Solar Technical Specification

SP-001
Revision 2022.0

Executed Date

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1.0 General

For Projects being bid in as a Build Transfer Agreement (BTA) this technical specification defines the minimum requirements acceptable by the Buyer governing solar photovoltaic Projects. The Seller may propose alternatives through value engineering that deviate from the requirements listed within this specification for the Buyer to evaluate. The criteria defined sets the minimum standards of quality for equipment and materials included in the Seller's design and it is not intended to limit the Seller to a single design approach. The primary purpose is to ensure safe and reliable operations and maintenance for the lifetime of the facility.

For Projects being bid in as a Development Asset Acquisition (DAA) only material that has been purchased by the Seller and will be supplied with the Project Bid (I.E. safe harbor equipment) will need to meet the relevant requirements contained within this specification for the supplied material.

The Seller shall also comply with the technical requirements contained in other Appendices 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 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 Buyer and Seller for the Seller to design, construct, and commission the Solar Facility.

1.1.9 The **Seller** shall mean – the party with whom Buyer 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 **MDL** shall mean – The Master Deliverable List for the Project.

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

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

1.1.23 **Buyer** shall mean – Consumers Energy Company.

1.1.24 **POI** shall mean – Point of Interconnect. The delineation between the equipment owned by the generating asset vs. that of the transmission/distribution Buyer.

1.1.25 **Production Estimate Report** shall mean – A written report detailing the information from the PVSyst Output Simulation Report, details on the assumptions used, post-processing calculation details and any other variables that have been used to estimate annual production from the Site.

1.1.26 **PVEL** shall mean – PV Evolution Labs

1.1.27 **PVSyst Simulation Output Report** shall mean – The output file generated from PVSyst showing all input parameters and output values

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

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

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

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

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

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

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

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

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

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

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

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

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

1.1.41 **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 Buyer'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 Seller 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 Seller 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 Seller shall provide submittals to Buyer pursuant to Section 1.5. Engineering submittals shall be provided at intervals sufficient for Buyer to review and comment on design decisions. Submittal milestones include:

1.3.3.1 30% Design Documents

1.3.3.2 60% Design Documents upon Buyer's request

1.3.3.3 90% Design Documents

1.3.3.4 Approved for Construction (AFC) Design Documents for informational purposes

1.3.3.5 As-Built – "For Record" Design Documents

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

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

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

1.3.7 The Project shall be designed and built with the following minimum parameters as were provided in the bid submittal:

1.3.7.1 The total DC nameplate capacity shall not be less than the MWdc provided in the Production Estimate Report

1.3.7.2 The Project shall ensure the year 0 P50 annual energy output is no less than what is provided in the Production Estimate Report included with the bid including any post processing calculations. This shall be

confirmed by the Seller submitting a revised, as designed, PVSyst report and Production Estimate Report along with any post processing calculations once engineering is complete, for review and approval by the Buyer, to confirm the estimated energy output is no less than the number of MWh/yr that was submitted in the original bid proposal. The following parameters are the only parameters that are allowed to be changed from the original submittal (all other parameters shall remain consistent with the original bid submittal)

1.3.7.2.1 AC Wiring losses pursuant to Section 5.2.1.

1.3.7.2.2 DC wiring losses pursuant to Section 5.1.2.

1.3.7.2.3 High Voltage Transformer losses.

1.3.7.2.4 Medium Voltage Transformer losses.

1.3.7.2.5 Row Pitch.

1.3.7.2.6 Tracking limit angle.

1.3.7.2.7 Selected PV module pursuant to Exhibit A Appendix B1.

1.3.7.2.8 Selected Inverter pursuant to Exhibit A Appendix B1.

1.3.7.2.9 DC Nameplate capacity pursuant to Section 1.3.7.1

1.3.7.2.10 The .pan file shall be a third party verified .pan file for the as-designed submittal.

1.3.7.2.10.1 If the third party verified PAN file is not available at the time of this submittal there shall be an additional submittal required once the PAN file is available and shall be prior to commencement of the capacity test.

1.3.7.2.11 All near shadings and far shadings shall be accounted for and modelled.

1.4 Permits

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

1.4.2 Seller 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 Seller shall follow the Buyer'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 Appendix A1.

1.5.1.3 The master deliverables list (MDL), Appendix-A2 contains an example of the minimum required submittal schedule, intended to be expanded

and maintained throughout the project. Submittals to be accounted for are also listed within various sections of this specification.

1.5.1.3.1 The Seller shall prepare a schedule of all submittals for the specific Project for Buyers review and approval. This schedule of submittals shall include estimated submittal dates.

1.5.1.3.1.1 It shall be the responsibility of the Seller to periodically, at least once per month, update the schedule of submittals and associated dates.

1.5.1.4 Drawing numbering shall be assigned as referenced in the Design Document Standards, Appendix A3.

1.5.1.5 The Seller shall fill out the Attribute Upload Form as shown in Appendix A4. The Attribute Upload Form shall be kept up to date by the Seller throughout the duration of the Project.

1.5.1.6 The following shall apply to documents transferred per Design Document Standards, Appendix A3:

1.5.1.6.1 Seller's sub-contractors may work outside of ProjectWise; Seller is responsible for submitting documents to Buyer via PW. CADs must be submitted with PDFs for Buyer Project File record maintenance.

1.5.1.6.2 Only current revisions shall be required to be uploaded to ProjectWise.

1.5.1.6.3 All Civil 3D full Native files should be provided to Buyer at AFC status in its current format for Buyer Project File but must be submitted for Record Issue as stand-alone AutoCAD files for each individual PDF. All native files shall have xrefs bound and custom/C3D elements exploded at Record Issue to allow opening with basic AutoCAD. This can be final step after all dwgs are accepted at Record Tech Review. For more clarification, the manager of Buyer drafting department can be consulted or GA-303 referenced.

1.5.2 As-Built Record Documentation

1.5.2.1 During construction the Seller 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 Seller shall provide to Buyer, a complete set of as-built "Record" drawings as indicated on the MDL. Record drawings shall be provided in accordance with Appendix A3.

1.5.2.3 Seller shall provide as-built Record drawings locating all underground utilities existing and installed 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 Seller's Professional Engineer registered in the State of Michigan. The as-built Record drawings shall be provided to the Buyer per the terms of the Agreement.

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

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

1.5.2.6.1 The Seller shall obtain the most recent AutoCAD borders from the Buyer prior to submitting.

1.5.3 Job Books

Job Books shall be supplied by submittal by the Seller in the form specified in Appendix M. Minimum expectations for the Job Books include the following items:

1.5.3.1 Completed Seller’s QA/QC Reports.

1.5.3.2 Completed PV module supplier QA/QC checklists

1.5.3.3 Material certifications and testing information (equipment factory test reports, flash tests results, etc.)

1.5.3.4 A complete, up to date record version of the job books shall be submitted to the Buyer for review and approval in accordance with submittal schedule.

1.5.4 Books and Records, Tax Accounting

A breakdown of the Purchase Price in accordance with the property retirement unit categories and other systems of accounts and in a records format in accordance with Exhibit A – Appendix L together with all Books and Records substantiating the Purchase Price breakdown shall be delivered to the Buyer per the terms of the Agreement. Overhead and profit shall not be listed as separate items. For physical Project Assets the Seller shall provide the information specified on Exhibit A – Appendix L.

1.5.5 Quality Control

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

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

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

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

1.5.5.2.3 Commissioning and testing of the Project.

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

1.5.5.2.5 The Quality Plan shall incorporate any suppliers or vendors quality plans.

1.5.5.2.5.1 If suppliers or vendors are not available by this time, they shall be added to the Quality Plan as they become available.

1.5.5.3 Seller shall allow the Buyer to visit the site at any point during construction and testing to observe installation and testing activities.

1.5.5.4 Seller shall include third party witnessing of the PV modules. This witnessing shall be conducted for the actual module production run for the Project. This shall include verification of factory quality control, bill of material verification, audits confirming material matches other third-party testing that has been previously completed on the modules, module flash testing verifications.

1.5.5.4.1 The Seller shall provide a Third-Party PV Module Witness Testing Plan to the Buyer for review and approval.

1.5.5.4.2 The Buyer shall have the option to send a representative to said witness testing

1.5.6 Required Manufacturer's Warranty

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

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

1.5.6.3 Inverters 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.

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

1.5.6.4 Tracker Systems shall have a minimum manufacturer's warranty of 10 years on the structural components and 5 years on all other parts

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

1.5.7 PV Performance Criteria

1.5.7.1 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 Buyer for review and approval prior to contract award. The production estimate requirements shall be as follows:

1.5.7.1.1 Utilization of PVSyst® version 7.0 or newer.

1.5.7.1.2 The PVSyst simulation output report shall demonstrate estimated energy yield for all inverters at the site. A PVSyst model only showing a single inverter is not acceptable.

1.5.7.1.3 The full PVSyst project files before post-processing shall be provided to the Buyer (both .prj and .sit files).

1.5.7.1.4 The only acceptable solar resource datasets used for modelling shall be either SolarAnywhere v3.4 or newer or 3Tier/Vaisala.

1.5.7.1.4.1 Ground tuning of the dataset shall be allowed with the following conditions:

1.5.7.1.4.1.1 The MET stations have been cleaned on a regular schedule. The cleaning logs must be available to the Buyer.

1.5.7.1.4.1.2 The length of the dataset to be used for tuning must be at least a full calendar year.

1.5.7.1.4.1.3 Tuning of the P50 solar resource dataset is performed by the satellite data provider.

1.5.7.1.5 The PVSyst output simulation report shall include monthly soiling values.

1.5.7.1.6 The PVSyst output simulation report shall include monthly albedo values if Bifacial modules are utilized.

1.5.7.1.7 The PVSyst model shall include all near shadings and they shall be modelled to accurately represent the layout of the site.

1.5.7.2 A Production Estimate Report shall be provided that includes all of the following:

1.5.7.2.1 Shall be written based on the PVSyst simulation output report submitted with the bid.

1.5.7.2.2 Detailed summary of all model inputs and loss/gain parameters.

1.5.7.2.3 Detailed summary of all auxiliary load losses for daytime and nighttime.

1.5.7.2.4 Detailed summary of all near shading losses input into the model shall be identified. Assumed tree heights and setbacks shall be listed.

1.5.7.2.5 Detailed summary of major equipment and principal design parameters.

1.5.7.2.5.1 Status of the .pan file shall be provided (whether it is an OEM file or a 3rd party source).

1.5.7.2.5.2 Summary shall include details on the racking configuration.

1.5.7.2.6 Details of any post-processing calculations which may be implemented after the PVsyst modeling software output is calculated shall be identified.

1.5.7.2.7 If any post-processing is performed, full details of all parameters used are to be provided.

1.5.7.2.8 Summary of key performance metrics including Annual specific yield, DC Capacity Factor, AC Capacity Factor at inverter terminals, AC Capacity factor at POI, Performance Ratio, Plane of Array Insolation, and P50/P90 Probability Estimates.

1.5.7.2.9 Summary of annual expected energy production (MWh) at the Point of Interconnect.

1.5.7.3 The Seller shall provide an Excel data file containing expected AC energy, POA irradiance, windspeed, air temperature and array temperature for every hour for all 8760 hours for year 1.

1.5.7.4 Seller shall obtain an independent, non-affiliated, third party evaluation of both the PVSyst Simulation Output Report and Production Estimate Report and any post processing calculations used in estimating total expected AC energy output including all input variables. The evaluation shall be provided to the Buyer.

1.5.7.5 A revised as-built PVSyst Model and Production Estimate Report shall be submitted to the Buyer, prior to the start of the Capacity Testing, meeting the requirements outlined in Section 1.3.7

1.5.7.5.1 The revised PVSyst model shall include a third party verified .pan file

1.6 Interconnection Requirements

1.6.1 Seller shall be responsible for submitting a generator interconnection application to the applicable entity for the Project.

1.6.2 Seller shall meet all obligations required from the authority governing interconnections for the Project.

1.6.3 The site shall be designed so that it can produce full AC nameplate capacity over the entire operating range required by the interconnection requirements at an ambient temperature of up to 40^0C.

1.7 Site Ownership Requirements

1.7.1 The Project assets shall be wholly owned by Consumers Energy. It shall not be acceptable to share any components with other Owners including but not limited to the substation, PV array, site fencing and the collection system.

2.0 Major Equipment

2.1 General Requirements

2.1.1 Seller 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 35-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 Manufacturer's installation and storage instructions shall be carefully followed by Seller. 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.

2.1.4 Approved Manufacturers of major equipment shall be used and is defined within Appendix B1.

2.2 Photovoltaic (PV) Modules

2.2.1 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.

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

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

2.2.4 PV Modules shall be UL/IEC 61730 certified.

2.2.5 PV modules shall be IEC 61215 certified.

2.2.6 PV module grounding method shall be approved by manufacturer.

2.2.7 PV modules are to be 100% flash tested, with full results provided to Buyer.

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

2.2.9 PV modules are to be rated for Potential Induced Degradation (PID) resistance and certified to IEC 62804.

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

2.2.11 If thin-film modules are utilized the site must be designed and constructed such that no shading that could cause permanent panel degradation is permitted.

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

2.2.13 Third party validation of a random sample from the PV module lot shall be required for PV module power output, LID, and PID resistance.

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

2.2.15 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 Seller as part of the Mounting System design specifications.

2.3.2 The Mounting System foundation shall be designed to withstand frost heave and the soil corrosion potential of the Site and other environmental conditions at the Project location for a minimum of 35 years without replacement.

2.3.3 The Mounting System including foundation design and support design shall be in compliance with the recommendations and results of the geotechnical report and results of onsite push-pull testing

2.3.4 The racking system design shall be stamped by a Licensed Professional Engineer registered in the State of Michigan.

2.3.5 The Mounting system shall withstand wind speeds per 4.2.6 and be designed for a minimum of 35 years without impact to structural integrity.

2.3.6 The minimum module height to ground shall not be less than 18” at any point of travel.

2.3.7 If PV modules are installed in areas of flood potential they shall be installed and configured such that they are, at a minimum, 12” above the 100-year flood level and designed in accordance with ASCE 24.

2.3.8 The mounting system shall be certified by UL or another approved testing agency to meet the requirements of UL 2703 and UL 3703.

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

2.3.10 The racking system shall be designed to meet all mounting requirements from the PV Module manufacturer.

2.3.11 The Seller shall provide written confirmation from the PV Module manufacturer that the selected racking system and installation methods for the Project will not impact warranties in any way.

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

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

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

2.3.12.3 The SAT system shall have provisions for snow stow at times when snow buildup is a concern.

2.3.12.4 The SAT system shall have provisions for hail stow.

2.3.12.5 The Tracker system shall provide communications to the SCADA systems providing data on tracker position and any faults/alarms. The SCADA system shall also be able to send a command to put the trackers into a stow position and restore them from a stow position to normal operation. The control system shall utilize real-time feedback and control algorithm to continuously optimize tracker tilt angle for maximum production.

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

2.3.12.7 If SAT systems utilize DC drive motors with PV module provided power, a battery shall be provided and sized to operate the drives for a

minimum of 3 days with no solar input. Batteries shall be capable of operating in cold weather down to the minus thirty degrees Celsius (-30°C).

2.3.12.8 The SAT control system shall be installed in NEMA 4/4X rated electrical enclosures.

2.3.12.9 The SAT control system shall have control capabilities to position the system for ease of mowing and other maintenance activities (O&M maintenance modes).

2.4 Combiner Boxes (if applicable)

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 +40°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 NEMA 3R/4/4X.

2.4.5 The combiner box shall include a DC load break disconnect for isolation purposes.

2.5 Inverters

2.5.1 Inverters shall be UL 1741 SA Certified for not less than the maximum DC voltage of the Project

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

2.5.3 Inverters shall comply with IEEE 1547-2003 including testing to IEEE 1547.1 and IEEE C62.45.

2.5.4 Inverters shall comply with IEEE C62.41.2 and CSA 107.1-01.1

2.5.5 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.

2.5.6 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 Inverters shall have an operating temperature range of -25^{0}C to +50^{0}C

2.5.7.1 Inverters shall be able to operate at full rated power through the temperature range of -25^{0}C to +25^{0}C.

2.5.7.1.1 The Project shall have sufficient inverter capacity to meet the AC site capacity at the point of interconnection under the operating range as defined by the interconnection agreement at an ambient temperature of 40^{0}C.

2.5.8 Inverters shall operate from 25-100% humidity.

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

2.5.10 Inverters shall be capable of remote shutdown and curtailment.

2.5.11 Data collection points shall be integrated into the inverter monitoring and capable to send all to the SCADA system via a hardwired connection.

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

2.5.12.1 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).

2.5.12.2 Inverter points map shall be submitted to the Buyer for information.

2.6 Transformers

2.6.1 The following general design guidance defines the expectation regarding the use of transformers specified between 150 KVA and 250 MVA.

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

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

2.6.1.1.2 Interconnection voltage: 46 kV – 345kV --- Pad mount Transformer(s) 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 shall have service life of at least 35 years .

2.6.3 Seller shall provide appropriately sized medium voltage transformer(s) for the purposes of stepping up inverter output voltage for efficient AC collection and matching of interconnection or collector substation voltage.

2.6.3.1 The medium voltage transformers shall be designed to withstand all harmonics produced from the inverters.

2.6.3.2 The medium voltage transformers shall meet IEEE C57.12, UL, IEEE C57.159 and IEC 60076 standards.

2.6.3.3 The transformer shall be rated for PV use.

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 Buyer.

2.7 Switchgear and Panelboards

2.7.1 Combining AC circuits and safely distributing shall be accomplished using 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 6.0 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 when applicable. Closing circuit and trip circuit shall be isolated from each other through two, 2 pole DC molded case DC circuit breakers with a lockable disconnecting means.

2.7.5 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.

2.7.6 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.

2.7.7 Low voltage panelboards shall meet the following requirements:

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

2.7.7.2 Panelboards shall be UL listed.

2.8 Meteorological Stations

2.8.1 The Seller shall supply and install one meteorological station for every 30 MW's of Project DC nameplate capacity (MWp), a minimum of two meteorological stations 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 All meteorological stations shall have instrumentation that meets the following minimum site condition requirements:

2.8.5.1.1 A wind gust rating of 130mph, 3 second gust ASCE7-10 and a 110mph sustained wind speed

2.8.5.1.2 Operating temperature range of -35 to 70C or better

2.8.5.1.3 NEMA 4X and UL 746C electrical enclosures

2.8.5.2 The meteorological station(s) shall be equipped with an uninterruptible power supply and a battery. The battery shall be sized to provide a minimum of five (5) days of continuous, battery only operation.

2.8.5.3 Tower mounted MET stations shall be mounted in a location that does not shade nearby PV modules.

2.8.5.4 Pyranometers shall be heated and dried with heater/desiccant attachment. Pyranometers shall be rated ISO 9060:2018 Spectrally Flat Class A pyranometer.

2.8.5.5 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:

2.8.5.5.1 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.

2.8.5.5.1.1 If bifacial modules are used in the design, a primary Bifacial-plane-of-array (BPOA) pyranometer shall be required. The sensor shall be mounted free and clear of obstructions at a height of 1.5m. Care shall be taken to ensure the sensor does not see reflection from the racking system support posts.

2.8.5.5.2 Three or more module temperature sensors, with accuracy of +/- 0.15 degree Celsius or better. These sensors shall be of the platinum RTD variety attached to back of separate modules halfway down a row with a thermally conductive adhesive designed for the purpose and conditions.

2.8.5.5.3 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 +/- 0.2 degree Celsius or better.

2.8.5.5.4 One ultrasonic anemometer with wind direction, installed above 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.

2.8.5.5.5 One barometric pressure sensor, accurate to +/- 0.5mbar or better.

2.8.5.5.6 One doppler, impact, optical or other non-mechanical rain gauge.

2.8.5.5.7 One snow depth sensor with a maximum uncertainty of +/- 0.4%

2.9 Required Spare Parts

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

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

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

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

2.9.1.4 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.

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

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

3.1.2 Fence design shall meet all requirements to meet local building codes and be approved by the Authority Having Jurisdiction.

3.1.3 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. Specifications for the substation fence can be found in Section 6.12.4

3.1.4 At a minimum one twenty (20) foot vehicle gate shall be provided at each Project entrance, with an additional vehicle at the substation, if applicable.

3.1.5 Any lighting used on the project shall be International Dark-sky Association IDA (or equivalent) certified.

3.2 AC Station and Auxiliary Power

3.2.1 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. Position of the switch shall be available to be monitored remotely.

3.3 Site Lighting

3.3.1 Lighting requirements associated with an AC collector substation are defined in Section 6.0 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 All above grade grounding conductors shall be copper-clad steel. Seller to install signs on the perimeter fence indicating that copper clad steel is used that has no scrap value.

3.4.5 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.

3.4.6 For ground grids below grade, except for the substation, each junction of the grid shall be bonded with an irreversible compression connection or an exothermic type connection.

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

3.4.8 Ground rods shall be placed at all junction box, sectionalizing cabinet, and inverter pad locations.

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

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

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

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

3.4.13 Requirements associated with the AC collector substation grounding are contained in Section 6.0 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 The Seller shall supply the lightning protection study to the Buyer.

3.5.3 Requirements associated with the AC collector substation are contained in Section 6.0 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.

3.6.3 The Project shall have a site billing meter at the Project Substation to measure total site energy.

3.6.3.1 The Seller shall supply and install a meter socket as described in Appendix J.

3.6.3.2 The Seller shall supply a billing meter that is either a LandisGYR Maxsys Elite or a Schneider Electric ION8650 meter that are capable of communicating over the Buyer's MV90 system.

3.6.3.3 The current transformers and potential transformers shall have the following wire sizes:

PT/CT Cable Sizing Chart				
Cable Distance	Up to 100'	Up to 200'	Up to 300'	Up to 400'
PT Cable Size	#10	#8	#6	#4
CT Cable Size	#10	#4	#2	#2

*The distance is the total wire length from the instrument transformer to the meter socket

3.6.3.4 The wiring shall be color coded as follows:

	X Phase	Y Phase	Z Phase	Ground
CT Cable	Red	Black	White	Green
PT Cable	Red	Black	White	Green

3.6.3.5 The PT circuits shall have a separate NEMA 3R enclosure mounted near the instrument transformers that contain knife disconnect switches for isolating the PT circuits from the meter socket.

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.

3.7.1.2 Instrument Transformers shall be designed for use at a PV plant and be transient resistant.

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

3.7.2.4 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.

3.7.2.5 CT circuits shall be supplied with shorting type cutout switches with test studs.

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 Buyer'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 native project files shall be furnished to the Buyer for Record.

3.8.1.1 The Arc Flash analysis shall be performed on both the AC system and the DC system.

3.8.1.2 The arc flash analysis shall be done using 18" working distance in the calculations

3.8.2 Installation shall comply with NFPA 70E Requirements.

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. All signage must meet current industry standards and shall have a life span of 30 years.

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 Appendix 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 Appendix 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. All major equipment shall be assigned a unique identification number in accordance with Appendix D2. All equipment that requires maintenance or is used as an electrical isolation point for safety shall be given a unique identification number.

3.9.3 Facility Signage

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

3.9.3.2 Signage requirements for the substation fence shall meet all local and industry codes and standards

3.10 Glare and Glint Prevention

3.10.1 A glare and glint analysis must be performed if required for FAA approval and permit or where required by the local AHJ.

4.0 Civil

Specific requirements associated the collector substation is contained within Section 6.0.

4.1 Geotechnical Requirements

4.1.1 Seller 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 Buyer 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, oxidation-reduction, pH, soluble sulfates, soluble chlorides).

4.1.2.3 Soil electrical resistivity and thermal resistivity tests. Seller shall perform soil resistivity tests using the Wenner Four-Pin Method, ASTM G57. Probe spacing shall range from 0.5 feet to 120.0 feet. Thermal Resistivity Tests to be completed in accordance to ASTM 5334 on soil proposed for backfill of underground conductors. 6.0

4.2 Structural Design Loads

4.2.1 Seller 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 Michigan 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 Michigan Building Code as modified by any locally adopted code. The Module rack shall be designed in such a way that deflections due to snow loading will not damage the Modules.

4.2.6 Wind loads shall be in accordance with the Michigan 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.

4.2.7 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 Seller based on the results of the subsurface investigation, which shall be performed by the Seller.

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 Seller 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 Seller 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, Seller 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 Seller’s Geotechnical Engineer based on the subsurface conditions found in the Geotechnical studies.

4.4.2 The PV Module mounting structure manufacturer shall approve Seller’s design and installation to ensure that the mounting structure warranty remains in effect.

4.4.3 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.

4.4.4 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.

4.4.5 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.

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

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

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

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

4.5 Equipment Foundations

4.5.1 Building and equipment foundations shall be of reinforced concrete or pier/pile foundations.

4.5.2 All foundations shall extend a minimum of three (3) 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. Design foundations for major equipment to be frost protected in accordance with Michigan Building Code. 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 4,500 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 Buyer prior to placing concrete.

4.6 Racking System Steel and Fasteners

4.6.1 All steel racking components shall be designed to meet a 35-year design life

4.6.2 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.

4.6.3 Pipe caps shall be utilized on any open pipes.

4.6.4 Fasteners used for PV racking and module mounting shall be approved for use by the manufacturer and designed to last for a minimum of 35 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 35-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 30-year Design Life of the Project.

4.8.7 Fasteners and hardware shall be designed to meet the design life of the Project.

4.8.8 Steel products that are galvanized 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 Seller 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 Design all facilities to maintain positive drainage across the entire Project area or to designed stormwater control areas. Ponding is not allowed within the array boundaries. Stormwater management to be designed in accordance to requirements set forth by authorities having jurisdiction. Design shall account for damaging cross flow of stormwater by a culvert, low water crossing or other method which does not allow erosion, deposition of fines, other deleterious actions. 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 Seller. 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 Buyer.

4.9.3 Seller 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, dewatering, 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. No facilities shall be placed within a 100-year flood plain as determined by currently available databases or hydrology studies conducted as part of this Project without written approval from the Buyer. All recommendations from applicable studies must be met.

4.9.4.1 All inverters, transformers, PV modules, switchgear, combiner boxes, MET stations and other electrical equipment shall be located at a minimum 12” above the 100-year flood plain.

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 Seller’s expense, to the satisfaction of the Buyer.

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

4.9.8 Seller shall submit site restoration plan to Buyer for approval.

4.9.9 The Project shall have a maximum of ten-degree (10°) slope in areas around the array that will be mowed or require mower access.

4.9.10 The row pitch shall be sized such that a mower with a fifteen-foot (15’) deck can efficiently operate through the rows as to complete mechanical mowing with minimal backtracking and/or maneuvering. Ingress/egress and clearance thereof for each row shall be adequate to permit exiting and entering the adjacent row

while mowing. Layouts with similar or better mechanical mowing and vegetation management efficiency may be proposed.

4.9.11 Whenever reasonably possible, the DC wiring and associated equipment shall be designed to reduce the blockages and interferences that prevent a lawn mower with a fifteen-foot (15') deck from passing between racks.

4.10 Roads

4.10.1 The main entrance drive shall extend from public roadway edge to the facility fence. Main entrance drive grades shall not exceed 5% and shall be designed to have smooth grade changes and transitions (K≥15). The section of the main entrance drive that is within the authority of the AHJ (Authority Having Jurisdiction) shall meet the requirements of the AHJ.

4.10.2 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 The SPCC plan shall be provided by the Seller and meet all codes and regulations.

4.11.2 The Seller shall provide spill containment as required in the SPCC plan

5.0 Collection System

5.1 DC Collection

5.1.1 All components utilized in the DC collection system shall be rated for a minimum of 1,500 VDC

5.1.2 Wire losses specific to any complete DC circuit from PV modules to inverters shall not exceed a maximum of 2.0% at STC conditions.

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

5.1.4 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.

5.2 AC Collection

5.2.1 Total wire losses from AC circuits from any inverter to the point of interconnect shall not exceed a maximum of 3.0%.

5.2.2 The 34.5 kV cable shall meet requirements contained within Appendix D1.

5.2.3 Surge arresters shall be installed on the high voltage side of all unused bushing wells of medium voltage transformers.

5.2.4 Splicing shall not be allowed in the AC collection system for any cable distances less than 1,500'

5.2.4.1 If the cable distance exceeds 1,500’ and a splice is used it shall have the following requirements

5.2.4.1.1 Splices will be installed in groups of three (one per phase) and all phases shall be spliced within 10’ of each other.

5.2.4.1.2 The location of the splice shall have GPS coordinates recorded onto the drawing showing the location.

5.2.4.1.3 A passive, programmable underground 3M marker ball shall be installed for future locating.

5.3 Isolation and Overcurrent Protection

5.3.1 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.

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

5.3.3 Fuses shall be rated for PV use and comply with IEC 60269-6 and UL-248-19

5.3.4 Fusing is required on the positive DC legs of the PV array.

5.3.5 Fusing on the negative DC legs is not required as long as adequate ground fault protection has been installed.

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

5.4 Power and Control Wiring

5.4.1 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.

5.4.2 No splices, other than those described in Section 5.2.4, shall be permitted, except with Buyer approval.

5.4.3 DC conductor in grounded and underground systems shall be listed and identified as 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.

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

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

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

5.5 Conduit

5.5.1 All directly buried conductors shall be protected by conduit from the trench up to the electrical enclosure termination point.

5.5.2 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. All conduit openings to be sealed with duct seal after all cables are installed to protect from rodent entry.

5.6 Terminations & Connectors

5.6.1 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.

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

5.6.3 Mating PV connectors shall be identical brand and type as those used on the PV module or meeting the intermatability requirement as defined in UL 6703, Connectors for Use in Photovoltaic Systems.

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

5.7 Direct Buried Conductors

5.7.1 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.

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

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

5.7.4 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.

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

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

5.7.7 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 shall be designed by one of the following approved contractors: Commonwealth Associates, Electrical Consultants Inc (ECI), or SubGrid Solutions.

6.1.2 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.

6.1.3 Seller 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.

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

6.1.5 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.

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

6.2.3 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 Appendix C1. If the Seller is using the transformer as safe harbor equipment the Buyer shall review the specifications used to procure the transformer.

6.4 MV and LV Circuit Breakers

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

6.5 Disconnect Switches

6.5.1 The disconnect switch specification is defined within Appendix E2.

6.5.2 The main facility breaker(s) shall include group operated disconnect switches on both the grid and station side of the breaker.

6.5.3 The low voltage side of the Main Power Transformer shall include a group operated disconnect.

6.5.4 All 34.5kV breakers shall include hook operated disconnect switches to be able to individually isolate the breaker without impacting other equipment.

6.6 EHV Circuit Breakers

6.6.1 The EHV circuit breaker specification is defined within Appendix 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. Seller to match Surge Arrester ratings and manufacturer as specified in Appendix F1.

6.8 DC Control Power

6.8.1 Seller 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 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.

6.8.5 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).

6.8.6 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.

6.9.2 The quantity and depth of driven ground rods shall be determined by a grounding study and site geotechnical conditions. The top of the ground rod shall be buried eighteen (18) inches below rough grade.

6.9.3 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.

6.9.4 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 Buyer.

6.10Collection 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 All equipment/structural metallic surfaces shall be bonded at least at two points. 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 Buyer review and approval.

6.12 Collection Substation Civil

6.12.1 General

6.12.1.1 Tree and vegetation removal, clearing, grubbing, grading, and compacting as necessary shall be performed by the Seller. All trees within falling range of the substation and its clear zone shall be removed.

6.12.1.2 The substation shall be designed to not have standing water or subject to flooding from offsite runoff and may not be located in a 100-year flood plain. 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 Seller 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 shall be designed to have provisions to connect grounding in accordance to industry standard.

6.12.2.4 Substation structural connections should be completed utilizing bolted connections.

6.12.3 Collector Substation Foundations

6.12.3.1 Seller 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 Sections 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 Michigan Building Code, 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. All critical foundations (Breakers, GSU, etc.) shall bear on or below the frost depth or be designed in accordance with ASCE 32.

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 and ACI 301.

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 Seller 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 Seller shall install an outward opening, 20 feet wide, and double leaf gate 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.

6.12.4.5 The fence shall be zinc coated No. 11 (.120”) gauge steel wire woven in a 1” mesh.

6.12.4.5.1 The zinc coating shall conform to the requirements of ASTM A392 and shall be a Class II coating.

6.12.4.6 All fence fixtures and fittings shall be hot dip galvanized.

6.12.4.7 All fencing shall meet requirements and details specified in Exhibit A – Appendix G5.

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 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 manhole.

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 Seller shall adequately size and configure the Substation Control Enclosure to comply with Buyer’s standards and requirements and shall be complete with

required equipment, foundation, normal and emergency lighting, emergency egress, 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 Control Enclosure shall be sized to accommodate two server racks for Owner Supplied equipment as described in Section 7.2.10

6.13.2 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.

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

6.13.3.1 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 minimum requirements are defined within Appendix G3. The Buyer will finalize Appendix G3 and supply to the Seller after the Seller provides a preliminary one-line drawing including all electrical equipment (breakers, circuit switchers, transformers, capacitor banks, line and feeder exits, neutral reactors, current transformers, voltage transformers, etc.). The Buyer will then update Appendix G3 based on Project Specific design and return to the Seller as outlined in Section 1.5.

6.14.1.2 The collector substation monitoring minimum requirements are defined within Appendix G4.

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

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

6.14.1.5 Seller 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.

6.14.1.6 The Buyer shall have the option to adjust relay and switchboard panel layouts in the design to align with Buyer standard layouts.

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). Seller shall design an appropriate protection scheme to be reviewed by the Buyer.

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 Appendix 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 (if applicable)

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 (if applicable)

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

6.15Collector Substation Animal Mitigation Requirements

6.15.1 The Collector Substation shall include polycarbonate panels attached to the perimeter of the substation fence utilizing standard details specified in Exhibit A – Appendix G5. Perimeter fence fabric shall be set at rough grade with surface coarse covering the fence base.

6.15.2 The Collector Substation shall include a concrete foundation under all gates with one-inch (1") maximum spacing between the bottom of the gate and top of foundation. Standard details shown in exhibit previously listed in this section.

6.15.3 Overhead lines utilizing wood pole structures shall be wrapped with aluminum flashing at minimum. Details for wrapping of wood poles are shown in Exhibit A – Appendix G5.

6.15.4 Incoming overhead lines into AC Substation (if applicable) shall include line discs for voltages less than 138 kV. Standard details are located within Appendix G5.

7.0 SCADA, Communication Networks, and Cyber Security

7.1 Supervisory Control and Data Acquisition

7.1.1 Local SCADA System - The Seller 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 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.

7.1.1.2 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).

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

7.1.1.4 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.

7.1.1.5 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

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

7.1.1.7 All data point tags and names shall be approved by the Buyer.

7.1.1.8 The local SCADA system shall have provisions for remote access from the Buyer.

7.1.1.9 All datapoints within the SCADA system shall be available to the Buyer via a Modbus TCP/IP or DNP3 TCP/IP connection.

7.1.1.10 The Buyer will supply an RTU enclosure to the Seller for installation.

7.1.1.10.1 The Seller shall install the Buyer supplied RTU enclosure and supply 24VDC UPS power and 120VAC non-UPS power to the RTU enclosure.

7.1.1.11 The local SCADA system shall connect to the Buyer supplied RTAC via a fiber communication link supplied and installed by the Seller.

7.1.1.11.1 The Seller is responsible for programming the local SCADA system to pass data, via DNP 3, to the Buyer supplied RTU.

7.1.1.11.2 The Buyer will provide a tag list for the Buyer supplied RTU.The local SCADA system shall be configured to pass data per the Owner supplied point list.

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 substation circuit breakers.

7.1.2.5 Place tracking system into stow position and restore to normal operation.

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.

