each phase of the high and low impedance current inputs when the (86BP) operates. Connect contacts of the bus protection cutoff switch to also short the high and low impedance inputs when the scheme is cut out of service.

Inputs are not used. Outputs are to be connected as follows

OUT1	Trip 86BP LOR

OUT3	Connect to test studs.
OUT4	Connect to relay alarm scheme. Will provide indication of Open CT.
ALARM	Connect to relay alarm scheme.

The (86BP) LOR will also trip and block closing of all medium voltage breakers.

Breaker failure tripping from the non-main collector breaker relays will also operate the (86BP) LOR relay.

Medium Voltage Collector Lines

Install a collector feeder breaker overcurrent protection scheme to each collector circuit. Two relays per collector circuit will be used to provide redundancy and continuity of operation should one relay fail.

Install Schweitzer SEL-351-6 relay (model #03516?C4E544X1). This relay will have Standard Firmware (includes Mirrored Bits® and Load Profile), Mounting as determined by designer, Standard User Interface including USB, 125/250 Vdc power supply, (2) 10/100Base-T with EIA-485 Communications Interface, 5 Amp phase and 5 Amp neutral Secondary Input Current, 125 Vdc Control Input Voltage, Additional 4 standard outputs and 16 inputs, No Conformal Coat and Standard Communications Protocols.

Connect each relay into the associated non-feeder side CTs of the collector line breaker Connect the medium voltage bus VTs to provide three-phase, four-wire potential for each collector feeder SEL-351-6 relay. When an appropriate current polarizing source is available, connect current polarizing to each relay's neutral current input (IN). The synchronizing voltage input (VS) will not be used.

Inputs and Outputs are to be connected as follows

IN101	Connect test trip studs to this input to enable the operator to test trip the breaker by connecting a jumper across the studs when the breaker is closed.
IN102	Connect breaker 52 'a' contact to this input.
IN104	Connect an output contact of the trip coil #1 TIR to this input. The relay will be programmed to initiate an event report for operation of the TIR.
IN105	Connect an output contact of the trip coil #2 TIR to this input.
IN201	Connect a contact of the Maintenance Switch to this input to indicate Normal mode.
IN202	Connect a contact of the Maintenance Switch to this input to indicate Maintenance mode.
IN203	Connect an "a" contact of the spring charging alarm to this input for indication of low stored energy.
IN204	Connect collector breaker heater Loss of AC voltage alarm to this input.
IN206	Connect to monitor breaker trip coil #1.
IN207	Connect a contact of the Close Coil voltage alarm to this input.
IN208	Connect to monitor breaker trip coil #2.
OUT101	Trip breaker (trip coil #1).
OUT102	Trip breaker (trip coil #2).
OUT103	Operate medium voltage bus protection lockout relay (86BP) to provide tripping for collector line breaker failure.
OUT104	Connect to relay alarm scheme.
OUT105	Connect to test studs.
ALARM	Connect to relay alarm scheme.

The SEL-351-6 relays will be used for the following functions: 27, 50/51N, 50/51P, 50BF, 59, 67N and 81O/U.

Additional Information for Fiber Optic Installation (when required)

The high voltage line will be equipped with OPGW fiber optic cable(s). The fiber optic cable in the OPGW will have multiple single-mode fibers.

Order the outdoor splice boxes. Order the sleeve for the fitting to connect the duct cable into the outdoor splice box. The outside diameter of the sleeve must be sized for the duct cable selected. The sleeve must be ordered from Alcoa Fujikura, and the part number is LCK XXX F, where the XXX is the outer diameter in thousandths of inches.

Order the indoor splice box(es), including the connector/adapter plates, the single-mode adapters and any necessary single-mode pigtails. Order the fiber optic duct cable that will be used to connect the outdoor splice boxes to the indoor splice boxes and the sufficient fiber optic jumpers to connect the line current differential relays and SEL-2506 modules to the indoor splice box. In order to match the OPGW, the duct cable must also have the same quantity of single-mode fibers.

Fiber Optic Connections (when required)

The outdoor splice box is to be mounted in the substation approximately 4 feet above the ground on the structure where the OPGW terminates. The duct cable will be spliced to the OPGW out in the yard where the Line OPGW terminates. These splices will be stored out in the yard in the outdoor splice box. The duct cable is to be brought into the control house to the indoor splice box. All the fibers in the duct cable are to be connected to the adapter plates in the indoor splice box (via pigtails, UNICAM connectors, etc.). Any splices will be stored in the indoor splice box. The fiber optic jumpers will connect to the other side of the adapter plates in the indoor splice box and will use ST or UNICAM connectors. The fiber optic jumpers are to run from the indoor splice box to the line current differential 11P1 and 11P2 relays and the SEL-2506 modules.

