AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE	OF	PAGES
J	1		2

2. AMENDMENT/MODIFICATION NUMBER	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQUISITION NUMBER	5. PROJECT NUMBER *(If applicable)*
0002	12 MAY 2025		505014

6. ISSUED BY	CODE	7. ADMINISTERED BY *(If other than Item 6)*	CODE
W912QR			

W072 ENDIST LOUISVILLE
KO CONTRACTING DIVISION, 600 DR MARTIN LUTHER KING JR PL
LOUISVILLE, KY 40202-2230
UNITED STATES
ALEX HAMILTON, EMAIL: ALEX.J.HAMILTON@USACE.ARMY.MIL

SCD: PAS:

8. NAME AND ADDRESS OF CONTRACTOR *(Number, street, county, State and ZIP Code)*

CODE | FACILITY CODE

(X)

☒ 9A. AMENDMENT OF SOLICITATION NUMBER: W912QR25RA023

9B. DATED *(SEE ITEM 11)*: 31 MAR 2025

☐ 10A. MODIFICATION OF CONTRACT/ORDER NUMBER

10B. DATED *(SEE ITEM 13)*

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

☒ The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers ☒ is extended. ☐ is not extended.

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
(a) By completing items 8 and 15, and returning 1 copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted;
or (c) By separate letter or electronic communication which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER.
If by virtue of this amendment you desire to change an offer already submitted, such change may be made by letter or electronic communication, provided each letter or electronic communication makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA *(If required)*

SEE SECTION G - CONTRACT ADMINISTRATION DATA

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS. IT MODIFIES THE CONTRACT/ORDER NUMBER AS DESCRIBED IN ITEM 14.

CHECK ONE	
☐	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: *(Specify authority)* THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NUMBER IN ITEM 10A.
☐	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES *(such as changes in paying office, appropriation data, etc.)* SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
☐	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
☐	D. OTHER *(Specify type of modification and authority)*

E. IMPORTANT: Contractor ☐ is not ☐ is required to sign this document and return _____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (*Organized by UCF section headings, including solicitation/contract subject matter where feasible.)*

SEE SCHEDULE

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER *(Type or print)*		16A. NAME AND TITLE OF CONTRACTING OFFICER *(Type or print)*	
15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
_____ *(Signature of person authorized to sign)*		_____ *(Signature of Contracting Officer)*	

Previous edition unusable

STANDARD FORM 30 (REV. 11/2016)
Prescribed by GSA FAR (48 CFR) 53.243

SECTION SF 30 BLOCK 14 CONTINUATION PAGE

SUMMARY OF CHANGES

Block 14 (Description of Amendment/Modification): SOLICITATION AMENDMENT 0002

Solicitation No. W912QR25RA023 for the Construction of a Microgrid System at Conroe Army Reserve Center (ARC) located in Conroe, TX is hereby amended as follows:

A. The proposal due date has been extended from 14 May 2025 at 2:00 PM ET to 20 May 2025 at 2:00 PM ET.

B. The following PLAN SHEETS have been replaced in their entirety:

G-002 GENERAL LEGEND & GENERAL NOTES
G-106 GENERAL LIFE SAFETY PLAN
B-100 GEOTECHNICAL BORING PLAN
E-005 ELECTRICAL MICROGRID OPERATION DESCRIPTION
ES400 ELECTRICAL ENLARGED PLANS SHEET 1
ES401 ELECTRICAL ENLARGED PLANS SHEET 2
ES402 ELECTRICAL ENLARGED PLANS SHEET 3
ES410 ELECTRICAL SITE LIGHTING PLANS
E-107 ELECTRICAL MICROGRID INTERCONNECTION SWITCHGEAR ENCLOSURE SECTIONS
E-600 ELECTRICAL MICROGRID INTERCONNECTION SWITCHGEAR ONE-LINE DIAGRAM
E-621 ELECTRICAL PV SYSTEM WIRING DIAGRAM
S-501 STRUCTURAL DETAILS SHEET 1

C. The following SPECIFICATION SECTIONS have been replaced in their entirety:

25 08 20 MICROGRID CONTROL SYSTEM
26 23 00 LOW-VOLTAGE SWITCHGEAR
26 31 00 FACILITY-SCALE SOLAR PHOTOVOLTAIC (PV) SYSTEMS

D. Offerors must acknowledge all amendments.

E. All other terms and conditions remain unchanged.

P2: 505014, Microgrid Design 750KWDC Conroe ARC
Conroe, TX

SECTION TABLE OF CONTENTS

DIVISION 25 - INTEGRATED AUTOMATION

SECTION 25 08 20

MICROGRID CONTROL SYSTEM

05/21

-- End of Section Table of Contents --

SECTION 25 08 20

MICROGRID CONTROL SYSTEM
05/21

Amendment 0002

PART 1 GENERAL

1.1 GENERAL REQUIREMENTS

This section includes the requirements developed for the microgrid control system (MGCS) which is part of the switchgear detailed in Section 26 23 00 LOW-VOLTAGE SWITCHGEAR.

This section includes general requirements for engineering, design, installation, supervisions, testing and commissioning of the microgrid control system including integration of new and existing Distributed Energy Resources (DER) under the scope of the project. The microgrid control system must perform system protection and control functions in manners to avoid threats to personnel safety, out-of-phase reclosing, and maintaining system stability and power quality. The Microgrid control system (MGCS) functionality for the project must comply with the microgrid control system functionality be as defined by the IEEE 2030.7 and IEEE 2030.8 microgrid controller standards.

The specification and design drawings included as part of tender document form basis of the design and are intended to convey general physical layout, functional and performance requirements of the microgrid control system. The design drawings of the control system do not show all of the required components and all of the power and communication interconnections required to provide a complete, fully integrated, and functional microgrid control system.

Provide the service of a qualified system integration company to develop and advance the design, and produce a complete, fully integrated electrical, control and communication microgrid installation design package for Engineer's review and approval. The design package must be developed based on the actual equipment to be installed and/or existing equipment to be integrated into the microgrid system. The system integrator company must demonstrate that it has successfully completed the development, construction and commissioning of at least three projects involving distributed energy resources with at least 1 MW with a minimum of twelve (12) months of successful operating history. Please include references from these projects.

The installation shop drawings must include layout/assembly/installation drawings of equipment, components terminal boxes and terminations drawings, schematic diagrams, point-to-point interconnection wirings with cable tags and termination identification for field installation. Coordinate all activities required to produce the installation shop drawings. Include all equipment and components, system interconnections, configuration, software programming, testing and commissioning necessary to achieve the project objectives, functions and performance requirements specified herein.

Perform supplemental studies and/or designs- necessary to comply with the requirements of the specification. Submit drawings and engineering data in accordance with the submittal requirements and schedule to assure compliance with the project requirements, overall construction schedule, and the project in service date. Take into considerations economics, safety of operation, acceptable performance, reliability, interchangeability of parts, O&M familiarity, and other benefits.

1.2 ENVIRONMENTAL CONDITION REQUIREMENTS

Microgrid control system equipment temperature, ingress protection ratings, corrosion protection measures, and hazardous area classification ratings must be suitable for the installation environment.

Design room temperature will be 50-80 degrees F with relative humidity (RH) in the range of 10 percent to 90 percent non-condensing. Outside air requirements will be based on ASHRAE 62.1 and/or ICC IMC. Cooling and heating loads, as performed by the switchgear provider, will be required to be calculated using weather data for the project location.

1.3 OPERATION AND FUNCTIONAL REQUIREMENTS

Operating the Microgrid system in parallel with the Electrical Power System (EPS).

Separating from and operating the Microgrid system in island mode intentionally or unintentionally.

Connecting the microgrid system back to parallel operation with the EPS when service condition is restored normal.

Dispatching and controlling Distributed Energy Resources (DER) that are part of microgrid control integration. The microgrid control system must have the capability to interface with the DER control system to allow dispatching, controlling, and disconnecting of the DER including initiate automatic synchronization, control mode of operation, power output control, source transfer and load transfer scheme, and prohibit unsynchronized sources tie-in.

Provide for reliable, fast, secure and real-time communication. Communication architecture, control hierarchy, data transmission requirements in terms of rate, delay (or latency), and reliability are to comply with specific functions necessary to accomplish a proper operation of the microgrid. The IEC 61850 standard (protocol used in digital substation systems and smart distribution systems) must be used as the standard communication protocol for the project.

1.4 DISTRIBUTED ENERGY RESOURCES (DER)

The following Distributed Energy Resources (DER) must be incorporated as part of the project microgrid system:

a. A car port roof-mounted solar photovoltaic (PV) system. The PV System will provide energy into the microgrid system whenever the solar energy is available.

b. Two (2) natural gas generator units that have the primary function of providing backup power during utility outages.

1.5 MODES OF OPERATION

There are three states (or Modes of Operation) of a microgrid power system: Grid Connected, Islanded, and Blackout state of conditions. The Grid Connected and the Islanded modes are the two working modes of operations where the microgrid power system is energized. In Blackout mode, the power system is completely deenergized. See Design Drawing for Microgrid's Mode of Operation Diagram and description.

1.6 SYSTEM PROTECTION

The microgrid control system must incorporate protection system components and schemes to detect defective power system elements or conditions of an abnormal or dangerous nature, to initiate the appropriate control circuit action, and to isolate the appropriate system components.

The microgrid control system must incorporate system control and protection schemes in such manners to avoid threats to personnel safety, prevent or minimize equipment damage, maintaining dynamic stability and power quality, and minimize the system outage area.

The microgrid system protection scheme achieves voltage and frequency ride through characteristics per the requirement of the IEEE 1547 standard at POI.

For all POI synchronization check (25) functionality must be provided to prevent unintentional out-of-synchronize closing generation sources. Reconnection of generator source(s) must be performed through an automatic synchronizer (25A). The IEEE C50.12 and IEEE C50.13 provide recommendation of synchronous generator synchronization settings used in a POI relay.

1.7 SYSTEM INTEGRATION

Microgrid System Integrator - Designate an individual (such as the Microgrid Protection and Control System Supplier) to act as the Project's System Integrator Lead. Coordinate the microgrid control system integration including:

a. Assemble a qualified system integration team.

b. Coordinate with Owner, Engineers, and equipment manufacturers in determining operational and maintenance requirements and system performance requirements that will have impact on how the microgrid system is integrated and implemented.

c. Advance the development of microgrid operating philosophy, control and protection scheme.

d. Facilitate development of final sequence of operations, system configuration, and programming specific to the project site operational requirements.

e. Coordinate with Owner, Engineers, and equipment manufacturers in determining the specific power, control and communication interface equipment, hardware, software and interconnection requirements between Microgrid control system and associated system components.

f. Determine, develop and optimize communication architecture, control hierarchy, data transmission requirements and select appropriate

control and communication media and equipment.

g. Develop microgrid implementation plan.

h. System Integrator will serve as a single point of contact responsible for microgrid system integration prior to, during the construction and warranty period, and must be available for consultation during all phases of the project. Further requirements for commissioning are defined in Section 01 46 00.00 07 COMMISSIONING - MICROGRID for the MicroGrid Integration Commissioning specialist.

i. Microgrid Systems Integrator must be present at factory acceptance testing and on site and directing all testing and commissioning of the microgrid control system.

j. Submit the qualifications of the Microgrid Systems Integrator as part of the proposal. Provide documents that substantiate the qualifications of the proposed individual with the following minimum requirements:

(1) Licensed Professional Electrical Engineer, Control Systems Engineer, or Computer Systems Engineer.

(2) Minimum of fifteen (15) years experiences with at least five (5) years in control system integration practice.

(3) Past experience with similar projects within the past ten (10) years.

The Owner will review the qualifications of the Microgrid System Integrator before the Contractor brings the microgrid system integrator onboard to the team.

1.8 REFERENCES

Electrical systems must be engineered, manufactured and installed in accordance with the National Electrical Codes. The design and engineering of the electrical installation must satisfy all statutory requirements of the national and/or local authorities. The electrical installation must be suitable for the site conditions as specified. Where necessary, special attention must be paid to the selection and installation of electrical equipment suitable for seismic conditions. Where relevant, the specific publications are referenced herein.

The following reference standards documents form part of the specification to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection must apply. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the work.