7.1.3.9 All data points shall follow the MESA standard where reasonably possible.

7.1.4 The Seller 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.

7.1.5 The Seller shall supply a single OPC server at the Project Site for passing data to the Buyer's OSI PI system and to the Buyer's SCADA overlay system from the site SCADA/data collection system.

7.1.5.1 The OPC server shall be OPC-UA.

7.1.5.2 The OPC server shall have a minimum of two concurrent connections from Buyer's equipment.

7.1.5.3 The OPC server shall have hardware and licensing to support the total tags used in the system plus a minimum of 10% (ten percent) spare.

7.1.5.4 The OPC server shall include a minimum of 30 days worth of data storage.

7.1.5.5 The OPC server shall include provisions for remote rebooting of the system.

7.2 Communication Requirements

7.2.1 Communications facilities shall be furnished by the Seller 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 Seller shall provide and install a fiber demark pedestal as found in Appendix K

7.2.2.1 The fiber demark pedestal shall be installed and powered no less than ninety (90) days prior to Substantial Completion.

7.2.2.2 The Buyer shall arrange and manage delivery of the communication service.

7.2.2.3 The Seller shall provide an address to the Project no less than twelve (12) months prior to Substantial Completion for the Buyer to have adequate time to procure the Telcom service.

7.2.3 The Seller shall arrange and manage the delivery of the necessary communication service from a telecom provider to the facility to satisfy the requirements of the Generator Interconnect Agreement.

7.2.4 Communication Protocol

7.2.4.1 Inverters and local SCADA shall be capable of utilizing DNP3 or Modbus TCP/IP.

7.2.5 Component Level Communication

7.2.5.1 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.

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

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

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

7.2.6 Ethernet

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

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

7.2.6.1.2 UL listed.

7.2.6.2 Ports shall be standard Ethernet RJ-45.

7.2.7 Fiber Optic

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

7.2.7.2 Fiber optic cable shall meet the following requirements:

7.2.7.2.1 Fiber-optic cable shall follow the requirements outlined in ANSI/TIA-568.3-D.

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

7.2.7.2.3 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.

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

7.2.7.2.5 Shall include minimum 10% spare fiber strands or two (2) strands, whichever is greater, for future use.

7.2.7.2.6 Splicing of fiber-optic cables shall only be allowed when approved by the Buyer.

7.2.7.3 All strands of the fiber optic cable shall be tested per ANSI/TIA-526-7 or ANSI/TIA-526-14.

7.2.8 Switches

7.2.8.1 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.

7.2.8.2 Switches shall be managed whenever possible and be Hirschmann Bobcat series.

7.2.8.2.1 All switches installed outside of the substation shall have a dedicated fiber optic communication connection back to the Buyer provided network monitoring device which will be installed in the substation control house.

7.2.8.2.2 All switches installed inside of the substation shall have a dedicated copper connection back to the Buyer provided network monitoring device.

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

7.2.10 Seller shall provide two (2) Main Distribution Frames (MDF) in the substation control house for the Buyer's IT equipment.

7.2.10.1 The MDF cabinets shall have 42U spaces each and have minimum dimensions of 600mm wide x 1200mm deep

7.2.10.2 The Seller shall install and power the MDF cabinets.

7.2.10.2.1 Both MDF cabinets shall have 120VAC UPS power installed.

7.2.10.3 The MDF cabinets shall be installed and powered a minimum of forty-five (45) days prior to the Commercial Operation Date.

7.3 Cyber Security

7.3.1 All wireless communication functionality must be turned off unless it is required to be used and only with approval from the Buyer.

7.3.1.1 The use of ZigBee network for the single axis tracker systems shall be acceptable.

7.3.2 The Seller shall ensure individuals needing remote access to the equipment or access to the substation after Commercial Operation have a completed Personal Risk Assessment on file at least thirty (30) business days prior to needing access.

8.0 Generator Tie Line (if Applicable)

8.1 General

8.1.1 The Seller 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 The Generator Tie Line shall be designed and built to 46kV, 138kV or 345kV (I.E. a 120kV interconnection voltage shall be design to 138kV standards).

8.1.4 The Generator Tie Line shall have clearances from trees and other hazards than meet all applicable codes and standards.

9.0 Commissioning, Testing, and Training

9.1 Commissioning

9.1.1 The Seller shall develop and provide a detailed Commissioning Plan for the Project and approved by the Buyer

9.1.2 The Commissioning Plan specifications shall 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, at a minimum, include the following requirements:

9.1.4.1 All relevant testing required to demonstrate compliance with the Project's interconnection.

9.1.4.2 Visual inspections that verify all equipment sizes, arrangements, markings, and labels, etc. are all installed per the design and requirements within the specifications.

9.1.4.3 Verification and testing of the grounding system in accordance with NETA-ATS Section 7.13 and E-11-01.

9.1.4.4 PV string open-circuit voltage testing to assess overall string performance. This test shall be done during periods between 10:00am and 2:00pm solar time when irradiance is greater than 700W/m^2. Results shall be within 5% of Voc-expected and 5% of all similar adjacent strings.

9.1.4.5 All DC strings and home run wires shall be checked for proper polarity before connection.

9.1.4.6 I-V curve testing for five percent (5%) of the overall number of individual PV module strings shall be performed. The test equipment shall also include a reference standard irradiance sensor, ambient temperature sensor and back of module temperature sensor. This test shall be performed during periods between 10:00am and 2:00pm solar time during the winter half of the year (Sept 22 through Mar 22), or between 9:00am and 3:00pm solar time during the summer half of the year (Mar 22 through Sept 22), when irradiance is stable and is greater than 600 W/m^2.

9.1.4.7 The commissioning plan shall include 100% aerial IR (infrared) inspection. Inspection shall be performed during periods between 9:00am and 3:00pm solar time, when irradiance is stable and greater

than 500 W/m2. Altitude angle and resolution shall be sufficient to detect hotspots within photovoltaic cells of PV modules. Any "hotspot" areas on PV modules shall be determined to be faulty and such PV modules shall be replaced. All images and /or videos shall include identification of the strings/subarray inspected. All images and/or videos shall include GPS coordinates, altitude, angle, and direction of camera orientation. All images and/or videos are to be submitted. Drone flightpath files are to be submitted.

9.1.4.8 The commissioning plan shall include IR inspection of all PV connectors during periods between 9:00am and 3:00pm solar time, when irradiance is stable and greater than 500 W/m2.

9.1.4.9 All cables (both AC and DC) shall be tested for insulation resistance in accordance with NETA-ATS. Any failed test shall require corrective action agreed upon by the Buyer.

9.1.4.10 Medium voltage cables shall be tested after all terminations and splices have been installed. Cables shall be inspected and tested in accordance with NETA-ATS 7.3.3. The preferred test method is by partial discharge analysis, any other test method may only be used with approval from the Buyer.

9.1.4.11 The Seller shall verify every point back to the SCADA system reads as expected. This includes all points hardwired to discrete I/O and all points coming over any communication links.

9.1.4.12 Sound level testing at all property lines. The sound level test shall be done before energization of equipment and after energization to compare results.

9.1.5 All other equipment not listed shall be tested in accordance with NETA-ATS

9.1.6 In addition to the requirements of the Commissioning Requirements, the Commissioning Plan to be provided by Seller 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 Buyer's attention for resolution.

9.1.7 The Seller 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 Seller will not begin commissioning activities until the Buyer has performed an inspection and provides approval.

9.1.8 Seller shall provide, for Buyer 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 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.

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

9.2 Functional Testing

9.2.1 The Seller shall perform a Functional Test as described in Appendix K1

9.3 Performance Testing

9.3.1 The Seller shall perform a Capacity Test as described in Appendix K

9.4 North American Electric Reliability Corporation (NERC) Testing

9.4.1 The Seller shall be required to ensure the site meets and is tested to all of the following NERC requirements for projects connected to the Bulk Electric System, as applicable.

- 9.4.1.1 NERC MOD-025-2 Verification and Data Reporting of Generator Real and Reactive Power Capability
- 9.4.1.2 NERC MOD-026-1 Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var control Functions
- 9.4.1.3 NERC Mod-027-1 Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions
- 9.4.1.4 NERC MOD-032-1 Data for Power System Modeling and Analysis
- 9.4.1.5 NERC Mod-033-1 Steady-State and Dynamic System Model Validation
- 9.4.1.6 NERC PRC-019-2 Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection

9.5 Buyer Testing

9.5.1 The Seller shall allow the Buyer five (5) business days prior to energization to perform checks in the substation and metering wiring.

9.5.2 The Seller shall allow the Buyer ten (10) business days after completion of the Functional Test to perform data point verification back to the Buyers data collection system. The Seller shall support the Buyer during this period and assist in operating equipment and devices and simulating datapoints to verify changes. This test shall be an end-to-end test of all datapoints. It is possible that this test can happen in parallel with the Functional Test.

END OF DOCUMENT

Solar Technical Specification

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Exhibit A Appendix A1 – Submittal Requirements

Executed Date

This document details the specifications for communicating information to the Buyer following the execution of a purchase and sale agreement. For specifications regarding the submission of a proposal in response to the Buyer'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 Buyer prior to Seller 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 Seller'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 Buyer approval prior to proceeding with the Work.

1.1.3 Submittal Requirements

1.1.3.1 The Seller shall prepare and maintain for the Buyer's concurrence, a schedule for submission of all Submittals specified by the universal master deliverables list (Appendix A2), and other submittals required within the Scope of Work or necessary for the Buyer'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 Seller or their SubSellers or any other Sellers as described herein.

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

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

1.1.3.4 The schedule shall indicate the anticipated dates of original submission for each item and the Buyer'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 Buyer's review and approval of the pertaining Submittal will be at the sole expense and responsibility of the Seller.

1.1.4 Transmittal of Submittals

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

The Seller shall submit to the Buyer the Attribute Upload Form spreadsheet (Appendix A4) prior to issuing any submittals.

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

1.1.4.1 Seller's file name/drawing number.

1.1.4.2 Seller'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 Buyer's Review

1.1.5.1 The Buyer will review and take appropriate action on Submittals in accordance with the accepted schedule of Submittals. The Buyer'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 Buyer's review and approval will not extend to design data reflected in Submittals which is within the special expertise of the Seller or the Seller's SubSellers 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 Buyer's review and approval of Shop Drawings, product data, or Samples will not relieve the Seller of responsibility for any deviation from requirements of the Contract Documents unless the Seller has in writing called the Buyer's attention to such deviation at the time of submission, and the Buyer has given written concurrence in and approval of the specific deviation. Approval by the Buyer shall not relieve the Seller from responsibility for errors or omissions in Submittals.

1.1.5.4 The Buyer's review action stamp, appropriately completed, will appear on all Submittals of the Seller when returned by the Buyer. Review status designations listed on the Buyer 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 Seller 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 Buyer's notations. The Seller is to proceed with fabrication or procurement of the items and with related Work in accordance with the Buyer'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 Buyer from completing their review. The Seller is to resubmit revised information responsive to the Buyer'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 Seller 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 Buyer 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 Buyer reviews such Submittals for general content but not for basic details.

1.1.5.5 Design changes that are made after Approved For Construction (AFC) and listed as "Required" in Exhibit A2 – Master Deliverables List shall be allowed an Buyer Review of the changes if the Buyer deems necessary.

Exhibit A Appendix A2 -- Solar Universal Master Deliverables List
Revision 2022

Deliverables	***30% Design Package***		***60% Design Package***		***90% Design Package***		***IFC Design Package***		***Record Package***	
	Applicable	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*
Civil Design Package										
Cover Sheet, Notes, Drawing Index, Legend & Symbols	X		As applicable		X		Informational Only		X	
Surveys (geotechnical, topographic, recordable easement exhibit, other)	X		As applicable		X		Informational Only		X	
Geotechnical Reports	X		As applicable		X		Informational Only		X	
Road and Drive Design Calculations	X		As applicable		X		Informational Only		X	
Road and Drive Drawings	X		As applicable		X		Informational Only		X	
Grading Drawings	X		As applicable		X		Informational Only		X	
Soil Erosion and Sedimentation Control Details and Drawings	X	TBD	As applicable	TBD	X	TBD	Informational Only	TBD	X	TBD
EGLE Permit Drawings	X		As applicable		X		Informational Only		X	
Foundation Calculations	X		As applicable		X		Informational Only		X	
Foundation Drawings	X		As applicable		X		Informational Only		X	
PV Mounting System Design Analysis and Calculations	X		As applicable		X		Informational Only		X	
PV Mounting System Design Drawings	X		As applicable		X		Informational Only		X	
Project Applicable Cutsheets Upon Request	X		As applicable		X		Informational Only		X	
Substation Design Package										
Cover Sheet, Notes, Drawing Index, Legend & Symbols	X		As applicable		X		Informational Only		X	
Building Plans, Elevations, Sections and Details	X		As applicable		X		Informational Only		X	
Foundation Plans, Sections and Details	X		As applicable		X		Informational Only		X	
Substation Structures and Miscellaneous Steel Details	X		As applicable		X		Informational Only		X	
Panel Layouts and Schedules	X		As applicable		X		Informational Only		X	
Grounding Plans, Sections and Details	X		As applicable		X		Informational Only		X	
Lighting/Illumination Plan and Details	X		As applicable		X		Informational Only		X	
Schematic and Loop Drawings	X		As applicable		X		Informational Only		X	
Wiring Drawings	X		As applicable		X		Informational Only		X	
Instrumentaion Mounting Details	X		As applicable		X		Informational Only		X	
Grounding Study and Analysis	X		As applicable		X		Informational Only		X	
Circuit and Raceway List	X		As applicable		X		Informational Only		X	
Control Enclosure Plans and Details	X		As applicable		X		Informational Only		X	
One Line and Three line Diagrams	X		As applicable		X		Informational Only		X	
Grading Details	X	TBD	As applicable	TBD	X	TBD	Informational Only	TBD	X	TBD
Fencing Layout and Details Drawing	X		As applicable		X		Informational Only		X	
Protective Relay Settings			As applicable		X		Informational Only		X	
Short Circuit Study			As applicable		X		Informational Only		X	
Arc Flash Study			As applicable		X		Informational Only		X	
Arc Flash Model									X	
Grounding Study			As applicable		X		Informational Only		X	
Reactive Requirements Study			As applicable		X		Informational Only		X	
Lighting Protection Study			As applicable		X		Informational Only		X	
Lightning and Switching Overvoltage Study			As applicable		X		Informational Only		X	
Temporary Overvoltage Study			As applicable		X		Informational Only		X	
Harmonic Desktop Study			As applicable		X		Informational Only		X	
Protective Device Coordination Study			As applicable		X		Informational Only		X	
NERC Compliance Report							Informational Only		X	
Transient Stability Model Validation and HVRT/LVRT									X	
Major Equipment Drawings					X		Informational Only		X	
Collection System Design Package										
Cover Sheet, Notes, Drawing Index, Legend & Symbols	X		As applicable		X		Informational Only		X	
AC and DC Collection Layout Drawings	X		As applicable		X		Informational Only		X	

Exhibit A Appendix A2 -- Solar Universal Master Deliverables List
Revision 2022

Deliverables	***30% Design Package***		***60% Design Package***		***90% Design Package***		***IFC Design Package***		***Record Package***	
	Applicable	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*
AC and DC Single Line Diagrams	X	TBD	As applicable	TBD	X	TBD	Informational Only	TBD	X	TBD
Communication Single Line Diagram	X		As applicable		X		Informational Only		X	
AC and DC Site Plan Drawings	X		As applicable		X		Informational Only		X	
DC Wiring Drawings	X		As applicable		X		Informational Only		X	
AC Wiring Drawings	X		As applicable		X		Informational Only		X	
Layout Drawings	X		As applicable		X		Informational Only		X	
Communication Detail Wiring Drawings			As applicable		X		Informational Only		X	
Underground Cable Details and Drawings	X		As applicable		X		Informational Only		X	
Schematic and Loop Drawings			As applicable		X		Informational Only		X	
Junction Box and Connection Details			As applicable		X		Informational Only		X	
Cable Splicing Details and Drawings			As applicable		X		Informational Only		X	
Circuit and Raceway List	X		As applicable		X		Informational Only		X	
AC and DC Voltage Drop Calculations	X		As applicable		X		Informational Only		X	
AC and DC Short Circuit Study					X		Informational Only		X	
Arc Flash Study			As applicable		X		Informational Only		X	
Arc Flash Model									X	
Arc Flash Hazard Label and Location Identification										
Cable Sizing Calculations	X		As applicable		X		Informational Only		X	
Protective Device Coordination Study					X		Informational Only		X	
Lightning Protection Analysis			As applicable		X		Informational Only		X	
Major Equipment Datasheets	X		As applicable		X		Informational Only		X	
Quantities and Bill of Materials	X		As applicable		X		Informational Only		X	
Balance of System Electrical Design										
Cover Sheet, Notes, Drawing Index, Legend & Symbols	X	TBD	As applicable	TBD	X	TBD	Informational Only	TBD	X	TBD
SCADA Network Diagram	X		As applicable		X		Informational Only		X	
SCADA Communication Block Diagram	X		As applicable		X		Informational Only		X	
SCADA Point List			As applicable		X		Informational Only		X	
MET Station Installation Drawings	X		As applicable		X		Informational Only		X	
MET Station Communication Diagrams	X		As applicable		X		Informational Only		X	
MET Station Datasheets	X		As applicable		X		Informational Only		X	
MET Station Manuals			As applicable		X		Informational Only		X	
Environmental										
Cover Sheet, Notes, Drawing Index, Legend & Symbols	X	TBD	As applicable	TBD	X	TBD	Informational Only	TBD	X	TBD
Permits and Agreements - Regulatory	X		As applicable		X		Informational Only		X	
Storm Water Pollution Prevention Plan (SWPPP) - Environmental	X		As applicable		X		Informational Only		X	
Wetland Delineation Study - Environmental	X		As applicable		X		Informational Only		X	
Miscellaneous										
Major equipment Factory Acceptance Test Reports		TBD		TBD		TBD		TBD	X	TBD
Manufacturer Field Service Reports									X	
Spare Parts Lists									X	
Operation and Maintenance Plans and Manuals							X		X	
Equipment Installation Manuals							Informational Only		X	
Written Letter of Approval from the Module, Racking, Inverter and other applicable OEM's Certifying the Installation Conforms to Their Guidelines and Full Warranty is in Effect									X	
Completed Warranty Cards and Certifications									X	
Equipment Commissioning Test Results									X	
Cyber Security Supporting Documentation for Vendor Access (PRA's etc)							Informational Only			
Equipment Datasheets/Cutsheets/Drawings					X		Informational Only		X	
Quality Control Plans (Including All Subcontractors)							Informational Only		X	
Commissioning, Operating, Shutdown and Emergency Procedures							Informational Only		X	
Noise Study					X		Informational Only		X	
Glare Study					X		Informational Only		X	
FAA Report (If applicable)									X	

Exhibit A Appendix A2 -- Solar Universal Master Deliverables List
Revision 2022

Deliverables	***30% Design Package***		***60% Design Package***		***90% Design Package***		***IFC Design Package***		***Record Package***	
	Applicable	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*	*Applicable*	*Deliverable Date*
Shading Study					X		Informational Only		X	
Solar Production Model and Report	X		As applicable		X		Informational Only		X	
Protective Relay Calibration Records									X	
Job Books									X	
Master Document List Template	X		As applicable		X		Informational Only		X	
Capacity Test Results Report									X	
Functional Test Results Report									X	
Major Equipment Drawings	X		As applicable		X		Informational Only		X	
Project Engineering Schedule	Monthly									
PV Module Witness Testing Plan	Minimum sixty days prior to witness testing									

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Exhibit A – Appendix A3 – Design Document Standards

Executed Date

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 Buyer in native format. The 3D drawings shall also be broken into 2D drawings and provided to the Buyer

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 Buyer 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 The Seller shall assign drawing numbers based on the Buyer’s standard naming convention.

1.1.6 Vendor Drawings

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

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

1.1.7 Vendor Manuals

1.1.7.1 Vendor Manuals shall be submitted to the Buyer in PDF format at the conclusion of the Project. All vendor manuals shall have a cover sheet and a drawing number assigned to it.

File Path	*File name*	CONST ID	CE DOCUMENT NUMBER	VENDOR DOCUMENT NUMBER	Description	DOCUMENT TITLE	REVISION	REVISION DATE	UNIT	DISCIPLINE	DOC TYPE	DOC SUB-TYPE	State	Version	KEYWORDS	CE_Submittal_Description	PLANT ID	CE_DWG_NUM	CE_SHT	CE_SCALE	CE_JOB_NUM	CE_CUR_REV	CE_Plant	CE_LOCATION	CE_Dwg_Size	SYSTEM
40-19_TDS_040816.pdf	40-19_TDS_040816.pdf			40-19_TDS_040816	4/0 19 STRAND 4/0 AWG CONCENTRIC SOFT-DRAWN BARE COPPER	4/0 19 STRAND 4/0 AWG CONCENTRIC SOFT-DRAWN BARE COPPER	0	2021-03-24		E-ELECT	STUDY	DATASHEET	AFC Tech Review		SUBSTATION BELOW GRADE										
1692-SUB-15-001.dwg	1692-SUB-15-001.dwg	8	1692-SUB-15-001		345/34.5KV SUBSTATION CONDUIT PLAN	345/34.5KV SUBSTATION CONDUIT PLAN	C	2021-03-25		E-ELECT	DRAWING		AFC Tech Review		SUBSTATION BELOW GRADE										
1692-SUB-15-001.pdf	1692-SUB-15-001.pdf	8	1692-SUB-15-001		345/34.5KV SUBSTATION CONDUIT PLAN	345/34.5KV SUBSTATION CONDUIT PLAN	C	2021-03-26		E-ELECT	DRAWING		AFC Tech Review		SUBSTATION BELOW GRADE										
These cells should match					These cells should match			Use this date format																		
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Solar Technical Specification

SP-001
Revision 2022.1

Exhibit A Appendix B1 – Approved Manufacturers List

Executed Date

1.0 General

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

Solar Facility Acceptable Manufacturers List	
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, GE, SMA, Mitsubishi (TMEIC), Power Electronics, Yaskawa Solectria
Low Voltage Circuit Breakers	Allen-Bradley, Eaton Cutler Hammer, General Electric, Square D
Main Power Step-Up Transformer	ABB , Delta Star, SPX, GE Prolec
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
Protective Relays	Schweitzer Engineering Laboratories (SEL)
PV Modules	First Solar Series 6, Hanwah Q-Cells, JA Solar, Jinko Solar, LONGi ,Trina, REC
SCADA	Green Power Monitor, Trimark Associates
Single Axis Trackers	ATI, Game Change , NexTracker, Solar Flex Rack
Capacitor Banks	ABB, Cooper, General Electric
Meteorological	Campbell Scientific, Empro, Hukseflux, Kipp & Zonen, Lufft, Texas Electronics

Solar Technical Specification

SP-001
Revision 2022.1

Exhibit A Appendix C1 – Main Power Step Up Transformer Specification

Executed Date

Table of Contents

1.0 General

This specification defines minimum requirements for design, construction, quality,testing, performance, and documentation three phase outdoor, continuous duty, power transformers. Where there is a discrepancy in requirements between the codes, standards, regulations, references, or this document, the Supplier shall apply the most stringent requirements of the conflicting documents so that the design, manufacture, and testing of the equipment are carried out to the highest degree of quality set forth by this group of documents.

2.0 Reference Standards

2.1 All equipment and components furnished under these specifications shall conform to the latest applicable ANSI, IEEE, NEMA, NEC, and UL standards in the design, material, manufacture, testing, and performance of this equipment. All equipment must be listed and labeled as defined in the NEC.

2.2 **IEEE C57.12.00:** General Requirements for Liquid-Immersed Distribution, Power and Regulating Transformers

2.3 **IEEE C57.12.70:** Terminal Markings and Connections for Distribution and Power Transformers

2.4 **IEEE C57.12.90:** Test Code for Liquid-Immersed Distribution, Power and Regulating Transformer

2.5 **IEEE C57.19.00:** General Requirements and Test Procedure for Outdoor Power Apparatus Bushings

2.6 **IEEE C57.19.01:** Performance Characteristics and Dimensions for Outdoor Apparatus Bushings

2.7 **IEEE C57.91:** Guide for Loading Mineral-Oil-Immersed Transformers

2.8 **IEEE C62.22:** Guide for the Application of Metal-Oxide Surge Arresters for Alternating-Current Systems

2.9 **ANSI/IEEE C63.2:** American National Standard for Electromagnetic Noise and Field Strength Instrumentation, 10 Hz to 40 GHz, Specification.

2.10 **ANSI/NETA AST:** Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

2.11 **NEMA 107:** Methods of Measurement of Radio Influence Voltage (RIV) of High Voltage Apparatus

2.12 **NEMA TR-I:** Transformers, Regulators and Reactors

2.13 **ANSI/IEEE Std 32:** Standard Requirements, Terminology, and Test Distribution and Power Transformers.

2.14 **ISO-9000:** Quality Assurance

2.15 **NFPA70:** National Electric Code

2.16 **NESC:** National Electric Safety Code

2.17 IEEE Seismic Guide for Power Transformers and Reactors

2.18 Audible sound levels shall be in accordance with the requirements of Paragraph TR-1-0.09 of NEMA Standard TR-1

3.0 Technical

3.1 General

3.1.1 The power transformer shall be rated for the site conditions.

3.1.2 The ambient temperature range for designing the transformer and its associated accessories is -40°C to +40°C.

3.1.3 The transformer shall be rated for outdoor installation on an effectively grounded system

3.2 Short Circuit Requirements

3.2.1 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).

3.2.2 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.

3.2.3 HV System Fault Capacity

3.2.3.1 The HV system shall be modeled as an infinite source.

3.2.3.2 HV system pre-fault voltage shall be 1.10 per unit per each HV DETC tap position.

3.2.3.3 For fault calculations requiring the use of an external HV system X0/X1 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).

3.2.4 XV System Fault Capacity

3.2.4.1 The XV system shall be modeled as an infinite source.

3.2.4.2 XV system pre-fault voltage shall be 1.11 per unit, based on TBD/34.5 kV line-line nominal system voltage.

3.2.4.3 For fault calculations requiring the use of an external XV system X0/X1 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.

3.2.5 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.

3.3 Temperature Requirements

3.3.1 The average winding temperature rise above ambient temperature shall not exceed 65 °C at the maximum rated kVA when tested in accordance with IEEE

C57.12.90 using the combination of connections and taps that give the highest average winding temperature rise. The winding hottestspot temperature rise shall not exceed 80ºC.

3.3.2 Transformers shall be designed for continuous self-cooled/forced air cooled operation. The transformer shall be designed, at a minimum, in accordance with the temperature requirements of IEEE C57.12.90. These temperature requirements assume that the temperature of ambient cooling air shall not exceed 40 ºC and the average temperature of the cooling air for any 24-hour period shall not exceed 30 ºC.

3.4 Loading Conditions

3.4.1 The transformers shall be suitable for the loading profile of a solar farm (load fluctuations, thermal cycling, fault ride-through conditions, harmonics and non-sinusoidal waves, etc.) with no impact on the minimum 35-year service life of the transformer when operated at the maximum rated kVA.

3.4.2 All transformers shall be capable of loading above nameplate MVA rating in accordance with the latest revision of IEEE C57.91. Constraining transformer components including but not limited to bushings, leads, tap changers, current transformers, or other equipment shall be rated at least 5% higher than the top rating of the transformer.

3.5 Bushings

3.5.1 Bushings must meet requirements for physical dimensions and electrical ratings as specified in ANSI/IEEE Standards C57.19.00 and C57.19.01. Bushings shall be capable of carrying, within their normal life expectancy, cyclical daily transformer loading between 0A and the maximum transformer nameplate rating. Bushings shall be equipped with a nameplate in accordance with ANSI standards, including bushing manufacturer, catalog number, and/or drawing number.

3.5.2 All bushings shall be removable without the need to process the transformer oil.

3.5.3 Bushings shall be standard light gray and rated appropriately to carry, at a minimum, the maximum currents + 10% in accordance with the transformer's MVA rating.

3.5.4 The bushing shall be supplied from PCORE Electric unless otherwise approved by the Buyer.

3.5.5 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.

3.5.6 The bushings' outer rain shed shall be made of porcelain for bushings for 345 kV system.

3.5.7 The high voltage winding bushings shall have ANSI Standard threaded studs.

3.5.8 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.

3.5.9 345 kV HV PHASE (PCORE # POC1675G800S)

3.5.9.1 BIL (kV): 1675

3.5.9.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.9.3 Minimum live part to ground, straight line, distance: 115 in.

3.5.9.4 Minimum Current Rating (A): 800

3.5.10 138 kV HV PHASE (PCORE # POC650G1216RS)

3.5.10.1 BIL (kV): 650

3.5.10.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.10.3 Minimum live part to ground, straight line, distance: 115 in.

3.5.10.4 Minimum Current Rating (A): 1200

3.5.11 69 kV HV PHASE (PCORE # TBD)

3.5.11.1 BIL (kV): 350

3.5.11.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.11.3 Minimum live part to ground, straight line, distance: TBD in.

3.5.11.4 Minimum Current Rating (A): TBD

3.5.12 46 kV HV PHASE (PCORE # POC650G1216RS)

3.5.12.1 BIL (kV): 250

3.5.12.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.12.3 Minimum live part to ground, straight line, distance: 115 in.

3.5.12.4 Minimum Current Rating (A): TBD

3.5.13 H0 (PCORE # B-89593-70)

3.5.13.1 BIL (kV): 250

3.5.13.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.13.3 Minimum live part to ground, straight line, distance: 22 in.

3.5.13.4 Minimum Current Rating (A): 400/1200 (draw lead/bottom connected)

3.5.14 XV PHASE (PCORE # B-88943-8-9)

3.5.14.1 BIL (kV): 250

3.5.14.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.14.3 Minimum live part to ground, straight line, distance: 22 in.

3.5.14.4 Minimum Current Rating (A): 4000

3.5.15 X0 (PCORE # B-89593-70)

3.5.15.1 BIL (kV): 350

3.5.15.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.15.3 Minimum live part to ground, straight line, distance: 22 in.

3.5.15.4 Minimum Current Rating (A): 400/1200 (draw lead/bottom connected)

3.5.16 YV (PCORE # B-89183-70)

3.5.16.1 BIL (kV): 110

3.5.16.2 Minimum Creep: 54 mm/kV (V Line-Ground), Extra Heavy per C57.19.100

3.5.16.3 Minimum live part to ground, straight line, distance: 13 in.

3.5.16.4 Minimum Current Rating (A): 600

3.6 Arrestors

3.6.1 Station Class arresters are required, in accordance with ANSI Standard C62.2

3.6.2 Provide brackets for mounting station class arresters near each high voltage and low voltage bushing. Structural support for HV surge arrester, strong enough to withstand the maximum cantilever strength of the surge arresters without deformation, shall be provided. Bracket details shall be shown.

3.7 Current Transformers

3.7.1 HV Phase Bushing CTs

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

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

3.7.2 HV Neutral Bushing CT

3.7.2.1 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.

3.7.3 XV Phase Bushing CTs

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

3.7.4 XV Neutral Bushing CT

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

3.7.5 Multi-ratio BCT’s shall terminate to shorting type terminal blocks located at an accessible point in the control cabinet. All CT leads shall terminate at the same general location in the control cabinet. The ground terminal on current transformer shorting blocks shall be wired to the grounding bus in the central

cabinet. Routing of grounding leads shall be on the internal wiring side of terminal boards.

3.7.6 Winding hot spot detecting CT's, one (1) located in each primary and secondary winding, shall be in addition to the above and specified by Supplier, complete with 4-20mA signals wired to the control cabinet for remote indication of the temperature. The 4-20mA transducer power supplies shall be provided.

3.8 Cooling System

3.8.1 Control power for cooling shall be single-phase 120/240 VAC.

3.8.2 Each stage of forced cooling shall be automatically controlled from its own contact of the winding temperature thermometer or manually controlled from its own selector switch. Selector switches shall be supplied with two (2) spare contacts: one closed only in the AUTO position and one only in the MANUAL position. Control shall be accessible for adjusting the temperature at which cooling equipment starts.

3.8.3 Cooling equipment shall consist of all fans, pumps, conduit, hardware, controls, wiring, and other accessories as required for each stage of forced-air cooling specified. The fans and pumps shall be individually connected to the power supply through a flexible rubber covered cord with weatherproof plugs and receptacles. The motors shall be totally enclosed with ball bearings, thermal protectors, and furnished without centrifugal switches.

3.8.4 For all transformers with removable radiators, the manufacturer shall furnish suitable valves on the transformer side of the radiator mounting flanges, and top and bottom pipe taps with oil drain plugs (minimum ½") on the radiators, to permit draining and removal of the radiators without draining oil from the transformer tank. Removable radiators shall be equipped with lifting eyes and so designed that they can be handled without the addition of special bracing. All radiators shall be designed to withstand the vacuum and pressure conditions specified for the main tank.

3.8.5 If cooling equipment includes oil circulating pumps, an oil flow indicator with alarm contacts shall be furnished for each pump to indicate low oil flow. If future pump installation is to be provided for, necessary provisions shall be made for future installation of oil flow indicators. Oil pumps, initial or future, shall be located near foundation level. Manufacturer shall furnish suitable valves on both sides of each pump (or each location of a future pump), and pipe tap with plug (minimum ½") at the lowest point on the pump section between valves, to permit draining, removal, and reinstallation of pump (or installation of future pump) without draining oil from the radiators or the transformer tank.

3.8.6 Each oil circulation valve must be labeled. Instructions must be included with the transformer upon delivery identifying the location of each valve and confirming the appropriate open/closed position for both normal operation and maintenance conditions. Commissioning inspection shall include a detailed checklist with a separate line item to verify the position of each and every valve.

3.8.7 Oil piping and piping accessories shall have welded joints. Bolted flange connections shall be provided at the transformer, oil pump, and cooler. Oil piping shall be furnished with gate or approved butterfly type valves located between the heat exchanger and main tank, and between the pump and main tank; in both

cases, next to the tank. Drain valves and vent plugs shall be furnished in the cooling system to permit draining oilfrom the heat exchanger or pumps. Oil piping shall be rigidly supported to avoid vibration during transit and while the pump is in operation. Flexible connections shall be furnished to minimize piping strains on coolers and pumps, and to facilitate maintenance.

3.9 Mechanical Requirements

3.9.1 Dial-type gauges, valves, and control cabinet should be grouped together on the low voltage side of the transformer for easy accessibility and maintenance. Gauges shall be mounted so they can be easily read. All gauges mounted higher than 6’ shall have their faces tilted down (30°) for ease in viewing.

3.9.2 Transformer terminals shall be arranged per C57.12.10.

3.9.3 Sealing gaskets of maximum quality shall be provided to prevent all risks of oil leakage. Such gaskets shall withstand the maximum temperatures of the tank and oil as well as the low ambient temperature down to the minimum site temperature when the transformer is de-energized. The Supplier shall take extreme precautions in ensuring proper sealing of the transformer tank, cooling system, and accessories to avoid any chronic issues that may arise further to oil leakage. Gaskets shall be fully compatible with the type of oil supplied and a certificate of compatibility shall be provided. Furthermore, gaskets shall not cause any adverse foaming effect during the oil treatment process.

3.9.4 The following provisions must be included in the transformer design:

3.9.4.1 Facilities for lifting core and coil assembly from tank and for lifting transformer cover.

3.9.4.2 Lifting eyes tank for lifting complete transformer.

3.9.4.3 Access covers for bushing current transformer replacement and tank entrance for inspection and maintenance.

3.9.4.4 Base designed for rolling with provision for pulling in directions of centerlines of segments.

3.9.4.5 Jacking facilities with pulling eyes at four corners of the base.

3.9.4.6 Globe-type combination drain and lower filter valve (2-inch screw end) with sampling device. This drain valve shall be located so as to allow draining or sampling from the bottom of the tank.