Current Polarizing

Depending on the type of transformer connection, the primary of the current polarizing circuit will be the transformer tertiary or totalized neutral CT circuit. Connect a 5/5 auxiliary CT to the secondary of this circuit. The secondary of the auxiliary CT will be used for current polarizing to the 11P1, 11P2, 11HSBU and collector line A&B relays.

Solar Technical Specification

SP-001

Exhibit G4 – Collector Substation System Monitoring Requirements

9/30/2019

Consumers Energy

System Protection

Monitoring Recommendation Sheet

Subject Monitoring for generic solar facility Station n/a

Collector Substation WO

Made by Will English Date 6/28/2019

References App'd By Date

Relay rec. dated 6/28/2019 by Will English Field Lab

Disturbance Monitoring Equipment (DME)

Install an APP Engineering, Inc. APP-601 Multifunction Recorder consisting of *(1) 601F Computer Chassis with an External HDD, and an appropriate number of 601 Data Chassis, three-channel Analog Cards, and eight-channel Event Cards.* Connect CT and VT circuits into the recorder to monitor the analog channels. Use the same CT circuits as the primary relaying, and wire them such that the phase will enter the DME first after leaving the CT and the totalized/neutral will enter the DME last before returning to the CT. Connect dry contacts from all breakers (52a), Trip coils, sudden pressure and lockout relays to monitor the digital (event channels). Connect the recorder's IRIG input to the GPS clock and set up remote communication through a dedicated digital circuit.

System Protection will submit the input list to APP Engineering. This list will contain the information needed for APP to build, test and calibrate the recorder. Once installed with inputs connected, the recorder will be ready for operation.

Analog Channels to be Monitored

**NOTE – Each medium voltage exit should have all three phases and the neutral connected to an analog channel on the DME. If more than 39 analog channels are used, additional analog boards will have to be added. The chart below may list equipment that is not installed; these entries can be ignored.*

Pt#	Analog Channel Description
01	High Voltage CCVT - V_{XG}
02	High Voltage CCVT - V_{YG}
03	High Voltage CCVT - V_{ZG}
04	High Voltage GCB I_X
05	High Voltage GCB I_Y
06	High Voltage GCB I_Z
07	High Voltage GCB I_N
08	Medium Voltage Main GCB I_X
09	Medium Voltage Main GCB I_Y
10	Medium Voltage Main GCB I_Z
11	Medium Voltage Main GCB I_N
12	MV Exit 1 GCB I_X
13	MV Exit 1 GCB I_Y
14	MV Exit 1 GCB I_Z
15	MV Exit 1 GCB I_N
16	MV Exit 2 GCB I_X
17	MV Exit 2 GCB I_Y
18	MV Exit 2 GCB I_Z
19	MV Exit 2 GCB I_N
20	MV Exit 3 GCB I_X
21	MV Exit 3 GCB I_Y
22	MV Exit 3 GCB I_Z
23	MV Exit 3 GCB I_N
24	MV Exit 4 GCB I_X
25	MV Exit 4 GCB I_Y
26	MV Exit 4 GCB I_Z
27	MV Exit 4 GCB I_N
28	Current Polarizing Circuit I_P
29	Medium Voltage Bus VT - V_{XG}
30	Medium Voltage Bus VT - V_{YG}
31	Medium Voltage Bus VT - V_{ZG}
32-39	Spares

Digital Event Points to be Monitored

**NOTE – Each medium voltage exit should have a 52a contact and both Trip coils connected to separate digital channels on the DME. The chart below may list equipment that is not installed; these entries can be ignored.*

Pt#	Event Point Description
01	High Voltage GCB 52a
02	Medium Voltage Main GCB 52a
03	MV Exit 1 GCB 52a
04	MV Exit 2 GCB 52a
05	MV Exit 3 GCB 52a
06	MV Exit 4 GCB 52a
07	Main Power Transformer 86T1 LOR
08	Main Power Transformer 86T2 LOR
09	High Voltage Breaker Failure 86BF LOR
10	MV Bus Protection 86BP LOR
11	MPT Sudden Pressure (63X)
12	High Voltage GCB Trip Coil #1 (TIR1)
13	High Voltage GCB Trip Coil #2 (TIR2)
14	MV Main GCB Trip Coil #1 (TIR1)
15	MV Main GCB Trip Coil #2 (TIR2)
16	MV Exit 1 GCB Trip Coil #1 (TIR1)
17	MV Exit 1 GCB Trip Coil #2 (TIR2)
18	MV Exit 2 GCB Trip Coil #1 (TIR1)
19	MV Exit 2 GCB Trip Coil #2 (TIR2)
20	MV Exit 3 GCB Trip Coil #1 (TIR1)
21	MV Exit 3 GCB Trip Coil #2 (TIR2)
22	MV Exit 4 GCB Trip Coil #1 (TIR1)
23	MV Exit 4 GCB Trip Coil #2 (TIR2)
24-32	Spares