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS (ASHRAE)

ASHRAE 62.1	(2019) Ventilation for Acceptable Indoor Air Quality

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 1547	(2018) Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE 1613	(2009) Standard Environmental and Testing Requirements for Communications Networking Devices in Electric Power Substations
IEEE 2030.7	(2017) Standard for the Specification of Microgrid Controllers
IEEE 2030.8	(2018) Standard for the Specification of Microgrid Controllers
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C37.118	(2021) Standard for Synchrophasor Measurements for Power Systems
IEEE C37.238	(2017) Standard Profile for Use of IEEE 1588 Precision Time Protocol in Power System Applications
IEEE C50.12	(2005; R 2010) Standard for Salient Pole 50 HZ and 60 Hz Synchronous Generators and Generation/Motors for Hydraulic Turbine Applications Rated 5 MVA and above

INTERNATIONAL CODE COUNCIL (ICC)

ICC IMC	(2018) International Mechanical Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60255	(2022) Measuring Relays and Protection Equipment - Part 1: Common Requirements
IEC 60255-21-1	(1988) Electrical Relays - Part 21: Vibration, Shock, Bump and Seismic Tests On Measuring Relays and Protection Equipment - Section One: Vibration Tests (Sinusoidal)

IEC 60255-21-2	(1988) Electrical Relays - Part 21: Vibration, Shock, Bump and Seismic Tests On Measuring Relays and Protection Equipment - Section Two: Shock and Bump Tests
IEC 60255-21-3	(1993; ED 1.0) Electrical Relays - Part 21: Vibration, Shock, Bump And Seismic Tests On Measuring Relays And Protection Equipment - Section 3: Seismic Tests
IEC 60255-26	(2013) Measuring Relays and Protectyion Equipment - Part 26: Electromagnetic Compatibility Requirements
IEC 60870-5-101	(2003-02) Telecontrol Equipment and Systems – Part 5-101: Transmission Protocols – Companion Standard for Basic Telecontrol Tasks
IEC 60870-5-104	(2006-06) Telecontrol Equipment and Systems – Part 5-101: Transmission Protocols – Companion Standard for Basic Telecontrol Tasks
IEC 61000-4-2	(2008) Electromagnetic Compatibility (EMC) - Part 4-2: Testing and Measurement Techniques - Electrostatic Discharge Immunity Test
IEC 61000-4-4	(2012) Electromagnetic Compatibility (EMC) - Part 4-4: Testing and Measurement Techniques - Electrical Fast Transient/Bust Immunity Test
IEC 61131-3	(2013) Programmable Controllers - Part 3: Programming Languages
IEC 61850	(2021) Communication networks and systems for power utility automation

TELECOMMUNICATIONS INDUSTRY ASSOCIATION (TIA)

TIA-232	(1997f; R 2012) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
TIA-485	(1998a; R 2012) Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems

1.9 DEFINITIONS

The following list of definitions may contain terms not found elsewhere in this Section but are included here for completeness. Some terms are followed with a protocol reference in parenthesis indicating to which protocol the term and definition applies. Inclusion of protocol-specific

definitions does not create a requirement to support that protocol, nor does it relax any requirements to support specific protocols as indicated e in this section.

1.9.1 Alarm Generation

The process of comparing a point value (the point being alarmed) with a pre-defined alarm condition (e.g. a High Limit) and performing some action based on the result of the comparison.

1.9.2 Alarm Handling

See paragraph ALARM ROUTING.

1.9.3 Alarm Routing

Alarm routing is M&C software functionality that starts with a notification that an alarm exists (typically as the output of an Alarm Generation process) and sends a specific message to a specific alarm recipient or device.

1.9.4 Control Logic Diagram

A graphicsl representation of control logic for multiple processes that make up a system.

1.9.5 Field Point of Connection (FPOC)

The FPOC is part of the UMCS IP network and acts as the point of connection between the UMCS IP Network and the field control IP network. The FPOC is an IT device such as a switch, IP router, or firewall, typically managed by the site IT staff. (Note that the field control IP network may consist of a single IP device, or that integration may require installation of a field control network IP device.)

1.9.6 Field Control Network

The network used by a field control system.

1.9.7 Gateway

A device that translates from one protocol to another. Devices that change only the transport mechanism of the protocol - "translating" from LonWorks over TP/FT-10 to LonWorks over IP for example - are not gateways as the underlying protocol (data format) does not change. Gateways are also called Communications Bridges or Protocol Translators.

1.9.8 Modbus

A basic protocol for control network communications generally used in utility control systems. The Modbus protocol standard is maintained by The Modbus Organization.

1.9.9 Monitoring and Control (M&C) Software

The UMCS 'front end' software which performs supervisory functions such as alarm handling, scheduling and data logging and provides a user interface for monitoring the system and configuring these functions.

1.9.10 Override

To change the value of a point outside of the normal sequence of operation where this change has priority over the sequence. An override can be accomplished in one of two ways: the point itself may be Commandable and written to with a priority or there may be a separate point on the controller for the express purpose of implementing the override.

1.9.11 Point, Calculated

A value within the M&C Software that is not a network point but has been calculated by logic within the software based on the value of network points or other calculated points. Calculated points are sometimes called virtual points or internal points.

1.9.12 Point, Network

A value that the M&C Software reads from or writes to a field control network.

1.9.13 Algorithm

A set of well-defined rules or procedures for solving a problem or providing an output from a specific set of inputs.

1.9.14 Analog

A signal that can take on continuous (as opposed to discrete) values. Sensors (e.g. temperature, pressure, flow) typically provide analog signals as outputs to represent the measured variable. Within the UMCS, analog signals are generally represented by either 0-10 volt or a 4-20 milliamp signal.

1.9.15 Binary

A two-state system where an "ON" condition is represented by a high signal level and an "OFF" condition is represented by a low signal level. "Digital" is sometimes used interchangeably with "binary".

1.9.16 Change-Of-Value (COV)

A type of data transmission over the network where the point value is transmitted over the network only when its value changes. COV is an efficient use of network bandwidth.

1.9.17 Control Wiring

This includes conduit, wire, and wiring devices to install complete HVAC control systems, including motor control circuits, interlocks, sensors, PE and EP switches, and like devices. This also includes all wiring from node to node, and nodes to all sensors and points defined in the I/O summary shown on drawings or specified herein, and required to execute the sequence of operation. Does not include line voltage power wiring.

1.9.18 Demand

The maximum rate of use of electrical energy averaged over a specific interval of time, usually expressed in kW.

1.9.19 Graphical User Interface (GUI)

Human-machine interfacing allows the operator to manage, command, monitor, and program the system.

1.9.20 Integration

Establishing communication between two or more systems to create a single system.

1.9.21 Protocol

In control systems, "protocol" is generally shorthand for "communication protocol"; a defined method by which digital information is exchanged electronically. Often more than one protocol is used in a BAS, for example, a typical BACnet system will use at a minimum (in addition to BACnet/IP and BACnet MS/TP) IP, UDP, ARP, Ethernet, and RS-485 protocols (and this does not include any protocols used internally in the front end or for communication with front end client workstations).

1.10 ADMINISTRATIVE REQUIREMENTS

1.10.1 Sequencing

Performance Verification Testing required by this Section must be proceeded by successful and accepted "contractors field testing" or "start-up and start-up testing" of the control system to be tested.

1.10.2 Scheduling

Coordinate testing schedules with the Government and with work in other Sections performed on the components or systems to be tested.

1.11 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Manufacturer Data; G-DO-AE

Manufacturer's Instruction; G-DO-AE

Draft As-Built Drawings; G-DO

Installation Drawings - electrical system interconnection diagrams and schedules; G-DO-AE

Point to Point Wiring Diagrams; G-DO-AE

Bills Of Material; G-DO-AE

Final As-Built Drawings; G-DO

Implementation Plan; G-DO-AE

SD-05 Design Data

Microgrid Installation Design Package; G-DO-AE

SD-06 Test Reports

Factory Acceptance Test Reports; G-DO-AE

Hardware in the Loop Test Report; G-DO-AE

Manufacturer's Field Test Reports; G-DO-AE

Test Instrumentation Calibration Certificates; G-DO

SD-07 Certificates

UL certification for applicable equipment and material.

Certificate of acceptance from authority having jurisdiction upon completion of Work to Owner Representative.

Test Instrumentation Calibration Certificates

SD-10 Operation and Maintenance Data

Operation and Maintenance (O&M) Instructions; G-DO

Preventive Maintenance Work Plan; G-DO

Operational Training Documentation; G-DO

Maintenance and Configuration Training Documentation; G-DO

SD-11 Closeout Submittals

Closeout QC Checklist; G-DO

1.12 SUBMITTAL REQUIREMENTS

1.12.1 Installation Drawings

All Installation Drawings must conform to the following:

a. Manufacturer's Literatures - The submittal information must have annotation of project's equipment identification (name and/or tags) on their respective sheets. Where equipment vendor's standard product data sheets and/or drawings are furnished which cover a number of variations of the general class of equipment, the information must be annotated to indicate exactly which equipment, parts, and/or accessories are being furnished. Technical data such as equipment ratings, operation parameters, performance data must be provided for each specific piece of electrical equipment as specified.

b. General Arrangement Drawings - The general arrangement (GA) drawings must indicate the physical and electrical limits of the microgrid(s) and all associated point of interconnections including site physical map showing site electrical distribution system; and locations of

POIs, controllable switches, switchgear, and other equipment that are part of the project microgrid. The drawing will delineate between new system and existing system.

c. Physical Dimensioned Drawings - Provide physical dimensioned drawings for electric service equipment including but not limited to: switchgear, control panels, operator control console, etc. Outline drawings must depict graphically and dimensionally the configurations, profile, and limitations of parts and assemblies.

d. Wiring Diagrams - Provide applicable one-line, three-line and schematic diagrams to shows wirings, connections and interconnections of the electrical system installation, equipment or its component devices and parts. Drawings must provide such detail as is necessary to be able to trace the electrical circuits and connections involved. The drawings must include cable numbers, conductor colors, pair/triad numbers, terminal source and designation identifications. If cables are shielded, the shields must be shown on the drawings. All spare conductors must be shown on the drawings.

e. Point to Point Wiring Diagrams - Provide applicable wiring diagrams showing line by line connections of wiring at both ends. Drawings must include cable numbers, conductor identification by color or number. Show cable shielding and number of spares on the drawings.

1.12.2 Shop Drawings

Submit copies of vendor, producer or manufacturer data for materials, devices and subsystems or standard or proprietary products. Include design and installation shop drawings, catalog cuts, specifications, testing requirements, and installation instructions for the following items, but not excluding other items or materials not specifically mentioned herein.

Submit manufacturer's instructions, printed product literature and product data including at a minimum, product characteristics, performance criteria, physical size, weights, arrangements of components, type of material used, type and characteristics of used electrical devices and the minimum space for the erection and maintenance.

System integration and/or engineered system shop drawings must be stamped and signed by registered professional engineer. Equipment shop drawings are not required to be stamped and signed by professional engineer but must have applicable equipment certification and/or label.

Prepare and submit installation shop drawings showing complete microgrid system interconnection and integration for Engineer's review and approval. The installation shop drawings must include layout, assembly, and installation drawings of equipment, components terminal boxes and terminations drawings, schematic diagrams, point-to-point interconnection wirings with cable tags and termination identification for field installation.

Identify any constructability issues or conflicts between manufacturers' shop drawings and contract documents (drawings and specification) during the Contractor shop drawing review and installation drawing development process. Identify variations between Contract Documents and product or system limitations or functionality that may be detrimental to the successful performance or operation of the completed work. Submit

proposed resolutions for review and approval by the Engineer.

Comprehensive Bills of Material must be included for each of the proposed major items of equipment and systems and sub-systems.

Complete assembly and installation drawings must be furnished. These drawings must clearly indicate how the work is to be performed in the field including requirements for operation and maintenance access and as required by applicable codes.

Submit electronic copies of all required shop drawings, unless otherwise directed, that include shop, assembly, installation, schematic and wiring Drawings. Drawings must be prepared for all electrical power, control and communication systems and must describe in physical, functional, schematic and wiring terminologies the proposed systems.

1.12.3 Draft As-Built Drawings

Draft As-Built Drawings as a single complete package: electronic drawings in PDF format for review before final set is issued.

1.12.4 Final As-Built Drawings

Final As-Built Drawings as a single complete package: 4 hard copies and 4 digital copies on CDROM. Submit hardcopy drawings on ISO A1 34 by 22 inches and A3 17 by 11 inches sheets, and electronic drawings in both PDF and AutoCAD format.

1.12.5 Implementation Plan

Operational Philosophy including explanation of modes and sequences of operation.

1.12.6 Microgrid Installation Design Package

Microgrid implementation documentation including implementation plan, operating philosophy, mode of operations, sequence of operation for each mode of operation and operating scenarios.

1.12.7 Operation and Maintenance (O&M) Instructions

Four bound O&M Instructions and 4 copies of the O&M Instructions in PDF format on optical disc. Index and tab bound instructions. Submit instructions in PDF form as a single PDF file with a PDF file table of contents containing links to the other files. O&M Instructions may be submitted as a Technical Data Package.

1.12.8 Preventive Maintenance Work Plan

Four copies of the Preventive Maintenance Work Plan. The Preventive Maintenance Work Plan may be submitted as a Technical Data Package.

1.12.9 Operational Training Documentation

Training manuals for Basic Training delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Submit two copies of the Course Attendance List with the archival copies. The Basic Training Documentation may be submitted as a Technical Data Package.

1.12.10 Maintenance and Configuration Training Documentation

One set of training manuals delivered for each trainee on the Course Attendance List with two additional copies delivered for archival at the project site. Submit two copies of the Course Attendance List with the archival copies. The Advanced Training Documentation may be submitted as a Technical Data Package.

1.12.11 Closeout QC Checklist

Submit four copies of the Closeout QC Checklist.

Provide printout documentation of programming logic, system configuration, and parameter settings as implemented for all equipment requiring programming, configuration setup, and parameter settings organized by DER system and by specific equipment.

1.13 TEST EQUIPMENT

Provide all test equipment unless otherwise noted in the contract documents. Use only test equipment with current calibration traceable to the National Institute of Science and Technology (NIST). For each test instrument, submit Test Instrumentation Calibration Certificates demonstrating calibration traceable to NIST. Use test equipment and test methods such that the overall accuracy of the test method, including all test instrumentation and any errors inherent in the test procedure, is at least 50 percent better than the accuracy specified for the sensor. For example, if a temperature sensor has an accuracy requirement of plus or minus 1 degree Farenheit degree overall accuracy of the test method, must be 0.5 degree Farenheit or better.

When validating sensor accuracy, the test instrument is treated as if it is perfectly accurate; that is, the measured value from the test instrument must lie within the bounds of the specified accuracy of the sensor. Expressed mathematically:

Given:
Sensor accuracy: Plus or minus X
Sensor reading: Y
Test equipment reading: Z
Where X, Y and Z are real numberts.