3.9.4.7 Globe-type upper filter valve (2-inch screw-end) for the transformer tank. Also, a ¾ inch globe valve with plug shall be installed and located on the transformer top cover. A splash baffle shall be installed below the valve, inside the tank, for vacuum filling of the transformer.

3.9.4.8 De-energized load tap changer.

3.9.4.9 Diagrammatic nameplate to include all ratings and impedances per ANSI C57-12.00.

3.9.4.10 The core ground lead shall be accessible at an inspection manhole location.

3.9.4.11 Main tank and all separate compartments designed to withstand full vacuum, unless otherwise specified.

3.10 Oil System

3.10.1 Provide a conservator type or pressurized dry nitrogen gas system for oil preservation. Conservator systems shall be supplied with an expansion bladder to prevent contact of the oil with the atmosphere. Freely vented systems using silica gel breathers are not acceptable.

3.10.2 The transformer shall be oil immersed and furnished complete with insulating liquid. The oil shall be inhibited Type II which meets or exceeds the latest ATSM D3487 standard. Oil having any detectable PCB level shall not be used. Oil type shall be appropriate to ensure continuous operation at the lowest expected ambient site temperature, for all levels of transformer loading.

3.10.3 When supplied, nitrogen gas systems shall include two (2) fully charged nitrogen cylinders (one active and one spare) and all equipment for proper regulation of gas pressure including gauges necessary to monitor remaining volume of gas in active tank. Low pressure alarm contacts with cylinder pressure gauge shall be provided as well as a weather-proof cabinet to house all gauges, valves, and regulators of the oil preservation system. Cover of the cabinet shall have a window suitably placed and large enough for viewing all gauges without opening the cabinet. Cover of cabinet hinged with hand-operated latch and provisions for padlocking closed.

3.10.4 The transformer shall be furnished complete with reducing valves, gauges, and tanks of nitrogen necessary to purge the gas space and place the transformer in service. The transformer shall be capable of withstanding, without developing leaks of deformation, the maximum pressure developed in the tank throughout a top oil temperature range of 100ºC.

3.10.5 If the inert-gas pressure system is supplied, the nitrogen cylinder shall be located at floor level. If the cylinder is in an enclosure, the arrangement shall be such as to facilitate replacement of the gas cylinder with a minimum of lifting. If a nitrogen system is proposed, the gauges and alarms are to be permanently mounted and not part of the manifold. Provisions shall be provided to connect the nitrogen bottles via a flexible hose outside of the control cabinet.

3.10.6 Nitrogen regulating equipment shall be fitted with Compressed Gas Association (CGA) Connection No. 580.

3.10.7 If the inert-gas pressure system is supplied, the following gauges are required: one (1) to read directly the pressure in the nitrogen cylinder and one (1) to read directly the pressure in the transformer tank. The transformer tank gauge shall be equipped with low pressure alarm contacts.

3.11 Painting

3.11.1 Supplier’s standard painting system will be satisfactory, provided a minimum of three coats is applied to all exterior metal surfaces meeting ANSI C57.12.28, including one coat of rust inhibiting primer, and provided the total dry film thickness is not less than 3 mils. Galvanized surfaces need not be painted. Supplier shall provide specifications on the corrosion protection system warranty. Color to be ANSI 70 Gray, unless specified otherwise in the Specific Provisions. The transformer shall be delivered with a gallon of the same colored touch-up paint with activator (if required).

3.12 Auxillaries and Cabinets

3.12.1 Cabinets and compartments that house auxiliary electrical equipment shall be waterproof, dust-tight, and weatherproof. Cabinet height shall be convenient for access from floor level. Control wiring shall be brought into control cabinet through suitable rigid conduit sized according to the NEC. Cabinet shall be arranged and designed to permit outgoing conduits to exit from the side and bottom as may be required with removable access plate for outgoing bottom conduit. Ten percent (10%) spare terminals shall be provided for terminating spare control cable wiring. Copper ground bus shall be included for grounding all spare control wires. Cabinets and compartments shall be vented adequately in or near the top and bottom. Vent openings shall be provided with nonferrous or stainless steel screens. Fully gasketed doors shall be provided, with provision for padlocking, and door-stops to hold open during servicing. A PTC technology cabinet heater shall be provided. A GFI duplex outlet and lighting shall be provided in the Control Cabinet. Cabinet shall include standard incandescent light socket and bulb. Light shall be switch activated by opening cabinet door.

3.13 Wiring

3.13.1 Power and control wiring shall be 600 Volt and shall be rated for use in conduits as well as cabinets and shall utilize insulation which is both fire resistant and resistant to transformer insulating oil. Power and control wiring for auxiliaries shall be not less than No. 12 AWG. Auxiliary power and similar wiring shall be substantially supported and protected from severe vibration and mechanical injury. External wiring shall be run in conduit or other suitable metal enclosure, adequately supported. All circuits that are to be continued by Customer shall be wired to terminal blocks located in the control cabinet. Wiring must be clearly and permanently marked at both ends. All devices must be labeled in amanner which will cross-reference them to the associated drawings. Each wire shall be labeled with to/from information at each termination end. Lighting and convenience outlets shall be wired so that no live parts are exposed.

3.13.2 Current transformer wiring shall be No. 10AWG, 600 Volt and shall utilize insulation which is both fire resistant and resistant to transformer insulating oil and approved by Underwriters' Laboratories, Inc., for 90ºC service

3.13.3 There shall be no more than one splice, if required, and one termination in the secondary leads of the current transformers between the current transformers and the terminal block(s). The terminal block(s) shall be of the short-circuiting type and conveniently located in the control cabinet.

3.13.4 Control wiring shall terminate in molded, screw type, terminal blocks, States Co., Type NT, solid link, IDEC, Marathon, or approved equivalent, with terminal marking strips. All terminal blocks shall use screw connections to accommodate wire sizes through No. 10AWG. Connections to terminal blocks shall be made with cup washers or washer head binding screws. Terminal blocks shall be mounted in readily accessible locations which are not obstructed by pipes, cables, or other components.

3.14 Grounding

3.14.1 Stainless steel NEMA 2-hole grounding pads shall be provided on the outside of the transformer tank, in segments 1 and 3, within 15 inches of the tank corners and between 12-15 inches of the transformer base. Additional NEMA 2-hole grounding pads shall be placed near the base of the neutral bushing(s) and each

surge arrester mounting location. Copper bus bars shall be installed for grounding of the neutral bushing(s) and surge arresters:

3.14.1.1 1/4" x 3" copper neutral bus bar shall be installed from the NEMA 2-hole ground pad at the base of the neutral bushing down the side of the transformer tank to a point 6 inches from the transformer base. There shall be a NEMA 4-hole pad at the bottom of the neutral bus bar for connection by others. In the event of a transformer with two neutral bushings, separate neutral bus bars shall be installed for each bushing. Seller shall also furnish flexible, removable, grounding cable between the neutral bushing to the bus bar/NEMA pad. Flexible grounding cable shall have continuous current carrying capacity not less than the winding load ampacity (minimum #4/0 AWG copper equivalent or greater).

3.14.1.2 1/4" x 3" copper surge arrester bus bar loops shall be installed for each set of surge arresters. The copper surge arrester bus bar loops shall extend from the NEMA 2-hole tank ground pad, near the transformer base, up the face of the tank, across the top of the transformer to each surge arrester NEMA 2-hole pad and down the adjacent tank corner to form a continuous loop. Surge arresters associated with each winding are required to have electrically separate grounding loops. Seller shall also furnish flexible, removable, grounding cable between each surge arrester and the surge arrester bus bar/NEMA pads. Flexible grounding cable shall have continuous current carrying capacity equivalent to #4/0 AWG copper.

3.15 Tank Construction

3.15.1 The transformer shall be of bolted or welded main cover construction. If the transformer is of the welded case design, the case shall be so constructed that the cover may be removed and re-welded without damage to the coils.

3.15.2 The transformer shall be arranged for skidding in both directions parallel to the base. Jacking pads shall be installed a minimum of 13" above the base and shall be installed in locations sufficient for the intended use.

3.15.3 The transformer shall be designed for vacuum filling in the field.

3.15.4 Transformer base shall be designed to permit anchoring (to resist earthquake stresses for the Seismic Zone which includes the location of installation) to concrete foundation by means of hold-down lugs and bolts. Hold-down lugs and bolts shall be located to permit moving transformer without sling into position. Supplier shall provide the hold-down lugs and Customer will furnish the hold-down bolts as recommended by Supplier. The lugs shall not be welded to the case but shall be placed over the hold down bolt and clamp the case to the foundation. Supplier shall indicate on its outline drawing the size, spacing, and projection of the hold-down bolts in order for Customer to complete its foundation design in advance of shipment.

3.16 Exciting Current and Phase Relation

3.16.1 The exciting current shall not exceed 5% (percent) of the rated current at rated voltage; less is preferred.

3.16.2 Phase relation shall be in accordance with ANSI Standard No. C57.12.00.

3.16.3 Three Phase Transformers, Wye-Wye Connection: The angular displacement between high voltage and low voltage terminal voltages shall be zero (0) degrees.

3.17 Accessories

3.17.1 Service life of accessories shall be the same or greater than the transformer design life.

3.17.2 Contacts on all devices shall be non-grounded, suitable for both 125 Volt AC and DC, and shall comply with ANSI Standard No. C57.12.

3.17.3 Shock mountings; if necessary, shall be provided to limit the vibration of indicating and contact portions of devices to less than 2 mils.

3.17.4 Indicators (dials) of temperature indicating and control equipment shall be located not more than six (6) feet from the base of the transformer. If transformer is more than six (6) feet, gauges mounted higher than 6’ shall have their faces tilted down (30°) for ease in viewing.

3.17.5 Indicators (dial), thermometers, relays, gauges, valves, and name plates shall be located preferably on the low voltage terminal side of the tank, unless otherwise specified.

3.17.6 Indicators (dials), thermometers, and relays shall be constructed and located in such a manner that the temperature sensitive portions can be removed from the transformer with the transformer energized by a service person keeping all portions of his body below the cover of the transformer.

3.17.7 Upper filter press - connection shall be extended to a point near the bottom of the tank and be equipped with a valve at the lower end.

3.17.8 Transformer shall be equipped with standard accessories and the following accessories: Oil temperature, hot spot, and winding temperature indicator with four (4) Form C alarm contacts. Supplier shall specify recommended temperature levels for contacts used for alarm and cooling control on the schematics and wiring diagrams. Each alarm contact output shall be electrically separate form all other alarm contact outputs.

3.17.9 Alarm outputs shall include the following:

3.17.9.1 Low oil level contact

3.17.9.2 Winding temperature high contact

3.17.9.3 Top oil temperature high contact

3.17.9.4 Operation of pressure relief device

3.17.9.5 Operation of sudden pressure relay

3.17.9.6 Loss of Auxiliary AC or DC power

3.17.9.7 Where furnished with a conservator oil preservation system, an operator of gas detector relay and operation of vacuum bleeder device.

3.17.9.8 Where furnished with an inert gas oil preservation system, low nitrogen cylinder pressure

3.17.9.9 Magnetic liquid level indicator with dial-type gauge, low level alarm contact, and separate sensor or contact to indicate an abnormally low

oil level (trip contacts both N.O. and N.C.). Liquid level gauge sensor and alarm contacts shall be contained in an externally accessible housing so as not to require untanking for their removal.

3.17.10 Mechanical pressure relief device with alarm contacts. Pressure relief device shall be cover mounted, automatic resealing-resetting, with a mechanical operation indicator.

3.17.11 Sudden pressure relay complete with seal-in relay. Seal-in relay shall be rated for 125VDC and mounted in termination cabinet including manual reset switch. Sudden pressure relay shall be wired separately from other DC circuits. Provide separate alarm and trip contacts. Relay shall be mounted to facilitate testing while transfer is in service. Qualitrol relay shall be provided or an equivalent shall be submitted for approval.

3.17.12 Supplier to provide a complete Morgan Schaffer online dissolved gas analyzer and all appropriate connections internal to the transformer. Buyer shall be able to directly wire status points as inputs to an RTU as well as connect via Ethernet for addressing the device on Customer's private network.

3.17.13 Supplier to supply bushing monitoring system, GE IntellixTM BMT 300 or newer version if transformer is equipped with oil filled bushings. If all transformer bushings are resin impregnated, no BMT is required.

3.17.14 Pressure-vacuum gauge, with adjustable high and low pressure alarm contacts.

3.17.15 Furnish all wire with stranded copper conductor sized in conformance with NEC, but not smaller than 14 AWG. Furnish extra flexible wire in areas subject to flexing, such as hinge points. Terminate all control wiring with ring tongue type terminal lugs.

3.17.16 Terminal blocks shall be of heavy-duty type, rated not less than 20 amperes, 600 volts. Current transformer leads shall be terminated on short-circuiting type blocks with the last terminal point on each block being a spare point with a connection to the ground bus. Enclose all wiring interconnecting transformer equipment enclosures in rigid steel conduit with flexible connections to motors. The conduit system shall conform to the NEC and shall be watertight.

3.17.17 Cooling equipment accessories

3.17.17.1 Top Liquid Temperature Device (single or separate devices at option of Supplier)

3.17.17.2 Dial Type Indicator: for local indication of top liquid temperature, with dial markings to cover the minimum range of 0ºC – 120ºC, complete with a red maximum hand and external reset device. If the top liquid temperature device is ambient compensated, the adjustment range of the contacts shall apply when the ambient is 25ºC. Adjustable contacts; one (1) set for alarm as follows:

Temperature Rise of Transformer	**55°C**	**65°C**
Contact Range	65-100°C	75-110°C
Contact Setting	75°C	85°C

3.17.17.3 Winding Temperature Device (single device preferred to facilitate calibrating, setting and testing) which shall be designed to allow each stage of the forced cooling equipment to operate until the temperature has dropped a minimum of 7ºC below the temperature at which it was actuated.

3.17.17.3.1 Dial Type Indicator: one phase only, for local indication of low voltage winding temperature, with dial markings to cover the minimum range of 0ºC – 160ºC, complete with current transformers, temperature coil, and a red maximum hand and an external reset device.

3.17.17.3.2 Ambient Compensated: if the winding temperature device is ambient compensated, the adjustment range of the contacts shall apply when the ambient is 25ºC.

3.17.17.3.3 Adjustable contacts: two (2) sets for automatic control of forced cooling equipment as follows:

Temperature Rise of Transformer		**55ºC**	**65ºC**
First stage:			
	Contact range	65-80ºC	75-90ºC
	Contact setting	70ºC	80ºC
Second stage:			
	Contact range	75-85ºC	80-95ºC
	Contact setting	75ºC	85ºC
One (1) set for alarm as follows:			
	Contact range	95-115ºC	105-125ºC
	Contact setting	95ºC	105ºC

3.17.17.4 Liquid Flow Indicator: Supplier shall furnish liquid flow indicator with alarm contacts for transformers supplied with FOA rating.

3.17.17.5 Manual Switch: A manual switch for each set of automatic forced cooling equipment control contacts shall be provided, connected in parallel with the automatic control contacts and enclosed in a weatherproof cabinet located at a convenient height, preferably on the low voltage terminal side of the tank.

3.17.17.6 Motor Protection: Each motor shall be protected by overload elements in each ungrounded conductor. Disconnecting Means: Each motor shall be provided with an electrical disconnecting means. In addition, a main (total) circuit breaker shall be provided.

3.17.17.7 Drain Valves: Cooler pumps and cooler radiators shall be furnished with valves to allow removal of the pump or radiator without draining oil from the main transformer tank.

3.17.17.8 Oil Immersed Design: If conservator (liquid-immersed) design is offered, furnish twin float Buchholz relay with seal in relay, with

separate alarm and trip contacts. Relay to monitor gas accumulation, oil loss, oil level, and oil flow velocity.

3.17.17.9 AC/DC Control: Transformer shall be equipped with a loss of AC & DC control power auxiliary relays with a minimum of two (2) N.O. and two (2) N.C contacts.

3.17.17.10 Thermal Magnetic Circuit Breaker: Provide main thermalmagnetic circuit breaker, conveniently located for termination of Customer's 120/240 volt power supply cables, as well as separate circuit breakers for each AC circuit.

3.17.17.11 Protective Devices: Each forced cooling equipment group shall be provided with a protective device as follows:

Forced Cooling Class	Equipment Group	Protective Device
ONAN/ONAF/ONAF	Single pump and/ or fans	Combination circuit breaker and starter
ONAN/ONAF/OFAF		

3.18 A de-energized tap changer for changing high voltage taps shall be provided. The operating handle shall be brought out through side of case at a height convenient to the design and shall have provision for padlocking in any position with a standard padlock.

3.18.1 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.

3.18.2 The preferred location of the tap changer is on the top of the core and coils.

3.18.3 Provide a position indicator and facilities for padlocking the tap changer's handle in any position.

3.18.4 Tap changing contacts and mechanism shall be accessible for inspection and repair without untanking the transformer or doing major disassembly/re-assembly.

3.18.5 The operation handle shall be directly connected to the tap changer shaft.

3.18.6 The tap changes shall require a maximum of 20 ft-lbs torque at the handle to operate.

3.18.7 The tap changing locking contacts shall be silver-to-silver or Buyer approved equivalent and shall be designed to wipe contact surface when operated.

3.18.8 A tap changer design that requires movement to wipe the contacts to prevent coking in periods of less than seven years is not acceptable.

3.18.9 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.

3.18.10 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.

4.0 Factory Acceptance Testing

4.1 The complete transformer including bushings shall be subjected to all tests required by latest industry standards. The transformer shall be capable of successfully withstanding ANSI impulse tests. Seller shall furnish evidence of testing in the form of detailed reports with direct outputs from testing software. Evidence must prove satisfactory to Buyer that transformer has been successfully subjected to all necessary tests. All tests shall conform to the requirements of ANSI Standard No. C57 as a minimum, using voltages required for a transformer with the BIL levels specified.

4.2 Tests are not limited to but shall include the following:

- 4.2.1 Turns-ratio tests for all tap positions.
- 4.2.2 Polarity and phase relation tests at rated voltage.
- 4.2.3 Series winding resistance measurements on all windings at nominal voltage taps and at extreme high and low voltage taps.
- 4.2.4 Calculated percent regulation at 100% and 80% power factor based upon wattmeter readings
- 4.2.5 No load loss in watts at full voltage
- 4.2.6 Impedance voltage consisting of resistive and reactive components for each winding pair, and load loss in watts at full voltage
- 4.2.7 Excitation current test at 100% and 110% rated voltage
- 4.2.8 Temperature test
- 4.2.9 Low frequency dielectric tests
- 4.2.10 Impulse tests to be performed on all terminals of the transformer winding, including full-wave, chopped wave and switching impulse characteristics
- 4.2.11 Insulation power factor test for all windings and high voltage bushings
- 4.2.12 Certified test data for sound dB results
- 4.2.13 Zero sequence impedance test, including resistive component or estimated X/R ratio at nominal voltage taps
- 4.2.14 Sweep frequency response analysis (SFRA)
- 4.2.15 Oil tests
  - 4.2.15.1 Dielectric strength, ASTM D1816, 1 mm gap; 20 kV minimum
  - 4.2.15.2 Dielectric strength, ASTM D1816, 2 mm gap; 35 kV minimum
  - 4.2.15.3 Dissipation (Power) Factor, ASTM D924, % at 25°C; 0.05 % maximum
  - 4.2.15.4 Dissipation (Power) Factor, ASTM D924, % at 100°C; 0.30 % maximum
  - 4.2.15.5 Interfacial Tension, ASTM D971; 40 mN/m minimum
  - 4.2.15.6 Color, ASTM D1500; 0.5 ASTM units maximum
  - 4.2.15.7 Visual Examination, ASTM D1524; “Bright and Clear”

4.2.15.8 Neutralization number (acidity), ASTM D974; 0.015 mg KOH/g maximum

4.2.15.9 Water content, ASTM D1533; 25 maximum ppm

4.2.15.10 Oxidation inhibitor content, Type II; 0.3% maximum, >0.08% minimum

4.2.15.11 Corrosive Sulfur, ASTM D1275, Method B; result "Not corrosive"

4.2.15.12 Relative density (specific gravity), ASTM D1298 15°C /15°C; 0.91 maximum

4.2.15.13 PCB content; Per all governing laws, etc. and PCB shall not be detectable at 1 PPM, mg/kg

4.3 The Buyer shall be notified at least three weeks in advance of testing and reserves the right to witness all testing.

4.4 The Buyer shall ne notified immediately of any failures or damage discovered during construction or testing and shall reserve the option to inspect damages.

4.5 Bushings shall be tested in accordance with applicable ANSI and NEMA standards

5.0 Site Acceptance Testing

5.1 Once the transformer arrives onsite the following tests and inspections shall be performed:

5.1.1 A full internal and external inspection. The Seller shall supply photos taken after the transformer has been placed into its final position. The photos shall show the interio of the transformer documenting cleanliness, FME and tap changer linkage.

5.1.2 Inspect impact recording devices to ensure the transformer has not been subject to damaging forces

5.1.3 Pressure test with dry air or nitrogen

5.1.4 Dew point test at the 24 hour mark

5.1.5 Begin main tank evacuation to 1 Torr

5.1.6 Vacuum hold at 1 Torr for 24 hours

5.1.7 Vacuum fill main tank along with radiators and conservator

5.1.8 Bleed transformer

5.1.9 Two degasification post passes

5.1.10 Oil sampling and Diagnostic Analysis. Oil samples shall be taken prior to filling and post filling process

5.1.11 TTR on all de-energized taps

5.1.12 Winding Power Factor

5.1.13 Insulation Resistance

5.1.14 Bushing Power Factor

5.1.15 Winding Resistance

5.1.16 Sweep Frequency Response Test

5.1.17 Excitation Current

5.1.18 Operation of accessories and alarms to control cabinet terminal blocks

5.1.19 CT Ratio, insulation resistance, saturation and polarity.

5.1.20 A detailed report shall be supplied to the Buyer upon completion of the testing scope.

6.0 Guaranteed Losses

6.1 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.

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

6.2.1 The Present Value of Load Losses will be calculated at: $680/kW.

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

6.3 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.

6.4 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.

7.0 Document Deliverables

7.1 Design review meeting minutes

7.2 Data sufficient for a complete review of the proposed design; including all detailed design data needed for the Anderson Programs

7.3 Drawings submitted for Approval

7.4 Approved drawings and preliminary instruction book submitted for Construction

7.5 NDE report of tank and piping welds

7.6 Tank and piping preparation for painting record

7.7 Tank and piping primer paint thickness record

7.8 Tank and piping final paint thickness record

7.9 Sub-supplier test records for bushings, CT's, pump and auxiliary devices

7.10 Protective device calibration records

7.11 CT curves with manufacturer's model # and serial #'s

7.12 Factory Acceptance Test Sequence and Schedule

7.13 Factory Acceptance Test notes and draft datasheets (immediately after test)

7.14 Certified Factory Acceptance Test final report

7.15 Site installation procedure

7.16 Final Operating Instruction Manual - including all sub-supplier instruction manuals

7.17 Record of fiber optic serial numbers match-up to penetration number

7.18 All NCR's

7.19 Spare parts list

7.20 Detail schedule (including hold point, document submittal, testing, manufacturing activities, and witness points)

7.21 Transformer internal connection drawings

7.22 Certified Oil Test Report, provided to Buyer before oil shipment.

7.23 Material Certificate for radiator and fan assembly galvanizing thickness.

Solar Technical Specification

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Exhibit A Appendix D1 – 35 kV Cable Specification

Executed Date

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 5, B 8, B 230, B 231, B 400, B 496, B609 (current editions)

1.1.1.2 ICEA S-94-649 (current edition)

1.1.1.3 IEC 60228

1.1.1.4 IEC 60840

1.1.1.5 ICEA T-31-610

1.1.1.6 NEMA WC 26-2008/EEMAC 201-2008

1.1.1.7 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 as specified in ASTM B 231.

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 mils 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.

1.1.2.14 Following 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 Each cable shall be tested prior to shipment. The factory test shall include, but not limited to, the following per ICEA S-108-720 and AEIC CS9:

- 1.1.4.2.1 AC high voltage test
- 1.1.4.2.2 Partial discharge test
- 1.1.4.2.3 Conductor resistance test
- 1.1.4.2.4 Capacitance measurement
- 1.1.4.2.5 Dimensional check for thickness of shields, insulation and jacket
- 1.1.4.2.6 Shield resistance test
- 1.1.4.2.7 Jacket integrity test

1.1.4.3 The compounds used in the cable shall be shown on the certified test report.

1.1.4.4 Each reel (not slave reel) of completed cable to be shipped shall meet the Partial Discharge Test specified in ICEA S-94-649.

1.1.4.5 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.

1.1.4.6 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.

1.1.4.7 The filled strand shall be tested in accordance with ICEA T-31-610.

1.1.4.8 The certified test report shall include the following data for each shipping length:

- 1.1.4.8.1 The number of the master or slave reel from which the shipping length was cut.
- 1.1.4.8.2 The length of cable on the shipping reel.

1.1.4.8.3 The corona factory test data for the shipping reel.

1.1.4.8.4 The minimum and maximum (not average) tension necessary to strip the insulation shield.

1.1.4.8.5 The minimum and maximum thickness of the strand shield.

1.1.4.8.6 The minimum and maximum thickness of the insulation.

1.1.4.8.7 The minimum and maximum thickness of the insulation shield.

1.1.4.8.8 The minimum and maximum thickness of the jacket.

1.1.4.8.9 The overall diameter over the insulation.

1.1.4.8.10 The overall diameter over the insulation shield.

1.1.4.8.11 The overall diameter over the jacket.

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Exhibit A – Appendix D2 – Naming Conventions

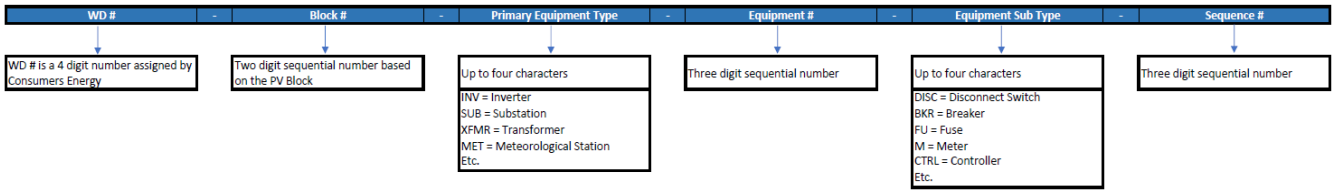
Executed Date

1.0 Naming Convention

1.1 Major Equipment

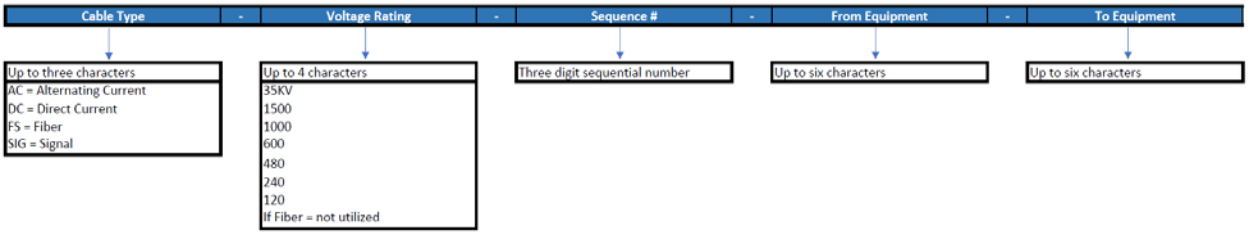
1.1.1 The Seller shall submit to the Buyer a spreadsheet with all equipment, circuits and raceway identified as described below for the Buyers approval.

1.1.2 The following naming convention shall be used for assigning identification to major equipment including, but not limited to, inverters, transformers, switches, breakers, MET stations.

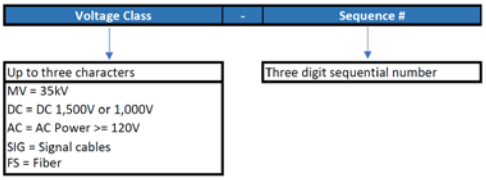


1.2 Circuits and Raceway

1.2.1 Electrical Circuits numbers shall be assigned a unique number. The unique number shall be created based on the following standard.



1.2.2 Electrical Raceways numbers shall be assigned a unique number. This unique number shall be created based on the following standard.



1.2.3 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

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Exhibit A Appendix E1 – Circuit Breaker Specification

Executed Date

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 shall be mounted so they are easily viewed and accessible.

1.9.1.2 Terminal lugs for terminating the wiring shall be used and shall be Burndy Type YAV, un-insulated ring type with a seamless barrel.

1.9.1.3 A spring type operating mechanism shall be provided, and shall be electrically and mechanically trip free.

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 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
Revision 2022.1

Exhibit A Appendix E2 – Switch Specification

Executed Date

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
Revision 2022.1

Exhibit A Appendix E3 – EHV Circuit Breaker Specification

Executed Date

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 shall be mounted so they are easily viewed and accessible.
1.9.1.2 Marker tags shall be attached so the tag can be removed without loosening the terminal lug connection.
1.9.1.3 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
Revision 2022.1

Exhibit A Appendix F1 – Surge Arrestor Specification

Executed Date

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

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Exhibit A Appendix G3 – Collector Substation

System Protection Relay Requirements

Executed Date

Consumers Energy

System Protection

Relay Recommendation Sheet

Subject Generic Solar Facility Collector Substation Station n/a

WO

Made By Will English Date 5/21/2021

References App'd By Jaron Bernath Date 5/21/2021

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

Each relay scheme shall be on its own panel and have its own DC breaker. Fusing multiple schemes from the same DC breaker is not acceptable. Schemes with multiple redundant relays (e.g. Primary A and Primary B) shall be in the same panel. A common DC switchboard bus shall be used to connect through all panels for connecting alarm schemes.

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.

- *Electroswitch 25304LR - 4 SECTIONS, 12 POSITIONS, NON-SHORTING, OVAL HANDLE WITH ARROW, FOR 3/16" PANEL, ESCUTCHEON 1-2-3-4-5-6-7-8-9-10-11 (CLOCKWISE) WITH 1 AT 1 O'CLOCK POSITION. NOTE: INSTALL STOP SCREWS TO BLOCK POSITIONS 10,11,& 12 (OFF). ENGRAVING CODE 008J-11X13A.*

Pushbutton breaker test trips noted below shall be part numbers:

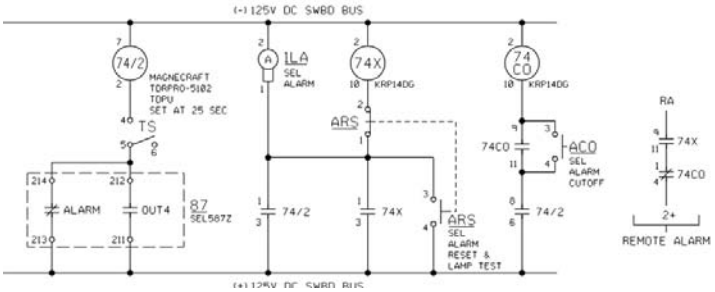
- *Pushbutton Test Trip - Schneider Electric Part No. 9001KR2R - 30mm Red Push Button With Extended Guard; Operator Only/No Contacts; Order Contact Block*
- *Push Button 1NC/1NO Contact Block - Schneider Electric Part No. 9001KA21 - 1NC/1NO Contact Block With Binder Head Screws; To Be Used With Push Button*
- *Push Button Guard Cover - Schneider Electric Part No. 9001K60 - Spring Loaded Cover, Clear, Cannot Be Padlocked; To Be Used With Push Button*

Test facilities (test studs *Megger 40091-B*) shall be included for each relay trip output for testing when relay is cutout. Additionally, test studs shall be included on each relay for a single output as noted in the relaying section below.

Relaying potential connected to each relay shall have a cutoff toggle switch (*Square D AP-221*) and test studs connected for injecting test potential when toggle in cutout position (up – In service, down - cutoff)

Relaying current and metering current / potential shall include test facilities with proper shorting for CT connections. Acceptable parts include, but not necessarily limited to, are *Metering Devices, 208-1492C-T 8-pole current, 209-1490C-T 3 current and 3 potential, 204-1491C-T 4 pole current.*

All relay alarms shall be connected to a time delay relay (*Magnecraft TDPRO-5102*) set for a 25 second delay upon relaying alarm. Operation of the time delay relay shall pick-up an alarm relay (*KRP*) which will seal-in a common remote alarm and provide an amber light on front of panel. A local relay alarm cutout scheme shall be provided. Sample scheme:



All relaying alarm contacts, DC alarm and station power alarm shall connect to a common mote alarm scheme which shall provide a single contact to the RTU and operate an amber light on the panel with the remote alarm. The alarm shall seal-in and require a pushbutton to reset the alarm.

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. Electrical separation is required for each scheme. This will ideally be separate panels for the Primary 1 and Primary 2 schemes. Separate DC breaker feeds must be provided for each scheme.

Primary 1: (11P1)

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 pushbutton test switch to an input to enable the operator to test trip the breaker 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 *(E-MAX 6319232)* 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: (11P2)

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 pushbutton test switch to an input to enable the operator to test trip the breaker 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 *(E-MAX 6319232)* 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 pushbutton test switch to this input to enable the operator to test trip the breaker when the breaker is closed. (Note: When using the pushbutton for breaker failure testing, it 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). Electrical separation is required for each scheme. This will ideally be separate panels for the Primary 1 and Primary 2 schemes. Separate DC breaker feeds must be provided for each scheme.

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, No Conformal Coat, 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, No Conformal Coat, 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, block closing and initiate breaker failure on the medium voltage main breaker (TC#1&2).

The 86T2 LOR will trip, block closing and initiate breaker failure on the high voltage Breaker (TC#1&2) and trip, block closing and initiate breaker failure on the medium voltage main breaker (TC#1&2).

Medium Voltage Main Breaker Failure Protection (when required)

Required when a medium voltage main breaker is installed.

Install a medium voltage main breaker failure relay. Install associated lockout relay (86BF).

Install one Schweitzer SEL-351A relay (model # 0351A0?2X4E54X1). This relay will have Standard Firmware, Mounting as determined by designer, Standard User Interface including USB, 125/250Vdc or 120/230Vac Power Supply, (2) 10/100 BASE-T, EIA-485 Communications Interface, 5A Phase & Neutral Secondary Current Input, 125Vdc Control Input Voltage, No Conformal Coat, and Standard Communications Protocols.

Connect one set of wye connected current transformers of the medium voltage breaker to provide three phase current to the relay.

Inputs and Outputs are to be connected as follows

IN101	Connect pushbutton test switch to this input to enable the operator to test trip the breaker when the breaker is closed. (Note: When using the pushbutton for breaker failure testing, it must be programmed to operate the 'Re-trip' output only).
IN102	Connect medium voltage main breaker 52 'a' contact to this input.
IN105	Connect contacts of the Main Power Transformer Bank lockout relays (86T1, 86T2) and a contact of the medium voltage bus protection lockout (86BP) to this input. This input will be programmed to initiate breaker failure.
OUT101	Trip medium voltage main breaker (trip coil #1). For breaker failure retrip.

OUT103 Operate breaker failure lockout relay (86BF)
OUT105 Connect to test studs.
OUT107 Connect to a lamp to provide indication of breaker failure operation.
ALARM Connect to relay alarm scheme

The SEL-351A relay will be used for the following functions: BF.

The (86BF) LOR will trip and block closing of all medium voltage breakers and the high voltage 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 (to be verified by design engineer), 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 and initiate breaker failure of the medium voltage main breaker.

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.

The SEL-351-6 relay must be verified as being able to meet the requirements of the currently active version of NERC Standard PRC-025. If the relay won't meet PRC-025 requirements, another relay may be selected, subject to approval of the buyer.

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 pushbutton test switch to this input to enable the operator to test trip the breaker 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 *(E-MAX 6319232)* 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 *(E-MAX 6319232)* 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.