High Voltage GCB – high voltage line to interconnecting company substation (when required)

Install Trip Indication Relays (TIR) on both high voltage GCB trip coils. Connect a contact from TIR1 to an input of the 11P1 relay, and a contact from TIR2 to an input of the 11P2 relay. Also monitor TIR1 and TIR2 on the DME as shown above. Connect the 11P1 & 11P2 line current differential relays to the RTU via DNP for SCADA monitoring. Connect the high voltage GCB 43R selector switch directly to the RTU for indication of remote or local control. The specific points that will be monitored via DNP are listed below.

Main Power Transformer

Connect the 11HSBU SEL-351-6 breaker failure relay to the RTU via DNP for SCADA monitoring. The specific points that will be monitored via DNP are listed below. Also connect the high voltage Breaker Failure 86BF LOR to the DME.

Install a "63X" TIR to be picked up by the Main Power Transformer sudden pressure relay. Wire one contact of the Sudden Pressure (63X) to the RTU and the other contact to the DME. Monitor contacts of the Main Power Transformer 86T1 and 86T2 LORs on the DME. Connect the 87P1 and 87P2 SEL-387 relays to the RTU via DNP for SCADA monitoring. The specific points that will be monitored via DNP are listed below.

Medium Voltage Bus Protection

Connect a TIR to OUT1 of the 87B SEL-587Z relay. Monitor a contact from this TIR and a contact from the 34.5 kV Bus Protection 86BP lockout relay to the DME and to the RTU for remote indication.

Medium Voltage Collector Lines

Connect a contact of each collector breakers "All Relays" TIR1 and TIR2 (specified in the Relay Recommendation) to the DME. Connect each feeder's 11A SEL-351-6 to the RTU via DNP for SCADA monitoring. The specific points that will be monitored via DNP are listed below. DNP connection of the 11B relays is not required.

Digital/Status points to be monitored directly on the RTU. The points indicated SOE are to be included in the SCADA Sequence of Events:

**NOTE – Every 43R from each feeder will have to be monitored directly on the RTU.*

High Voltage GCB Remote/Local (43R)
Main Power Transformer Sudden Pressure (63X) ← SOE
Medium Voltage Bus Protection TIR Diff SEL-587Z ← SOE
Medium Voltage Bus Protection 86BP LOR ← SOE
MV Main GCB Remote/Local (43R)
MV Exit 1 GCB Remote/Local (43R)
MV Exit 2 GCB Remote/Local (43R)
MV Exit 3 GCB Remote/Local (43R)
MV Exit 4 GCB Remote/Local (43R)

DNP SCADA Monitoring Points

The following points will be monitored on SCADA through the DNP connection of the relays. Note: Precise Descriptors cannot be provided until site specific breaker and transformer naming / numbering is complete. Partial Descriptors are provided below to list functions only. Final Descriptors to be provided after a one line is available.

High Voltage Line Relay 11P1 (when installed)

DNPB Point #	Name	Descriptor	Type
	INPUT X	11P1 HV Breaker Test Trip	SOE
	INPUT X	11P1 HV Breaker 52a	SOE
	INPUT X	11P1 HV Breaker TIR1	SOE
	INPUT X	11P1 HV Breaker 86BF LOR	SOE
	INPUT X	11P1 HV Breaker Breaker Alarm	
	OUTPUT X	11P1 HV Breaker TC #1	SOE
	OUTPUT X	11P1 HV Breaker TC #2	SOE
	OUTPUTX	11P1 HV Breaker Alarm	
	ILOP	11P1 Loss of Potential	
	M2P	11P1 Phase Fault Detect	SOE
	32GF	11P1 Ground Fault Detect	SOE
	OUTPUT X	11P1 HV Breaker Fail Initiate	SOE
	87ALARM	11P1 87 Scheme Failure	SOE
	TMB1A	11P1 Send DTT	SOE
	RMB1A	11P1 Receive DTT	SOE

High Voltage Line Relay 11P2 (when installed)

DNPB Point #	Name	Descriptor	Type
	INPUT X	11P2 HV Breaker Test Trip	SOE
	INPUT X	11P2 HV Breaker TIR2	SOE
	OUTPUT X	11P2 HV Breaker TC #1	SOE
	87ALARM	11P2 87 Scheme Failure	SOE
	TMB1A	11P2 Send DTT	SOE
	RMB1A	11P2 Receive DTT	SOE

11HSBU SEL-351-6

DNPB numbers greater than 500 will receive the Sequence of Events (SOE) timestamp.