Then
Sensor passes if: (Y-X) <= Z <= (Y+X)
otherwise, sensor fails

PART 2 PRODUCTS

Equipment indicated by manufacturer, brand name and/or by model number or other specific identification are intended to form the basis of the design. Equipment by other manufacturer may be acceptable provided that it meets the contract requirements and that it is equal in function, performance, quality and other salient features. The contract must provide document showing clear evidence by comparison of equal in function, performance, quality and salient features of substitutions of equal named products by other manufacturers. Equivalent item manufactured by another manufacturer, subject to approval by the engineer with the understanding that all design and/or method of installation changes

required by the substitution must be made by the Contractor at no additional cost to the contract.

Amendment 0002

2.1 MICROGRID CONTROL SYSTEM PRODUCT REQUIREMENTS

The microgrid controller and system protection will comply with IEEE 1547, IEEE 2030.7 and IEEE 2030.8 and meets the functional requirements specific to microgrids. The microgrid control system will consist of **one** real time automation controller, DER control interface terminal units, **a** local human-machine interface (HMI) computer station, **one** network switch, network security gateway, satellite-synchronized network clock, and protective relay system. The control system network architecture will be configured to provide a robust and reliable data communication network via loop communication links between the microgrid control system components.

Microgrid controller (MGC) - The MGC serve as a centralized command, control, and communication for the microgrid power system. The MGC provides functional control and monitoring of the microgrid electrical distribution system and the DERs in accordance with the programmed interoperability principles for interactive relationships among the various system components. The MGC runs powerful algorithms to monitor electrical loads, DERs capacity and power production, the electrical distribution system operating parameters and execute command and control functions including disconnection and reconnection of microgrid to the utility grid, dispatch of DERs, active and reactive power sharing, peak shaving, maintaining system voltage and frequency stability in island mode, and the black-start sequence. A touch screen human-machine interface (HMI) will be provided for controlling and monitoring microgrid power system including mode of operations, control parameters adjustments, motoring of real-time data, manage alarms, track critical parameter trends, event logs, and reporting.

DMZ Router - One switch is used to provide the interface with the DERs communicating all necessary commands, control and monitoring data between the DERs local controller to the MGC.

Amendment 0002

2.2 APPLICATION SOFTWARE, OPERATING SYSTEM, AND LICENSES

Provide all the required software packages with the relevant licenses, programming, and system configurations necessary to implement the microgrid system protection and control functions as described in the project specification.

The licenses must not have restriction concerning the number of signals that can be managed. Neither partial licenses (like database licenses with limitation on record number configuration) nor fixed deadline licenses are acceptable.

All system configuration and application developed for project application must be provided both in compiled and in source version, in order to allow any modification and reload by the Owner/Contractor.

The source files must be properly commented during the implementation to allow a complete understanding by the operation and maintenance staff.

Detailed operating instruction for programming and configuration must be supplied by the Vendor.

Standard software license must be assigned to Owner for software provided upon initial installation of each software component. Software licenses must be issued in Owner's name and transferred without restrictions to Owner upon completion of Project.

Extend to Owner all rights of software purchased including telephone support during warranty period must be extended to the Owner.

Complete software and programming backup package must be provided by Vendor at the end of the project.

2.3 MICROGRID CONTROL SYSTEM PRODUCT SPECIFICATION

2.3.1 Real-Time Automation Controller (RTAC)

The device must operate as a computer with network access to provide a combination of functions including, but not limited to, visualization and control of process equipment, data aggregation, simultaneous collection of data from serial and Ethernet server devices, and simultaneous data access for multiple client devices. The device must conform to various industry standards, operate in harsh environments, and provide the operational and functional requirements as described below.

The RTAC system must operate simultaneously on multiple serial and Ethernet communications networks. It must provide a combination of functions that include digital input and digital output support, deterministic logic processing, automatic transmission of outgoing messages and processing of responses, data scaling, data aggregation, simultaneous collection of data from multiple server devices, and simultaneous data access for multiple client (master) devices.

a. Power Supply. The device must be available with dual modular hot-swappable power supplies capable of load sharing and operating concurrently among independent power sources on a wide range of both ac and dc input power source voltages: 120/240 Vac.

b. Temperature. The device must be capable of continuous operation over a temperature range of -40 degrees F to +120 degrees F.

c. Environmental Testing. The device must be tested to the same standards as protective relays including IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3, IEC 60255-26, IEC 61000-4-2, IEC 61000-4-4, and IEEE C37.90.1.

d. Communications Ports. The device must come standard with a minimum of two USB ports, two serial ports, and two rear-panel Ethernet ports. Each standard serial port must be TIA-232, BIOS selectable for +5 Vdc port power and capable of operation at 300-115200 bps. Ethernet ports must be independent 10/100/1000 Mbps.

e. Hot-Swappable Industrial Solid-State Drives. The device must have high quality, industrial-temperature rated hard drives. All drives must support hot-swapping.

f. Configuration. Configuration of messages and data processing functions must be through a simple GUI interface. Configuration

interface must be through local keyboard, mouse, and monitor port.

g. Alarm Output. There must be an alarm contact output to signal internal errors and malfunctions. The alarm contact must be supervised by an internal watchdog system that independently monitors the operating system.

h. Operating System. The device must support at least one of the following operating systems: Microsoft® Windows® 7, Windows 8/8.1, Windows 10, Windows Server® 2008 R2, Windows Server 2012 R2, CentOS Linux® 6, CentOS Linux 7, Red Hat® Enterprise Linux 6, Red Hat Enterprise Linux 7, and VMware® ESXi™ 5.x.

i. Nonvolatile Storage. There must be flash memory used as nonvolatile storage of settings, configuration, and incoming and calculated data within the RTAC. Data stored in the nonvolatile memory must be available for retrieval after sustained power outage, including failure of the internal battery.

j. Manufacturer. The device must be manufactured in the United States.

k. Warranty. The device must include a ten-year warranty for all material and workmanship defects.

2.3.2 Modular Input/Output Backplane

The BackPlane must be dependable, ultra-rugged and designed for harsh environments in a fully integrated, flexible platform.

The microprocessor-based controller system must have the following general features:

a. Real-Time Automation Controller (RTAC) provides high-speed, deterministic control and performance.

b. Modular design supports custom configuration mix of analog and digital I/O options.

c. Provide a 10-slot chassis for large I/O control and monitoring applications.

d. Hardware and components meet or exceed IEEE 1613 specifications for harsh conditions.

e. A whitelist antivirus technology that allows only authorized applications to run.

2.3.2.1 Operational and Functional Requirements

a. Protocols. The information processor must provide the following protocols:

(1) Server: SES-92, FTP, SFTP

(2) Client: CP2179, ASCII and Binary, SNMP

b. Client/Server: DNP3 serial, DNP3 LAN/WAN, IEC 61850 MMS, Modbus® RTU, Modbus TCP, LG 8979, IEEE C37.118, IEC 60870-5-101/IEC 60870-5-104

c. Peer-to-Peer: IEC 61850 GOOSE transmit and receive messages, Parallel Redundancy Protocol

d. Digital Inputs Sequential Events. The system must maintain a user-configurable record of digital input operations on the EtherCAT network that is accurate to 1 ms.

e. DC Analog Inputs. The system can include as many as 16 DC analog input modules.

f. DC Analog Outputs. The system can include as many as 16 DC analog output modules.

g. DC Analog Outputs. The system can include as many as 16 DC analog output modules.

h. AC Protection Inputs. The system can include as many as 16 CT/PT protection modules.

i. Intelligent and Secure Components. All electronic equipment must continuously self-test and report internal errors. The system must have a hardwire contact indicating system health.

j. IEC 61131-3 Programming. The system must include an integrated IEC 61131-3 programming environment, with the ability to monitor and control every connected EtherCAT I/O module, protective relay, and other serial or Ethernet-based intelligent electronic devices (IED) continuously. The IEC 61131-3 programming environment must be integrated in one software package with the communications protocol mapping environment.

k. Role-Based Security. The system must incorporate independent user-based security with strong passwords, role-based accounts, and settable account expirations dates. The system must provide a mechanism to map security related system tags into SCADA reports.

l. Redundant Power Supply Operation. The system must allow the use of two power supply modules that continuously share load. If the incoming power for one module becomes unavailable, the remaining power supply must have sufficient capacity to accommodate an entire node.

m. High-Speed Peer-to-Peer Communication. The system must use IEC 61850 GOOSE protocol to transmit and receive high-speed digital data to/from IEDs to create custom protection and control schemes. IEC 61850 GOOSE must be an available option for the system.

n. IEC 61850. The information processor must have an option to support IEC 61850 GOOSE transmit and receive messaging. There must also be an option to support IEC 61850 MMS client/server for polling and sending data sets and reports from IEDs.

o. Serial Communications Ports. The system must have four serial ports that must be software configurable for TIA-232 or TIA-485 communications modes. Each serial port connector must have an available demodulated IRIG-B time-synchronization signal.

p. Ethernet Communications Ports. The CPU module for the system must have two Ethernet ports that can operate simultaneously on different networks through independent MAC addresses.

q. Alarm Output. There must be an alarm contact output to signal internal errors and malfunctions. The alarm contact must be programmable so that the alarm conditions that activate the output can include additional conditions.

r. Environmental Testing. All system modules must be tested to IEEE 1613 for communications and networking equipment in electric power substations. The system modules must also be tested to the same standards as those used for protective relays.

s. Retained Memory. The system CPU must have nonvolatile memory available for user-programmable retained variables.

t. Engineering Access. The system CPU must have methods to create transparent connections between any two serial or Ethernet communications ports for engineering access.

u. Reliability. The vendor must supply the actual measured mean time between failures (MTBF) for the device upon request.

v. Service. The device must include no-cost technical support for the life of the product.

w. Manufacturer. The device must be manufactured in the United States of America.

x. Conformal Coating. The device must have UL CSA conformal coating for each module to protect the circuit boards from harsh environments.

y. Warranty Return. The manufacturer will endeavor to support a 72-hour turnaround on all warranty repairs.

z. Warranty. The device must include a ten-year warranty for all material and workmanship defects.

aa. Remote I/O Expansion: Provide capability to increase the number of I/O points with as many as 60 modules.

2.3.2.2 Processor Module

a. Processor speed: 533 MHz

b. Memory: 512 MB DDR2 error-correcting code (ECC) RAM

c. User storage 2 GB I/O Modules

2.3.2.3 Input and Output Modules

a. Digital input 24 contact inputs

b. Standard digital output 16 standard control outputs

c. FHC digital output 10 fast, high-current control outputs

d. DC analog input 16 transducer inputs

e. DC analog output 8 self-sourcing outputs

2.3.2.4 Security Features

a. Account Management: Lightweight Directory Access Protocol (LDAP) and Microsoft® Active Directory® user accounts; User roles; Strong passwords

b. Intrusion Detection: Access/audit logs; Syslog; Alarm LED; Alarm contact

c. Secure Encrypted Communications: TLS/SSH; HTTPS

d. Communication protocols:

(1) Client: DNP3 Serial, DNP3 LAN/WAN, Modbus RTU, Modbus TCP, ASCII, IEEE C37.118, IEC 60870-5-101/IEC 60870-5-104, IEC 61850 MMS, LG 8979, CP2179

(2) Server DNP3 Serial, DNP3 LAN/WAN, Modbus RTU, Modbus TCP, IEEE C37.118, IEC 61850 MMS, IEC 60870-5-101/IEC 60870-5-104, SES-92, LG 8979

2.3.2.5 Programmable Control

a. Peer-to-Peer: IEC 61850 GOOSE, NGVL

b. IEC 61131-3 logic engine

c. Programming languages: Ladder diagram; Structured text Continuous function chart; and Tag processor

2.3.3 Network Switches

Network switches shall meet the following requirements:

a. Modular Hardware. Modular hardware design shall permit repair or reconfiguration of the switch through the use of hot-swappable, field-replaceable modules.

b. SNMP. The front and back ports of the switch shall support SNMP v2c and SNMPv3.

c. Suitability for Harsh Environments. The switch shall meet IEEE 1613, IEC 61850-3, and IEC 60255 standards.

d. OpenFlow Support. The switch shall support OpenFlow 1.3.

e. Deny-by-Default Security. The switch shall support a deny-by-default security architecture.

f. Activity Indications. The switch shall support local indications of traffic activity.

g. Secure Flow Controller Communications. The switch shall only support secure communications with the flow controller.

h. Flow Retention Through Power Cycles. The switch shall maintain all flows, groups, and meters through a power cycle without the need for the flow controller to be online.

i. Secure Firmware Upgrading. The switch shall support authentication of firmware through digital signatures.

j. Network Time Protocol (NTP) Time Synchronization and Distribution. The switch shall be able to perform as an NTP client.

k. Precision Time Protocol (PTP). The switch shall support IEEE C37.238 Power Profile Transparent Clock with syntonization.

l. Dual Power Supply. The switch shall have a redundant power supply option.

m. Logging. The switch shall log events locally and forward them to both the flow controller and remote syslog servers with the ability to send logs through acknowledged and secure transport.

n. Reliability. The vendor shall supply the actual measured mean time between failures (MTBF) for the switch upon request.

o. Warranty. The switch shall include a ten-year warranty for all material and workmanship defects.