34.5 kV Capacitor Bank (when required)

Required when capacitor bank is installed.

Install two relays for capacitor bank protection (11A & 11B). Install associated lockout relay (86CB).

Install two Schweitzer SEL-487V relays (model # 0487V0X6151XB0X4?444XXX). This relay will have Standard Firmware, no conformal coat, 125-250 Vdc or 110-240Vac Power Supply, Screw Terminal Block Connector Type, 300 V Phase-Neutral Maximum (Wye) and 5 A W & X Current Terminals Secondary Inputs, 6 AC voltage and 6 AC Current AC Input Channels, FTP and Telnet & Synchrophasors and DNP3 LAN/WAN Ethernet Communications Protocols, Ethernet Card With Two 10/100BASE-T Connectors Ethernet Connection Options, 125 Vdc Mainboard Input Voltage, Mounting as determined by designer, 4U Chassis, 24 Optoisolated Level-Sensitive Inputs and 8 Outputs I/O Board Position B, 125 Vdc I/O Board Position B Input Voltage.

Connect bus side CTs at an appropriate ratio for the size of the capacitor bank and the relay setting range and connect the CT circuit to each relay. Connect the 34.5kV bus VTs to provide the three-phase, four-wire potential to each relay. Connect the circuit from the capacitor bank neutral VT having an appropriate ratio for the capacitor bank and the relay setting range to each relay.

Inputs and Outputs of each relay are to be connected as follows

IN106	Connect 52 'a' contact of the capacitor bank breaker to this input.
IN107	Connect pushbutton test switch to this input to enable the operator to test trip the breaker when the breaker is closed.
IN201	Connect a contact of the breaker Maintenance Switch to this input to indicate Normal mode.
IN202	Connect a contact of the breaker Maintenance Switch to this input to indicate Maintenance mode.
IN204	Connect a contact of the breaker Close Coil voltage alarm to this input.
IN205	Connect a contact of the breaker Not Ready alarm to this input.

IN206	Connect a contact of the breaker loss of heater ac alarm to this input.
IN213	Connect a contact of the circuit switcher Maintenance Switch to this input to indicate Normal mode.
IN214	Connect a contact of the circuit switcher Maintenance Switch to this input to indicate Maintenance mode.
IN215	Connect to monitor the circuit switcher trip coil.
IN216	Connect an output of the 86CB LOR to this input to provide LOR status.
IN217	Connect a contact of the circuit switcher local/remote switch to this input.
IN218	Connect a 52 (89) 'a' contact of the circuit switcher to this input.
IN219	Connect a contact of the circuit switcher low gas lockout to this input.
IN220	Connect a contact of the circuit switcher spring charge alarm to this input.
IN221	Connect a contact of the circuit switcher loss of ac supply to this input.
IN222	Connect a contact of the circuit switcher loss of dc supply to this input.
IN223	Connect a contact of the circuit switcher low gas alarm to this input.
OUT104	Operate 34.5 kV bus protection lockout relay (86BP) for breaker failure.
OUT105	Connect to test studs.
OUT108	Connect 'b' contact to relay alarm scheme.
OUT203	Trip capacitor bank circuit switcher.
OUT205	Trip 86CB LOR.
OUT207	Trip capacitor bank breaker (TC1)
OUT208	Trip capacitor bank breaker (TC2)

The functions for the SEL-487V (11) are: 27, 50, 51, 50N, 51N, 59, 59N, 87V and BF.

The (86CB) LOR will trip, block closing and initiate breaker failure of the capacitor bank circuit switcher.

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.

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 (when required by interconnecting company to transmit breaker status).

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

Exhibit A Appendix G4 – Collector Substation System Monitoring Requirements

[Executed Dated]

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 or SEL Fast Messaging 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 SEL real time automation controller (RTAC), SEL-2730M managed network switch, and two SEL-3610 port servers to communicate with the substation Intelligent Electronic Device(s) (IED's). Port Specific connections are listed below

Install a GPS clock. Connect the GPS clock to the SEL-3610. The GPS signal will time synchronize all the relays in the relay data communications network through the communication interface or IRIG-B.

Connect the digital relays to the SEL-3610 port server 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 SEL-3610 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
6-15	Spares
16	Medium Voltage SEL-3610

Connect the medium voltage SEL-3610 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-3610
16	Spare

Solar Technical Specification

SP-001

Revision 2022.1

Exhibit A Appendix G5 – Collector Substation Fence Standard Details

Executed Date

Consumers Energy

SUBSTATION STANDARDS

SS2002

SPECIFICATION FOR SUBSTATION FENCE SS2002

ORIGINAL:

Prepared By JS GROULX Date 4/10/2001

Division Approval JH SOSINSKI Date 6/11/2001

REVISION:

Prepared By Adam K. Nuechterlein Date 10/15/2010

Division Approval LT VANBLARCUM Date 10/15/2010

SS2002 CONTENTS

Consumers Energy

SUBSTATION STANDARDS

SS2002

1. SCOPE

1.1 These specifications cover the layout, design, materials and erection of chain-link type fence for use in and around electric substations.

1.2 Exceptions to these specifications, such as may be included in purchase orders, shall not be construed as applying to subsequent purchase orders.

1.3 Points not covered by these specifications shall be in accordance with the applicable parts of ASTM A392, latest revision, if galvanized fabric is specified and ASTM A491, latest revision, if aluminum coated fabric is specified.

2. SPECIFICATIONS FOR THE FABRICATOR

2.1 GENERAL DESCRIPTION OF FENCE

2.1.1 Sufficient material shall be supplied by fence Seller to properly erect the fence in accordance with the fence layout sketches furnished with the purchase order. All fence shall be 96 inches high when measured from the bottom of the fence fabric, including the 84 inch wide fence fabric and the 12 inch, 45 degree barbed wire extension arms.

2.1.2 Special fence used to enclose equipment located inside the substation area fence may be installed without the barbed wire extensions. This exception shall be noted on the purchase order.

2.2 FENCE FABRIC

2.2.1 Fabric Description

The fence fabric shall be either No. 9 (.148") steel wire woven in a 2" square mesh having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions or No. 11 (.120") gauge steel wire woven in a 1" mesh having a 46 diamond mesh count in 84" of width, as specified in the purchase order. Fabric 84" wide, and 2" square mesh shall be knuckled at one selvage. Fabric 84" wide and 1" square shall be knuckled at both selvages. The fabric shall be either hot dip galvanized or aluminum coated steel as specified in the purchase order according to the following requirements.

2.2.2 Zinc Coated Fabric

Zinc coated fabric shall be hot dip galvanized after weaving. The fabric shall conform to the requirements of ASTM Specification A392, latest revision, Zinc Coated Steel Chain Link Fence Fabric. The zinc coating weight shall be as for a Class II coating (2.0 oz of zinc per sq ft-min.) as specified in ASTM-A392, latest revision.

2.2.3 Aluminum Coated Steel Fabric

The aluminum coated steel fabric shall conform to ASTM Specification A491, latest revision, Aluminum Coated Steel Chain Link Fence Fabric. The weight of the coating

shall be as specified in Table 3 of ASTM A491, latest revision, for No. 9 wire (.40 oz per sq ft-min.) Or No. 11 wire (.35 oz per sq ft-min.).

2.3 FENCE FIXTURES AND FITTINGS

2.3.1 Zinc Coatings

All fence fixtures and fittings shall be hot dip galvanized. The hot dip galvanized coatings shall conform as nearly as possible with ATSM designation: A-123, latest revision, Zinc Coatings on Products Fabricated From Rolled, Pressed and Forged Steel Shapes, Plates, Bars and Strip.

2.3.2 Fence Posts

2.3.2.1 Size and Shape

Fence posts shall be of a size as shown in the table on Drawing DSF7016, Sh 041, latest revision. If pipe posts are specified, the wall thickness shall not be less than that for ANSI Schedule 40 pipe.

2.3.2.2 Quantity

Enough line posts shall be provided so the spacing will not exceed either 10 feet or 8 feet as specified in the purchase order. Pipe posts shall include a cap to close the post top to the weather.

2.3.2.3 Bracings

Adequate bracing and trussing shall be provided in the spans adjacent to each corner, gate and end post for bracing the posts in the direction of the fence fabric, except in straight runs of fence three spans or less in length. A top rail shall be provided tying the top of the fence posts together and a tension wire shall be provided between the bottoms of the fence posts for supporting the fence fabric laterally.

2.4 FENCE GATES

Gates shall be made to swing both in and out unless otherwise specified. The frame shall be welded. Gates shall include all necessary hinges, latches, lock assembly, bracing and fittings for complete installation. Non-sag bracing may be eliminated on gate leaves with welded frames less than 7' wide. Gate and fittings shall be hot dip galvanized as specified in Paragraph 2.3.1 above. Welds on gate frame shall be cleaned and then coated with Brite Zinc galvanizing compound per ASTM designation: A780, latest revision, Repair of Damaged and Uncoated Areas of Hot Dip Galvanized Coatings. For clearance under gates, see Paragraph 3.6.

2.5 TOP RAIL

The top rail of the fence shall be the size specified in the table on Drawing DSF7016, Sh 041, latest revision. Ties or other devices shall be furnished for fastening the fence fabric to it at not less than six points for each 10 ft length. One expansion coupling shall be provided in the top rail for each 100 feet fence and any fraction thereof, in each straight run. Slip fittings for the top rail shall be provided at the fence post tops.

2.6 BARBED WIRE

Brackets shall be provided for three strands of barbed wire at all posts. Line and corner posts shall have brackets extending 45 degrees outward and one foot high. Gate, gate post and end post brackets shall be one foot vertical. Barbed wire shall be aluminum coated steel double strand 12? gauge twisted wire with 14 gauge four point round aluminum barbs spaced on approximately 5" centers, conforming to ASTM-A585, latest revision.

2.7 ASSEMBLY BOLTS

The fittings used for assembling the various parts of the fence covered by these specifications shall be so designed and fabricated that nuts to all assemblies will be on the inside of the fence.

2.8 ERECTION

All fences covered by these specifications are to be erected by the Purchaser unless otherwise stated in the purchase order.

2.9 POINTS NOT COVERED

Any and all items of design, materials and fabrication furnished as a part of the fence and not specifically covered by these specifications shall conform to the accepted practices of the industry for highest quality. The Purchaser reserves the right to reject fence or parts which do not meet these specifications or the requirements as stated in ASTM A392 or ASTM 491, latest revisions.

3. INSTRUCTIONS FOR FENCE DESIGN

3.1 DESIGN

All fence for use in substations shall be made of the materials, and in accordance with the other requirements of these specifications, unless special conditions warrant exceptions.

3.2 FENCE LAYOUT PLAN

A layout plan of the fence shall be prepared to accompany the purchase order for the fence and shall show its overall dimensions and shape, locations of all gates, insulated sections if required, and any other unusual features. Overall dimensions of the sides of the fence or of a run of fence shall be to the outside limits of the fence posts. Gate dimensions shall be for the clear opening between gate posts.

3.3 FENCE DETAILS

Fence details shall be specified as being in accordance with detail drawings DSF7016, Sh 035, 038, 039, 040 and 041, latest revisions, including the gate, corner, line and end post sizes, top rail, bracings, gate latches, stops, etc. The manufacturer's standards shall be followed, when possible, if they do not conflict with these specifications.

3.4 BARBED WIRE BRACKETS

The fence must be located at least one foot in from the Company's property line in order that the 45-degree barbed wire brackets may be turned outward. **Note recommendations for safe grounding practices require 7' minimum distance from Company fence to property line**. In instances when it is necessary to locate fences on the property line, an attempt shall be made to gain overhang rights and/or easements for the barbed wire brackets and grounding clearances from the adjacent property owner. If this is impossible, then the barbed wire brackets should be turned in or vertical brackets supplied. This exception shall be specified on the Purchase Order.

3.5 GATES

When conditions permit, fence gates shall be specified which would swing both inward and outward. When it is possible, due to surrounding conditions, for a gate to swing in one direction only, offset hinges may be specified, if desirable, which will permit the gate to open a full 180 degrees.

3.6 CLEARANCE UNDER GATES

3.6.1 Drive gates shall be constructed and adjusted to provide a construction clearance of 1" between the bottom of the gates and the top of the gate foundation as shown on Drawings DSF7016, Sh 043 and 044, latest revisions. The centerline crown of the driveway shall be reduced as it approaches the gate to provide clearance to the gates.

3.6.2 Walk gates shall be constructed and adjusted to provide a clearance of 1" between the bottom of the gate and the top of the gate foundation as shown on Drawing DSF7016, Sh 045, latest revision.

3.6.3 Except for the above and for insulated sections, the fence shall be designed to come down to the rough grade surface of the substation.

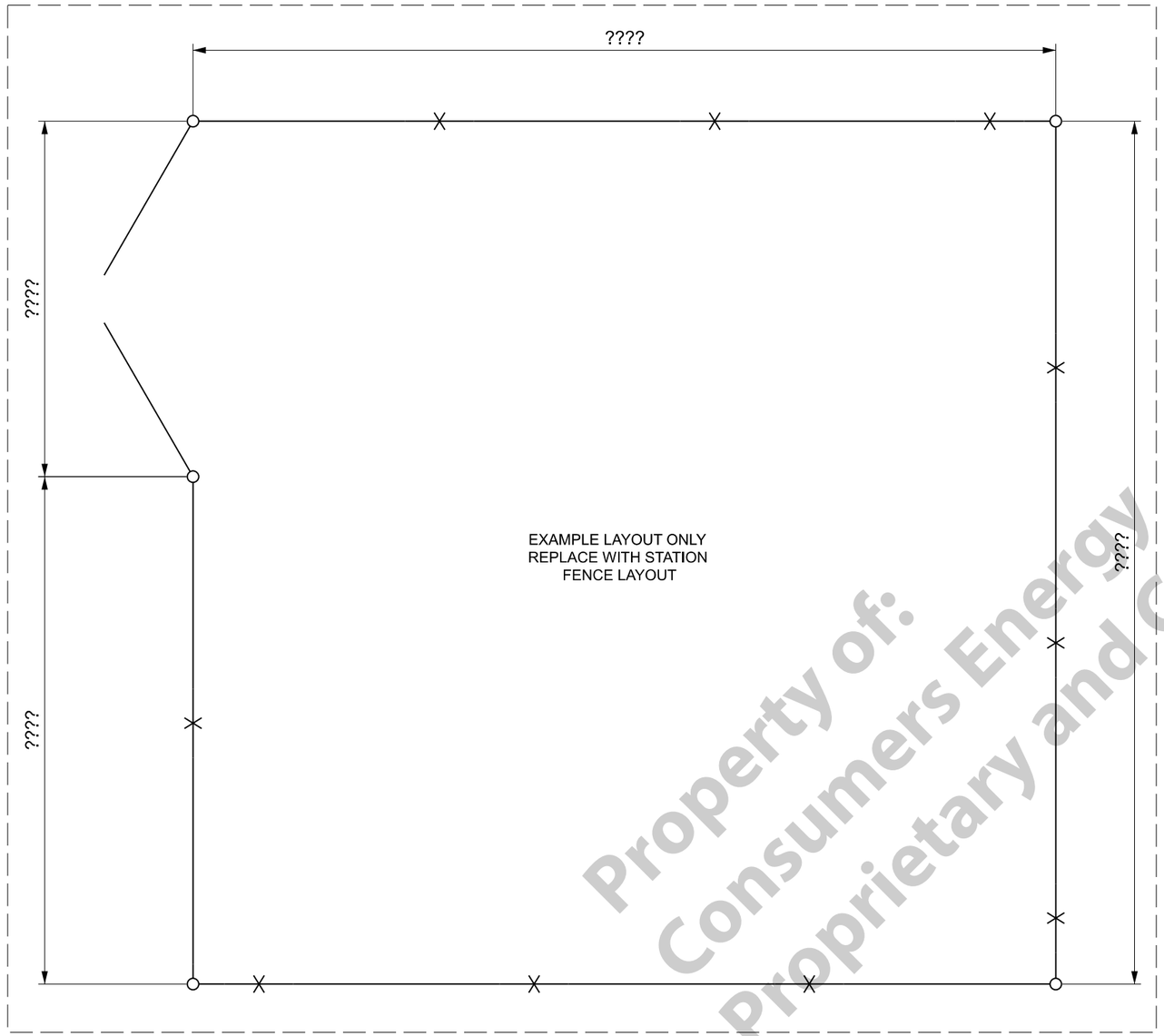
3.7 INSULATED SECTION

An insulated section of fence may be installed where it is necessary to electrically isolate an adjoining fence from the substation fence for personnel protection. The minimum distance between the two sections of fence to be isolated shall by 7'-0", as shown on Drawing DSF7016, Sh 041, latest revision. The bottom edge of the fence fabric should not contact the ground, as shown on Drawing DSF7016, Sh 041, latest revision.

3.8 SPECIAL BARRIERS

At locations along the fence, where it is impossible to make the fence fabric conform to the irregularities of the earth's surface, such as between rails of a railroad track, ruts of a driveway and at ditches, special barriers shall be provided to prevent children from crawling under the fence. Barriers supported by the fence, concrete curbs or walls, closely spaced vertical rods set in concrete, etc., may be used.

END OF SPECIFICATION SS2002



FENCE LAYOUT

1/8" = 1'-0"

SKETCH AND GENERAL NOTES (FOR ORDERING MATERIALS ONLY)

1. THIS ORDER SHALL INCLUDE ALL FENCING MATERIAL NECESSARY TO COMPLETELY CONSTRUCT THE LENGTH OF FENCE SHOWN, INCLUDING POSTS, FABRIC, BARBED WIRE, POST ORNAMENTS, BRACES, TOP RAIL, BOTTOM TENSION WIRE, GATES AND OTHER ACCESSORIES. (DO NOT INCLUDE CONCRETE FOR FOUNDATIONS.)

2. THIS ORDER SHALL COMPLY WITH THE REQUIREMENTS OF CONSUMERS ENERGY SPECIFICATION SS-2002 AND STANDARD DRAWINGS DSF7016 SHEETS 038, 039, 040, 041, 043, 044, 045, & 047 FOR MATERIALS, FABRICATION & INSTALLATION, WITH THE FOLLOWING EXCEPTIONS, CLARIFICATIONS, OR CHOICES:

   A. FENCE FABRIC TO BE CHAIN LINK, #11 GAGE ALUMINUM COATED STEEL WIRE, 84" WIDE, 1" DIAMOND MESH.

   B. POST SPACING TO BE EQUIDISTANT WITH 8'-0" MAXIMUM CENTER TO CENTER.

   C. FENCE FABRIC STRETCHER BARS TO BE 3/16" BY 3/8". TWO (2) EXTRA STRETCHER BARS ARE TO BE INCLUDED IN ORDER.

   D. LINE AND CORNER POSTS TO HAVE 3 WIRE 45 DEGREE X 1'-0" HIGH BARBED WIRE EXTENSIONS. GATES, GATE POSTS AND END POSTS TO EXTEND 1'-0" VERTICALLY.

   E. POSTS SHALL BE AS FOLLOWS TO ALLOW FOR CUT OFF OF DAMAGED TOPS DUE TO DRIVING:

      1. LINE POST - 2½" GALVANIZED SS40 FENCE POST, 2⅜" O.D. X 10'-9" LONG (3.12 LB/FT)
      2. CORNER POST - 3" GALVANIZED SCHEDULE 40 FENCE POST, 2⅞" O.D. X 11'-5" LONG (5.79 LB/FT)
      3. END POST - 3" GALVANIZED SCHEDULE 40 FENCE POST, 2⅞" O.D. X 12'-0" LONG (5.79 LB/FT)
      4. 4FT SINGLE WALK GATE - 3" GALVANIZED SCHEDULE 40 FENCE POST, 2⅞" O.D. X 11'-5" LONG (5.79 LB/FT)
      5. DOUBLE SWING GATES - 4" SCHEDULE 40 FENCE POST, 4" O.D. X 12'-0" LONG (9.12 LB/FT)

   F. TOTAL LENGTH OF FENCE REQUIRED IS: _____
   VENDOR TO INCLUDE 7% OF EXTRA FABRIC TO ABOVE QUANTITY.

   G. GATES AND ACCESSORIES REQUIRED ARE:
   (_) 4'-0" SINGLE WALK GATE PER DRAWINGS DSF7016 SHEETS 038, 040, & 045
   (_) 14'-0" DOUBLE SWING GATE PER DRAWING DSF7016 SHEETS 039, 040, 043, & 047.
   (_) 20'-0" DOUBLE SWING GATE PER DRAWING DSF7016 SHEETS 039, 040, 044 & 047.
   (_) 24'-0" DOUBLE SWING GATE PER DRAWING DSF7016 SHEETS 039, 040, 046, & 047.

DESIGN GUIDE NOTES:

(TO BE REMOVED)

1. USE THIS SET OF NOTES TO ORDER FENCE MATERIALS FOR 1" MESH FABRIC AS OF 10/98.
2. SHOW FENCE LAYOUT, DIMENSONS AND TOTAL LENGTH IN NOTES.
3. SHOW GATE DIMENSIONS AND QUANTITY IN NOTES.
4. REMOVED M# NOT NEEDED

M02219 - WITH GATES
M02221 - WITHOUT GATES

DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.

SECTION HEAD — DATE
APP SECTION HEAD 00/00/00
DIVISION HEAD
APP DIV HEAD 00/00/00
DEPARTMENT HEAD
APP DEPT HEAD 00/00/00

DR DESIGNER 00/00/00
CK CHECKER 00/00/00

Consumers Energy

SCALE AS NOTED

SUBSTATION FENCE SPECIFICATIONS
1" FABRIC
SUBNAME & SUBNUMBER

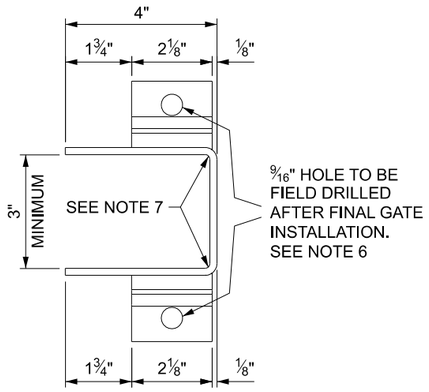
DWG SK SHEET 00 REV -

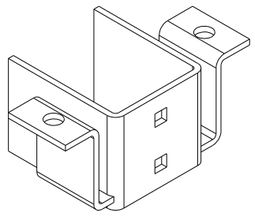
WO#:00000000

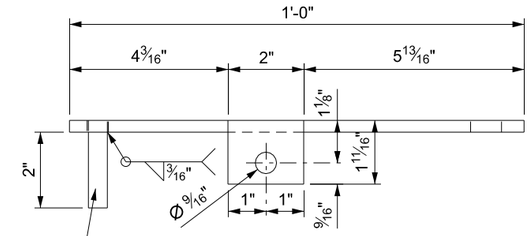
D S E L B 7 0 1 6 0 3 6 H

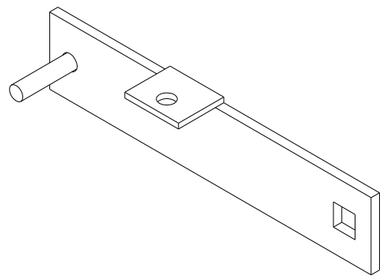
7016036

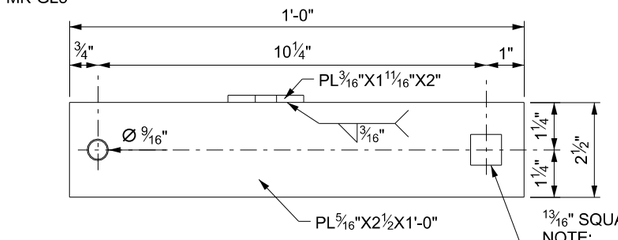
ECB#M02212/SAP#10078502 INCLUDES MK PCS AND HARDWARE			
COMPONENT#	QTY	UNIT	DESCRIPTION
O01274	1	EA	BOLT MACH GALV .500" X 5.00"
O01700	4	EA	BOLT CARRIAGE .375" X 3"
O01701	2	EA	BOLT CARRIAGE .375" X 4"
O01725	8	EA	WASHER FLAT GALV RD .375"
O07127	2	EA	WASHER FLAT GALV RD .50"
O07170	4	EA	WASHER LOCK RD GALV .375"
O07172	1	EA	WASHER LOCK RD GALV .50"
O07504	1	EA	NUT GALV .500" SQ.





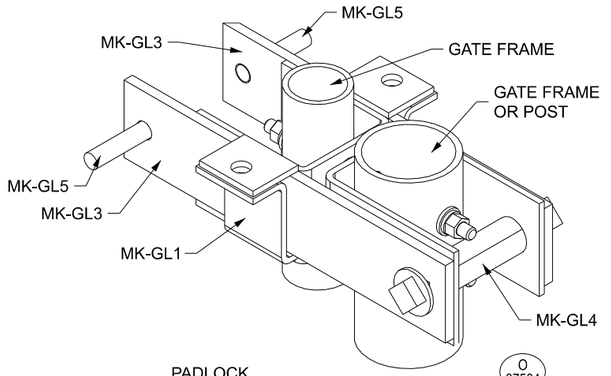


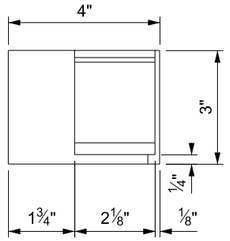


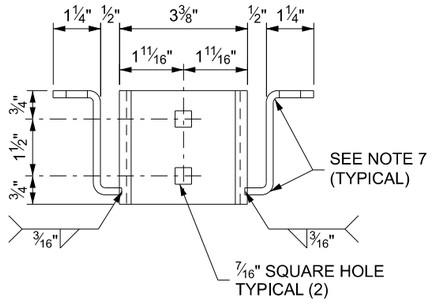


MK-GL3

(2) REQUIRED PER ASSEMBLY
(1) AS SHOWN (1) OPPOSITE HAND
SCALE: 3" = 1'-0"

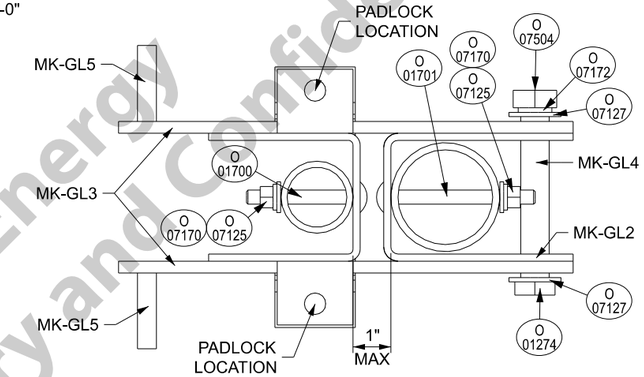




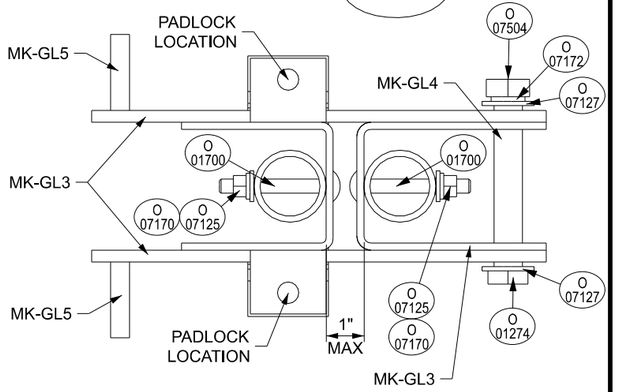


MK-GL1

3/16" PLATE
(1) REQUIRED PER ASSEMBLY
SCALE: 3" = 1'-0"



POST ASSEMBLY

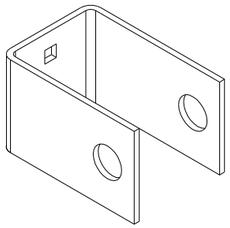


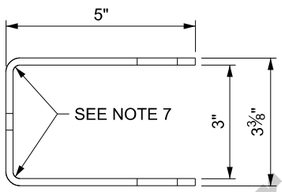
FRAME ASSEMBLY

GATE LATCH ASSEMBLY

(1)GL1 (1)GL2 (2)GL3 (1)GL4 (2)GL5
PLUS BOLTS NUTS AND WASHERS

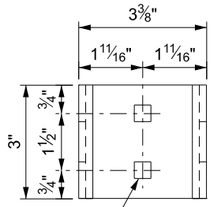
4¼" MAXIMUM
4 3/16" MINIMUM
AFTER GALVANIZING

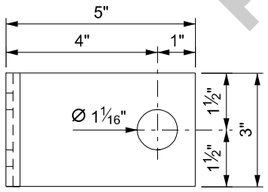




MK-GL4

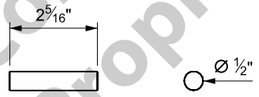
¾"x14 GAUGE SQUARE TUBING
(1) REQUIRED PER ASSEMBLY
SCALE: 3" = 1'-0"





MK-GL2

3/16" PLATE
(1) REQUIRED PER ASSEMBLY
SCALE: 3" = 1'-0"



MK-GL5

½" ROD
(2) REQUIRED PER ASSEMBLY
SCALE: 3" = 1'-0"

NOTES:

1. ALL STEEL SHALL BE ASTM A-36 LATEST REVISION SUITABLE FOR GALVANIZING.
2. ALL PIECES SHALL BE GALVANIZED PER ASTM A-123 LATEST REVISION AFTER FABRICATION AND WELDING.
3. FABRICATION SHALL BE PER AISC SPECIFICATIONS LATEST REVISION.
4. FABRICATOR TO ASSEMBLE LATCH PIECES BEFORE SHIPPING.
5. DRIPS OR ICICLES WHICH MAY CAUSE PHYSICAL DISCOMFORT WHILE HANDLING MATERIALS SHALL BE GROUND SMOOTH WITHOUT DESTROYING THE GALVANIZED COVERING.
6. SUBOX ZINC RICH PAINT SHALL BE APPLIED TO ALL HOLES DRILLED (EXPOSED METAL) AFTER GALVANIZING.
7. BEND RADIUS SHALL BE AS SMALL AS PRACTICAL WITHOUT CRACKING STEEL WHILE COLD BENDING.

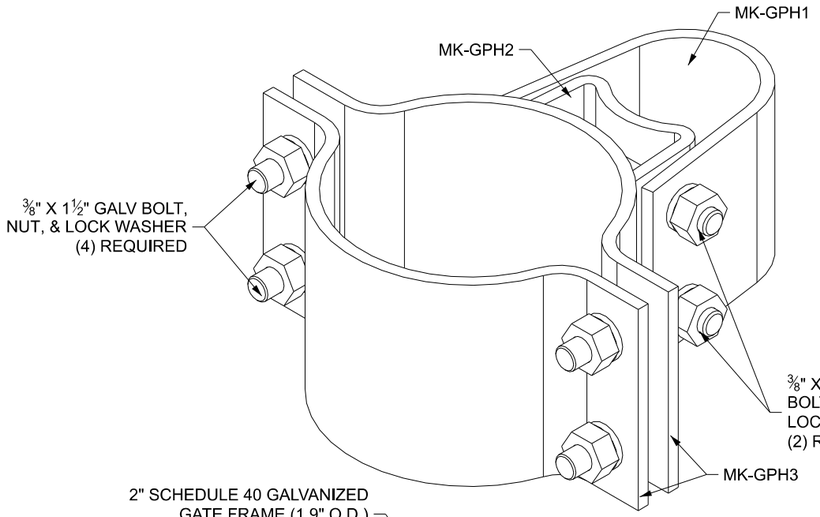
DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.
		I	05/02/18	RELOCATED TAB IN GL3. ADDED 1" MAX DIMENSION TO ASSEMBLY.	KDR	JEW

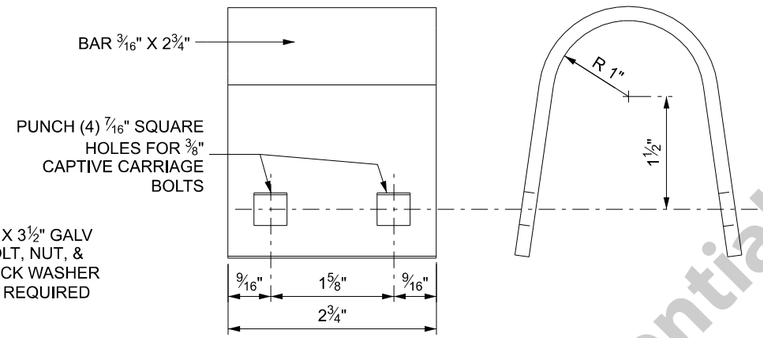
SECTION HEAD — APP JS GROULX — DATE 02/03/98
DIVISION HEAD — APP
DEPARTMENT HEAD — APP
DR ME FLICK 02/03/98
CK
SCALE 3" = 1'-0"

Consumers Energy

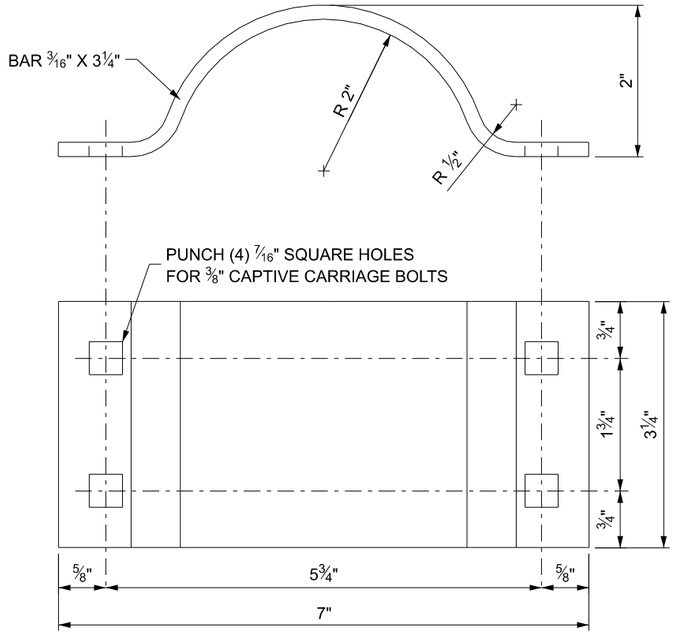
GATE LATCH ASSEMBLY DETAILS
FITS UP TO TO 3" POST OR FRAME
M02212

DWG DSB7016 SHEET 035 REV I

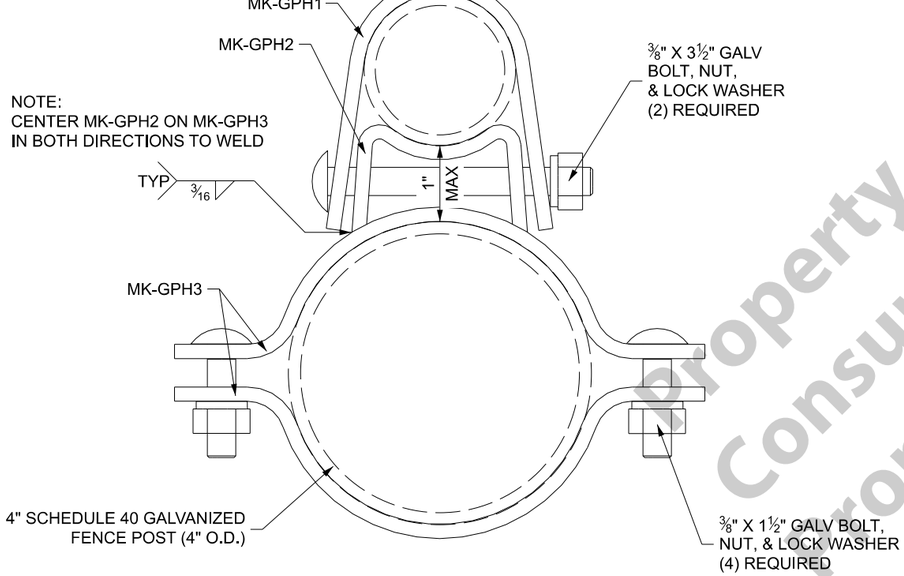




MK-GPH1 (1 REQUIRED)

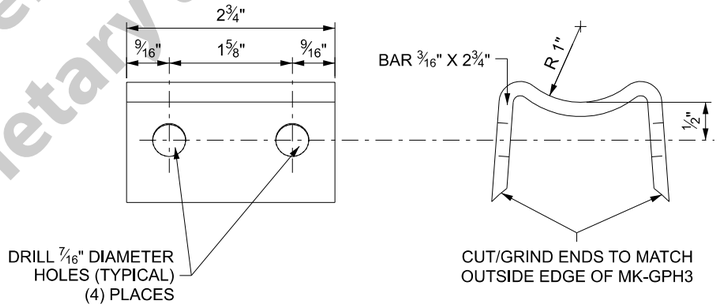


MK-GPH3 (2 REQUIRED)



GATE POST HINGE (GPH) ASSEMBLY

(1) GPH4, (1) GPH5, (2) GPH6
PLUS BOLTS, NUTS, & WASHERS



MK-GPH2 (1 REQUIRED)

NOTES:

1. ALL STEEL SHALL BE ASTM A-36 LATEST REVISION, SUITABLE FOR GALVANIZING
2. ALL PIECES SHALL BE GALVANIZED PER ASTM A-123 LATEST REVISION, AFTER FABRICATION AND WELDING.
3. FABRICATION SHALL BE PER AISC SPECIFICATIONS, LATEST REVISION.
4. FABRICATOR TO ASSEMBLE BEFORE SHIPPING.
5. DRIPS OR ICICLES WHICH MAY CAUSE PHYSICAL DISCOMFORT WHILE HANDLING MATERIALS SHALL BE GROUND SMOOTH WITHOUT DESTROYING THE GALVANIZED COVERING.

DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.
		D	04/27/18	ADDED BACK GPH1 & GP2. RELOCATED STOPPER ASSY TO SH.047	JAH	LJB
DSB7016 SH.046	FENCE ERECTION DETAILS 24FT DRIVE GATE	C	10/21/16	REMOVED GATE PLUNGER ASSY. ADDED GATE STOPPER ASSY.	JAH	LJB
DSB7016 SH.044	FENCE ERECTION DETAILS 20FT DRIVE GATE	B	01/05/10	CORRECTED SIZE.	JAH	LJB
DSB7016 SH.043	FENCE ERECTION DETAILS 14FT DRIVE GATE	A	08/28/98	CHANGED DWG SIZE FROM G TO F. REVISED REF DWGS.	MSO	JSG

SECTION HEAD / DATE / APP
DIVISION HEAD / APP
DEPARTMENT HEAD / APP

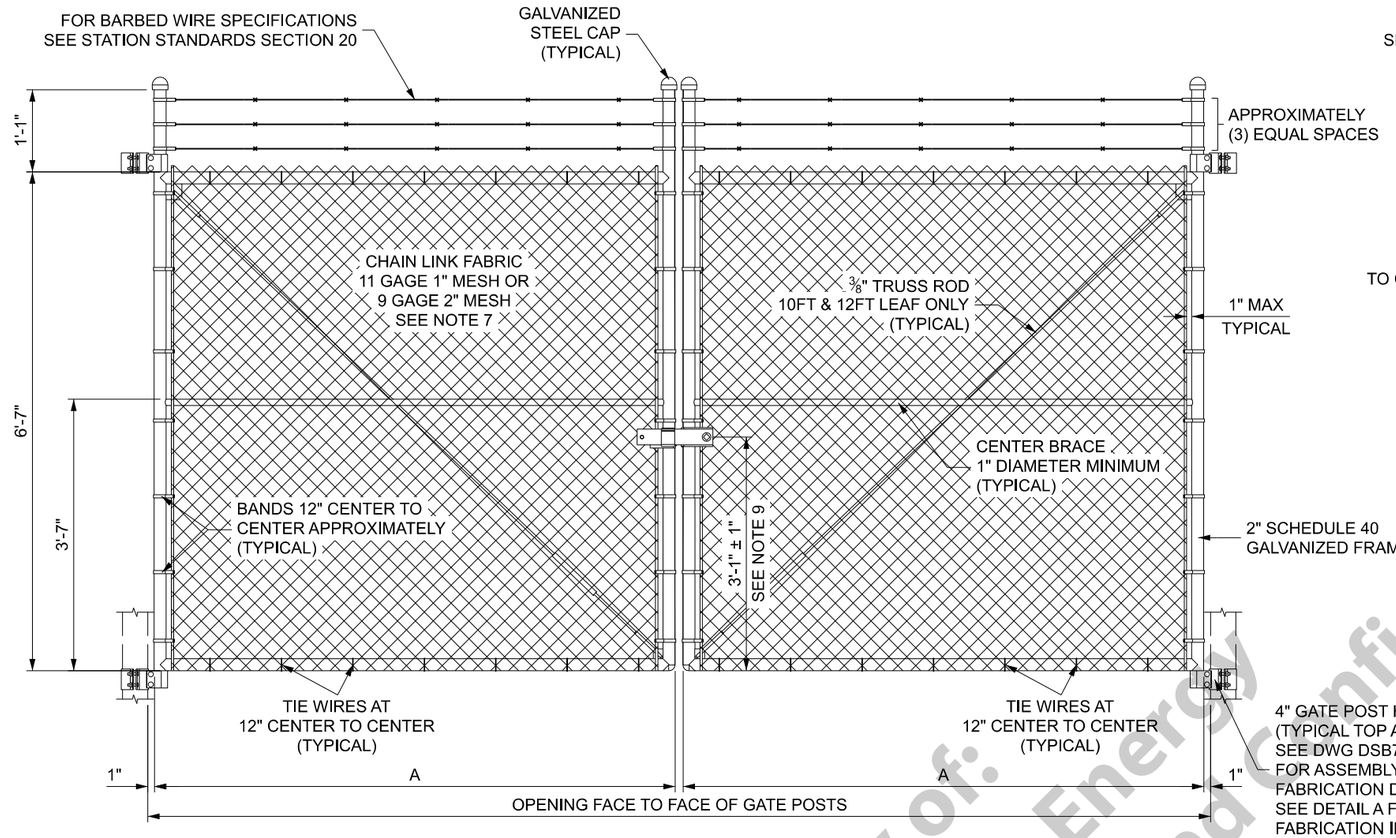
DR ME FLICK 02/05/98
CK JS GROULX 02/05/98

SCALE 6" = 1'-0"

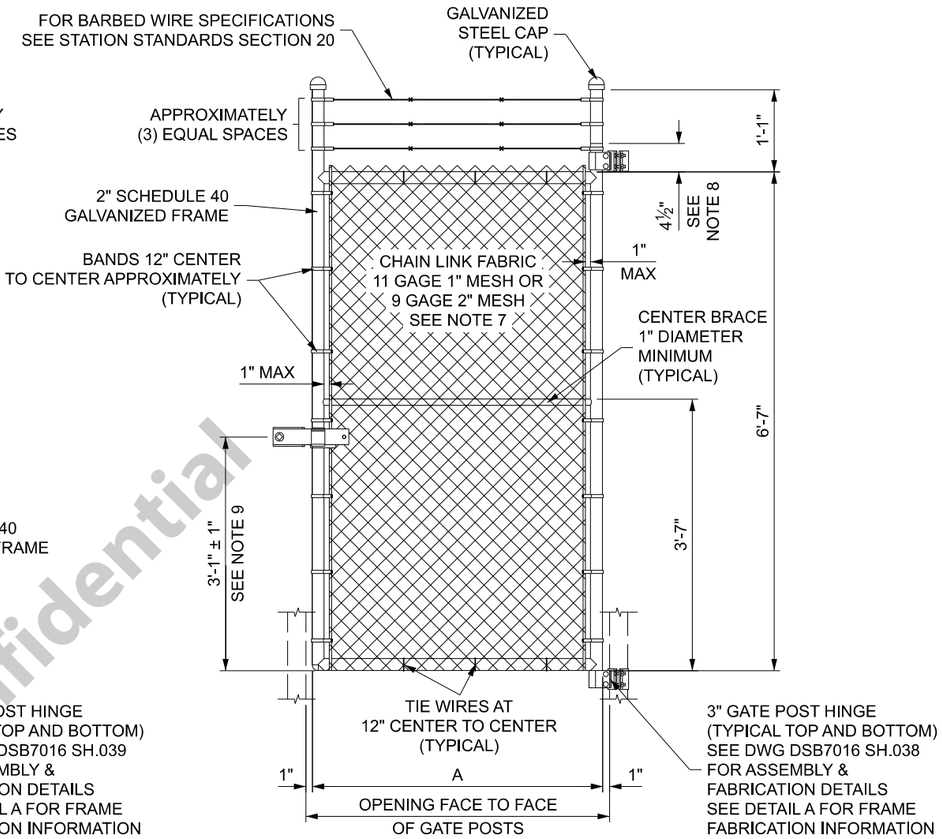
Consumers Energy

4" GATE POST HINGE ASSEMBLY

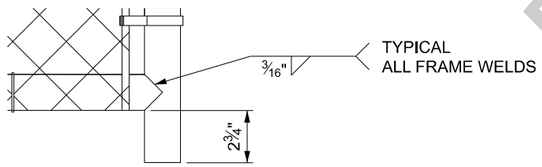
DWG DSB7016 SHEET 039 REV D



TYPICAL DOUBLE GATE FRAME ASSEMBLY DETAILS



TYPICAL SINGLE GATE FRAME ASSEMBLY DETAILS



DETAIL A

1½" = 1'-0"

GATE FRAME DIMENSIONS			
CMS#/SAP#	GATE TYPE	GATE POSTS FACE TO FACE	A
N/A	SINGLE W/O BARB WIRE	4'-0"	3'-10"
M02237 10140484	SINGLE WITH BARB WIRE	4'-0"	3'-10"
M02225 10140475	DOUBLE	14'-0"	6'-10½"
M02235 10140482	DOUBLE	20'-0"	9'-10½"
M02236 10140483	DOUBLE	24'-0"	11'-10½"

FABRICATION NOTES:

1. ALL MATERIAL TO BE ASTM A-36 LATEST REVISION, SUITABLE FOR GALVANIZING.
2. ALL PIECES SHALL BE GALVANIZED PER ASTM A-123 LATEST REVISION. WELDS ON GATE FRAME SHALL BE CLEANED AND THEN COATED WITH BRITE ZINC GALVANIZING COMPOUND PER ASTM A780 LATEST REVISION.
3. FABRICATION PER AISC SPECIFICATIONS, LATEST REVISION.
4. FABRICATOR TO ASSEMBLE BEFORE SHIPPING.
5. DRIPS OR ICICLES WHICH MAY CAUSE PHYSICAL DISCOMFORT WHILE HANDLING MATERIAL SHALL BE GROUND SMOOTH WITHOUT DESTROYING THE GALVANIZED COVERING.
6. SUBOX RICH PAINT SHALL BE APPLIED TO ALL HOLES DRILLED (EXPOSED METAL) AFTER GALVANIZING.
7. FENCE FABRIC SHALL BE AS SPECIFIED ON PURCHASE ORDER.
8. LENGTH OF GATE FRAME EXTENSION WITHOUT BARBED WIRE.
9. APPROXIMATE GATE LATCH LOCATION. SEE DSF7016 SH.035 FOR ASSEMBLY & FABRICATION DETAILS.

DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.
DSB7016 SH.047	DOUBLE SWING GATE STOPPER ROD.	F	04/27/18	REDRAWN. ADDED FRAME MATERIAL SPECIFICATION.	KDR	JEW
DSB7016 SH.039	4" GATE HINGE DETAILS.	E	01/12/10	CORRECTED FORM.	JAH	LJB
DSB7016 SH.038	3" GATE HINGE DETAILS.	D	05/16/00	REMOVED TRUSS ROD FROM 4FT GATE	MSO	AJS
DSF7016 SH.035	GATE LATCH ASSEMBLY DETAILS.	C	10/08/99	ADDED 24FT GATE AND REVISED NOTE 2.	JPZ	AJS

SECTION HEAD — APP JS GROULX — DATE 02/04/98
DIVISION HEAD — APP
DEPARTMENT HEAD — APP
DR ME FLICK 02/04/98
CK
SCALE 1/2" = 1'-0"

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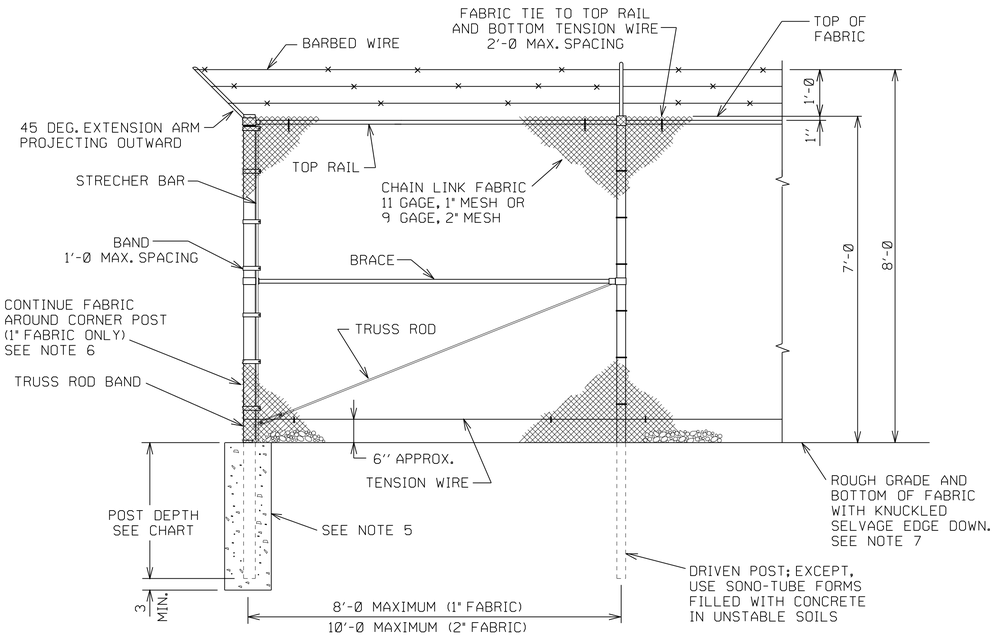
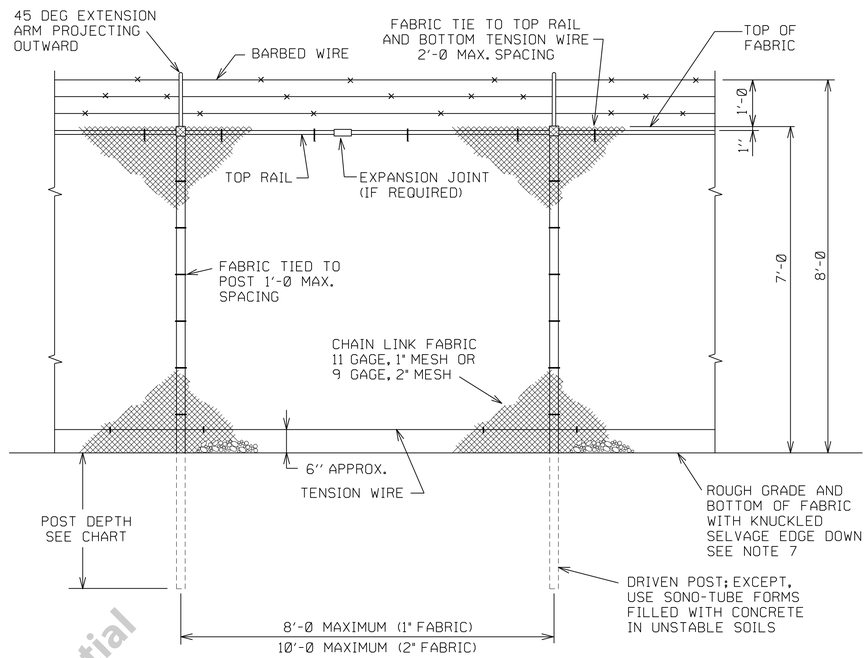
GATE FRAME ASSEMBLY
4'-0", 14'-0", 20'-0", 24'-0"

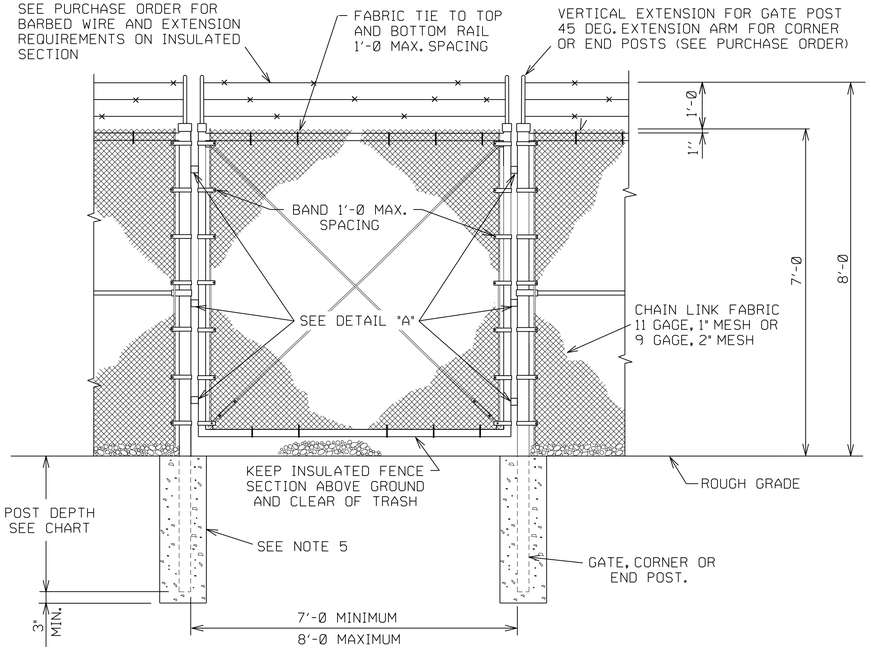
DWG DSB7016 SHEET 040 REV F



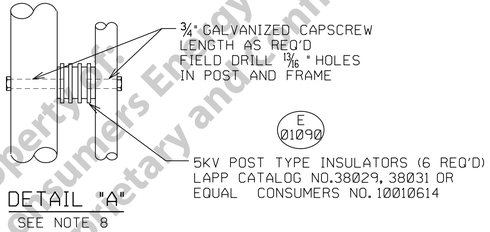
FENCE CORNER



FENCE LINE SPAN



INSULATED FENCE SECTION



DETAIL "A"

SEE NOTE 8

NAME OF PART	PIPE SIZE O.D.	POST DEPTH IN FOOTING	FOOTING DEPTH	CONC C.Y. W/12" TUBE
LINE POST SEE NOTE 4	SEE NOTE 2	3'-3	3'-6	.1
CORNER POST	3	3'-3	3'-6	.1
END AND ANGLE POST	3	3'-3	3'-6	.1
SINGLE GATE POST, WIDTH 6 FT AND UNDER	3	3'-3	3'-6	.1
SINGLE GATE POST, WIDTH OVER 6 TO 13 FT	4	4'-0	4'-3	.13
DOUBLE GATE POST, WIDTH 12 FT AND UNDER	3	SEE FOUNDATION DETAIL		
DOUBLE GATE POST, WIDTH 12 TO 26 FT	4	SEE FOUNDATION DETAIL		
GATE AND INSULATED SECTION FRAME	2			
TOP RAIL	1 5/8			
BRACE	1 5/8			

GENERAL NOTES:

1. ALL DIMENSIONS ARE IN INCHES EXCEPT AS NOTED.
2. LINE POST 2½" OD SS40 @ 3.12 LB/FT TO BE USED.
3. FABRIC TIES TO BE MINIMUM 9 GAUGE ALUMINUM WIRE OR APPROVED MANUFACTURERS STANDARD.
4. ALL LINE POSTS SHALL BE DRIVEN THREE FEET INTO THE GROUND BY MECHANICAL MEANS EXCEPT IN UNSTABLE SOILS.
5. CONCRETE CORNER POST/ END POST FOOTINGS SHALL BE SET IN A MINIMUM OF 12" DIAMETER FORMS. CONTRACTOR TO DETERMINE AND FURNISH FORM. EARTH FORMS ARE UNACCEPTABLE.
6. 1" MESH FENCE FABRIC IS TO BE INSTALLED CONTINUOUSLY (DO NOT CUT OR BREAK) AROUND FENCE CORNERS.
7. BOTTOM OF FENCE FABRIC TO BE PLACED AT ROUGH GRADE ELEVATION AND BURIED WITH A MINIMUM OF 3" OF YARD STONE, OR AS SPECIFIED ON GRADING DRAWING.
8. ZINC RICH PAINT SHALL BE USED BY THE CONSTRUCTION CONTRACTOR ON ANY EXPOSED METAL SURFACES THAT WOULD OTHERWISE HAVE A PROTECTIVE COATING. PAINT SHALL BE "ZINC-IT" (M05423) CONSUMERS #10058357 OR APPROVED EQUAL.

DRAWING NO.	REFERENCE DRAWINGS

REV	DATE	DESCRIPTION	BY	APP
H	10-13-15	REVISED GENERAL NOTE 5	JAH	FMH
G	03-26-15	REVISED GENERAL NOTE 5 REVISED POST & FOOTING DEPTH CHART	JAH	FMH
F	09-02-10	REVISED GENERAL NOTE 2.	DRB	AKN

REV	DATE	DESCRIPTION	BY	APP
E	01/12/10	CORRECTED FORM	JAH	LJB
D	6-22-09	CHANGED STOCK #01-65001 TO SAP #10010614 IN DETAIL "A"	JAH	AKN
C	5-12-00	REVISED GENERAL NOTE 2 TO DELETE 2½" OD POST. ADDED CONCRETE REQ'D FOR POSTS TO TABLE	MSO	JSG
B	12-18-98	REVISED GENERAL NOTE 5, CONTRACTOR TO FURNISH SONO TUBE FORMS.	MSO	JSG

	DATE
DR. ME FLICK	02/04/98
CK.	/ /
SECTION HEAD APP. JS GROULX	02/04/98
DIVISION HEAD APP.	/ /
DEPARTMENT HEAD APP.	/ /

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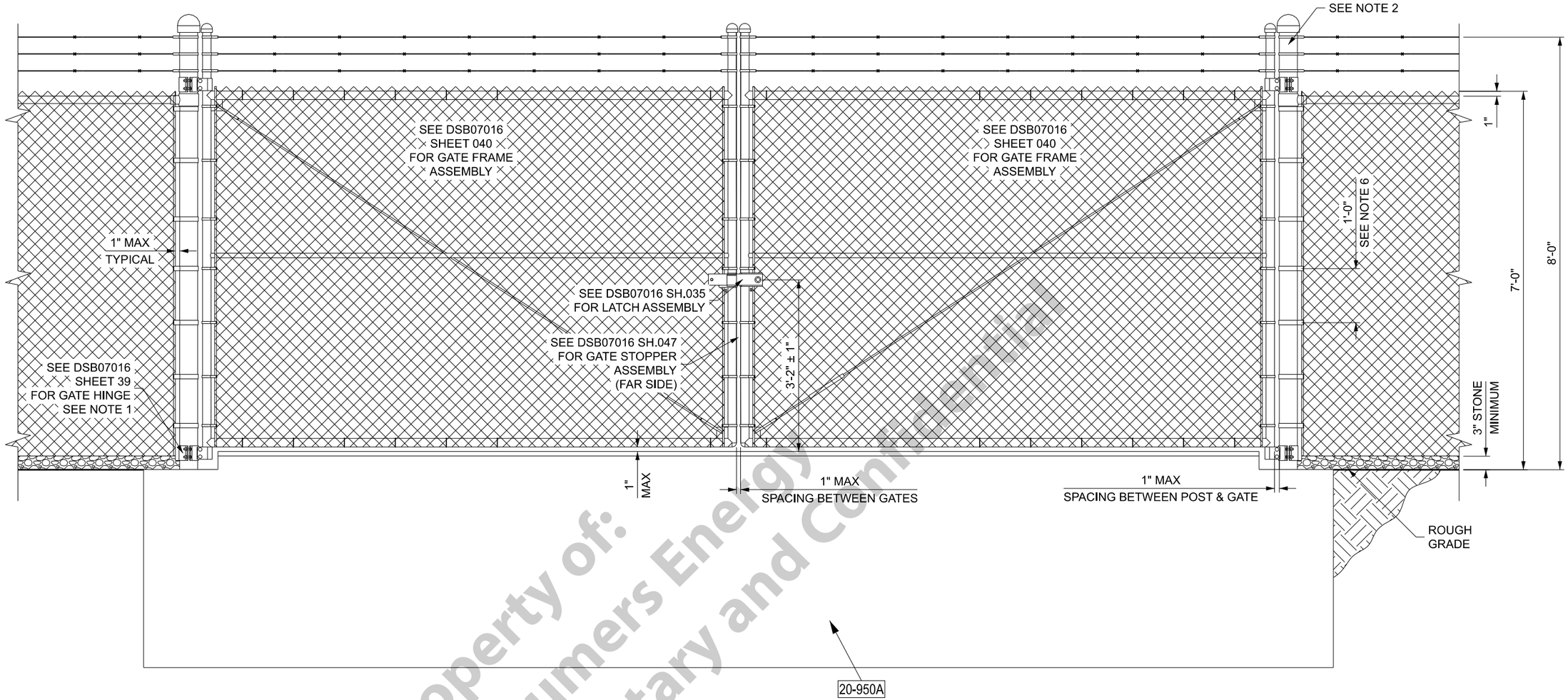
FENCE DETAILS

SCALE	DRAWING NO.	SHEET	REV.
NONE	DSEL-07016-	041	H

JOB

7016-041



ELEVATION

NOTES:

1. BURY THE GATE HINGES ON BOTH GATES AS REQUIRED IN FIELD TO USE AS A HEIGHT ADJUSTMENT TO MAINTAIN A MAXIMUM 1" GAP FROM GATE FRAME TO FOUNDATION.
2. REFER TO PURCHASE ORDER FOR HEIGHT OF POST AND FENCE PIPE SPECIFICATIONS.
3. BOTTOM OF FENCE FABRIC TO BE PLACED AT ROUGH GRADE ELEVATION AND BURIED WITH A MINIMUM OF 3" OF YARD STONE, OR AS SPECIFIED ON GRADING DRAWING.
4. SEE SUBSTATION STANDARDS SECTION 20 FOR FENCE SPECIFICATIONS.
5. WHEN INSTALLING LATCH ASSEMBLY, IF BOLT HEADS NEED TO BE TRIMMED, COLD GALVANIZE AFTER TRIMMING.
6. TYPICAL STRAP SPACING, INSTALL (7) STRAPS AS INDICATED.

DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.
DSB7016 SH.47	GATE STOPPER ROD ASSEMBLY					
DSB7016 SH.40	GATE FRAME ASSEMBLY	C	05/02/18	REDRAWN. REVISED NOTE 2 & REMOVED PREVIOUS 4.	KDR	JEW
DSB7016 SH.39	4" GATE POST HINGE	B	01/08/10	CHANGED FILE FROM DSF7016 SH.044 TO DSEL-07016-044.DGN	JAH	LJB
DSB7016 SH.35	GATE LATCH ASSEMBLY DETAILS	A	09/01/98	CHANGED FILE FROM DSF7016 SH.052 TO DSF7016 SH.044	DRB	MSO

SECTION HEAD APP JSGROULX	DATE 09/01/98	DR DRBOLEY 09/01/98
DIVISION HEAD APP JHSOSINSKI	09/01/98	CK MSOCONNELL 09/01/98
DEPARTMENT HEAD APP JALZUBAYDI	09/01/98	SCALE 1/2" = 1'-0"

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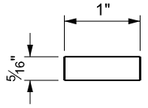
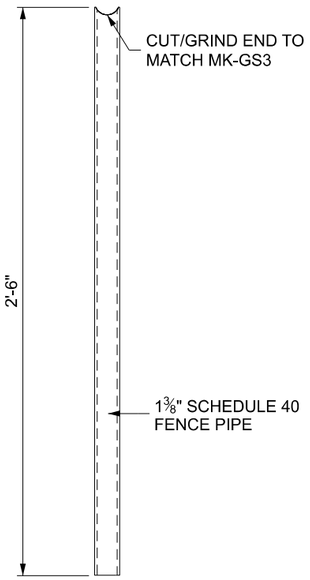
FENCE ERECTION DETAILS
20FT DRIVE GATE
M02235

DWG DSB7016 SHEET 044 REV C



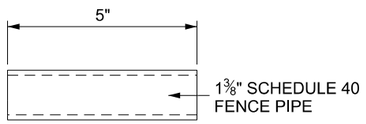
MK-GS1

ROD 5/16" X 1"
SCALE: 6" = 1'-0"



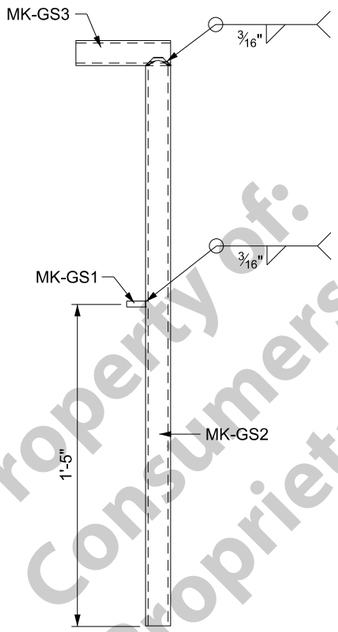
MK-GS2

1½" = 1'-0"



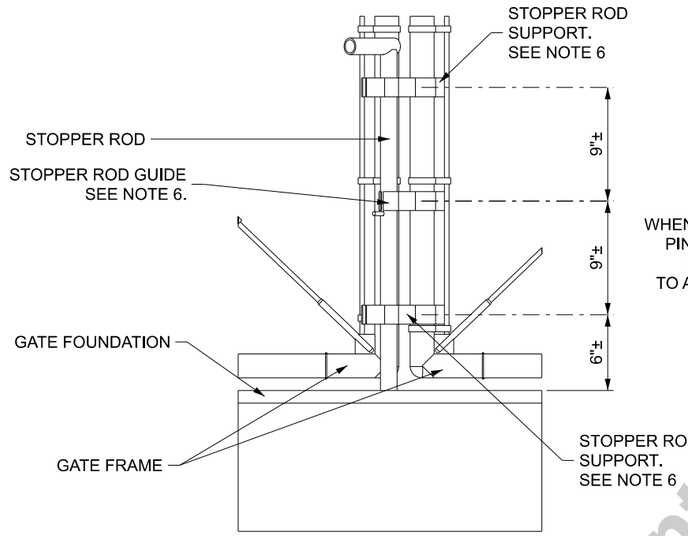
MK-GS3

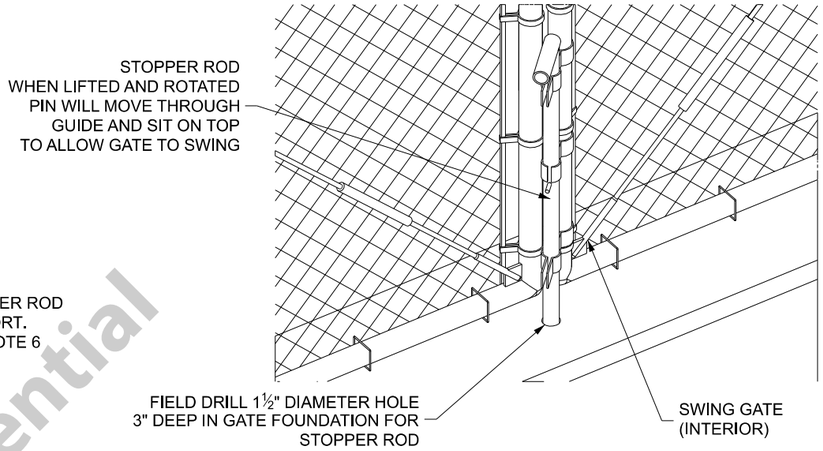
3" = 1'-0"



GATE STOPPER ROD ASSEMBLY

1½" = 1'-0"





GATE STOPPER INSTALLATION

STOPPER ROD TO BE INSTALLED ON THE INTERIOR OF THE GATE
1" = 1'-0"

NOTES:

1. ALL STEEL SHALL BE ASTM A-36 LATEST REVISION, SUITABLE FOR GALVANIZING.
2. ALL PIECES SHALL BE GALVANIZED PER ASTM A-123 LATEST REVISION, AFTER FABRICATION AND WELDING.
3. FABRICATION SHALL BE PER AISC SPECIFICATIONS, LATEST REVISION.
4. FABRICATOR TO ASSEMBLE BEFORE SHIPPING.
5. DRIPS OR ICICLES WHICH MAY CAUSE PHYSICAL DISCOMFORT WHILE HANDLING MATERIALS SHALL BE GROUND SMOOTH WITHOUT DESTROYING THE GALVANIZED COVERING.
6. GATE STOPPER SHALL BE INSTALLED SO IT CAN LIFT AND ROTATE WITHOUT ANY BINDING.

DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.

SECTION HEAD — APP JE WATSON — DATE 05/07/18
DIVISION HEAD — APP ER HARVEY — 05/09/18
DEPARTMENT HEAD — APP KJ REININGER — 05/11/18

DR KD RICHARDSON 05/01/18
CK SA SULZMAN 05/04/18

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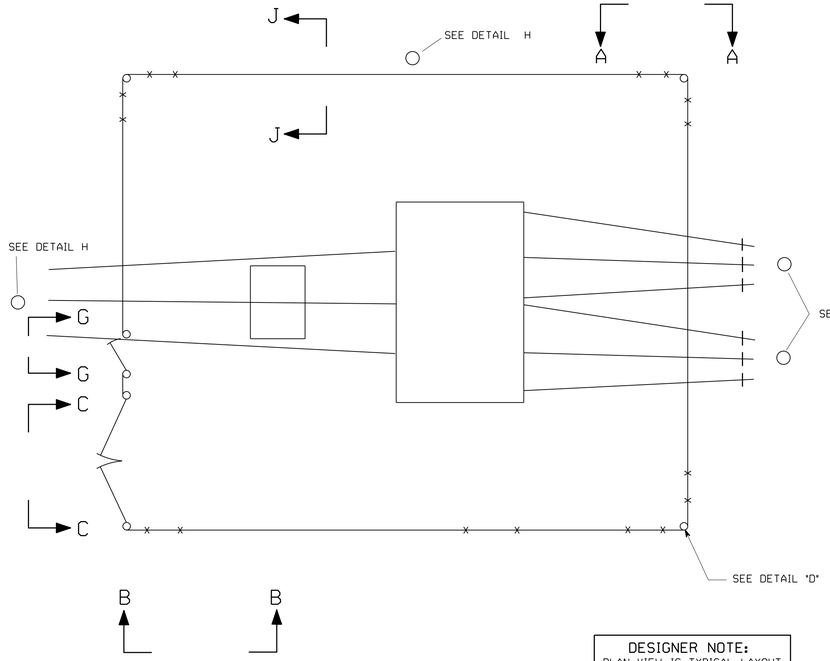
SCALE AS NOTED

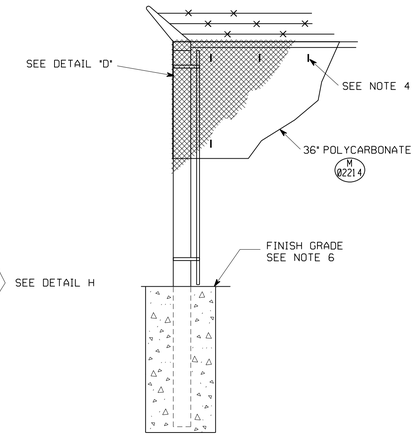
DOUBLE SWING GATE STOPPER ROD ASSEMBLY

DWG DSB7016 SHEET 047 REV -

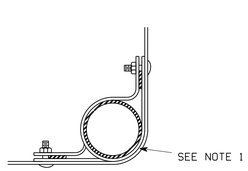


PLAN VIEW

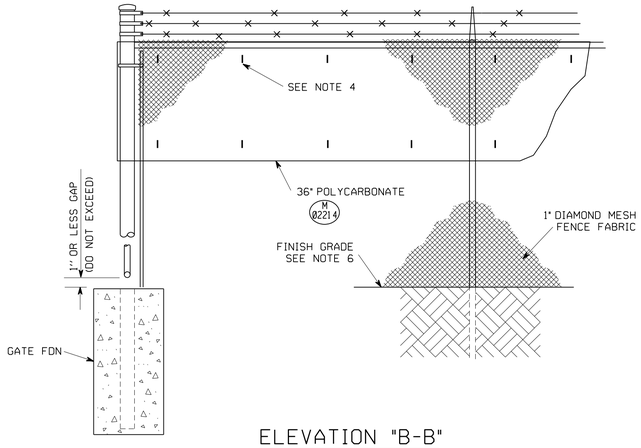
DESIGNER NOTE:
PLAN VIEW IS TYPICAL LAYOUT. ADJUST FENCE LAYOUT, GATES, STRUCTURES, LINES AND LINE BARRIERS PER JOB SPECIFIC REQUIREMENTS.