DNPB Point #	Name	Descriptor
676	IN101	11HSBU Test Trip
677	IN102	11HSBU HV Breaker 52a
178	IN103	11HSBU HV Line Side Disc Switch B
179	IN104	11HSBU HV MPT Side Disc Switch B
680	IN105	11HSBU Breaker Failure Initiate
681	IN106	11HSBU Low Gas Pressure
360	IN201	11HSBU Pole Disagreement
361	IN202	11HSBU HV Breaker Alarm
364	IN205	11HSBU Close Coil DC Monitor
311	ALARM	11HSBU Alarm
804	OUT101	11HSBU Trip TC #1
805	OUT102	11HSBU Trip TC #2
806	OUT103	11HSBU Initiate 86BF

MPT-87P1 SEL-387

DNPB numbers greater than 800 will receive the Sequence of Events (SOE) timestamp.
Note: NOTALM is logical 1 when the relay is operating correctly.

DNPB Point #	Name	Descriptor
1001	IN102	MPT 86T1 LOR
1004	IN105	MPT 86T2 LOR
335	NOTALM	MPT Alarm
1128	OUT101	MPT Breaker Fail Initiate
1129	OUT102	MPT Differential Trip

MPT-87P2 SEL-387

DNPB numbers greater than 800 will receive the Sequence of Events (SOE) timestamp.
Note: NOTALM is logical 1 when the relay is operating correctly.

DNPB Point #	Name	Descriptor
335	NOTALM	MPT Alarm
1128	OUT101	MPT Breaker Fail Initiate
1129	OUT102	MPT Differential Trip

MV Exit 1 11A SEL-351-6
DNPB numbers greater than 500 will receive the Sequence of Events (SOE) timestamp.

DNPB Point #	Name	Descriptor
676	IN101	MV Exit 1 11A Test Trip
677	IN102	MV Exit 1 11A 52A
679	IN104	MV Exit 1 11A TIR1
680	IN105	MV Exit 1 11A TIR2
360	IN201	MV Exit 1 11A Maint Mode (Normal)
361	IN202	MV Exit 1 11A Maint Mode (Maint)
362	IN203	MV Exit 1 11A Spring Charging Alarm
363	IN204	MV Exit 1 11A Heater AC Alarm
365	IN206	MV Exit 1 11A Trip Coil #1 Monitor
366	IN207	MV Exit 1 11A Close Coil DC Monitor
367	IN208	MV Exit 1 11A Trip Coil #2 Monitor
311	ALARM	MV Exit 1 11A Alarm
806	OUT103	MV Exit 1 11A Initiate 86BP for BF
535	51P	MV Exit 1 11A Phase Fault Detector
621	32GF	MV Exit 1 11A Ground Fault Detector

All MV Exit 11A relays will all use the same points as the MV Exit 1 relay above; this also includes any future feeders. The descriptors will be the same except for the exit number.

Relay Data Communications

Install a high voltage side SEL-2032 communications processor. The high voltage side SEL-2032 will connect to the substation router. See the specific connections listed below.

Install a medium voltage side SEL-2032 communications processor. Connect the medium voltage side SEL-2032 to the high voltage side SEL-2032 using the appropriate cable to carry both the data and IRIG signals to the medium voltage SEL-2032. See the specific connections listed below.

Install a GPS clock near the high voltage side SEL-2032. Connect the GPS clock to the high voltage side SEL-2032. The GPS signal will time synchronize all the relays in the relay data communications network through both SEL-2032 communications processors.

Connect the digital relays to the SEL-2032 communications processors using the appropriate cables to carry both the data and IRIG signals to the relays. See the specific connections listed below.

The connection chart may list equipment that is not installed; these entries can be ignored.

Specific Relay Data Communications Connections:

Connect the high voltage side SEL-2032 as follows:

PORT	DEVICE
1	11HSBU SEL-351-6
2	MPT SEL-387 PRI1
3	MPT SEL-387 PRI2
4	HV Line Current Diff 11P1
5	HV Line Current Diff 11P2
6-14	Spares
15	Router
16	Medium Voltage SEL-2032

Connect the medium voltage side SEL-2032 as follows:

PORT	DEVICE
1	Medium Voltage BUS SEL-587Z
2	MV Exit 1 SEL-351-6 PRIA
3	MV Exit 1 SEL-351-6 PRIB
4	MV Exit 2 SEL-351-6 PRIA
5	MV Exit 2 SEL-351-6 PRIB
6	MV Exit 3 SEL-351-6 PRIA
7	MV Exit 3 SEL-351-6 PRIB
8	MV Exit 4 SEL-351-6 PRIA
9	MV Exit 4 SEL-351-6 PRIB
10	
11	
12-14	Spares
15	High voltage side SEL-2032
16	Spare