2.3.4 Satellite-Synchronized Network Clock

a. The Satellite-Synchronized Network Clock receives Global Navigation Satellite System (GNSS) time signals and distributes precise time via multiple output protocols, including IRIG-B and the Network Time Protocol (NTP). Provide Parallel Redundancy Protocol (PRP) to support a Dual-Attached Node (DAN) device for NTP time distribution.

b. GNSS Antenna

(1) IP68 rated, surge immunity

(2) Receiver for both GPS and GLONASS signals

(3) Temperature rating -40 Degree F to 185 Degree F

(4) Mount: Surface Mount Kit

c. Coaxial Cable

(1) LMR-400

(2) Connectors: TNC

(3) Length: 25 feet

(4) Rated: Indoor/Outdoor

2.3.5 Rack-Mount Touchscreen Monitor(s)

Touchscreen Monitor(s) must be 19 inch diagonal display, active matrix TFT LCD (LED), 1280 x 1024 resolution. The touchscreen monitor must provide a high-quality display and user-friendly touch interface for applications. The PCAP (capacitive) touch interface has multitouch capability, with a scratch-resistant glass surface and drift-free accuracy. The touchscreen monitor kit to include the touch monitor, rack-mount bracket, and power supply.

2.3.6 Rack-Mount USB Keyboard with Integrated Trackball

Provide keyboards, 104-key keyboard, 3-button trackball, 2 USB ports, rack-mount installations that can be stowed in the rack when not in use.

2.3.7 Control Devices

Provide fused, circuit breakers, control switches, indication lights, displays, relay devices, terminal blocks, wire management, and other components and hardware as required to perform the control functions as indicated on drawings and as specified. Furnish standard catalog electrical components items under regular manufacture with pre-existing catalog ratings equal to or better than the requirements of the contract drawings and specifications. Accompany request for approval of equipment other than as specified or as indicated by technical and descriptive data and specifications sufficient for the Engineer to determine its adequacy. Unless otherwise specified or indicated, electrical materials and equipment must meet the standards, specifications, and tests referenced. Submit data specifications and assembly drawings showing sizes, ratings, parts and material lists, overall dimensions, and mounting dimensions with the product data.

2.3.8 Control Circuit Wiring

The wiring within the control cabinet(s) must be arranged systematically so that all circuits can be readily traced. All conductors must be terminated on easily accessible terminal blocks mounted inside at the rear or as appropriately determined by the microgrid control systems vendor. Spare terminals that total at least 20 percent of those actually used must be provided. All circuit wirings must be clearly identified and correspond to the shop drawing circuit wiring diagrams.

PART 3 EXECUTION

3.1 INSTALLATION

Verification of Conditions: verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for installation in accordance with manufacturer's written instructions.

The electrical installation work must be installed as indicated on the Contract Drawings and in accordance with approved shop drawings and manufacturer's recommendations.

All associated construction and installation work must be installed using good installation judgement and in accordance with all prevailing national and local codes and ordinances.

3.2 TESTS, INSPECTIONS, AND VERIFICATIONS

Testing must include all system hardware, communications, back-up and redundancy operations, 100 percent of I/O points (including spares) with simulated inputs and outputs (hardware I/O simulator with real tag numbers must be arranged before testing), local panel (if any), and any other external device communications interface. Testing must also include complete integrated testing of the interfaces including Distributed Generator Resource (DER) control panels and associated field devices.

Testing must include functional tests of all logic block diagrams, including all associated interfaces with the operator console and graphic displays. All testing is to be carried out to show that the system operates correctly and in compliance with the performance requirements of the contract.

In the event testing is interrupted for repairs or modification of the Microgrid Control System, the Contractor/Owner may require testing be restarted completely.

Provide all necessary test equipment and software including any special software or hardware required for a complete functional test of the system.

The supplier/equipment vendor of microgrid control system and the DER package must provide the necessary assistance to co-ordinate the field tests, to supervise the commissioning and start-up activities.

3.3 FACTORY ACCEPTANCE TEST (FAT)

Performs Factory Acceptance Testing (FAT) to verify functional performance of all systems prior to shipment. An FAT may include but is not limited to dimensional check-out, wiring verification, system leak checks and control logic check-out.

Schedule and testing procedures must be submitted to Government or Government's Representative as early in the design as possible, but not less than 60 days prior to test. After schedule approval, at least 4 weeks prior to the start of testing, the Vendor must provide the following documentation:

a. Detailed FAT procedure

b. Full documentation concerning hardware

c. Full documentation concerning software configuration complete with relevant comments

Hardware FAT must be performed before and independently from Software FAT.

During the test, all the mentioned documents must be available.

A check list must be issued during the FAT at Vendor's workshop. Detailed check list must be prepared by the Vendor and included in the FAT procedure. Other tests can be required according to the project needs and will be defined during detailed engineering.

The control system must be installed in its final configuration and mainly the following items must be tested:

a. Project documentation check

b. Visual check in order to verify the equipment quantities and conformity to drawings and contractual characteristics, identification tags, safety coverings, cable run, interconnection between panels, etc.

c. Hardware components and power supply

d. Insulation resistance and dielectric test of components

e. Redundancy systems test

f. Test of all I/O cards

g. Test of loss of power and subsequent power up

h. Automation Control System diagnostic

i. Application software

j. HMI Graphics

k. Communication

l. As general statement, 100 percent of hardware (spares included), application software, and communication must be tested.

All the necessary hardware components and software application necessary to perform the test will be provided by the Vendor.

After the completion of the hardwired FAT, testing procedure must foresee a complete integrated testing of the Microgrid Control System using Hardware in the Loop (HIL) power system simulation to evaluate the performance of the Microgrid controllers.

All the anomalies, defections or changes will be reported and corrected by the Vendor before the end of testing or, at least with the Contractor approval, before shipment. Re-test and approve all punch list items before the Automation Control system may be released for shipping. If during the test activity problems occur so that it will be difficult to continue, in the opinion of the Contractor personnel, the testing will be interrupted until the Vendor remedies to these problems. In the event testing is interrupted for repairs or modification of the Automation Control System, the Owner or Contractor may require testing to be restarted from the beginning.

Positive result in the test does not release the Vendor from his responsibilities to provide a system completely working and to perform all the modification, which could be necessary to assure system correct working in the field.

After successful completion of the FAT, completed Factory Acceptance Test Reports must be signed by the Vendor and Contractor and Owner's Engineer/Government Representative.

A final report must be issued at the end of FAT, highlighting possible reservation as far the Contractor/Owner are concerned; shipment authorization will be generally issued by the Contractor only after the complete solution for the pending reservation.

3.4 HARDWARE IN THE LOOP (HIL) TEST

Hardware in the Loop (HIL) power system simulation must be performed to evaluate the performance of the Microgrid controllers.

The components that comprise microgrids must include distributed energy resources (DERs), protection equipment, and distribution equipment.

The following information will be provided to VENDOR to be used for HIL

power system simulation:

a. Project system one-line diagram

b. Utility's Thevenin equivalent and available fault current

c. Generator ratings, capacity, exciter, and governor data

d. Distribution transformer ratings and capacity

e. Feeder cables information

f. Distribution feeder and loading characteristic

The Hardware in the Loop (HIL) power system simulation must be performed to evaluate the performance of the Microgrid controllers under various operating conditions. All viable operating condition must be simulated and tested that the Microgrid control system performances are in compliance with IEEE 2030.7 and IEEE 2030.8 microgrid controller standards. As a HIL power system simulation must include as a minimum the following operating scenarios:

a. Grid Connected Mode (Normal Mode of Operation, generator units are off-line)

    (1) Utility outage event

    (2) High-impedance and low-impedance fault events on the incoming utility line

    (3) High-impedance and low-impedance fault events on the microgrid distribution feeder circuit

    (4) Test the effect of loss of communication (failed network switch)

b. Planned Disconnect from the Utility Grid (with Generator units coming online before the Microgrid islanding)

    (1) Verifies permissive conditions of the microgrid power system to initiate GOTO ISLAND MODE (disconnect from the utility grid) process.

    (2) Starts standby generator units to provide additional spinning reserve and inertia on the microgrid.

    (3) Changes one DER (Generator Unit) to isochronous mode.

c. Planned Disconnect from the Utility Grid (generator units come-online after the Microgrid islanded)

    (1) Verifies permissive conditions of the microgrid power system to initiate GOTO ISLAND MODE (disconnect from the utility grid) process.

    (2) Starts standby generator units to provide additional spinning reserve and inertia on the microgrid.

    (3) Changes one DER (Generator Unit) to isochronous mode.

d. Unplanned Disconnect from the Utility Grid (while exporting power to grid at at various kW setpoints).

(1) Simulate fault events to cause the PCC breaker to trip.

e. Island Mode (Contingency Mode of Operation)

(1) Generator units

(a) Test the effect of High-impedance and low-impedance fault events on the microgrid distribution feeder circuit.

(b) Test the effect of utility outage event.

(c) Test the effect of loss of communication (failed network switch).

f. Transition from Island Mode to Grid Connected/Parallel Mode.

(1) While in Island Mode with Generator unit(s) on-line only - Reconnect (resynchronization using generator unit synchronization controller) the Live Microgrid to the Utility Grid (transition from Island Mode to Grid Connected/Parallel Mode).

g. Reconnect the Dead Microgrid to the Utility Grid (Blackout State to Grid Connected Mode)

After successful completion of the HIL test, provide documentation of completed hardware in the loop test report, signed by both Vendor and Contractor's Representative. Note any corrective actions taken as a result of the test.

System control logic and parameters adjustment:

a. Make adjustments necessary to optimize the performance of the Microgrid Control System and the protective relay system with system resiliency as the primary objective.

b. Provide system configuration and program logic ready for field application based on specified mode of operations.

3.5 MICROGRID SYSTEM FIELD TESTING AND COMMISSIONING

3.5.1 Commissioning

Conduct commissioning accordance with Section 01 46 00.00 07 COMMISSIONING - MICROGRID.

3.5.2 General Requirements

Testing and Commissioning Plan (Cx) is a planned program of tests, procedures and checks to be carried out systematically on devices, equipment, sub-systems and integrated systems to ensure the design and construction of the microgrid system meet project requirements and constructed and operate as intended by the design team and users.

Commissioning activities must be a systematic process of ensuring that the subject systems perform according to the design intent and the Owner's operational requirements. All equipment and systems should be installed

according to manufacturer's recommendations and the best practices and standards of the industry. The following are goals and objectives:

a. The devices, equipment and systems have been properly installed and checked per manufacturer's recommendations.

b. The devices, equipment and systems operate and function properly.

c. Verify and document system performance with thorough functional performance testing and monitoring.

d. Ensure that the equipment installation and operational performance meet contract requirements, applicable codes and standards.

e. Facilitate the final acceptance of the project.

f. Facilitate the transfer of the project to the Owner's staff.

3.5.3 Commissioning Overview

The commissioning process must be performed in the following stages:

a. Stage 1 - Contractor's Field Tests

b. Stage 2 - Conditional Acceptance Tests

c. Stage 3 - Acceptance Tests

Cx activities supplement field quality and testing procedures described in relevant technical.

Cx must be conducted in concert with activities performed during the defined stage of project delivery.

Cx must identify issues in early project stages to ensure the built swing Microgrid structural, mechanical, power and control systems are constructed and proven to operate satisfactorily under weather, environmental and occupancy conditions to meet functional and operational requirements.

Cx activities must include transfer of critical knowledge to facility operational personnel.

Provide cost as a line item for the Cx with Phase IV of the Endurance Testing cost component broken out separately.

3.5.4 Starting and Testing

Notify Government at least 21 days prior to start of Cx.

Start Cx after elements of the Microgrid affecting start-up and performance verification of systems have been completed.

Contractor assumes liabilities and costs for commissioning. Including disassembly and re-assembly after approval, starting, testing and adjusting, including supply of testing equipment.

3.5.5 Witnessing of Starting and Testing

Provide 14 days notice prior to commencement.

Government to witness of start-up and testing.

Contractor's Cx Agent must be present at tests performed by sub-trades, suppliers and equipment manufacturers. Cx Agent must be responsible for obtaining test reports from the sub-trades, suppliers and equipment manufacturers, and incorporate them into the final Cx report.

3.5.6 Manufacturer(s) and System Vendor(s) Involvement

Factory testing:

a. Coordinate time and location of testing.

b. Provide factory acceptance test plan for approval by Departmental Representative.

c. Arrange for Government to witness tests for equipment requiring factory witness testing per technical specification requirement.

Factory acceptance test must be completed with all issues resolved, documented, and be approved by Department's Representative before factory release of equipment shipment to the project site.

Obtain manufacturers installation, start-up and operations instructions prior to start-up of components, equipment and systems and review with Owner's Engineer or Government Representative.

Compare completed installation with manufacturer's published data, record discrepancies, and review with manufacturer.

Modify procedures detrimental to equipment performance and review same with manufacturer before start-up.

Integrity of warranties:

a. Use manufacturer's trained start-up personnel where specified elsewhere in other divisions or required to maintain integrity of warranty.

b. Verify with manufacturer that testing as specified will not void warranties.

Qualifications of manufacturer's personnel:

a. Experienced in design, installation and operation of equipment and systems.

b. Ability to interpret test results accurately.

c. To report results in clear, concise, logical manner.

3.5.7 Start-Up Documentation

Assemble start-up documentation and submit to Government for approval before commencement of commissioning.

Start-up documentation to include:

a. Factory and manufacturer's field test reports for specified equipment.

b. Pre-start-up inspection reports.

c. Signed installation/start-up check lists.

d. Start-up reports.

e. Step-by-step description of complete start-up procedures, to permit Government to repeat start-up at any time.