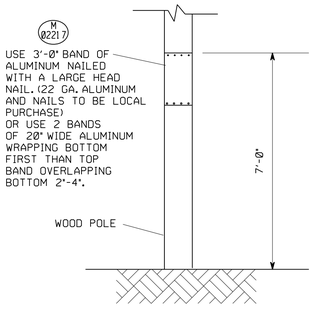
ELEVATION "A-A"



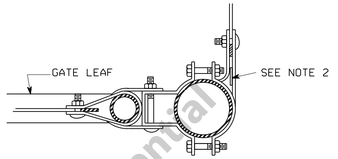
DETAIL "D"
TYPICAL



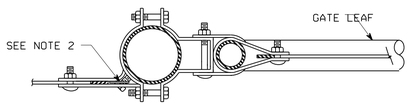
ELEVATION "B-B"



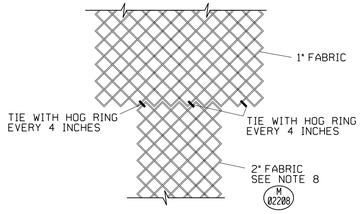
DETAIL "H"



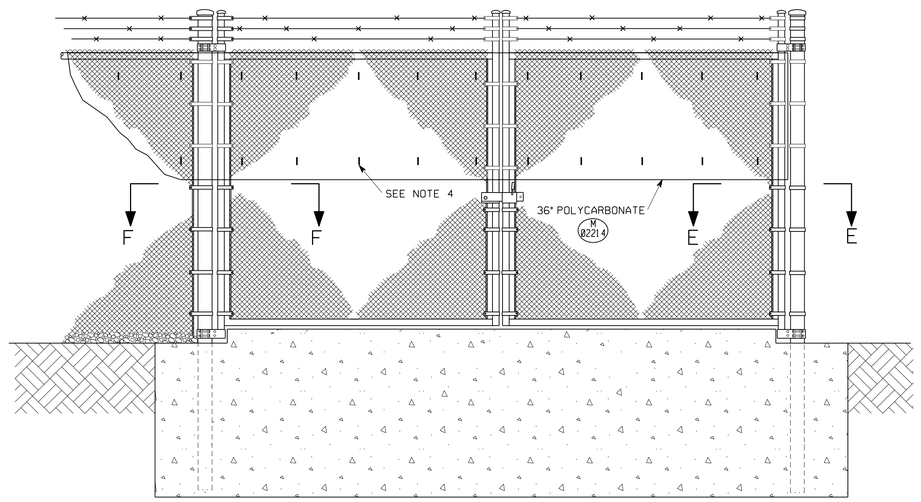
SECTION "E-E"
(GATE POST AT CORNER)



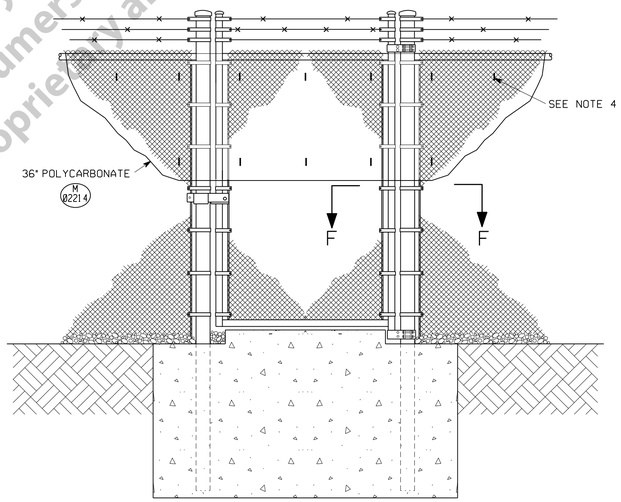
SECTION "F-F"
(GATE POST IN LINE)



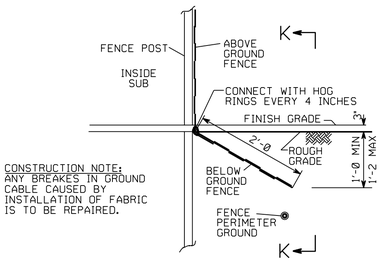
SECTION "K-K"



ELEVATION "C-C"



ELEVATION "G-G"



CONSTRUCTION NOTE:
ANY BREAKES IN GROUND CABLE CAUSED BY INSTALLATION OF FABRIC IS TO BE REPAIRED.

SECTION "J-J"
TYPICAL ALL SIDES
SEE NOTE 8

GENERAL NOTES

1. FENCE FABRIC TO BE INSTALLED CONTINUOUSLY AROUND ALL CORNER POSTS.
2. USE 1" POLYCARBONATE STRIP TO PLUG THE GAPS AT THE GATE POSTS AND ANY LOCATION GREATER THAN 1" BETWEEN POSTS AND STRETCHER BARS.
3. BURY THE GATE HINGES ON BOTH LEAFS AS REQUIRED IN FIELD TO USE AS A HEIGHT ADJUSTMENT TO MAINTAIN A MAX. 1" GAP FROM GATE FRAME TO FOUNDATION.
4. ALL POLYCARBONATE TO FENCE FABRIC TIES ARE TO BE MADE WITH #6 SINGLE STRAND, ALUMINUM WIRE AND SHALL BE INSTALLED VERTICALLY. (M02292 FURNISHED BY CONTRACTOR.)
5. CUT AND TRIM ALL SHRUBS LOCATED WITHIN 10' OF FENCE TO A HEIGHT 1'-0 BELOW BOTTOM OF POLYCARBONATE.
6. BOTTOM OF FENCE FABRIC TO BE PLACED AT ROUGH GRADE ELEVATION AND BURIED WITH A MINIMUM OF 3" OF YARD STONE, OR AS SPECIFIED ON GRADING DRAWING.
7. SEE "SUBSTATION STANDARDS" SECTION 20 FOR FENCE SPECIFICATIONS.
8. THIS INSTALLATION ONLY REQUIRED WHEN RACCOON PROOFING IS REQUIRED PER CRITERIA OUTLINED IN "SUBSTATION STANDARDS" SECTION 23. FIELD CUT 24" WIDE FENCE FROM 48" WIDE ROLL OF FABRIC. FASTEN 24" FABRIC TO BOTTOM OF SUBSTATION FENCE AT KNUCKLED END.
9. INSTALL TOP EDGE OF POLYCARBONATE PANELS EVEN WITH TOP OF FENCE FABRIC.

1" FABRIC

DRAWING NO.	REFERENCE DRAWINGS		REV	DATE	DESCRIPTION	BY	APP
	POLYCARBONATE LAYOUT & DETAILS						

DATE
DR. / /
CK. / /
SECTION HEAD
APP. / /
DIVISION HEAD
APP. / /
DEPARTMENT HEAD
APP. / /

Consumers Energy

FENCE AND ANIMAL BARRIER MISCELLANEOUS DETAILS

SUBSTATION

SCALE	NONE	DRAWING NO.	-F16	SHEET	052	REV.
JOB	WO					

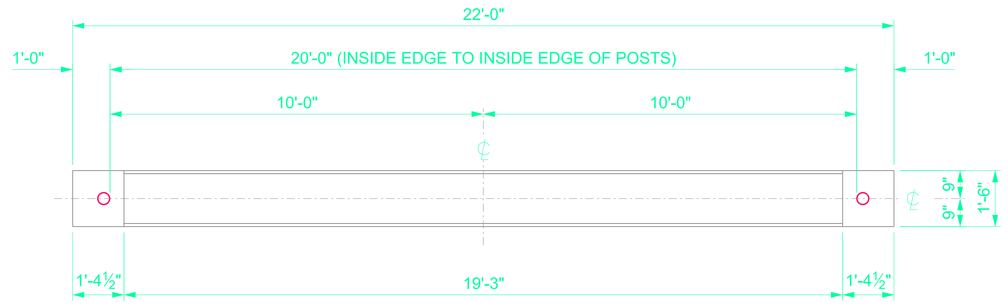
7016052

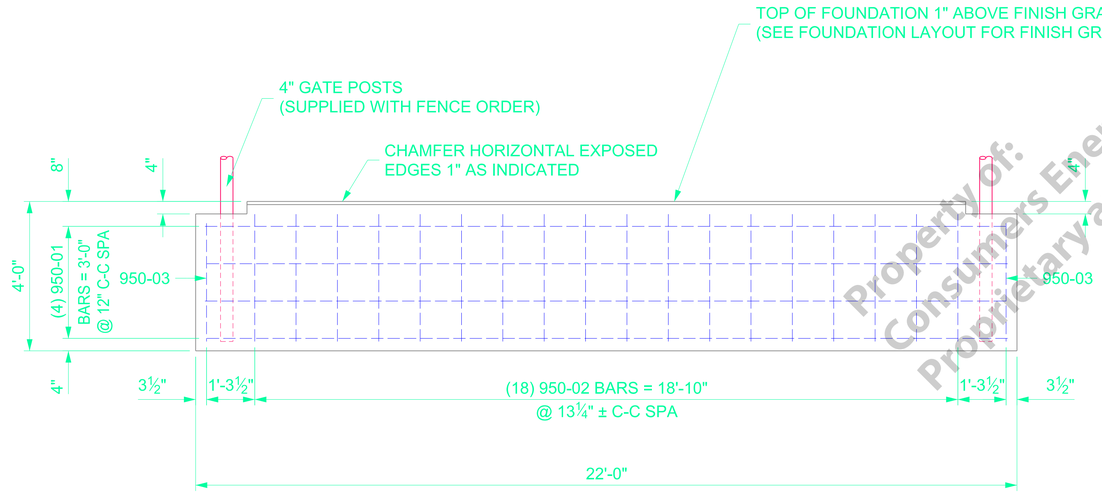
RS

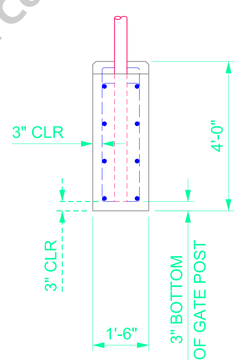
DSF7016 052 F

FOUNDATION ORIENTATION

N 950A 2A
W 950A 3A





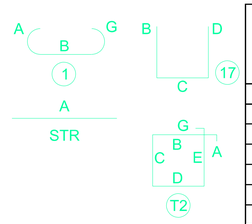


FOUNDATION 20-950A 2A
FOUNDATION 20-950A 3A

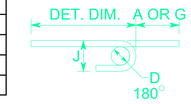
ASSEMBLY#: F200Z950A (MATERIAL FOR ONE UNIT ONLY)

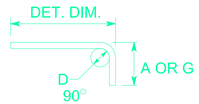
CMS#/ASSY#	QTY	UNIT	DESCRIPTION	SAP#
M03015	5	CY	CONCRETE, READY MIX 4500#	10217986
M90450	8	EA	FDN. REBAR MK 950-01	50017733
M90451	18	EA	FDN. REBAR MK 950-02	50017734
M90452	2	EA	FDN. REBAR MK 950-03	50017735

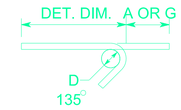
BAR BENDING DATA



BAR SIZE	END HOOKS D	180° HOOK A OR G	180° HOOK J	90° HOOK A OR G	STIRRUP & TIE HOOK D	90° HOOKS A OR G	BAR SIZE
3	2 1/4	5	3	6	1 1/2	4	3
4	3	6	4	8	2	4 1/2	4
5	3 3/4	7	5	10	2 1/2	6	5
6	4 1/2	8	6	12			
7	5 1/4	10	7	14			
8	6	11	8	16			
9	9	15	11 1/4	19			
10	10	17	12 3/4	22			







NOTES:
1. DIMENSIONS OMITTED ARE ZERO.
2. DIMENSIONS ARE OUT TO OUT EXCEPT A&G ON STANDARD 180° HOOK (SEE DET.)
3. DEFORMED REINFORCED BARS ARE TO BE GRADE 60 STEEL (ASTM-A615).
4. ALL HOOKS AND BENDS TO CONFORM TO CURRENT ACI CODE 318 STANDARDS.
5. BARS (1) AND (17) TO BE BENT AS MAIN REINFORCEMENT AND (T2) AND (T4) TO BE BENT AS TIE REINFORCEMENT.
6. ALL DIMENSION ARE IN INCHES.

BAR MARK	CMS#	QUANTITY	SIZE	NOMINAL LENGTH (IN)	TYPE	A (IN.)	B (IN.)	C (IN.)	D (IN.)	E (IN.)	G (IN.)	WT/BAR	TOTAL WEIGHT
950-01	M90450	8	4	258.0	STR	258						14.36	114.90
950-02	M90451	18	4	117.0	T2	4.5	12.0	42.0	12.0	42.0	4.5	6.51	117.23
950-03	M90452	2	4	109.0	T2	4.5	12.0	38.0	12.0	38.0	4.5	6.07	12.14

TOTAL WEIGHT: 244.27

GENERAL NOTES

1. ALL CONCRETE TO HAVE A MINIMUM STRENGTH OF 4500 POUNDS PER SQUARE INCH AT 28 DAYS AND TO BE FURNISHED AND PLACED IN ACCORDANCE WITH CONSUMERS SPECIFICATION SS-1951.01 AND SS-1951.05
2. TOP OF GATE FOUNDATION TO BE 1" ABOVE FINISH GRADE.
3. FIBER REINFORCING MANUFACTURED BY FIBERMESH COMPANY CHATTANOOGA, TN. MAY BE USED IN PLACE OF STEEL. FIBERMESH SHALL BE ADDED TO THE CONCRETE AT A RATE OF 2½ LBS/CU YARD MINIMUM.

SCALE: 1/4" = 1'-0"

CONSTRUCTION NOTE:

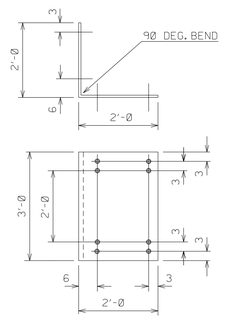
FOUNDATION MUST BE BUILT WITH FORMS.
EARTH FORMING IS UNACCEPTABLE.

20	Consumers Energy FOUNDATION ASSEMBLY DETAILS	ASSEMBLY#	ICON#	REV
		F200Z950A	8522	F

REV	DATE	DESCRIPTION	BY	APP
F	06/21/18	UPDATED CONCRETE TO 4500PSI (ACI 318-14)	KDR	JEW
E	01/21/15	REM END CHAMFERS & REV GEN NOTE	JAH	SAS
D	02/04/10	CORRECTED FORM	JAH	
C	10/16/09	ADDED LOGO	SRT	

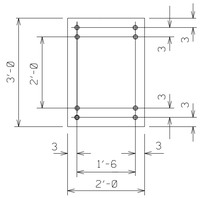
ORIGINAL BY: --- APP: JGB DATE:09/06/95

20FT GATE FOUNDATION



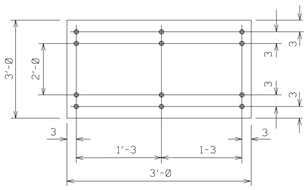
POLYCARBONATE #101

36"x⅛"x4'-0



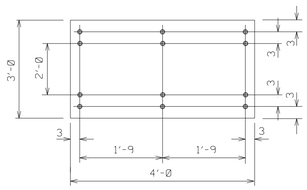
POLYCARBONATE #102

36"x⅛"x2'-0



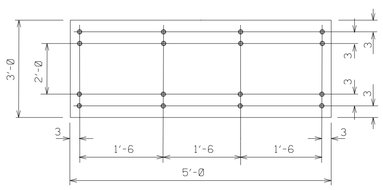
POLYCARBONATE #103

36"x⅛"x3'-0



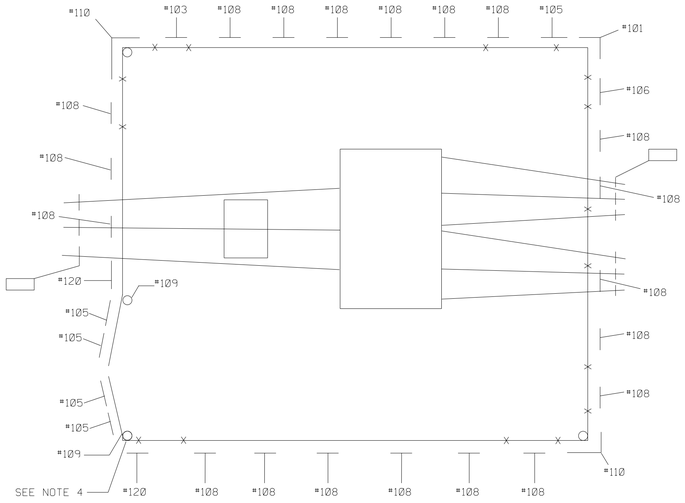
POLYCARBONATE #104

36"x⅛"x4'-0

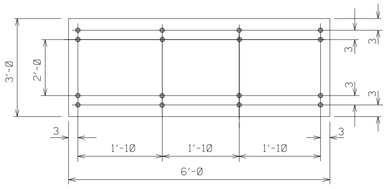


POLYCARBONATE #105

36"x⅛"x5'-0

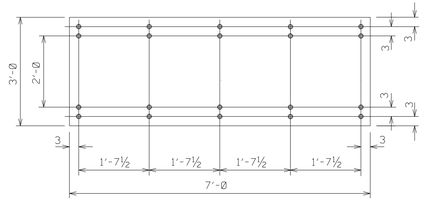


TYPICAL SUBSTATION FENCE LAYOUT



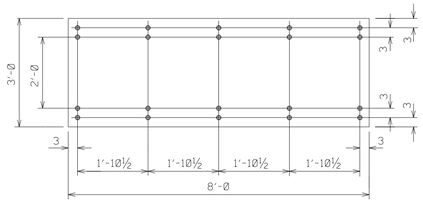
POLYCARBONATE #106

36"x⅛"x6'-0



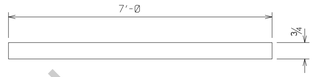
POLYCARBONATE #107

36"x⅛"x7'-0



POLYCARBONATE #108

36"x⅛"x8'-0

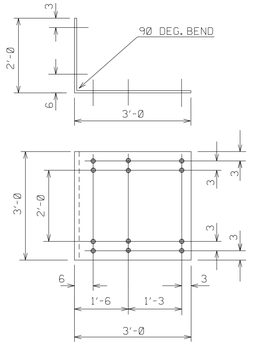


POLYCARBONATE #109

¾"x⅛"x7'-0

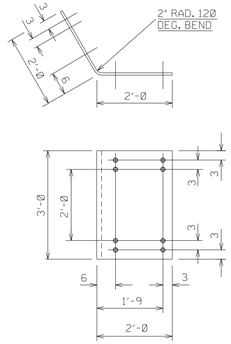
DESIGNER NOTE:
PLAN VIEW IS TYPICAL LAYOUT. ADJUST FENCE LAYOUT, GATES, STRUCTURES, POLYCARBONATE, LINES AND LINE BARRIERS PER JOB SPECIFIC REQUIREMENTS.

PIECE NO.	WIDTH IN.	LENGTH IN.	SQ. FT.	QUANTITY	SQ. FT. TOTAL
101	36	48	12		
102	36	24	6		
103	36	36	9		
104	36	48	12		
105	36	60	15		
106	36	72	18		
107	36	84	21		
108	36	96	24		
109	0.75	84	0.4375		
110	36	60	15		
111	36	48	12		
112	36	48	12		
113	36	48	12		
114					
115					
116	15	60	6.25		
117					
118					
119	36	48	12		
120	36	49	12.25		



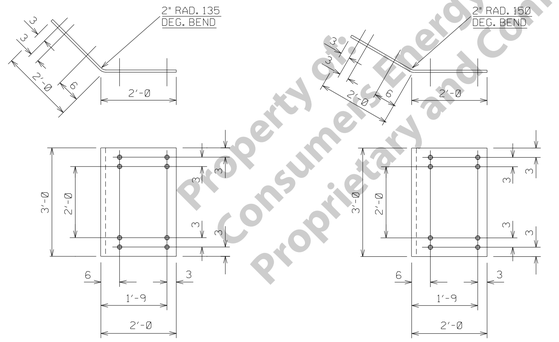
POLYCARBONATE #110

36"x⅛"x5'-0



POLYCARBONATE #111

36"x⅛"x4'-0

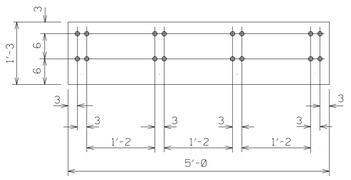


POLYCARBONATE #112

36"x⅛"x4'-0

POLYCARBONATE #113

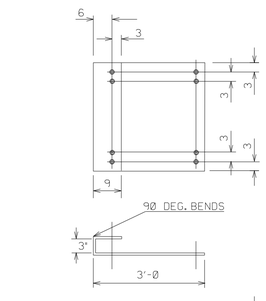
36"x⅛"x4'-0



POLYCARBONATE #116

15"x⅛"x5'-0

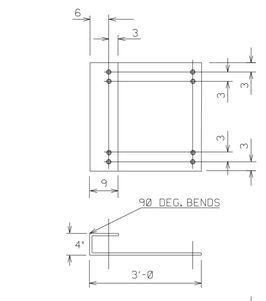
(USE AT CAPACITOR BANK GATE)



POLYCARBONATE #119

36"x⅛"x 4'-0

(USE AT EACH 3" GATE POST)



POLYCARBONATE #120

36"x⅛"x 4'-1

(USE AT EACH 4" GATE POST)

GENERAL NOTES

1. POLYCARBONATE PIECES (M02214) ARE TO BE OVERLAPPED 1" POLYCARBONATE HAS BEEN FURNISHED APPROX. ONE FOOT LONGER THAN THE GIVEN FENCE DIMENSIONS TO ALLOW FOR INACCURACIES. FIELD DRILL HOLES AS NEEDED.
2. ALL POLYCARBONATE TO FENCE TIES ARE TO BE MADE WITH #6 SINGLE STRAND, ALUMINUM WIRE (M02292 TO BE FURNISHED BY CONTRACTOR).
3. ALL HOLES TO BE 5/16" DIA UNLESS OTHERWISE SPECIFIED.
4. USE 1" POLYCARBONATE STRIP (#109) TO PLUG GAPS AT GATE POSTS, AT STRETCHER BARS OR ANY LOCATION GREATER THAN 1".
5. REFER TO DWG DSA 7022 SHEET 051, LATEST REVISION AND ASSEMBLY DETAILS IN ASSEMBLY SECTION OF SAM STANDARDS BOOK 6 FOR PROPER SIZE DISC BARRIER. CLAMPS AND INSTALLATION. INSTALL ON ALL LINES CROSSING SUB FENCE A MINIMUM OF 6 FEET OUTSIDE FENCE. REQUIRED ON 46KV AND BELOW LINES ONLY.
6. INSTALL SIGNS ON FENCE BEFORE INSTALLING POLYCARBONATE.

DRAWING NO.	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP
DSA7022 SH.051	LINE BARRIER DETAILS					
	FENCE AND ANIMAL BARRIER MISC DETAILS					

DR. / /
CK. / /
APP. SECTION HEAD / /
APP. DIVISION HEAD / /
APP. DEPARTMENT HEAD / /

Consumers Energy

POLYCARBONATE LAYOUT AND DETAILS ANIMAL BARRIERS

SUBSTATION

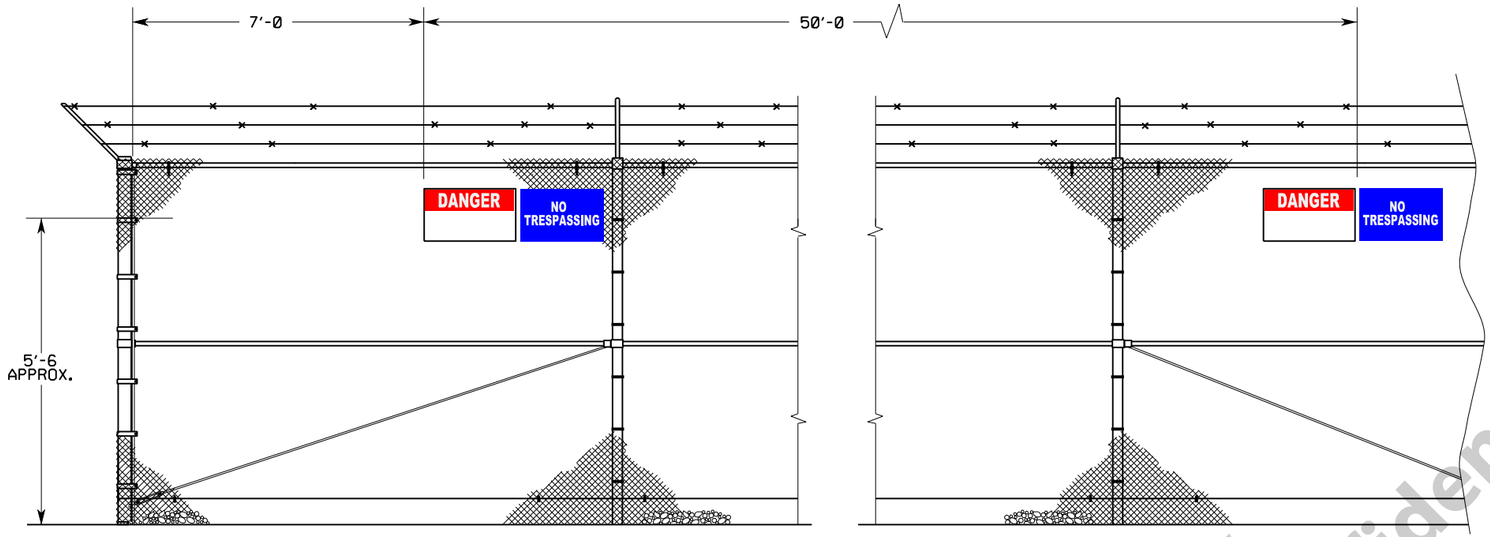
SCALE NONE | DRAWING NO. -F16 | SHEET 053 | REV.

JOB WO

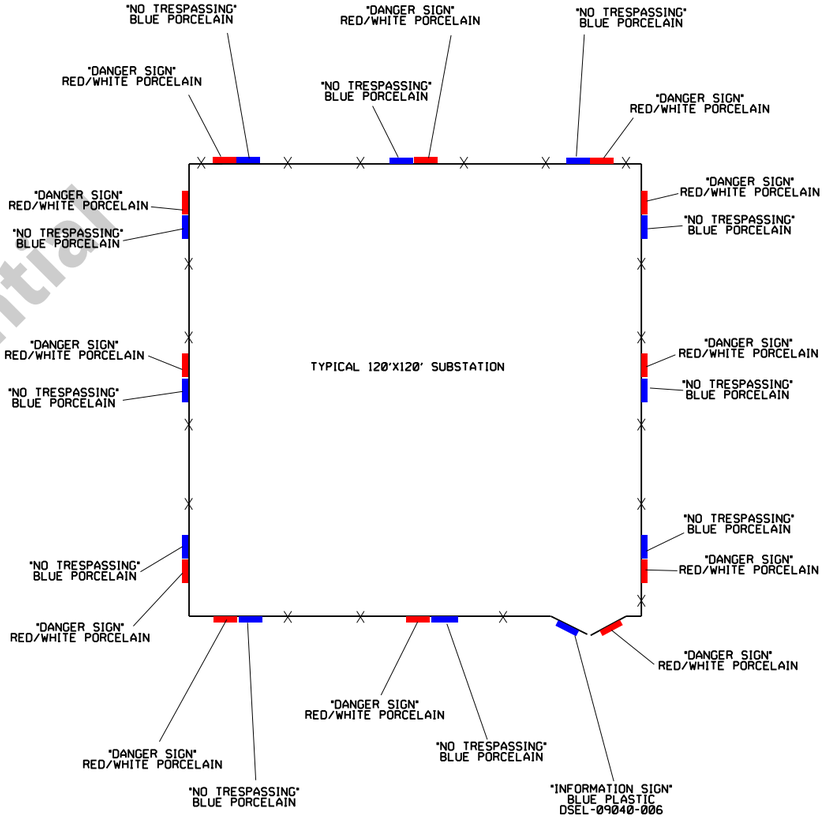
RS

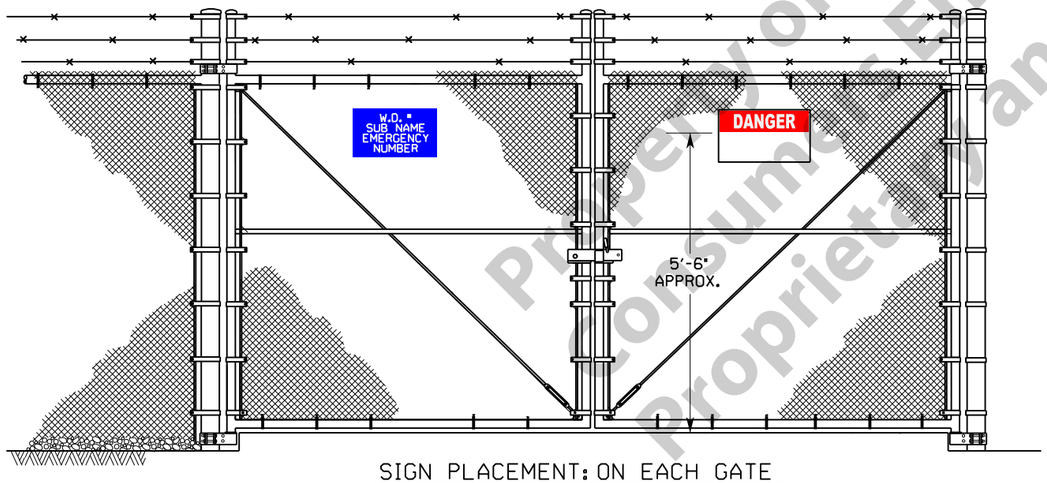
DSF7016-0053L

7016053



SIGN PLACEMENT: 7'-0 FROM CORNER & EVERY 50'-0 ON PERIMETER OF FENCE





SIGN PLACEMENT: ON EACH GATE

NOTES:

1. MOUNT SIGNS APPROX. 5'-6 ABOVE FINAL GRADE
2. SIGNS TO BE PLACED ON OUTSIDE OF FENCE AND UNDER POLYCARBONATE ANIMAL PROOFING, IF APPLIED.

DRAWING	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.

SECTION HEAD DATE
APP
DIVISION HEAD
APP
DEPARTMENT HEAD
APP

DR JA HYDEN 05/22/13 CK

Consumers Energy

TYPICAL SUBSTATION SIGN PLACEMENT ON FENCE & GATE

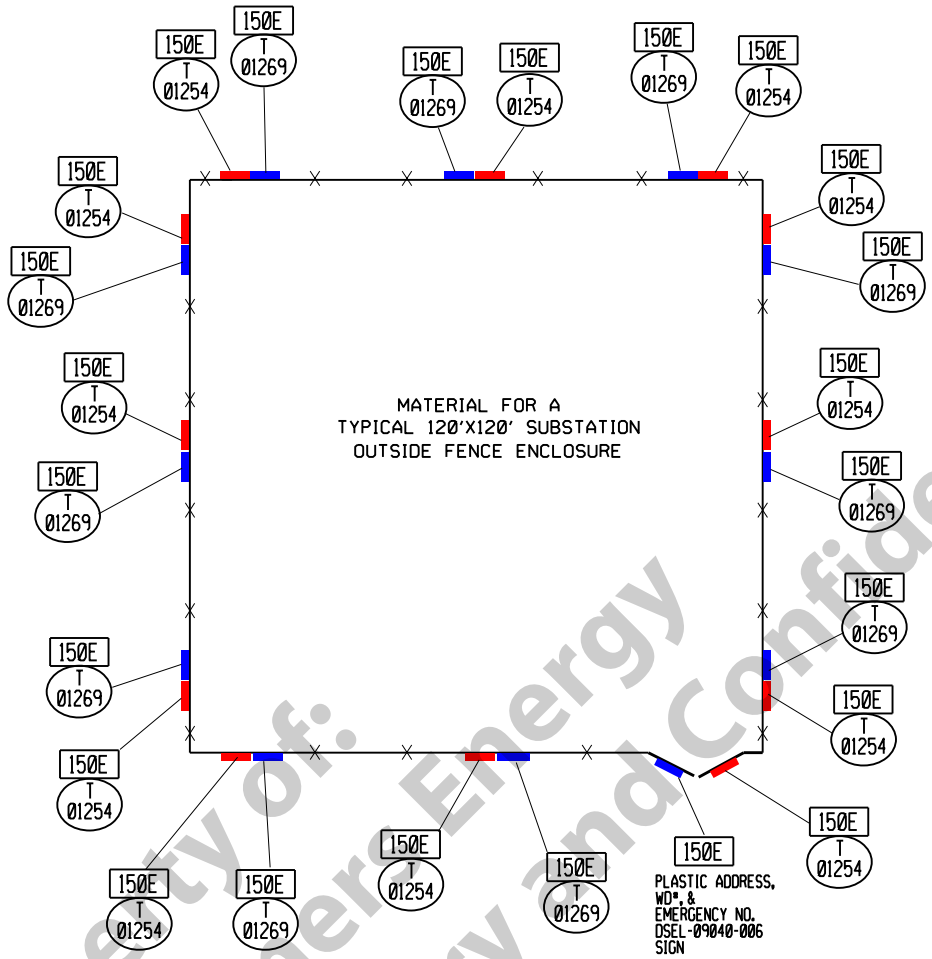
DWG. 09039 REV. E SHEET 140

SUBSTATION ASSEMBLY DETAILS

Consumers Energy

ASSEMBLY # E399B089 (MATERIAL FOR ONE UNIT ONLY)

COMP/ASSY	QTY	UNIT	DESCRIPTION	SAP NUM.
E399B150E	24		4-HOLE SIGN MTG TO FENCE	
T01254	12	EA	P/E SIGN "DANGER, HIGH VOLTAGE, KEEP OUT	10194072
T01269	11	EA	P/E SIGN "NO TRESPASSING, VIOLATORS..	10142569



= "DANGER SIGN" RED/WHITE PORCELAIN T01254
SIGNS REQUIRED TO BE WITHIN 7 FT. OF EACH CORNER AND AT A MAXIMUM OF 50' APART ON PERIMETER OF FENCE.