3.5.8 Operation and Maintenance of Equipment and Systems

Start-up, operate and maintain equipment and/or systems as directed by equipment/system manufacturer.

With assistance of manufacturer develop written maintenance program and submit to Government for approval before implementation.

Operate and maintain systems for length of time required for commissioning to be completed.

After completion of commissioning, operate and maintain systems until issuance of certificate of substantial completion.

3.5.9 Test Results

If start-up, testing and/or PV produce unacceptable results, repair, replace or repeat specified starting and/or PV procedures until acceptable results are achieved.

Provide manpower and materials, assume costs for re-commissioning.

3.5.10 Instruments/Equipment

Submit to Government for review:

a. Complete list of instruments proposed to be used.

b. Listed data including, serial number, current calibration certificate, calibration date, calibration expiry date and calibration accuracy.

Provide the following equipment as required:

a. 2-way radios.

b. Ladders.

c. Equipment as required to complete work.

3.5.11 Commissioning Performance Verification (PV)

Carry out Cx in accordance with Cx Plan:

a. Under actual operating conditions, over entire operating range, in all modes of operation.

b. On independent systems and interacting systems.

Cx procedures to be repeatable and reported results are to be verifiable.

Follow equipment manufacturer's operating instructions.

3.5.12 Authorities Having Jurisdiction

Where specified, start-up, testing or commissioning procedures duplicate verification requirements of authority having jurisdiction, arrange for authority to witness procedures so as to avoid duplication of tests and to facilitate expedient acceptance of facility.

Obtain certificates of approval, acceptance and compliance with rules and regulation of authority having jurisdiction.

Provide copies certificates of approval to Government within 5 days of test and with Cx report.

3.5.13 Checks, Adjustments, and Tuning

Perform static and operational checks as applicable and as required.

Make necessary adjustments and tunings to optimize system performance as part of the commissioning process.

3.5.14 Deficiencies, Faults, Defects

Correct deficiencies found during start-up and Cx to satisfaction of Departmental Representative.

Report problems, faults or defects affecting Cx to Government in writing. Stop Cx until problems are rectified or interim corrective measures are in place for continuation of Cx in safe manner and without potential damage to equipment. Proceed with written approval from Departmental Representative.

3.5.15 Training

Microgrid specific additional training requirements:

a. Provide training at Owner's site facilities following substantial completion. Training shall include aspects of operator's interface, system operation, and maintenance. Purpose of training session will be to answer questions by operations and maintenance personnel, which have arisen out of initial use of system during site acceptance and commissioning activities.

b. Furnish training programs to train Government and Local utility personnel in administration, configuration, operation, and maintenance of microgrid control system.

c. Two separate training programs shall be developed. Sessions shall be presented as operational training (2 sessions) and maintenance and configuration training (1 session). Training programs shall be conducted for numbers of personnel as listed below.

(1) Operator Training Group A: 6 personnel.

(2) Operator Training Group B: 6 personnel.

(3) Maintenance and configuration training:

(a) 10 maintenance technicians/personnel.

(b) 4 engineers/personnel.

d. Provide following quantities of training:

(1) Operator Training Group A: minimum 8 hours.

(2) Operator Training Group B: minimum 8 hours.

(3) Maintenance and Configuration Training: 12 hours over 2 days.

e. Provide copies of training material for Owner.

f. Provide training to familiarize Owner' personnel with system. Training shall be oriented toward installed equipment and software and satisfy requirements for following.

(1) General training: Familiarize project management personnel, engineers, operators, and maintenance personnel with control system overview, philosophy, major hardware components, reporting, and data retrieval.

(2) Operator training:

(a) System equipment operation, both individually and collectively as operating system.

(b) Procedures required to operate and to modify each process from operator's workstation.

(c) Normal and abnormal startup and shutdown operating conditions.

(d) Operator/control system interactions in conjunction with use of process information system functions.

(3) Programmer training:

(a) Use and modify programs, as desired, during plant operation.

(b) Compose and generate required monitor-based process graphics and report/log formats.

(c) Write, edit, file, delete, and apply applicable programming language and high-level process control language programs necessary to implement control system and process information functions.

(d) Function and use of support and application software.

g. Training shall be taught by person with significant training experience. Instructor and course materials shall be approved in advance of training.

h. Tuition costs associated with training shall be included with Bid. For on-site training, food, lodging, and travel expenses for trainer shall be included.

i. Courses shall be scheduled such that courses do not overlap to allow same personnel to attend more than one training course.

j. Training shall be scheduled by system supplier minimum of 60 days in advance of start of training.

3.5.16 Maintenance Materials, Spare Parts, Special Tools

Supply, deliver, and document maintenance materials, spare parts, and special tools as specified in contract.

3.5.17 Installed Instrumentation

Use instruments installed under Contract for TAB and PV if:

a. Accuracy complies with these specifications.

b. Calibration certificates have been deposited with Departmental Representative.

3.5.18 Performance Verification Tolerances

Application tolerances:

a. Specified range of acceptable deviations of measured values from specified values or specified design criteria as indicated in technical specifications.

b. Instrument accuracy tolerances: To be of higher order of magnitude than equipment or system being tested.

c. Measurement tolerances during verification: Unless otherwise specified actual values to be within +/-2 percent of recorded values.

3.5.19 Owner's Operational Testing

Operational testing of Government's facilities, equipment or system by Government will not relieve Contractor from compliance with specified start-up and testing procedures.

The government will only proceed with operational testing of equipment or system after received, in writing, that the Stage 2- Conditional Functional Testing has been completed and correction of all outstanding deficiencies has been satisfactorily completed.

3.5.20 Testing and Commissioning Stages

The work under this item is to demonstrate that all of the Microgrid System including auxiliary systems have been correctly installed and function properly.

Provide all test equipment, safety equipment, personnel, and monitoring devices necessary to show each piece of equipment has been installed, operates properly, is in proper operating condition, and integrated into the Microgrid power and control system.

Testing and Commissioning must include the following stages:

STAGE 1 - CONTRACTOR'S FIELD TESTS
STAGE 2 - CONDITIONAL ACCEPTANCE PERFORMANCE TESTS
STAGE 3 - ACCEPTANCE TESTS
STAGE 4 - ENDURANCE TESTS

3.5.20.1 Stage 1 - Contractor's Field Tests

General Electrical Test Requirements

a. Inspection and testing must be performed on all new installations and alterations to an existing installation in accordance with the requirements of this Section. The NETA ATS must be referred and adopted where appropriate. In the event of any test indicating failure to comply, that test and those preceding, the results of which may have been influenced by the fault indicated, must be repeated after the fault has been rectified. Provide all necessary test equipment, labor, and personnel to perform the tests, as herein specified. The following tests must be performed.

b. Continuity Test: Perform continuity test to insure correct cable connection (i.e. correct phase conductor, grounded conductor, and Grounding conductor wiring) end-to end. The continuity of all conductors, including the circuit protective conductor of every ring final circuit, must be verified for proper installation. The wire and cable must be isolated completely all from all extraneous electrical connections at cable terminations and joints. Repair and re-verify any damages to existing or new electrical equipment resulting from improper wiring.

c. Insulation Resistance: Perform insulation-resistance test on electrical switchgear, motors, and on each field-installed power and control conductor with respect to ground and adjacent conductors. For general facility branch circuit load conductors (i.e. serving lights, receptacles, power outlets, exhaust fans, etc.) with conductor sizes 10 AWG and smaller, insulation resistance testing is not required. The insulation resistance of the installation must be tested in accordance with the NETA ATS. The resistance measured must not be less than the recommended values set by the NETA testing standards pending on voltage class.

d. Contact Resistance: Perform a contact-resistance test on each connection point of uninsulated busway, across each contactors, switchblade and fuse holder of motor controllers/starters, interrupters, and isolation switches.

e. Grounding System Resistance: The resistance of every ground electrode must be measured to ensure that the ground resistance of the ground electrode will perform the intended design function and comply with the applicable code requirements.

(1) Perform three-point fall-of-potential test per IEEE 81 on the main grounding electrode or system. Resistance must be no greater than 5 ohms.

(2) Perform the two-point method test per IEEE 81 to determine the ground resistance between the main ground system and all major

electrical equipment frames, system neutral, and/or derived neutral points. Resistance must be no greater than 5 ohms.

f. Polarity Test: Polarity test must be performed to verify proper connection of voltage transformers, current transformers, meter, protective relay devices, electrical instruments, and proper connection to other electrical equipment.

g. Phasing: Conduct phase-rotation tests on all three-phase circuits using a phase-rotation indicating instrument. Perform phase rotation of electrical connections to connected equipment clockwise, facing the source. Motor circuits must be checked for proper rotation and motors "bumped" to verify correct machine rotation. Interconnection points between different source circuits must be verified for proper phasing connections.

h. Load Balancing: Perform load balancing of switchboards and panelboards. Measure phase current to panelboards in normal operating condition at time of acceptance; adjust branch circuit connections as required to obtain best balance of current between phases and record changes.

i. Equipment Test: Testing on electrical equipment and appliances supplied within the electrical installation contract, e.g. switchboard, motor, generator, busway, pumps, exhaust fans, etc. must be carried out in accordance with manufacturer's recommended procedures.

j. Perform functional check of the equipment per manufacturer recommendations and/or operating instructions. Provide the services of a factory trained manufacturer's representative to assist the Contractor in the installation and start-up service of the specialized equipment including medium-voltage switchgear, source transfer switches, packaged generator units, and other equipment as required.

k. Obtain the service of a licensed Fire Protection Service Contractor to perform testing of fire protection system upon the completion and readiness of fire protection system installation. The test must also be inspected and/or witnessed by Owner and local official with Authority Having Jurisdiction (i.e. local fire official. Coordinate with the required personnel and/or organizations to inspect and witness the final tests of the fire protection system installations and rectification of any works found not complying with the applicable codes and standards.

l. Testing of Emergency Backup Power System: Perform the following tests for the applicable emergency backup power system (emergency lighting, exit sign, UPS, and emergency generator) included in the scope of the electrical installation contract:

(1) Test the functionality of the emergency lighting system and verify that the lighting levels during emergency condition meet the design requirements and applicable code requirements for safe egress and/or evacuation of personnel.

(2) Perform functionality test of the emergency power system (i.e. emergency generator, UPS, etc.) in accordance to the design requirements, manufacturer's instructions, and recommendations. Ensure that the detection of loss or normal power source, load

transfer, switching scheme and sequence function properly and meet the design criteria.

m. Provide preliminary field Acceptance Performance Test Report for Owner and/or Owner's Engineer for review within 30 days after completion of tests. Acceptance Performance Test Report must be organized by logical system (i.e. power distribution system, control system, lighting, fire alarm, emergency generator, etc.) The test report must include the following:

(1) Summary of project

(2) Date of inspections and tests performance

(3) Environmental conditions: humidity, temperature, and other conditions that may affect the results of the tests/calibrations.

(4) Identification of the testing organization

(5) Identification of the testing technician

(6) Test equipment used to perform the tests with date of test equipment calibrations

(7) Identification and description of equipment inspected and tested

(8) Description of tests

(9) Test data

(10) Analysis of test results

n. The electrical power equipment and system under the scope of the contract must be inspected and tested in accordance with the manufacturer instructions and in accordance with the NETA ATS. These field inspection and acceptance tests of the electrical power equipment and system must be performed to ensure suitability for initial energization, and to ensure that ensure installed electrical power equipment and system perform satisfactorily per manufacturer performance specification. Coordinate project specification. Provide the services of a factory trained manufacturer's representative to assist the Contractor in the installation and start up service of the equipment and to train Owner's personnel as specified.

o. The electrical power equipment and system requiring field inspection and acceptance tests include, but not limited to:

(1) Utility Service Disconnect Switch (Medium-voltage, metal enclosed switchgear)

(2) Utility Service Metering Equipment and Instrument Transformers

(3) Utility Service Switchgear (Medium-voltage, metal-clad switchgear)

(4) Protective Relays and Instrument Transformers

(5) Medium-voltage distribution feeder circuit conductors and terminations

(6) Engine-Generator Units

(7) Distribution Transformers

(8) Low-voltage, Switchboards and Power Distribution Panels

(9) Direct-Current Systems, Batteries, Flooded Lead-Acid

(10) Direct-Current Systems, Chargers/Rectifiers

(11) Uninterruptible Power Systems

(12) Microgrid Control Equipment/Systems

(13) Communication Equipment and Systems

(14) Grounding Systems

(15) Fiber-Optic Cables

(16) Auxiliary heating, cooling and/or ventilation system

(17) Other miscellaneous electrical power equipment and auxiliary systems:

(a) Verify operation of lighting controls (dimming, photo-control, regular switching).

(b) Check loads on all breakers to ensure that the breaker is properly sized.

(c) Enter all schedules per occupant's direction.

(d) For Operator Interfaces: Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.

(e) Output all specified reports for review and approval.

(f) Verify the alarm printing and logging is functional and per requirements.

(g) Validate all interfaces with other systems on a point-by-point basis.

Protective Relay Testing Performance Requirements

a. The testing must be done by an International Electric Testing Association (NETA) accredited testing company by a NETA level 3 or level 4 certified technician.

b. Arrange for the protective relay device to be tested by an independent testing company at Contractor's expense.

c. Provide protective relay testing plan and procedures for approval by Engineer and local utility. Local utility must approve the test procedure before the tests are conducted. For this project local utility must approve the test results and is the final arbiter of the

approval.

d. Coordinate with local utility for the witnessing of the protective relay tests as required by local utility.

Engine-Generator Unit

a. Perform installation check and functional check of the equipment per manufacturer recommendations and instructions. Test system hardware, communications, backup and redundancy system, auxiliary system, 100 percent of I/O points (including spares), local control panel, and other external device power and communications interfaces. Provide the services of a factory trained manufacturer's representative to assist the Contractor in the installation and start-up service of the engine-generator units.

b. Refer to Section 26 32 15.00 ENGINE-GENERATOR SET STATIONARY 15-2500 KW, WITH AUXILIARIES requirements.

Ensure that any inspections require by the local government and regulatory agencies are completed and any applicable permits are obtained before energization of the microgrid power system.

Submit two copies of the equipment test reports to local utility a minimum of 30 working days before energizing the Microgrid Power System. Each test report must identify the equipment tested and that identification must match that in the single-line or three-line diagrams. Coordinate testing and commissioning with local utility and obtain local utility approval of the test reports at least ten working days before local utility energizes the Microgrid Power System.

3.5.20.2 Stage 2 - Conditional Acceptance Performance Tests

Upon successful completion of Stage 1 - Contractor's Field Tests and their acceptance by the Government, demonstrate that Microgrid System meets the functional and performance requirements of the project as specified. Perform the Conditional Acceptance Tests using the detailed test procedures as outlined in the Testing and Commissioning Plan (developed and submitted by the Contractor and approved by the Government). The Conditional Acceptance Functional Testing, as specified, must not commence until receipt by the Contractor of written permission from the Government, based on the Contractor's certification of successful completion of Stage 1- Contractor's Field Tests, as specified above. The Government may terminate and/or defer specific portion of the test that failed to perform as specified. If at any time the Microgrid system and/or sub-systems failed to function or fail to meet performance requirements if the issue can not be readily resolved and be retested.

Upon a failure resulting in termination of testing by the Government or by the Contractor, commence an assessment period. Identity all failures, determine causes of all failures, repair all failures, and deliver a written report to the Government. The report must explain in detail the nature of each failure, corrective action taken, results of tests performed, and must recommend the point at which testing should be resumed. After delivering the written report, convene a test review meeting at the job site to present the results and recommendations to the Government. As a part of this test review meeting, demonstrate and/or provide evidence that the issues have been corrected and ready for reperformance of the Conditional Acceptance Tests. Based on the

Contractor's report and the test review meeting, the Contractor will propose the retest date.

Upon successful completion of the Conditional Acceptance Tests, provide test reports and other documentation specified to the Government for approval prior to commencing the Stage 3 -Acceptance Test.

CONDITIONAL ACCEPTANCE TESTS must include the following operating scenarios:

a. Grid Connected Mode (Normal Mode of Operation with generator units off-line)

   (1) Test the loss of communication segment link in the communication loop during Island Mode of Operation.

   (2) Test the loss of communication Control Network Switch 1 during Island Mode of Operation.

   (3) Test the loss of communication Control Network Switch 2 during Island Mode of Operation.

   (4) Test the loss of Microgrid Controller 1 during Island Mode of Operation. (Microgrid Controller 1 and Controller 2 are configured for a hot-standby)

   (5) Test the loss of Microgrid Controller 2 during Island Mode of Operation. (Microgrid Controller 1 and Controller 2 are configured for a hot-standby)

b. Test a planned disconnect from the Utility Grid (generator units synchronize to Microgrid system after Microgrid islanded). Simulate a planned utility outage event by issue command to the Microgrid Control System to go to Island Mode. The Microgrid Control System should execute programmed sequence of control to prepare for transition to Island Mode and open the Main Utility Service Breaker. Observe and record data for breaker status, protective relay event logs, voltages, currents, power (VA, W, VAR), power factor (PF) profiles at all the breakers on the Main Utility Service Switchgear. The following are the expected automatic sequence of operations:

   (1) Verifies permissive conditions of the microgrid power system to initiate GOTO ISLAND MODE (disconnect from the utility grid) process.

   (2) Starts standby generator units to provide additional spinning reserve and inertia on the microgrid.

   (3) Synchronize generator units and closed generator unit breakers

   (4) Changes one DER (Generator Unit) to isochronous mode

c. Test a planned disconnect from the Utility Grid (the generator units coming online with before the Microgrid islanding). Simulate a planned utility outage event by issue command to the Microgrid Control System to go to Island Mode. The Microgrid Control System should execute programmed sequence of control to prepare for transition to Island Mode and open the Main Utility Service Breaker. Observe and record data for breaker status, protective relay event logs, voltages,

currents, power (VA, W, VAR), power factor (PF) profiles at all the breakers on the Main Utility Service Switchgear. The following are the expected automatic sequence of operations:

(1) Verifies permissive conditions of the microgrid power system to initiate GOTO ISLAND MODE (disconnect from the utility grid) process.

(2) Starts standby generator units to provide additional spinning reserve and inertia on the microgrid.

(3) Synchronize generator units and closed generator unit breakers

(4) Adjusts renewable DER power outputs for island operation

(5) Changes one DER (Generator Unit) to isochronous mode

d. Unplanned Disconnect from the Utility Grid while exporting power to grid (export power values at 50kW, 150kW, 300kW). Simulate fault events to cause the PCC breaker to trip by opening the Main Utility Service Breaker 52-M1. Observe and record data for breaker status, protective relay event logs, voltages, currents, power (VA, W, VAR), power factor (PF) profiles at all the breakers on the Main Utility Service Switchgear.

e. Unplanned Disconnect from the Utility Grid (while importing power from the utility grid at grid (import power values at 50kW, 150kW, entire site electrical load). Simulate fault events to cause the PCC breaker to trip by opening the Main Utility Service Breaker 52-M1. Observe and record data for breaker status, protective relay event logs, voltages, currents, power (VA, W, VAR), power factor (PF) profiles at all the breakers on the Main Utility Service Switchgear.

f. Island Mode (Contingency Mode of Operation)

(1) Generator Units available only, no control. Observe and record data for voltages, currents, power (VA, W, VAR), power factor (PF) profiles at all the breakers on the Main Utility Service Switchgear. One 24-hour test periods are required. Record fuel consumption and total runtime of the generator units during Island Mode Operation Test period.

(2) Test the loss of communication segment link in the communication loop during Island Mode of Operation.

(3) Test the loss of communication Control Network Switch 1 during Island Mode of Operation.

(4) Test the loss of communication Control Network Switch 2 during Island Mode of Operation.

(5) Test the loss of Microgrid Controller 1 during Island Mode of Operation. (Microgrid Controller 1 and Controller 2 are configured for a hot-standby)

(6) Test the loss of Microgrid Controller 2 during Island Mode of Operation. (Microgrid Controller 1 and Controller 2 are configured for a hot-standby)

g. Transition from Island Mode to Grid Connected/Parallel Mode).

(1) While in Island Mode with Generator unit(s) on-line only - Reconnect the Live Microgrid to the Utility Grid.

(2) While in Island Mode (generator units are off-line) - Reconnect the Live Microgrid to the Utility Grid.

(3) While in Island Mode Generator units - Reconnect the Live Microgrid to the Utility Grid (synchronization through generator synchronization controller).

h. Reconnect the Dead Microgrid to the Utility Grid (Blackout State to Grid Connected Mode)

i. Make corrective measures, modification and/or adjustment necessary to bring nonconformance items into conformance with the project specifications and performance requirements of the applicable reference standards.

j. System control logic and parameters adjustment - make field adjustment and/or programming modification necessary to optimize the performance of the Microgrid Control System and the protective relay system with system resiliency as the primary objective.

3.5.20.3 Stage 3 - Acceptance Tests

As a prerequisite to the performance of the Acceptance Tests, the complete and provide testing and commissioning report for the Stage 2 Conditional Acceptance Tests, including corrective measures, modification and/or adjustments made during the Stage 2 Conditional Acceptance Tests. The Government approval of the testing and commissioning report for the Stage 2 - Conditional Acceptance Tests is required prior to commencing the Stage 3 - Acceptance Test.

Repeat all tests performed in the for the Stage 2 - Conditional Acceptance Tests and demonstrate all mode of operations. The test duration of test period may be reduced as appropriate but must be sufficient to demonstrate proper function and performance.

The Stage 3 - Acceptance Test must be witnessed by local utility Representatives, Owner and Owner's Representatives, and Microgrid System Operators.

3.5.20.4 Stage 4 - Endurance Tests

Complete an endurance in which the system is operated continuously for 90 days without operational issue or failure. During the endurance test period the Government's microgrid system operation staff will document observed operational issue or failure, and will notify the Contractor within 24-hr. The Contractor is required to investigate and resolve the identified operational issue or failure. The Contractor is responsible for the cost associated with the implementation of the corrective measures of all issues or failures due to improper installation, system component failures, improper implementation of system configuration, setting parameters, or programming (not in compliance with the requirements of the Contract document).

If the system experiences any failures during the endurance test portion

of the PVT, repair the system and repeat the endurance test period until the system operates continuously and without operational issue or failure for the specified endurance test period.

3.5.21 Training

Provide training course to instruct the operator and maintenance personnel on the operation of the Microgrid Control System and the associated DER and site electrical distribution system.

The training must be trailered to achieve the following:

a. Owner/Operator understand of major components of the microgrid system

b. Owner/Operator understanding of the intended functions

c. Owner/Operator understanding of how the microgrid system should operate in each mode of operation

d. Owner/Operator understanding of how the microgrid system should response to the utility outage event and/or abnormal event such as system fault

e. Owner/Operator understanding of how the operator should properly response to the utility outage event and/or abnormal event such as system fault and/or what actions should operator take in response to such an event.

The course content must contain as a minimum:

a. Introduction to the Microgrid System

b. System Components and Configuration

c. Operating Philosophy and Procedure for all Mode of Operations

d. Demonstrate each mode of operations including transition between mode of operations

e. Demonstrate contingency response to probable abnormal events that may occur. Provide at least six abnormal event scenarios for training purpose.

-- End of Section --

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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

ASTM INTERNATIONAL (ASTM)

ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A240/A240M	(2022b) Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
ASTM A653/A653M	(2022) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A780/A780M	(2020) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D1535	(2014; R 2018) Standard Practice for Specifying Color by the Munsell System

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 81	(2012) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEEE 100	(2000; Archived) The Authoritative

	Dictionary of IEEE Standards Terms
IEEE C2	(2023) National Electrical Safety Code
IEEE C37.13	(2015) Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1A	(2020) Metal-Enclosed Low-Voltage (1000 Vac and below, 3200 Vdc and below) Power Circuit-Breaker Switchgear Amendment 1: Control and Secondary Circuits and Devices, and All Wiring
IEEE C37.20.7	(2017; Corr 2021) Guide for Testing Switchgear Rated Up to 52 kV for Internal Arcing Faults
IEEE C37.90.1	(2013) Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
IEEE C57.12.28	(2014) Standard for Pad-Mounted Equipment - Enclosure Integrity
IEEE C57.13	(2016) Standard Requirements for Instrument Transformers
	INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)
NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
	NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA LI 1	(1998; R 2011) Industrial Laminating Thermosetting Products
	NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
NFPA 70	(2023) National Electrical Code
	UNDERWRITERS LABORATORIES (UL)
UL 467	(2022) UL Standard for Safety Grounding and Bonding Equipment
UL 1558	(2016; Reprint Nov 2019) UL Standard for Safety Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

1.2 RELATED REQUIREMENTS

Section 26 08 00 APPARATUS INSPECTION AND TESTING applies to this section, with the additions and modifications specified herein.

1.3 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in IEEE 100.

1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Switchgear Drawings; G, DO

SD-03 Product Data

Switchgear; G, DO

SD-06 Test Reports

Switchgear Design Tests; G, DO

Switchgear Production Tests; G, DO

Acceptance Checks and Tests; G, DO

SD-07 Certificates

Submit certification indicating conformance with the paragraph CYBERSECURITY EQUIPMENT CERTIFICATION.

Submit certification indicating conformance with the paragraph CYBERSECURITY INSTALLATION CERTIFICATION.

SD-10 Operation and Maintenance Data

Switchgear Operation and Maintenance, Data Package 5; G, DO

SD-11 Closeout Submittals

Assembled Operation and Maintenance Manuals; G, DO

Equipment Test Schedule; G, DO

Required Settings; G, DO

Service Entrance Available Fault Current Label; G, DO

1.5 QUALITY ASSURANCE

1.5.1 Product Data

Include manufacturer's information on each submittal for each component, device and accessory provided with the switchgear including:

a. Circuit breaker type, interrupting rating, and trip devices, including available settings.

b. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device.

1.5.2 Switchgear Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Identify circuit terminals on wiring diagrams and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Indicate on the drawings adequate clearance for operation, maintenance, and replacement of operating equipment devices. Include the nameplate data, size, and capacity on submittal. Also include applicable federal, military, industry, and technical society publication references on submittals. Include the following:

a. One-line diagram including breakers, fuses, current transformers, and meters.

b. Outline drawings including front elevation, section views, footprint, and overall dimensions.

c. Bus configuration including dimensions and ampere ratings of bus bars.

d. Markings and NEMA nameplate data, including fuse information (manufacturer's name, catalog number, and ratings).

e. Circuit breaker type, interrupting rating, and trip devices, including available settings.

f. Wiring diagrams and elementary diagrams with terminals identified, and indicating prewired interconnections between items of equipment and the interconnection between the items.

g. Manufacturer's instruction manuals and published time-current curves (in electronic format) of the main secondary breaker and largest secondary feeder device. Use this information (designer of record) to provide breaker settings that ensures protection and coordination are achieved.