= "NO TRESPASSING" BLUE PORCELAIN T01269
SIGNS REQUIRED TO BE PLACED NEXT TO "DANGER" SIGN ON PERIMETER OF FENCE.

= "INFORMATION SIGN" BLUE PLASTIC DSEL-09040-006
SIGN REQUIRED ON EACH GATE.

NOTES:

1. MOUNT SIGNS APPROX. 5'-6 ABOVE FINAL GRADE
2. SIGNS TO BE PLACED ON OUTSIDE OF FENCE AND UNDER POLYCARBONATE ANIMAL PROFFING, IF APPLIED.

LEGEND: MATERIAL ASSEMBLY NUMBER

E | 39 | 9 | A | 013B

- CLASS: C: CONDUIT; E: ELECTRICAL; F: FOUNDATIONS; G: GROUNDING; S: STEEL
- CODE: 16: GRADING/DRAINAGE; 17: GROUNDING; 20: FOUND.; 21: STEEL; 22: GRATING; 26: 345KV; 27: 138KV; 28: 46KV; 29: ELEC.DET.(ALL VOL.); 30: 15KV; 31: CONDUIT BOXES; 32: CONDUIT; 34: CONTROL HOUSES; 39: SIGNS (STOCK); 40: SIGNS (NON-STOCK)
- VOLTAGE: 0: NOT VOL. DEPENDANT; 2: 15KV; 3:24.9KV; 4: NOT USED; 5: 46KV; 6: 138KV; 7: 345KV; 9: ALL
- TYPE (39): A: VPF PIECES; B: VPF PIECES & ASSEMBLYS
- DETAIL: DETAIL NO.

39 STOCK STATION SIGN DETAILS

(MATERIAL)# E399B089

ICON# 6486

J	06/15/15	REVISED SIZE OF TYPICAL SUBSTATION OUTSIDE FENCE. AND ADDED EXTRA SIGNS TO B/M	JAH	DR. JA HYDEN 07/15/97
I	06/24/14	REVISED ORANGE WARNING SIGN TO RED/WHT. DANGER SIGN	JAH	OUTSIDE FENCE TYPICAL SUBSTATION SIGN PLACEMENT
H	10/02/13	REVISED BLACK ADDRESS SIGN FROM BLACK TO BLUE	JAH	
G	04/15/13	REVISED B/M	JAH	

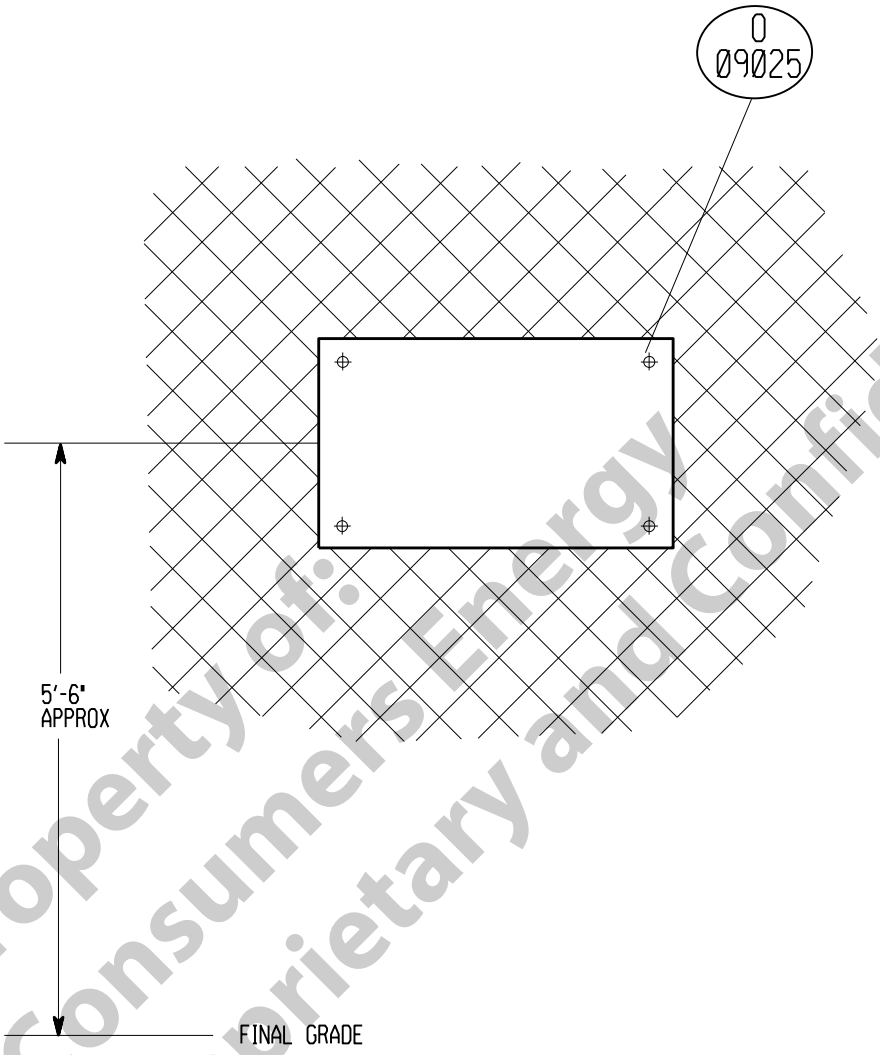
E399B089 | DGN | SHT | ASSY ICON NO. 6486 | REV. J

SUBSTATION ASSEMBLY DETAILS

Consumers Energy

ASSEMBLY # E399B150E (MATERIAL FOR ONE UNIT ONLY)

COMP/ASSY	QTY	UNIT	DESCRIPTION	SAP NUM.
009025	2	EA	FENCE BRACKET KIT	10194680



LEGEND: MATERIAL ASSEMBLY NUMBER

E 39 9 A 013B

CLASS	CODE	VOLTAGE	TYPE (39)	DETAIL
C: CONDUIT E: ELECTRICAL F: FOUNDATIONS G: GROUNDING S: STEEL	16: GRADING/DRAINAGE 17: GROUNDING 20: FOUND. 21: STEEL 22: GRATING 26: 345KV 27: 138KV 28: 46KV 29: ELEC.DET.(ALL VOL.) 30: 15KV 31: CONDUIT BOXES 32: CONDUIT 34: CONTROL HOUSES 39: SIGNS (STOCK) 40: SIGNS (NON-STOCK)	0: NOT VOL. DEPENDANT 2: 15KV 3: 24.9KV 4: NOT USED 5: 46KV 6: 138KV 7: 345KV 9: ALL	A: VPF PIECES B: VPF PIECES & ASSEMBLYS	DETAIL NO.

39 STOCK STATION SIGN DETAILS

(MATERIAL)# **E399B150E**

ICON# **5504**

G	10/07/14	REPLACED MTG. DET. #010A WITH ITEM 009025	JAH	DR. JA HYDEN 09/09/96
F	05/29/13	REVISED TITLE	JAH	FENCES & BARRIERS MTG. MATERIAL FOR 4 HOLE SIGN
E	12/05/11	REMOVED "T01278 & T01269" FROM B/M	JAH	
D	09/25/09	REPLACED DETAIL #1504B WITH 150E	JAH	

E399B150E | DGN | SHT | ASSY ICON NO. 5504 | REV. G

Solar Technical Specification

SP-001

Revision 2022.1

Exhibit A Appendix H – Lead Acid Battery Standards

Executed Date

SPECIFICATION NO SB-5

FOR

LEAD-ACID STORAGE BATTERIES

FOR SUBSTATIONS

Prepared By: F M Huguet Date 12/15/05

Approved By: J H Sosinski Date

TABLE OF CONTENTS

1.0 SCOPE

This specification covers the manufacture, furnishing and delivery of lead-acid storage batteries utilizing lead-antimony, or lead-selenium, type plate construction for use in Consumers Energy's electric substations. Lead-acid batteries of lead-calcium plate construction lie outside the scope of this specification. A battery for the purposes of this specification consists of 12, 24 or 60 individual cells which, when connected in series, will supply a nominal dc voltage of 24V, 48V or 125V.

2.0 APPLICATION

Lead-acid storage batteries will supply the substation dc load. The batteries will normally be floated at 2.20 volts per cell. They will be given an equalizing charge at 2.33 volts per cell for approximately 48 hours quarterly.

3.0 REFERENCE SPECIFICATIONS

Materials and work shall be designed and fabricated in accordance with the practices and standards of the latest revisions of ANSI C18.1 - 1986, IEEE 484-2002, and NEMA IB 1-1982 and IB 2-1987 in the order listed, except as otherwise specified herein.

4.1 REQUIREMENTS

4.2 The battery will be sized according to the latest revision of IEEE Standard 485 (R 2003). If the battery is to be sized by the supplier, the load cycle, lowest expected operating temperature and the desired design margin and aging factor shall be given in a supplement to this specification. The battery size shall be corrected for temperature so that the voltage on discharge does not drop below 1.75 volts per cell during any part of the load cycle with the battery charger disconnected. If the battery is sized by Consumers Energy, the manufacturer's type, the catalog number and the ampere-hour rating shall be specified on the inquiry accompanying this specification.

4.3 The batteries shall be the flat pasted plate, lead-acid type with lead antimony, or lead-selenium, type grids, assembled in clear, heat and shock resistant plastic containers with leakproof covers and seals, and shall have high- and low-electrolyte level lines marked on all four sides of each container. Individual containers may contain two or more series connected cells.

4.4 The edges of the plates shall be visible to permit visual inspection of the plates for warping or cracking. The build-up of sediment in the bottom of the container must be visible.

4.5 Each battery shall have provisions for measuring individual cell voltages and individual cell specific gravity.

4.6 The individual cell voltage of a newly delivered and assembled battery shall be 2.33 ± 0.03 volts when measured with the freshening charge applied. The freshening charge voltage is equal to the number of cells times 2.33 volts.

4.7 The nominal specific gravity shall be as defined below when corrected to 25°C with the cells fully charged and the electrolyte level is at the high-level mark. The spread of individual cell specific gravities for a newly delivered battery following assembly and freshening charge shall not exceed 10 points (0.010).

Lead-Antimony	Lead-Selenium
1.210-1.215	1.240-1.245

4.8 The manufacturer's standard battery rack shall be supplied when requested. Racks are to be factory prepainted with a primer and two acid resistant topcoats. Metal racks have rubber, plastic or wooden insulating material provided to prevent contact between the cells and the metal. The rack shall be furnished complete with all necessary bolts, nuts, washers, lock washers and assembly instructions required for field assembly. Two-tier racks shall meet the following requirements for battery maintenance purposes:

a. 18-inch minimum measured from the cover of the batteries in the lower row to the bottom of the upper row rails.

b. 60-inch maximum measured from the floor to the cover of the batteries in the upper row.

Two-step rack shall be dimensioned so as to expose the upper one-half of the back row cells.

When two adjacent racks are required because of battery size or because of space limitations, the purchaser shall specify back-to-back or end-to-end installation on the purchase order.

Three-step/Three-tier racks are not acceptable.

4.9 If the battery being purchased is to be installed in an existing rack, the rack dimensions shall be supplied by the purchaser on the purchase order or specification supplement. If the existing rack is not suitable, the manufacturer shall notify the purchaser and include data and cost of a suitable rack at the time of the inquiry.

4.10 Each battery shall be identified with month and year of manufacture; in an understandable fashion (i.e., no special manufacturer codes). Decoding of this information shall not be required.

5.1 ACCESSORIES

Each battery shall be supplied with necessary accessories including, but not limited to, the following:

- Lead-Plated Copper Intercell Connector Straps and Terminal Plates.
- Stainless Steel Standard English Measure Hex-Head Connector Bolts.
- All Inter-Step, Inter-Tier and Inter-Rack Connectors Necessary for Installation on the Battery Rack Arrangement Specified in Paragraphs 4.7 and 4.8 Above.
- Hydrometer and Hydrometer Holder, if Specified.
- Thermometer
- Flame Arresters
- No OX-ID Grease
- Lifting Sling and Spreader Block When Required for Handling Large Cells.
- Plastic Cell Numbers

6.1 SHIPPING

6.2 MARKINGS

The shipment should be clearly marked as follows:

6.2.1 Consumers Power Company's project and location.

6.2.2 Consumers Power Company's purchase order number.

6.2.3 Consumers Power Company's item number.

6.2.4 Supplier's order number.

6.3 BATTERY

Battery containers shall be individually packaged in suitable cardboard boxes, banded onto one or more pallets.

6.4 RACKS

Racks, if supplied, shall be shipped unassembled, with all necessary bolts, nuts, washers, lock washers and assembly instructions required for field assembly.

7.0 INSPECTION

The manufacturer shall be responsible for making the necessary inspection to determine if the battery conforms to the provisions of these specifications. In addition, the purchaser and/or a representative of the purchaser's inspection agency will inspect and accept or reject the batteries at either the manufacturer's plant or the point of delivery. Inspection by the purchaser and/or representative of the purchaser's inspection agency or the waiving of inspection shall not relieve the supplier from obligation to furnish batteries in accordance with these specifications.

8.1 REQUIRED DOCUMENTS

All drawings to be sent as specified on the purchase order.

8.2 FINAL DRAWINGS

One set of certified prints of the following drawings and one set of electronic drawing files, shall be sent as specified in the purchase order. The drawings shall include a transmittal letter that references the purchase order and project name.

8.2.1 Outline Drawings

8.2.2 Detail Wiring Diagrams

8.2.3 Schematic Diagrams

8.2.4 Drilling Layouts

8.2.5 Instruction Books

8.3 INSTALLATION DRAWINGS

All necessary drawings and instructions for field assembly, installation and maintenance of the battery shall be shipped with the battery.

8.4 [redacted]

8.4.1 [redacted]

[redacted]

8.4.1.1 [redacted]

[redacted]

9.0 WARRANTY

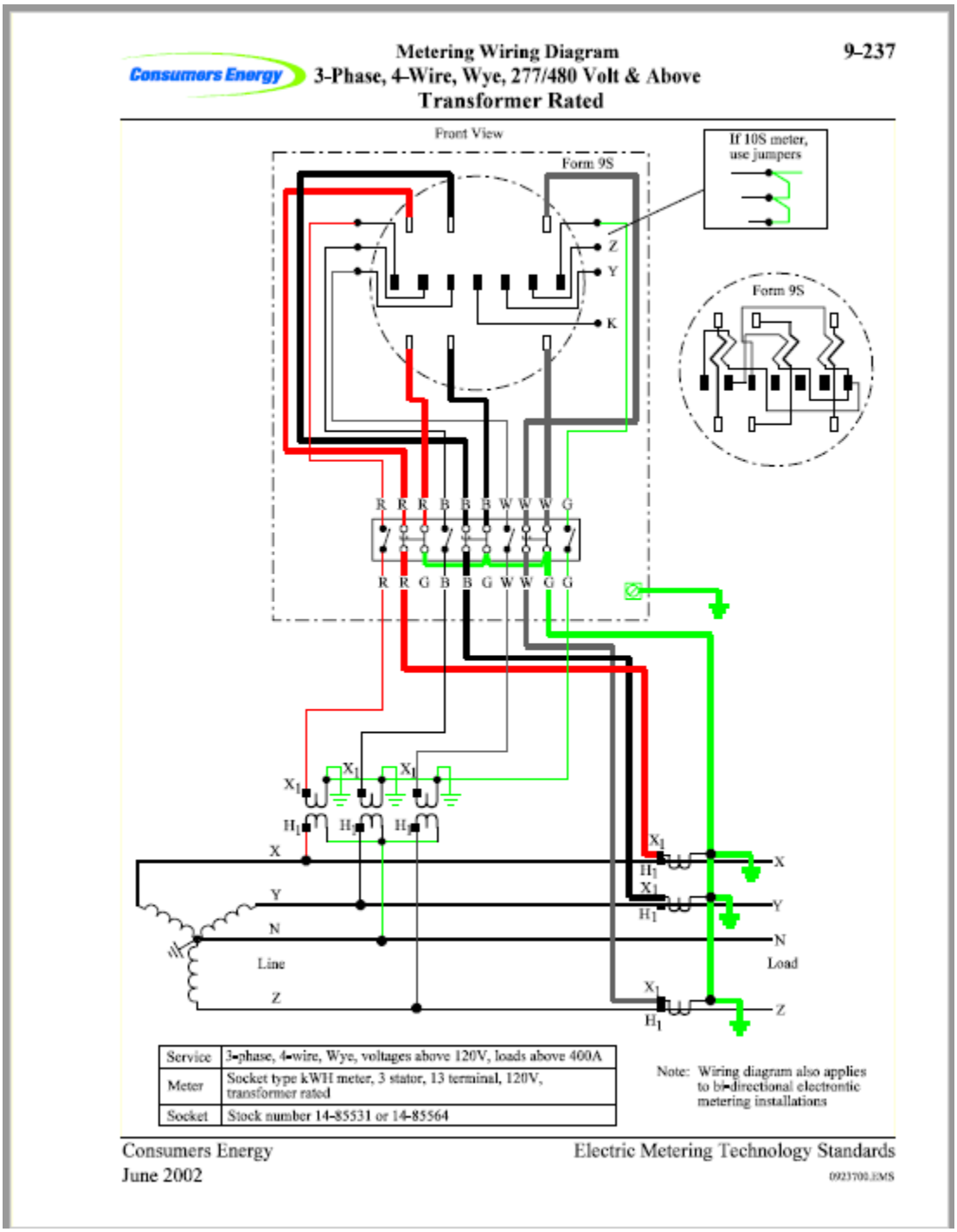
Manufacturer shall provide a warranty for fifteen (15) years from the date of commissioning. Warranty terms shall provide for full free replacement guarantee for the first three (3) years of service, against defective materials and workmanship or if the battery fails to deliver its rated capacity.

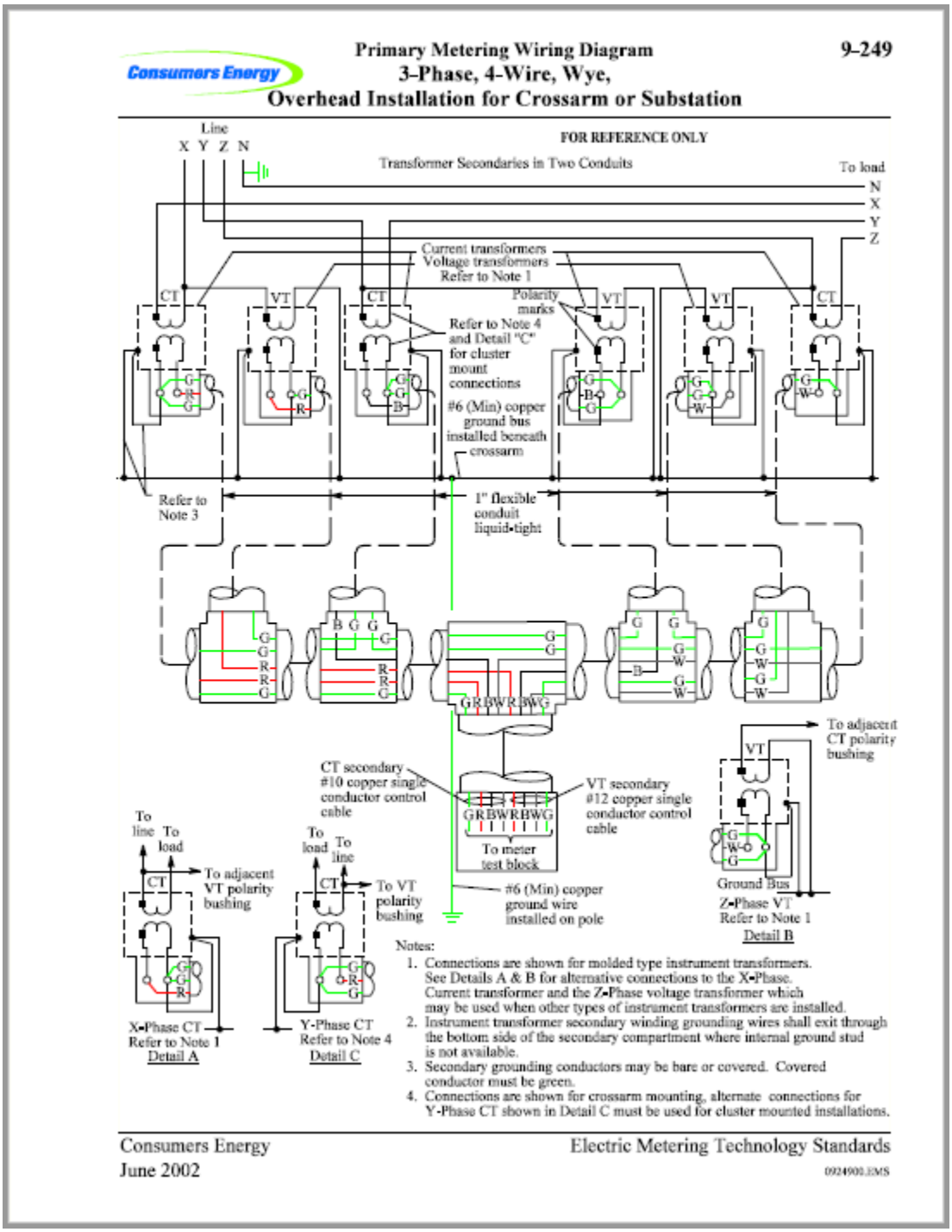
Build Transfer Scope of Work

SP-001
Revision 2022.1

Exhibit A – Appendix J – Standard Metering Details

Executed Date


Consumers Energy
Metering Wiring Diagram
3-Phase, 4-Wire, Wye, 277/480 Volt & Above
Transformer Rated
9-237
Front View
Form 9S
If 10S meter, use jumpers
Z
Y
K
Form 9S
R R R B B B W W W G
R R G B B G W W G G
X1
H1
X
Y
N
Line
Z
Load
Service
3-phase, 4-wire, Wye, voltages above 120V, loads above 400A
Meter
Socket type kWH meter, 3 stator, 13 terminal, 120V, transformer rated
Socket
Stock number 14-85531 or 14-85564
Note: Wiring diagram also applies to bi-directional electronic metering installations
Consumers Energy
June 2002
Electric Metering Technology Standards
0923700.EMS


Consumers Energy
Primary Metering Wiring Diagram
3-Phase, 4-Wire, Wye,
Overhead Installation for Crossarm or Substation
9-249
FOR REFERENCE ONLY
Transformer Secondaries in Two Conduits
Line
X Y Z N
To load
N
X
Y
Z
Current transformers
Voltage transformers
Refer to Note 1
CT
VT
Polarity marks
Refer to Note 4 and Detail "C" for cluster mount connections
#6 (Min) copper ground bus installed beneath crossarm
Refer to Note 3
1" flexible conduit liquid-tight
GRBWRBWG
CT secondary #10 copper single conductor control cable
VT secondary #12 copper single conductor control cable
To meter test block
#6 (Min) copper ground wire installed on pole
To adjacent CT polarity bushing
Ground Bus
Z-Phase VT
Refer to Note 1
Detail B
To line
To load
To adjacent VT polarity bushing
X-Phase CT
Refer to Note 1
Detail A
To VT polarity bushing
Y-Phase CT
Refer to Note 4
Detail C
Notes:
1. Connections are shown for molded type instrument transformers. See Details A & B for alternative connections to the X-Phase. Current transformer and the Z-Phase voltage transformer which may be used when other types of instrument transformers are installed.
2. Instrument transformer secondary winding grounding wires shall exit through the bottom side of the secondary compartment where internal ground stud is not available.
3. Secondary grounding conductors may be bare or covered. Covered conductor must be green.
4. Connections are shown for crossarm mounting, alternate connections for Y-Phase CT shown in Detail C must be used for cluster mounted installations.
Consumers Energy
June 2002
Electric Metering Technology Standards
0924901.EMS

Consumers Energy

ITR Meter Sockets

Large 15 Terminal **Stock Number 14-85564 / 10029639**

(back to index)

Description:

Instrument Transformer Rated meter socket; 15 terminal; two piece ringless cover; side wire-way with right-hand offset meter position; approved unplated 10 pole test switch installed; bonding lug; solid top; two 1" knock-outs on the bottom and one on the lower back; G-90 painted steel; stainless steel rotary latch and rivet; minimum cabinet dimensions: 20" x 34" x 8"; with 18" x 18" x ¾" treated plywood mounted 3" up from the bottom.

		Dimensions		
Approved Vendor	**Catalog Number**	**W**	**H**	**D**
Durham	1006774B	34"	20"	8"
Meter Devices				
Milbank	SC4233-O-TS100110-CE			

Intended Uses:

For Instrument Transformer Rated metering where a large socket is needed for additional equipment.

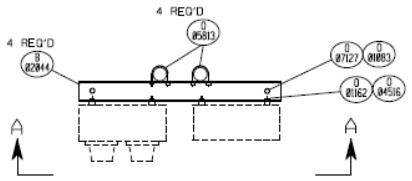
Notes:

VT's can be mounted inside socket if necessary.

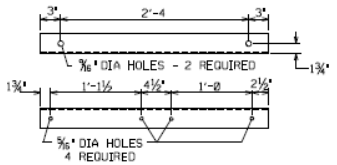
ABCD

ASSEMBLY # C322M712 (MATERIAL FOR ONE UNIT ONLY)

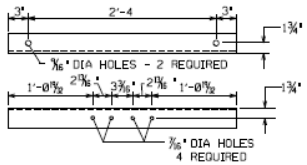
PIECE/ASSY	QTY	UNIT	DESCRIPTION	SAP Num.
B02044	12	FT	BUS ANGLE 3-1/4" AL	10022480
B07064	2	EA	CLAMP GROUND BRZ 2" IPS	10024343
C01032	1	EA	BEND COND GAL 2" 90D 18"R	10028229
C01343	2	EA	CAP CONDUIT 2" THD	10028429
C01370	20	FT	CONDUIT GALV 2" 10'L	10028616
C01385	3	EA	CPLG COND 2" GALV THD	10028792
C05010	5	FT	CONDUIT FLEX 2" GRAY	10028585
C05207	1	EA	CONN INS STRAIGHT 2"	10034312
C05405	1	EA	CONN INS 2" CONDUIT BOX	10028716
J07000	2	EA	POST GUARD 4"OD 7'L STEEL	10096388
M03016	1	YD3	CONCRETE, READY MIX 2000#	10140541
Q01083	4	EA	BOLT TWR GAL 1/2X1-1/2	10013614
Q01162	8	EA	BOLT MA GAL 1/4X1" SQ	10013905
Q04516	8	EA	WASHER LOCK BR 5/16"	10017620
Q05813	4	EA	U-BOLT GALV 2"PIPE 200SG	10014348
Q07127	4	EA	WASHER FLAT GAL 1/2" RD	10017671



PLAN



DETAIL "A"
3¼"X3¼"X¼"X2'-10" ALUM ANGLE
2 REQUIRED
FIELD DRILL



DETAIL "B"
3¼"X3¼"X¼"X2'-10" ALUM ANGLE
2 REQUIRED
FIELD DRILL

LEGEND\GENERAL NOTES:

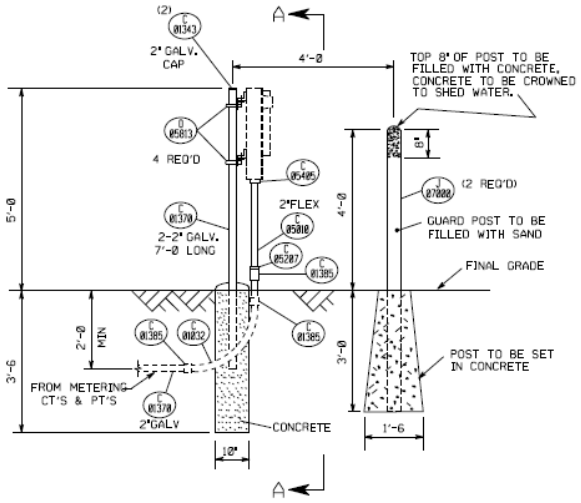
= BILL OF MATERIAL ITEM

= B/M ITEMS NOT PART OF THIS UNIT

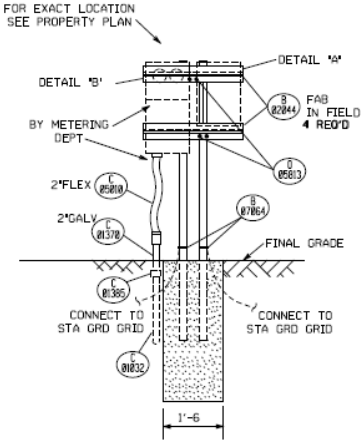
= SEE ELECTRICAL ASSEMBLY DETAIL PACKAGE OR BLUE BOOK

= DETAIL NOT PART OF THIS UNIT

1. ALL CONDUIT CONNECTIONS TO CONDUIT BOXES OR OTHER EQUIPMENT SHALL HAVE THE THREADED PART WRAPPED WITH TEFLON TAPE. (C06848)
2. INSTALL SMALLER CONDUIT INSIDE OF LARGER CONDUIT. END SMALLER CONDUIT 6" BELOW BOTTOM OF BOX. REMOVE ALL BURRS FROM CONDUIT ENDS.
3. GRIND SIGN MOUNTING SCREWS FLUSH WITH BACK OF COVER AFTER ASSEMBLY.
4. COAT BURIED GALVANIZED CONDUIT WITH BITUMINOUS COMPOUND. (M05520)
5. SEAL ALL CONDUITS INTO BOX WITH DUXSEAL (B09088) AFTER CABLES ARE INSTALLED.
6. SOME FIELD FABRICATION AND/OR MINOR MATERIALS MAY BE REQUIRED TO COMPLETE INSTALLATIONS AS SHOWN.



ELEVATION



SECTION A-A

NOTE:
1. CONFORMS TO ELECTRIC METERING STANDARD 8-418
2. CONTRACTOR SHALL PICK-UP METER BASE AT METER SERVICES AND MOUNT IT ON THE PEDESTAL.

C322M712

6363

REV	DATE	DESCRIPTION	BY	APP

DATE
DR. / /
CK. / /
SECTION HEAD
APP. / /
DIVISION HEAD
APP. / /
DEPARTMENT HEAD
APP. / /

Consumers Energy

GROUNDING & CONTROL CONDUIT DETAIL DETAIL #712

McINERNEY SUBSTATION

SCALE NONE | DRAWING NO. Ø948-E32 | SHEET 2 | REV.

JOB WO 33435109

ASSY MATERIAL NO. C322M712 | ASSY ICON NO. 6363 | REV. E

RS# 65388 | DRWG | SHT

E RMS 11-12-08

Solar Technical Specification

SP-001
Revision 2022.1

Exhibit A Appendix K – PV Plant Capacity Test Requirements

Executed Date

Table of Contents

1.0 Purpose

This purpose of the Capacity Test is to verify the as-built Project capacity. This document establishes the references, standards and procedures to be used to calculate the Project capacity. The PV Plant Capacity Test follows a modified version of the ASTM-E2848-13 Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance.

The results of this test will determine if the Project has successfully met the capacity requirements of the design.

2.0 Reference Standards

2.1 ASTM E2848-13, 2018 – Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance

2.2 ASTM E2939-13, 2018 – Standard Practice for Determining Reporting Conditions and Expected Capacity for Photovoltaic Non-Concentrator Systems

2.3 NREL – Suggested Modification for Bifacial Capacity Testing

2.4 Sandia SAND2004-3535 – Photovoltaic Array Performance Model

2.5 IEC 61853-1 – Photovoltaic Module Performance Testing and Energy Rating

2.6 IEC 61724-2 - Photovoltaic system performance - Part 2: Capacity evaluation method

3.0 Definitions

3.1 Auxiliary Parameters – A parameter used for verifying the operating condition of the Project. This includes parameters such as inverter operating status, DC voltage and inverter AC power.

3.2 Capacity Test – A short term test for the entire Project meeting the requirements of this document to verify the Project is fully commissioned and producing energy as per design.

3.3 Data Record – A set of measurements representing aggregate values during a defined time interval.

3.4 Expected Capacity – Power output expected to be generated by the Project when exposed to Reporting Conditions

3.5 Guaranteed Capacity – Shall mean ninety-eight percent (98.0%) of Expected Capacity.

3.6 Input Parameter - Effective value used as input to the performance regression

3.7 Minimum Guaranteed Capacity – Shall mean ninety-six percent (96.0%) of Expected Capacity

3.8 Measured Capacity – Power output measured by the Project during the PV Plant Capacity Test Measurement Period

3.9 Measured Capacity Ratio – The Measured Capacity divided by the Target Capacity rounded to the nearest 0.1%

3.10 Project Model – The PVSyst model and post-processing calculations/models.

3.11 PV Plant Capacity Test Measurement Period – A period of at least five (5) consecutive days during which the minimum irradiance requirement has been satisfied and over which data will be evaluated to establish whether the Project has met the requirements of the Capacity Test.

3.12 Reporting Conditions – A defined set of measurements of the plane-of-array irradiance, ambient temperature, wind speed and PV module temperature. One Reporting Condition is defined for each month of the year.

3.13 Revenue Meter – A revenue grade meter, as agreed to by all parties, located at the Point of Interconnection.

4.0 Pre-Test Activities

4.1 PV Plant Capacity Test Plan

4.1.1 No less than 45 Business Days prior to the first day of the scheduled Capacity Test, a draft Capacity Test Procedure shall be submitted to the Buyer for review and comment. The Buyer shall return any comments or approvals as noted in Exhibit A1 – Submittal Requirements. The Seller shall incorporate comments and resubmit the Capacity Test Procedure for Buyer's review and approval.

4.1.2 The PV Plant Capacity Test Plan shall include the following minimum information:

4.1.2.1 This test procedure.

4.1.2.2 The as-built Project Model including all PVSyst native files (PAN, OND, SHD, MET, PRJ, VC).

4.1.2.2.1 For the purposes of this test the following modifications shall be made to the Project Model:

4.1.2.2.1.1 Soiling/snow loss shall be set to zero percent (0%).

4.1.2.2.1.2 Availability shall be set to one hundred percent (100%).

4.1.2.3 Identification of all parties involved.

4.1.2.4 The estimated starting and ending dates of the PV Plant Capacity Test Measurement Period.

4.1.2.5 Project parameters including, at a minimum, manufacturer/model/quantity of PV Modules, array orientation, location, racking type, tracker range of motion, manufacturer/model/quantity of inverters.

4.1.2.6 Identification of all sensors and transducers to be used including cut sheets, calibration certificates and records, map locating sensors with sufficient detail to locate.

4.1.2.7 Identification of the SCADA System data channels and calibration parameters for each data channel.

4.1.2.8 Identification of the sensors intended for Redundant Measurement.

4.1.2.9 Identification of multiple measurement formulas and weighting factors.

4.1.2.10 Identification of known times or areas of data quality concerns.

4.1.2.11 Time stamp convention and data logging averaging method and interval.

4.1.2.12 Expected Capacity calculations as described in Section 7.0 and monthly Reporting Conditions.

4.2 Written notification must be made to the Buyer five (5) business days before starting the PV Plant Capacity Test.

4.3 No less than two (2) business days prior to commencement of the PV Plant Capacity Test, a pre-test meeting shall be held. The meeting shall review the PV Plant Capacity Test Plan, instrumentation locations, calibration sheets, safety requirements and other relevant topics. Meeting minutes shall be recorded and published by the Seller.

5.0 Data Sets and Instrumentation

5.1 Data Quality and Instrumentation Requirements

5.1.1 Data quality shall be identified as one item from a set of quality categories for each Data Record analyzed. Only data where all Input Parameters are valid and within the specified limits shall be used for computing capacity estimates

5.1.2 Recorded data shall be sampled at no greater than at five (5) second intervals and averaged at no greater than five (5) minute intervals. Data shall be averaged and filtered based on requirements within this Capacity Test Requirements.