1.5.3 Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" or "must" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.5.4 Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship, and:

a. Have been in satisfactory commercial or industrial use for 2 years prior to bid opening including applications of equipment and materials under similar circumstances and of similar size.

b. Have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.

c. Where two or more items of the same class of equipment are required, provide products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.5.4.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.5.4.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site are not acceptable.

1.6 MAINTENANCE

1.6.1 Switchgear Operation and Maintenance Data

Submit Operation and Maintenance Manuals in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

1.6.2 Assembled Operation and Maintenance Manuals

Assemble and securely bind manuals in durable, hard covered, water resistant binders. Assemble and index the manuals in the following order with a table of contents:

a. Manufacturer's O&M information required by the paragraph SD-10, OPERATION AND MAINTENANCE DATA.

b. Catalog data required by the paragraph SD-03, PRODUCT DATA.

c. Drawings required by the paragraph SD-02, SHOP DRAWINGS.

d. Prices for spare parts and supply list.

e. Information on metering.

f. Design test reports.

g. Production test reports.

1.6.3 Spare Parts

Provide spare parts as specified below. Provide spare parts that are of the same material and workmanship, meet the same requirements, and are interchangeable with the corresponding original parts furnished.

a. Quantity 2 - Fuses of each type and size.

1.7 WARRANTY

Provide equipment items that are supported by service organizations reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

PART 2 PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be switchgear and related accessories are specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION, Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and Section 25 08 20 MICROGRID CONTROL SYSTEM.

Low voltage switchgear must incorporate microgrid control system and functional requirements per Section 25 08 20 MICROGRID CONTROL SYSTEM.

2.2 SWITCHGEAR

IEEE C37.20.1A and UL 1558.

2.2.1 Ratings

Provide equipment with the following ratings:

a. Voltage rating: 480Y/277 volts AC, 4-wire three-phase, 4-wire.

b. Continuous current rating of the main bus: 3000 amperes.

c. Short-circuit current rating: 100k rms symmetrical amperes.

d. UL listed and labeled for its intended use and as service entrance equipment.

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2.2.2 Construction

Provide the following:

a. Switchgear: consisting of vertical sections bolted together to form a rigid assembly and aligned as indicated.

b. All circuit breakers: front accessible with rear load connections.

c. Compartmentalized switchgear: vertical insulating barriers between the front device section, the main bus section, and the cable compartment with full front to rear vertical insulating barriers between adjacent sections.

d. Where indicated, "space for future" or "space" means to include all necessary components and hardware to be fully equipped for racking in a circuit breaker element.

e. Insulating barriers: provided in accordance with NEMA LI 1, Type GPO-3, 0.25 inch minimum thickness.

f. Moisture resistant coating: applied to all rough-cut edges of barriers.

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2.2.2.1 Enclosure

Provide the following:

a. Enclosure: NEMA ICS 6 Type 1as indicated.

b. Enclosure: bolted together with removable bolt-on side and hinged rear covers.

c. Front doors: provided with padlockable vault handles with a three point catch.

d. Bases, frames and channels of enclosure: corrosion resistant and fabricated of ASTM A240/A240M type 304 or 304L stainless steel or galvanized steel.

e. Base: includes any part of enclosure that is within 3 inches of concrete pad.

f. Galvanized steel: ASTM A123/A123M, ASTM A653/A653M G90 coating, and ASTM A153/A153M, as applicable. Galvanize after fabrication where practicable.

g. Paint color: ASTM D1535 light gray No. 61 or No. 49 over rust inhibitor.

h. Paint coating system: comply with IEEE C57.12.28 for galvanized steel.

i. Infrared viewing windows: install to allow the use of an infrared camera or thermal imager direct line of site to inspect electrical connections without requiring the opening of panels and doors. These windows are intended to allow thermographers the ability to inspect the electrical equipment without directly exposing themselves to live electrical components and energized devices.

2.2.2.2 Bus Bars

Provide the following:

a. Bus bars: copper with silver-plated contact surfaces.

(1) Phase bus bars: uninsulated.

(2) Neutral bus: rated 100 percent of the main bus continuous current rating.

b. Make bus connections and joints with hardened steel bolts.

c. Main-bus (through bus): rated at the full ampacity of the main throughout the switchgear.

d. Minimum one-quarter by 2 inch copper ground bus secured to each vertical section along the entire length of the switchgear.

2.2.2.3 Main Section

Provide the main section consisting of drawout air power circuit breaker.

2.2.2.4 Distribution Sections

Provide the distribution section consisting of individually mounted,drawout, air power circuit breakers as indicated.

2.2.2.5 Auxiliary Sections

Provide auxiliary sections consisting of indicated instruments, metering equipment, control equipment, and current transformer compartments as indicated.

2.2.2.6 Handles

Provide handles for individually mounted devices of the same design and method of external operation. Label handles prominently to indicate device ampere rating, color coded for device type. Identify ON-OFF indication by handle position and by prominent marking.

2.2.3 Protective Device

Provide switchgear circuit breakers with multifunction microprocessor relays and protective functions as indicated on single line diagram.

Provide the following:

a. IEEE C37.13. 120 Vac operated drawout, unfused, low-voltage power circuit breaker with a short-circuit current rating as indicated at 480 volts.

b. Breaker frame size: as indicated.

c. Equip electrically operated breakers with motor-charged, stored-energy closing mechanism to permit rapid and safe closing of the breaker against fault currents within the short time rating of the breaker, independent of the operator's strength or effort in closing the handle.

2.2.4 Drawout Breakers

Equip drawout breakers with disconnecting contacts, wheels, and interlocks for drawout application. Provide main, auxiliary, and control disconnecting contacts with silver-plated, multifinger, positive pressure, self-aligning type. Provide drawout compartment shutters to protect operators from accidental contact with breaker stabs when the breaker is withdrawn from its cubicle. Provide each drawout breaker with four-position operation with each position clearly identified by an indicator on the circuit breaker front panel as follows.

a. Connected Position: Primary and secondary contacts are fully engaged. Breaker must be tripped before racking into or out of position.

b. Test Position: Primary contacts are disconnected but secondary contacts remain fully engaged. This position allows complete test and operation of the breaker without energizing the primary circuit.

c. Disconnected Position: Primary and secondary contacts are disconnected.

d. Withdrawn (Removed) Position: Places breaker completely out of compartment, ready for removal. Removal of the breaker actuates assembly that isolates the primary stabs.

Generator circuit breaker (IEEE device 52) ratings must be consistent with the generator rated voltage and frequency, with continuous, short circuit withstand, and interrupting current ratings. Generator circuit breakers are capable of synchronization and parallel operation.

2.2.5 Protective Device

Equip main and distribution breakers with a solid-state tripping system consisting of three current sensors and a microprocessor-based multifunction relay. Equip switchgear breakers with multifunction relay, including VT and CT as required to perform protective, control, and metering functions as specified and indicated on single line diagram. Include the following:

a. Current sensors ampere rating: the same as the breaker frame rating.

b. Trip unit ampere rating: as indicated.

c. Ground fault protection: residual type sensing.

d. Provide additional features:

(1) Breakers: include a digital display for phase and ground current.

(2) Breakers: include a digital display for watts, vars, VA, kWh, kvarh, and kVAh.

(3) Breakers: include a digital display for phase voltage, and percent THD voltage and current.

(4) Breakers: include provisions for communication via a network twisted pair cable for remote monitoring and control. Provide the following communications protocol: Modbus.

(5) For breakers that are rated for or can be adjusted to 1,200 amperes or higher, provide arc energy reduction capability with an energy-reducing maintenance switch with local status indicator.

2.2.6 Metering

2.2.6.1 Digital Meters

IEEE C37.90.1 for surge withstand. Provide true rms, plus/minus one percent accuracy, programmable, microprocessor-based meter enclosed in a

sealed case with the following features.

a. Display capability:

(1) Multi-Function Meter: Display a selected phase to neutral voltage, phase to phase voltage, percent phase to neutral voltage THD, percent phase to phase voltage THD; a selected phase current, neutral current, percent phase current THD, percent neutral current; selected total PF, kW, KVA, kVAR, FREQ, kVAh, kWh. Detected alarm conditions include over/under current, over/under voltage, over/under KVA, over/under frequency, over/under selected PF/kVAR, voltage phase reversal, voltage imbalance, reverse power, over percent THD. Include a Form C KYZ pulse output relay on the meter.

(2) Power Meter: Display Watts, VARs, and selected KVA/PF. Detected alarm conditions include over/under KVA, over/under PF, over/under VARs, over/under reverse power.

(3) Volt Meter: Provide capability to be selectable between display of the three phases of phase to neutral voltages and simultaneous display of the three phases of the phase to phase voltages. Detected alarm conditions include over/under voltage, over/under voltage imbalance, over percent THD.

(4) Ammeter: Display phase A, B, and C currents. Detected alarm conditions include over/under current, over percent THD.

(5) Digital Watthour Meter: Provide a single selectable display for watts, total kilowatt hours (kWh) and watt demand (Wd). Include a Form C KYZ pulse output relay on the meter.

b. Design meters to accept input from standard 5A secondary instrument transformers.

c. Provide programming via a front panel display and a communication interface accessible by a computer.

d. Provide password secured programming stored in non-volatile EEPROM memory.

e. Provide digital communications in a Modbus RTU protocol via a RS485 serial port and an independently addressable RS485 serial port.

f. Provide meter that calculates and stores average max/min demand values with time and date for all readings based on a user selectable sliding window averaging period.

g. Provide meter with programmable hi/low set limits with two Form C dry contact relays when exceeding alarm conditions.

h. Provide meter with a display of Total Harmonic Distortion (THD) measurement to a minimum of the thirty-first order.

i. Include historical trend logging capability with the ability to store up to 100,000 data points with intervals of 1 second to 180 minutes. Provide a unit that can store and time stamp up to 1000 programmable triggered conditions.

j. Provide event waveform recording triggered by the rms of 2 cycles of voltage or current exceeding programmable set points. Store waveforms for all 6 channels of voltage and current for a minimum of 10 cycles prior to the event and 50 cycles past the event.

2.2.6.2 Electronic Watthour Meter

ANSI C12.1. Provide a switchgear style electronic programmable watthour meter, semi-flush mounted, as indicated. Meter can be either programmed at the factory or programmed in the field. Turn field programming device over to the Contracting Officer at completion of project. Coordinate meter to system requirements.

a. Design: Provide meter designed for use on a 3-phase, 4-wire, 480Y/277 volt system with 3 current transformers. Include necessary KYZ pulse initiation hardware for Energy Monitoring and Control System (EMCS).

b. Coordination: Provide meter coordinated with ratios of current transformers and transformer secondary voltage.

c. Class: 20. Accuracy: plus or minus 1.0 percent. Finish: Class II.

d. Kilowatt-hour Register: five digit electronic programmable type.

e. Demand Register:

(1) Provide solid state.

(2) Display actual values and readings of the metered circuit. No multipliers must be required.

(3) Demand interval length: programmed for 15 minutes with rolling demand up to six subintervals per interval.

f. Meter fusing: Provide a fuse block mounted in the metering compartment containing one fuse per phase to protect the voltage input to the watthour meter. Size fuses as recommended by the meter manufacturer.

g. Provide meter with a communications port, RS485, with Modbus RTU serial or Ethernet, Modbus-TCP communications.

IEEE C57.13. Provide single ratio transformers, 60 hertz, 3000 to 5-ampere ratio, 1.5 rating factor, with a metering accuracy class of 0.3 through B-1.8.

2.2.7 Terminal Boards

Provide with engraved plastic terminal strips and screw type terminals for external wiring between components and for internal wiring between removable assemblies. Provide short-circuiting type terminal boards associated with current transformer. Terminate conductors for current transformers with ring-tongue lugs. Provide terminal board identification that is identical in similar units. Provide color coded external wiring that is color coded consistently for similar terminal boards.

2.2.8 Wire Marking

Mark control and metering conductors at each end. Provide factory installed, white, plastic tubing, heat stamped with black block type

letters on factory-installed wiring. On field-installed wiring, provide white, preprinted, polyvinyl chloride (PVC) sleeves, heat stamped with black block type letters. Provide a single letter or number on each sleeve, elliptically shaped to securely grip the wire, and keyed in such a manner to ensure alignment with adjacent sleeves. Provide specific wire markings using the appropriate combination of individual sleeves. Indicate on each wire marker the device or equipment, including specific terminal number to which the remote end of the wire is attached.

2.3 MANUFACTURER'S NAMEPLATE

Provide a nameplate on each item of equipment bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent is not acceptable. This nameplate and method of attachment may be the manufacturer's standard if it contains the required information.

2.4 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each switchgear, equipment enclosure, relay, switch, and device; as specified in this section or as indicated on the drawings. Identify on each nameplate inscription the function and, when applicable, the position. Provide nameplates of melamine plastic, 0.125 inch thick, white with black center core. Provide matte finish surface. Provide square corners. Accurately align lettering and engrave into the core. Provide nameplates with minimum size of one by 2.5 inches. Provide lettering that is a minimum of 0.25 inch high normal block style.

2.5 SOURCE QUALITY CONTROL

2.5.1 Equipment Test Schedule

The Government reserves the right to witness tests. Provide equipment test schedules for tests to be performed at the manufacturer's test facility. Submit required test schedule and location, and notify the Contracting Officer 30 calendar days before scheduled test date. Notify Contracting Officer 15 calendar days in advance of changes to scheduled date.