5.1.3 The PV Plant Capacity Test Measurement Period shall be no less than five (5) consecutive days and contain at a minimum 150 valid data points after filtering. The PV Plant Capacity Test Measurement Period shall be extended for consecutive days until the minimum irradiance requirement and the minimum number of valid data points can be met.

5.1.4 Sensor Requirements

5.1.4.1 Irradiance sensors shall be, at a minimum, ISO 9060 Secondary Standard rated pyranometers. Pyranometers shall include device specific characterization data that shall, at a minimum, include cosine and temperature response.

5.1.4.2 Pyranometers shall only be used within their valid calibration period and shall be cleared at the start of the Capacity Test of any debris or soiling and daily during the PV Plant Capacity Test Measurement Period. Calibration shall have certificates from the National Institute of Standards and Technology (NIST) or equivalent.

5.1.4.3 Sensors shall have the following minimum range and accuracy:

Table 1 – Instrument Ranges and Accuracy

Measurement	Instrument Type	Range	Accuracy
Plane of Array Irradiance	Front & Rear Pyranometer	0 to 1600 W/m2 285 to 2800 nm	±1.8%
Global Horizontal Irradiance	Pyranometer	0 to 1600 W/m2 285 to 2800 nm	±1.8%
Ambient Air Temperature	Temperature Probe	-40°C to +60°C	±1°C
Back of Module Temperature	Temperature Probe	-40°C to +120°C	±0.5°C
Wind Speed	Sonic Wind Sensor	0 – 60 m/s	±5%
PV Plant Power	PV Power Revenue Meter	0 to PV Power Plant size +20%	ANSI C-12.20
Inverter Power	Inverter Internal Meter	Inverter Specific	Inverter Specific

5.1.5 Input Parameters – The following inputs are required for completing the PV Plant Capacity Test

5.1.5.1 Plane-of-Array (POA) Irradiance: An estimate of the average irradiance incident upon each PV array in the Project. Provisions for addressing multiple orientations and geographic diversity are identified through multiple measurements from Multiple Measurement Sets. No provision is allowed for shading. Any significant shading shall be excluded from the Data Record.

5.1.5.2 Ambient Temperature: This is the ambient temperature for the location of the Project.

5.1.5.3 Back of Module Temperature: This is characteristic of the operating temperature at which the PV Module is producing power which effects PV Module efficiency.

5.1.5.4 Revenue Meter Energy: Energy generation is the sum of actual power output from the Project as recorded by the Revenue Meter during the PV Plant Capacity Test Measurement Period.

5.1.5.5 Inverter-Level Energy: AC output data for each inverter shall be provided to identify periods of inverter clipping.

5.1.5.6 Wind Speed: Wind velocity.

5.1.6 Sensor Redundancy – A Redundant Measurement dataset shall consist of sensors located sufficiently close to each other such that recorded data is expected to be in agreement

5.1.7 Multiple Measurements – Multiple measurements from Multiple Measurement Sets shall be recorded for all environmental data throughout the Project Site in order to capture operating conditions for all regions. All measurements , whether from a single sensor or a Redundant Measurement Set identified as part of a Multiple Measurement Set must be valid for the Data Record to be included for calculations

5.1.7.1 POA Irradiance – One sensor shall be installed for each orientation within the Project Site (within +-2 degrees) for up to twenty (20) MWp. Multiple orientations and large arrays shall require multiple measurements from Multiple Measurement Sets.

5.1.7.2 Bifacial Plane of Array (BPOA) irradiance - One sensor shall be installed for each orientation within the Project Site (within ±2 degrees) for up to twenty (20) MWp. Multiple orientations and large arrays shall require multiple measurements from Multiple Measurement Sets.

5.1.7.3 Total Plane of Array (TPOA) Irradiance – Calculated based on POA and BPOA

5.1.7.4 Back of Module Temperature – A minimum of three (3) temperature sensors shall be installed for every twenty (20) MWp of array

5.1.7.5 Ambient Temperature – One sensor shall be installed for every twenty (20) MWp.

5.1.7.6 Wind Speed – One wind speed sensor shall be installed for every twenty (20) MWp.

5.1.8 Multiple Measurement datasets will be aggregated, and a weighted average shall be calculated. Averaging of multiple quality checked sensors is required.

5.2 Primary Data Exclusions

5.2.1 All data shall be reviewed and filtered as noted in ASTM 2848. Primary data exclusions shall include:

5.2.1.1 Missing Data (ASTM E2848-9.1.4). Missing data shall be marked with a non-numeric value. Missing data shall not be included in the analysis but shall be documented

5.2.1.2 Data Acquisition System Equipment Malfunction (ASTM E2848-9.1.5). Data Records with invalid Input Parameters shall also be marked as invalid.

5.2.1.3 Below Minimum Irradiance - Prior to the application of the ASTM E2848 9.1.6 irradiance requirements, a minimum irradiance filter must be applied. Any plane of array irradiance measurements below the minimum irradiance threshold (400 W/m2) must be marked as too low and excluded from the analysis.

5.2.1.4 Unstable Irradiance (ASTM E2848-9.1.7) - For each of the irradiance sensors used in computing the irradiance Input Parameter, calculate the mean and standard deviation of all 5-second interval measurements to

be averaged into a 5-minute interval record. If any of the standard deviations of samples within the aggregation interval exceed the specifications of ASTM E2848-9.1.7.2 of the corresponding irradiance mean value for that aggregation interval, then the record shall be marked as unstable. Any record for which any of the standard deviations of samples for irradiance is missing shall be marked as indeterminate stability, unless Buyer agrees not to mark it. The visual technique option of ASTM E2848-9.1.7.2 may be used.

5.2.1.5 Inverter not peak power tracking (ASTM E2848-9.1.8). The PV Plant Capacity Test Plan shall indicate how marking Data Records for this condition will be determined.

5.2.1.6 Internal and External array shading (ASTM E2848-9.1.9). A schedule of expected shade periods shall be defined in the PV Plant Capacity Test Plan. Environmental shading, such as snow, shall be noted by onsite observers and documented.

5.2.1.7 Radiometer not coplanar with system under test (ASTM E2848-9.1.10): For a fixed array, this condition disqualifies all data acquired while the condition exists. For a tracking array, this condition may occur intermittently so the Project Performance Test portion of the Commissioning Plan shall identify Auxiliary Parameters (e.g., measured and commanded tracker position) and algorithms for confirming tracking position. Any record interval during.

5.2.1.8 Wind Speed – Any intervals in which the average wind speed is greater than 15m/s will be excluded from the dataset.

5.3 Secondary Data Exclusions

5.3.1 The secondary data exclusion is that irradiance values must be ±20% of the Reporting Condition per ASTM E2848-9.1.6

6.0 Reporting Conditions

6.1 Reporting Conditions are defined as the set of irradiance, wind speed and temperature values entered into Table 2 in Section 7.1.7.1. The following algorithm shall be used to identify Reporting Conditions.

6.1.1 Procure simulated Data Records from the annual energy production simulation (i.e. Project Model).

6.1.1.1 The simulated Data Records shall exclude any assumed soiling, snow, curtailment and availability losses (i.e. set the soiling loss value to 0% and the availability to 100%).

6.1.1.2 Simulated Data Records shall not be of intervals longer than one (1) hour.

6.1.1.3 Simulated Data Records shall include the following assumed data points:

6.1.1.3.1 POA irradiance

6.1.1.3.2 Bifacial POA irradiance (if bifacial modules are utilized)

6.1.1.3.3 Ambient temperature

6.1.1.3.4 Back of module temperature

6.1.1.3.5 Wind speed input parameters

6.1.1.3.6 Any simulated Auxiliary Parameters necessary for making Data Records according to the primary data exclusion criteria.

6.1.2 Apply the primary data exclusion criteria identified in Section 5.2 of this document to the simulated Data Records

6.1.3 Grouping the remaining simulated Data Records by month, find the 60th percentile value of incident POA irradiance, the mean of the ambient air temperature, and the mean of the wind speed. The Reporting Condition for POA irradiance shall not be less than 500W/m^2.

6.1.4 Round the monthly POA irradiance to the nearest integer (W/m2), mean temperatures to the nearest degree (°C) and corrected mean wind speed to the nearest 0.1 m/s. Use these values to populate the table shown in Table 2 in Section 7.1.7.1 as Reporting Conditions.

7.0 Expected Capacity Calculations

7.1 Expected Capacity is a predicted Project power output value measured at the Revenue Meter at the point of interconnect as set forth in Table 2 in Section 7.1.7.1 below that defines the power output the completed Project is expected to produce when exposed to specified Reporting Conditions. Values for Table 2 shall be provided 45 business days prior to commissioning based on as-built information as part of the PV Plant Capacity Test Plan in Section 4.1.

7.1.1 Reporting Conditions have been provided and are included in Table 2 in Section 7.1.7.1

7.1.2 The primary data exclusion criteria identified in Section 5.2 of this document has been applied to the simulated Data Records

7.1.3 The secondary data exclusion criteria identified in Section 5.3 of this document has been applied to the simulated Data Records

7.1.4 A minimum of three (3) kWh/m2 of irradiation at irradiance levels exceeding the Reporting Conditions irradiance are present in the remaining Data Records

7.1.5 The remaining simulated Data Records have been grouped by month.

7.1.6 Calculate the regression coefficients for each simulation month by performing a least squares regression of PExpected as defined below.

$$E_{total,E} = E_{POA,E} + E_{Rear,E} * \varphi$$

$$P_{Expected} = E_{total,E} * (a_{1,E} + a_{2,E} * E_{total,E} + a_{3,E} * T_{a,E} + a_{4,E} * v_E)$$

7.1.6.1 $P_{Expected}$ is the expected power value (W)

7.1.6.2 $E_{POA,E}$ is the average front side plane of array irradiance (W/m^2)

7.1.6.3 $E_{Rear,E}$ is the average rear side irradiance (W/m^2)

7.1.6.4 $E_{Total,E}$ is the total front and rear side irradiance as described in the equation above (W/m^2)

7.1.6.5 $T_{a,E}$ is the ambient temperature (°C)

7.1.6.6 v_E is the wind speed (m/s)

7.1.6.7 φ is the bifaciality factor of the PV Module from the datasheet.

7.1.6.8 $a_{1,E}$, $a_{2,E}$, $a_{3,E}$, *and* $a_{4,E}$ are the Expected Capacity regression coefficients to be solved

7.1.7 Using the calculated Expected Capacity regression coefficients $a_{1,E}$, $a_{2,E}$, $a_{3,E}$, *and* $a_{4,E}$ from Section 7.1.6 calculate the Expected Capacity for each Reporting Condition month using the equation below for $P_{Expected,RC}$.

$$P_{Expected,RC} = E_{total,RC} * (a_{1,E} + a_{2,E} * E_{total,RC} + a_{3,E} * T_{a,RC} + a_{4,E} * v_{RC})$$

7.1.7.1 $P_{Expected,RC}$ is the expected power value for the Reporting Condition Month (W)

7.1.7.2 $E_{Total,RC}$ is the total irradiance for the Reporting Condition Month (W/m^2)

7.1.7.3 $T_{a,RC}$ is the ambient temperature at the Reporting Condition Month (°C)

7.1.7.4 $v_{,RC}$ is the wind speed of the Reporting Condition Month (m/s)

7.1.7.5 $a_{1,E}$, $a_{2,E}$, $a_{3,E}$, *and* $a_{4,E}$ are the Expected Capacity regression coefficients calculated in Section 7.1.6

7.1.8 The expected power output values have been rounded to four (4) significant figures. Rounded values have been used as $P_{Expected,\ RC}$ Expected Capacity rating values in Table 2.

Table 2 – Reporting Conditions and Expected Capacity

Month	Total Irradiance (W/m^2) $E_{Total,RC}$	Ambient Temperature (°C) $Ta_{,RC}$	Wind Speed (m/s) v_{RC}	$a_{1,E}$	$a_{2,E}$	$a_{3,E}$	$a_{4,E}$	Expected Capacity (kW) $P_{Expected,\ RC}$
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

8.0 Measured Capacity Identification

8.1 The following procedure shall be used to identify the Measured Capacity value for the Project.

8.1.1 Use measured Data Records acquired in accordance with the PV Plant Capacity Test Plan.

8.1.2 The primary data exclusion criteria identified in Section 5.2 of this document has been applied to the Data Records.

8.1.3 The secondary data exclusion criteria identified in Section 5.3 of this document has been applied to the Data Records.

8.1.4 If the PV Plant Capacity Test Measurement Period Data Records cross over multiple Reporting Conditions, a single weighted average Reporting Condition must be calculated as follows:

8.1.4.1 The weighted average Reporting Condition is calculated by taking the percentage of filtered measured Data Records from each Reporting Condition.

$$RC_{WA} = RC_a * \frac{DR_{RCa}}{DR_{Total}} + RC_b * \frac{DR_{RCb}}{DR_{Total}} + \cdots RC_m * \frac{DR_{RCm}}{DR_{Total}}$$

8.1.4.2 RC_{WA} is the weighted average Reporting Condition

8.1.4.3 RC_a is the first Reporting Condition during the PV Plant Capacity Test Measurement Period

8.1.4.4 RC_b is the second Reporting Condition during the PV Plant Capacity Test Measurement Period

8.1.4.5 DR_{RCa} is the number of filtered Data Records that are in Reporting Condition RC_a

8.1.4.6 DR_{RCb} is the number of filtered Data Records that are in Reporting Condition RC_b

8.1.4.7 DR_{Total} is the total number of filtered Data Records during the PV Plant Capacity Test Measurement Period

8.1.5 A minimum of three (3) kWh/m^2 of irradiation at irradiance levels exceeding the Reporting Conditions irradiance and at least the number of data points specified in ASTM E2939-13.8.2 are present in the remaining Measured Data Records in order to proceed with the analysis. The PV Plant Capacity Test Measurement Period is to be extended until sufficient data is collected but shall not be less than five (5) consecutive days.

8.1.6 Measured Capacity shall be measured at the Revenue Meter without any adjustments to account for losses in components of the Project prior to the Point of Interconnection.

8.1.7 Calculate the Measured Capacity regression coefficients by performing a least squares regression of $P_{Measured}$ as defined below.

$$E_{total,M} = E_{POA,M} + E_{Rear,M} * \varphi$$

$$P_{Measured} = E_{total,M} * (a_{1,M} + a_{2,M} * E_{total,M} + a_{3,M} * T_{a,M} + a_{4,M} * v_M)$$

8.1.7.1 $P_{Measured}$ is the measured power value (W)

8.1.7.2 $T_{a,M}$ is the measured ambient temperature (°C).

8.1.7.3 E_{POA} is the front side plane of array irradiance (W/m^2)

8.1.7.4 E_{Rear} is the rear side irradiance (W/m^2)

8.1.7.5 $E_{total,M}$ is the total plane of array irradiance (W/m^2)

8.1.7.6 φ is the bifaciality factor of the PV Module from the datasheet.

8.1.7.7 v_m is the measured wind speed at the site (m/s)

8.1.7.8 $a_{1,M}$, $a_{2,M}$, $a_{3,M}$, *and* $a_{4,M}$ are the Measured Capacity regression coefficients to be solved

8.1.8 Using the Measured Capacity regression coefficients $a_{1,M}$, $a_{2,M}$, $a_{3,M}$, *and* $a_{4,M}$ along with the Reporting Condition from Table 2 or calculated in Section 8.1.4,

as applicable, corresponding to the month of the PV Plant Capacity Test Period.

$$Measured\ Capacity = E_{total,RC} * (a_{1,M} + a_{2,M} * E_{total,RC} + a_{3,M} * T_{a,RC} + a_{4,M} * v_{RC})$$

8.1.8.1 *Measured Capacity* is the calculated power value based on Reporting Conditions using Measured Capacity regression coefficients (W)

8.1.8.2 $T_{a,RC}$ is the ambient temperature at the Reporting Condition (°C).

8.1.8.3 $E_{total,RC}$ is the total plane of array irradiance at the Reporting Condition (W/m^2)

8.1.8.4 $v_{m,RC}$ is the wind speed at the Reporting Condition (m/s).

8.1.8.5 $a_{1,M}$, $a_{2,M}$, $a_{3,M}$, *and* $a_{4,M}$ are the Measured Capacity regression coefficients calculated in Section 8.1.7

8.2 All measured data shall be made available to the Buyer upon request during the PV Plant Capacity Test Measurement Period

9.0 Test Reporting

9.1 PV Plant Capacity Test Report

9.1.1 No more than five (5) business days following the end of the PV Plant Capacity Test Measurement Period a draft PV Plant Capacity test report shall be submitted to the Buyer. The Buyer shall review and accept or reject the results of the draft PV Plant Capacity Test report within ten (10) business days. The Buyer shall submit all comments and reasoning for rejecting such report.

9.1.2 The PV Plant Capacity Test Report shall contain:

9.1.2.1 The portions of the Commissioning Plan applicable to the Project Performance Test to determine PV Plant Capacity

9.1.2.2 The actual start and end dates/times of the PV Plant Capacity Test Measurement Period.

9.1.2.3 General environmental conditions during the PV Plant Capacity Test Measurement Period.

9.1.2.4 Summary of quality control results for all Data Records.

9.1.2.5 Summary of the test and test results

9.1.2.6 Uncertainty analysis

9.1.2.7 Comparison of test results with the Guaranteed PV Plant Capacity and Minimum PV Plant Capacity.

9.1.2.8 Summary of findings if the test results are less than the Guaranteed PV Plant Capacity

9.1.2.9 Raw data of all test points shall be provided to the Buyer electronically (.CSV, .XLS or .XLSX format)

9.2 Pass/Failure of PV Plant Capacity Test

9.2.1 The Guaranteed Capacity and Minimum Guaranteed Capacity shall be as defined in Sections 3.5 and 3.7. The Measured Capacity shall be as calculated in Section 8.1.8.

9.2.2 If the Measured Capacity is equal to or greater than the Guaranteed Capacity, then the Seller has achieved the Guaranteed Capacity

$$Measured\ Capacity \geq Guaranteed\ Capacity$$

9.2.3 If the Measured Capacity is equal to or greater than the Minimum Guaranteed Capacity and the Measured Capacity is less than the Guaranteed Capacity, then the Seller has achieved the Minimum Guaranteed Capacity.

$$Measured\ Capacity < Guaranteed\ Capacity$$
$$and$$
$$Measured\ Capacity \geq Minimum\ Guaranteed\ Capacity$$

9.2.3.1 The Seller shall be required to pay Liquidated Damages as defined by PV Plant Capacity Buydown in Section 7.6.2 of the Build Transfer Agreement

9.2.4 If the Measured Capacity is less than the Minimum Guaranteed Capacity, then the Seller has not achieved the Minimum Guaranteed Capacity and corrective actions are required.

$$Measured\ Capacity < Minimum\ Guaranteed\ Capacity$$

9.2.4.1 If the Project does not meet the Minimum Guaranteed Capacity the Seller shall be responsible to take corrective actions to the Project and reperform the PV Plant Capacity Test. The Buyer will not accept the Project until, at a minimum, the Minimum Guaranteed Capacity can be met.

Solar Technical Specification

SP-001

Revision 2022.1

Exhibit K1 – PV Plant Functional Test Requirements

Executed Date

Table of Contents

1.0 Purpose

This purpose of the PV Plant Functional Test is to verify that the Project is capable of operating through daily generation cycles. The PV Plant Functional Test ensures that all equipment is functioning as intended and able to produce energy, at the Point of Interconnection and shall be a minimum of five (5) consecutive days without interruption. The Measured Project Availability shall be 100% over the test period for the test to be considered successful.

2.0 Pre-Test Activities

2.1 The Seller shall provide to the Buyer no less than forty-five (45) Business Days prior to the Functional Test a draft PV Plant Functional Test Procedure for review and comment.

2.1.0 The PV Plant Functional Test Plan shall include the following:

2.1.0.1 Identification of all parties involved including contact information.

2.1.0.2 The estimated starting and ending dates of the PV Plant Functional Test Measurement Period.

2.1.0.3 Project parameters including, at a minimum, manufacturer/model/quantity of PV Modules, array orientation, location, racking type, tracker range of motion, manufacturer/model/quantity of inverters.

2.1.0.4 Identification of the SCADA System data channels and calibration parameters for each data channel.

2.2 The Seller shall provide written notification to the Buyer no less than ten (10) Business Days prior to the planned start of the PV Plant Functional Test.

2.3 No less than two (2) Business Days prior to commencing the PV Plant Functional Test the Seller shall schedule a pre-test meeting with the Buyer.

2.3.0 All equipment required for normal operation of the Project shall be operated in normal or automatic mode as applicable.

2.3.1 All equipment shall be installed, tested and verified in accordance with OEM requirements, requirements within the Scope of Work for the Project and in accordance with the Project Design Basis.

3.0 Data Acquisition System Availability

3.1 The Data Acquisition System shall be available without interruption during the entire Data Collection Period

3.2 The data shall be collected for the entire Data Collection Period which, at a minimum, is five (5) consecutive Business Days. The Data Collection Interval shall not exceed five (5) minutes for any data point.

3.3 The following data points shall be collected through the Data Acquisition System and timestamped:

3.3.0 Power measured by the Revenue Meter at the Point of Interconnection (kW).

3.3.1 Plane of Array irradiance (W/m^2).

3.3.1.1 The Plane of Array irradiance shall be measured by no less than two independent instruments.

3.3.2 Bifacial Plane of Array irradiance (W/m^2), if applicable.

3.3.2.1 The Bifacial Plane of Array irradiance shall be measured by no less than two independent instruments.

3.3.3 Global Horizontal Irradiance (W/m^2)

3.3.4 Ambient Temperature (°C)

3.3.5 Wind Speed (m/s)

3.3.6 Inverter Input Power (kW_{DC})

3.3.7 Inverter Output Power (kW_{AC})

3.3.8 All Inverter Alarms

3.3.9 Tracker position for all trackers in the Project

3.3.10 All Tracker System Alarms

3.3.11 All substation relaying statuses and alarms

4.0 Inverter Availability

4.1 The data collected in Section 5.0 shall be filtered with the following requirements:

4.1.0 All data points shall be removed from the data set when all Plane of Array irradiance measurements are less than 50W/m^2.

4.2 Inverter Operational State ($I_{z,t}$) shall be calculated as follows:

4.2.0 If the measured Inverter Output Power (kW) of Inverter (z) at time (t) is greater than 0 kW then $I_{z,t} = 1$

4.2.1 If the measured Inverter Output Power (kW) of Inverter (z) at time (t) is 0 kW then $I_{z,t} = 0$

4.3 Inverter Availability shall be calculated using the following equation:

$$IA_z = \frac{\sum_{t=1}^{n} I_t}{n}$$

4.3.0 IA_z is the inverter availability for each inverter.

4.3.1 n is the number of data points

4.4 Project Availability shall be calculated using the following equation:

$$PA = \frac{\sum_{z=1}^{m} PA_z}{m}$$

4.4.0 PA is the Project Availability.

4.4.1 m is the number of Inverters

4.5 No Inverter alarms shall occur during the duration of the PV Plant Functional Test Period.

5.0 Tracker Availability

5.1 The data collected in Section 5.0 shall be used for determining Tracker Availability

5.2 All trackers shall demonstrate tracking with the sun position throughout the day.

5.3 Any tracker whose position feedback does not show proper change with respect to the sun position shall be considered unavailable.

5.4 No tracker alarms shall be allowed during the duration of the PV Plant Functional Test Period.

5.5 The Tracker Availability shall be calculated using the following equation:

$$TA = \frac{\sum_i^n THr_i}{\sum_i^n (THr_i + THd_i)}$$

5.5.0 TA is the tracker availability over the duration of the test period expressed as a percentage

5.5.1 THr_i - for each tracker (i), the total number of hours during the test where the tracker is within ten (10) radial degrees of the target position

5.5.2 THd_i - for each tracker (i), the total number of hours during the test where the tracker is NOT within ten (10) radial degrees of the target position

5.5.3 n is the number of trackers

6.0 Results and Reporting

6.1 The Project is given a Pass/Fail rating based on the test results

6.1.0 The PV Plant Functional Test is considered a Passing Test if the following requirements are met during the PV Plant Functional Test Period:

6.1.0.1 Measured Project Availability = 100%

6.1.0.2 No alarm from any Inverter is observed.

6.1.0.3 Tracker availability = 100%

6.1.0.4 No alarms from the Tracker System is observed

6.1.0.5 Data Acquisition System operates without interruption

6.2 The PV Plant Functional Test is considered a Failing Test if any of the following occur

6.2.0.1 Measured Project Availability < 100%.

6.2.0.2 Measured Tracker Availability is <100%

6.2.0.3 Data Acquisition System does not operate continuously without interruption

6.2.0.4 For clarity if any post filtering datapoint does not show an inverter as available the test is considered a failing test.

6.2.0.5 If the PV Plant Functional Test has failed the Seller shall make corrections/repairs to the Project.

6.2.0.6 The PV Plant Functional Test shall be reperformed until a Passing Test has been achieved

6.3 If the PV Plant Functional Test results in a Failing Test the Seller shall make necessary repairs/corrections to the Project and reperform the test until a Passing Test is achieved.

6.4 At the completion of the Functional Test a written Test Report shall be submitted to the Buyer no later than fifteen (15) business days after completion of the test. At a minimum, the Test Report shall include the following information:

6.4.0 Date and Time of when the PV Plant Functional Test Started and Stopped

6.4.1 Description of the operating conditions

6.4.2 Instrument calibration data

6.4.3 Raw test data (.csv, .xls or .xlsx format)

6.4.4 Test calculations

6.4.5 Comments on uncertainty

6.4.6 Test Results

6.4.7 Conclusions

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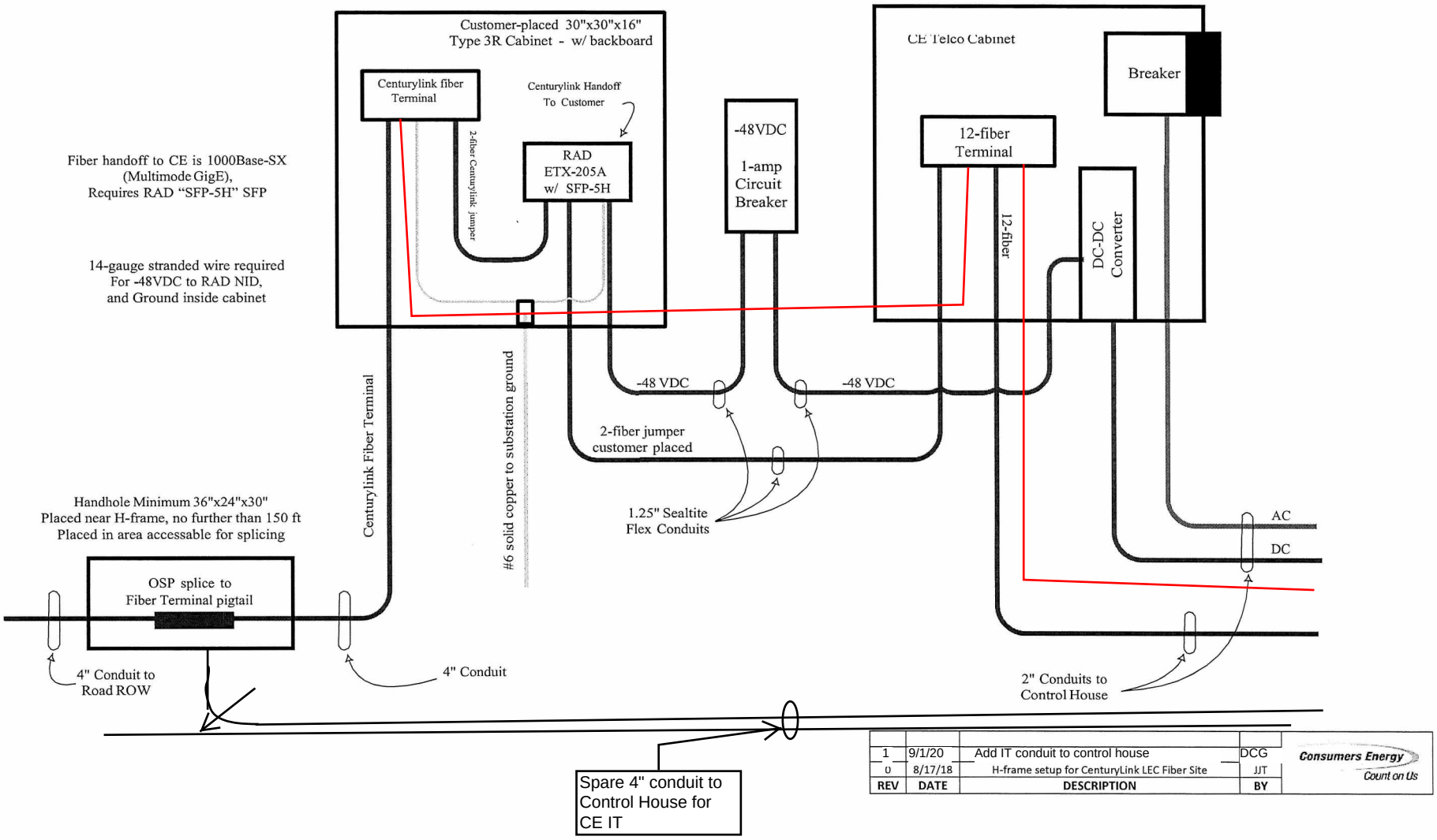
Exhibit A Appendix L – Fiber Pedestal H

Frame Diagrams

Executed Date

CMS Energy - AMD Project - Centurylink LEC Sites - H-Frame - Fiber Site



REV	DATE	DESCRIPTION	BY
1	9/1/20	Add IT conduit to control house	DCG
0	8/17/18	H-frame setup for CenturyLink LEC Fiber Site	JJT

Consumers Energy
Count on Us

Example of Outdoor Demarc Enclosure Locations

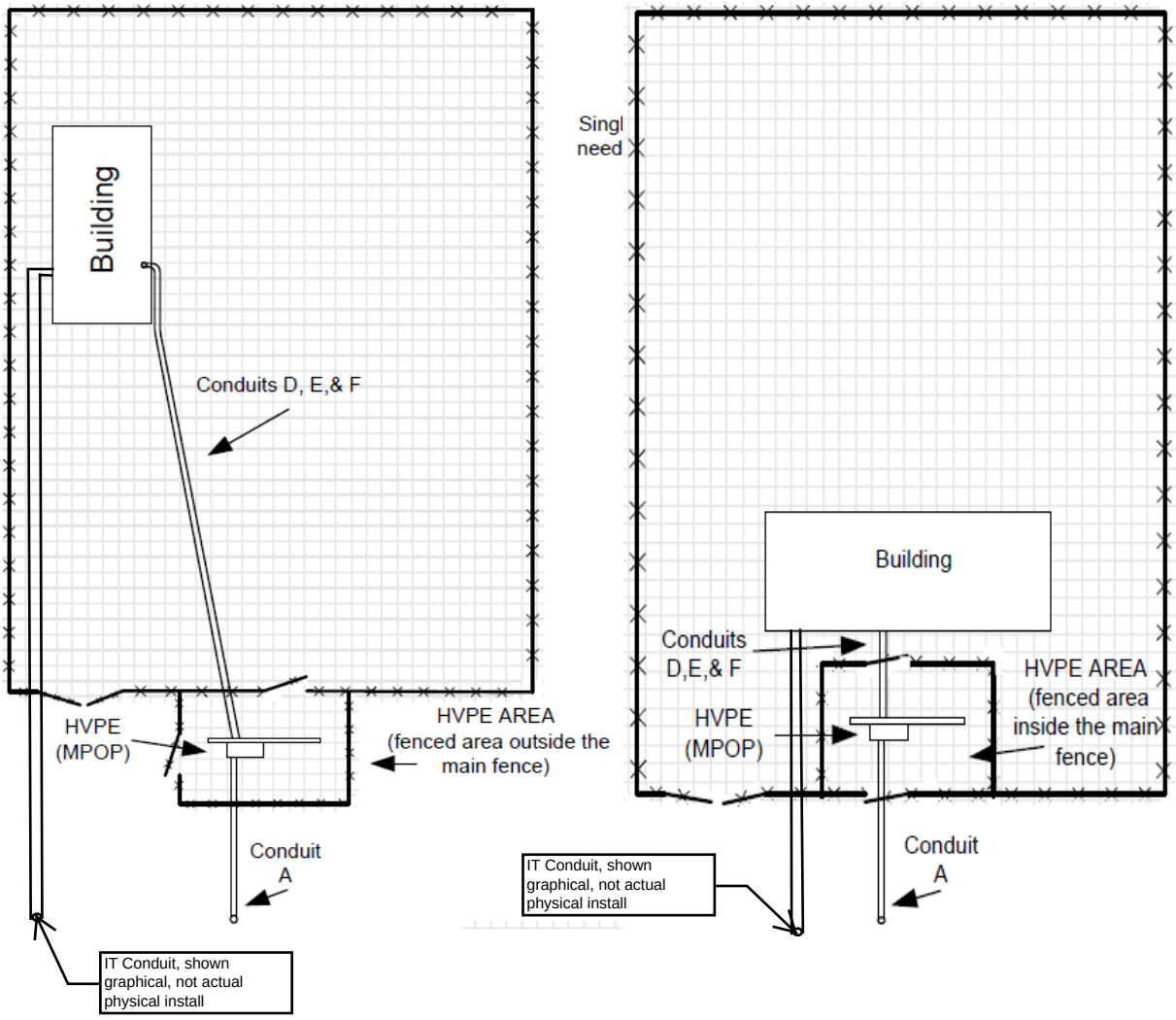


Exhibit [A] Appendix [M] Records Format-Retirments Unit Format Example

Asset ID	Item Name	In Service Date	Major Category	Minor Category	Location	Comments	Quantity	Total Cost
			COMMN_COMP SOFTWARE	COMP SOFTWARE				
			COMMN_IT HARDWARE	IT HARDWARE				
			DEV_SOLAR_MET STATION	MET STATION				
			LAND	LAND				
			LEASEHOLD_IMPROVEMENTS	OFFICE BUILDOUTS				
			SOLAR_ACCESS ROADS	ACCESS ROADS				
			SOLAR_COLL SYST	COLL SYS				
			SOLAR_CONTRA ASSET	ARR GRANT				
			SOLAR_CONTRA ASSET	CONTRA ASSET				
			SOLAR_CONTRA ASSET	OTHER				
			SOLAR_CONTRA ASSET	SY REIMB				
			SOLAR_DRAINAGE TILE	DRAINAGE TILE				
			SOLAR_FENCE	FENCE				
			SOLAR_MET STATION	MET STATION				
			SOLAR_OPER MAINT BLDG	BUILDING 2				
			SOLAR_OPER MAINT BLDG	ELECTRICAL SYS				
			SOLAR_OPER MAINT BLDG	ELEVATORS				
			SOLAR_OPER MAINT BLDG	ESCALATORS				
			SOLAR_OPER MAINT BLDG	FIRE PROT ALARM SYS				
			SOLAR_OPER MAINT BLDG	GAS DIST SYS				
			SOLAR_OPER MAINT BLDG	HVAC SYST				
			SOLAR_OPER MAINT BLDG	PLUMBING SYS				
			SOLAR_OPER MAINT BLDG	SECURITY SYS				
			SOLAR_PANELS BLOCKS	INVERTERS				
			SOLAR_PANELS BLOCKS	MOUNTED SOLAR PANEL BLOCK				
			SOLAR_PANELS BLOCKS	SOLAR PANELS				
			SOLAR_POI SUBSTATION	SUBSTATION				
			SOLAR_POI SUBSTATION	SWITCH GEAR				
			SOLAR_POI SUBSTATION	TRANSFORMERS				
			SOLAR_SUBSTATION	SUBSTATION				
			SOLAR_SUBSTATION	SWITCH GEAR				
			SOLAR_SUBSTATION	TRANSFORMERS				
			SOLAR_TRANS SYST	TRANS SYS 2				