Provide the following as part of test equipment calibration:

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration labels: visible on all test equipment.

e. Calibrating standard: higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration,

include the following:

(1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

(2) Identify the third party/laboratory calibrated instrument to verify that calibrating standard is met.

2.5.2 Switchgear Design Tests

IEEE C37.20.1A and UL 1558IEEE C37.20.1A, IEEE C37.20.7, and UL 1558.

2.5.2.1 Design Tests

Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

a. Short-circuit current test.

b. Enclosure tests.

c. Dielectric test.

2.5.3 Switchgear Production Tests

IEEE C37.20.1A and UL 1558. Furnish reports which include results of production tests performed on the actual equipment for this project. These tests include:

a. 60-hertz dielectric tests.

b. Mechanical operation tests.

c. Electrical operation and control wiring tests.

d. Ground fault sensing equipment test.

2.6 COORDINATED POWER SYSTEM PROTECTION

Provide a power system study as specified in Section 26 28 01.00 10 COORDINATED POWER SYSTEM PROTECTION.

2.7 ARC FLASH WARNING LABEL

Provide warning label for switchgear. Locate this self-adhesive warning label on the outside of the enclosure warning of potential electrical arc flash hazards and appropriate PPE required. Provide label format as indicated.

2.8 SERVICE ENTRANCE AVAILABLE FAULT CURRENT LABEL

Provide label on exterior of switchgear used as service equipment listing the maximum available fault current at that location. Include on the label the date that the fault calculation was performed and the contact information for the organization that completed the calculation. Locate this self-adhesive warning label on the outside of the switchgear. Provide label format as indicated.

2.9 MIMIC BUS LABELING

Provide a mimic bus on the front of the equipment to diagrammatically show the internal bus structure of the lineup.

PART 3 EXECUTION

3.1 INSTALLATION

Conform to IEEE C2, NFPA 70, and to the requirements specified herein. Provide new equipment and materials unless indicated or specified otherwise.

3.2 GROUNDING

NFPA 70 and IEEE C2, except that grounds and grounding systems with a resistance to solid earth ground not exceeding 25 ohms.

3.2.1 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.2.2 Equipment Grounding

Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 inches below grade connecting to the indicated ground rods. When work in addition to that indicated or specified is directed to obtain the specified ground resistance, the provision of the contract covering "Changes" applies.

3.2.3 Connections

Make joints in grounding conductors and loops by exothermic weld or compression connector. Install exothermic welds and compression connectors as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.2.4 Grounding and Bonding Equipment

UL 467, except as indicated or specified otherwise.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

Install and connect equipment furnished under this section as indicated on project drawings, the approved shop drawings, and as specified herein.

3.3.1 Switchgear

IEEE C37.20.1A.

3.3.2 Meters and Instrument Transformers

ANSI C12.1.

3.3.3 Field Applied Painting

Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

3.3.4 Galvanizing Repair

Repair damage to galvanized coatings using ASTM A780/A780M, zinc rich paint, for galvanizing damaged by handling, transporting, cutting, welding, or bolting. Do not heat surfaces that repair paint has been applied to.

3.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

3.4 FOUNDATION FOR EQUIPMENT AND ASSEMBLIES

3.4.1 Interior Location

Mount switchgear on concrete slab as follows:

a. Unless otherwise indicated, provide the slab with dimensions at least 4 inches thick.

b. Install slab such that the top of the concrete slab is approximately 4 inches above the finished grade.

c. Provide edges above grade 1/2 inch chamfer.

d. Provide slab of adequate size to project at least 8 inches beyond the equipment.

e. Provide conduit turnups and cable entrance space required by the equipment to be mounted.

f. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant.

g. Cut off and bush conduits 3 inches above slab surface.

h. Provide concrete work as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE.

3.5 FIELD QUALITY CONTROL

Submit Required Settings of breakers to the Contracting Officer after approval of switchgear and at least 30 days in advance of their requirement.

3.5.1 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.5.1.1 Switchgear

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical, electrical, and mechanical condition.

(3) Verify appropriate anchorage, required area clearances, and correct alignment.

(4) Clean switchgear and verify shipping bracing, loose parts, and documentation shipped inside cubicles have been removed.

(5) Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

(6) Verify that circuit breaker sizes and types correspond to approved shop drawings as well as to the circuit breaker’s address for microprocessor-communication packages.

(7) Verify that current transformer ratios correspond to approved shop drawings.

(8) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(9) Confirm correct operation and sequencing of electrical and mechanical interlock systems.

(10) Confirm correct application of manufacturer's recommended lubricants.

(11) Inspect insulators for evidence of physical damage or contaminated surfaces.

(12) Verify correct barrier and shutter installation and operation.

(13) Exercise all active components.

(14) Inspect all mechanical indicating devices for correct operation.

(15) Verify that filters are in place and vents are clear.

(16) Test operation, alignment, and penetration of instrument transformer withdrawal disconnects.

(17) Inspect control power transformers.

b. Electrical Tests

(1) Perform insulation-resistance tests on each bus section.

(2) Perform dielectric withstand voltage tests.

(3) Perform insulation-resistance test on control wiring; Do not perform this test on wiring connected to solid-state components.

(4) Perform control wiring performance test.

(5) Perform primary current injection tests on the entire current circuit in each section of assembly.

(6) Perform phasing check on double-ended switchgear to ensure correct bus phasing from each source.

3.5.1.2 Circuit Breakers - Low Voltage - Power

a. Visual and Mechanical Inspection

(1) Compare nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Inspect anchorage, alignment, and grounding.

(4) Verify that all maintenance devices are available for servicing and operating the breaker.

(5) Inspect arc chutes.

(6) Inspect moving and stationary contacts for condition, wear, and alignment.

(7) Verify that primary and secondary contact wipe and other dimensions vital to satisfactory operation of the breaker are correct.

(8) Perform all mechanical operator and contact alignment tests on both the breaker and its operating mechanism.

(9) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(10) Verify cell fit and element alignment.

(11) Verify racking mechanism.

(12) Confirm correct application of manufacturer's recommended lubricants.

b. Electrical Tests

(1) Perform contact-resistance tests on each breaker.

(2) Perform insulation-resistance tests.

(3) Adjust Breaker(s) for final settings in accordance with Government provided settings.

(4) Determine long-time minimum pickup current by primary current

injection.

(5) Determine long-time delay by primary current injection.

(6) Determine short-time pickup and delay by primary current injection.

(7) Determine ground-fault pickup and delay by primary current injection.

(8) Determine instantaneous pickup value by primary current injection.

(9) Activate auxiliary protective devices, such as ground-fault or undervoltage relays, to ensure operation of shunt trip devices; Check the operation of electrically-operated breakers in their cubicle.

(10) Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and antipump function.

(11) Verify operation of charging mechanism.

3.5.1.3 Current Transformers

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify correct connection.

(4) Verify that adequate clearances exist between primary and secondary circuit.

(5) Inspect all bolted electrical connections for high resistance using low-resistance ohmmeter, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey.

(6) Verify that all required grounding and shorting connections provide good contact.

b. Electrical Tests

(1) Perform resistance measurements through all bolted connections with low-resistance ohmmeter, if applicable.

(2) Perform insulation-resistance tests.

(3) Perform polarity tests.

(4) Perform ratio-verification tests.

3.5.1.4 Metering and Instrumentation

a. Visual and Mechanical Inspection

(1) Compare equipment nameplate data with specifications and approved shop drawings.

(2) Inspect physical and mechanical condition.

(3) Verify tightness of electrical connections.

b. Electrical Tests

(1) Determine accuracy of meters at 25, 50, 75, and 100 percent of full scale.

(2) Calibrate watthour meters according to manufacturer's published data.

(3) Verify all instrument multipliers.

(4) Electrically confirm that current transformer and voltage transformer secondary circuits are intact.

3.5.1.5 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) IEEE 81. Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.5.2 Follow-Up Verification

Upon completion of acceptance checks, settings, and tests, show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. Trip circuit

breakers by operation of each protective device. Test each item to perform its function not less than three times. As an exception to requirements stated elsewhere in the contract, provide the Contracting Officer 5 working days advance notice of the dates and times for checks, settings, and tests.

-- End of Section --

P2: 505014, Microgrid Design 750KWDC Conroe ARC
Conroe, TX

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DIVISION 26 - ELECTRICAL

SECTION 26 31 00

FACILITY-SCALE SOLAR PHOTOVOLTAIC (PV) SYSTEMS

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-- End of Section Table of Contents --

SECTION 26 31 00

FACILITY-SCALE SOLAR PHOTOVOLTAIC (PV) SYSTEMS
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PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C12.1	(2014; Errata 2016) Electric Meters - Code for Electricity Metering

AMERICAN SOCIETY OF CIVIL ENGINEERS (ASCE)

ASCE 7-16	(2017; Errata 2018; Supp 1 2018) Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASTM INTERNATIONAL (ASTM)

ASTM D149	(2020) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D257	(2014) Standard Test Methods for D-C Resistance or Conductance of Insulating Materials
ASTM D709	(2017) Standard Specification for Laminated Thermosetting Materials
ASTM D882	(2012) Tensile Properties of Thin Plastic Sheeting
ASTM D903	(1998; R 2017) Standard Test Method for Peel or Stripping Strength of Adhesive Bonds
ASTM D1876	(2008; R 2015; E 2015) Standard Test Method for Peel Resistance of Adhesives (T-Peel Test)
ASTM D2244	(2016) Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
ASTM D2765	(2016) Standard Test Methods for

	Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics
ASTM D5870	(2016) Standard Practice for Calculating Property Retention Index of Plastics
ASTM D7567	(2009) Standard Test Method for Determining Gel Content in Crosslinked Ethylene Plastics Using Pressurized Liquid Extraction
ASTM E308	(2022) Standard Practice for Computing the Colors of Objects by Using the CIE System
ASTM E424	(1971; R 2015) Standard Test Methods for Solar Energy Transmittance and Reflectance (Terrestrial) of Sheet Materials
ASTM E772	(2015; R 2021) Standard Terminology of Solar Energy Conversion
ASTM E1171	(2015) Standard Test Methods for Photovoltaic Modules in Cyclic Temperature and Humidity Environments
ASTM F1249	(2020) Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor
ASTM G155	(2021) Standard Practice for Operating Xenon Arc Lamp Apparatus for Exposure of Materials

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 1547	(2018) Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
IEEE C2	(2023) National Electrical Safety Code
IEEE Stds Dictionary	(2009) IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL CODE COUNCIL (ICC)

ICC IBC	(2021) International Building Code
ICC IgCC	(2018) International Green Construction Code

INTERNATIONAL ELECTRICAL TESTING ASSOCIATION (NETA)

NETA ATS	(2021) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

ANSI IEC 60529	(2020) Degrees of Protection Provided by Enclosures
IEC 61853-1	(2011; ED 1.0) Photovoltaic (Pv) Module Performance Testing and Energy Rating – Part 1: Irradiance and Temperature Performance Measurements and Power Rating
IEC 62446	(2018) Photovoltaic (PV) Systems - Requirements for Testing, Documentation, and Maintenance - Part 1: Grid Connected Systems - Documentation, Commissioning Tests and Inspection

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

ISO 9001	(2015) Quality Management Systems-Requirements

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	(2020) Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA IEC 60529	(2004) Degrees of Protection Provided by Enclosures (IP Code)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 1	(2021) Fire Code
NFPA 70	(2023) National Electrical Code
NFPA 70E	(2021) Standard for Electrical Safety in the Workplace
NFPA 780	(2023) Standard for the Installation of Lightning Protection Systems

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910	Occupational Safety and Health Standards

UNDERWRITERS LABORATORIES (UL)

UL 969	(2017; Reprint Mar 2018) UL Standard for Safety Marking and Labeling Systems
UL 1703	(2002; Reprint Jun 2016) UL Standard for Safety Flat-Plate Photovoltaic Modules and Panels
UL 1741	(2010; Reprint Jan 2015) UL Standard for Safety Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources

UL 6703	(2014, ANSI Approved December 22, 2017) Standard for Connectors for Use in Photovoltaic Systems
UL Electrical Construction	(2012) Electrical Construction Equipment Directory

1.2 RELATED REQUIREMENTS

Sections 26 20 00 INTERIOR DISTRIBUTION SYSTEM apply to this section with additions and modifications specified herein.

1.3 DEFINITIONS

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in the IEEE Stds Dictionary.

b. Unless otherwise specified or indicated, solar energy conversion terms used in these specifications, and on the drawings, are as defined in ASTM E772.

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1.4 SUBMITTALS

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Commissioning Plan; G

Commissioning Schedule; G

SD-02 Shop Drawings

Schematic Diagrams; G

Interconnection Diagrams; G

Installation Drawings; G

Site Plan Drawings; G

Riser Diagram and General Notes; G

Installation and Assembly Details; G

Shop Drawings; G

Complete Solar PV System Diagrams; G

SD-03 Product Data

Combiner Boxes; G

Disconnects; G

Inverters; G; S

String Inverter Efficiency; G; S

PV Array Mounting Structure; G

Photovoltaic Module Backsheet; G

Photovoltaic Module Encapsulent; G

Photovoltaic Modules; G; S

Photovoltaic Wire; G

System Monitoring; G

System Wiring; G

SD-05 Design Data

System Operation; G

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1.5 MAINTENANCE MATERIAL SUBMITTALS

Comply with requirements specified in Section 01 33 00 SUBMITTAL PROCEDURES.

1.6 QUALITY ASSURANCE

1.6.1 Regulatory Requirements

Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Contracting Officers. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 unless more stringent requirements are specified or indicated.

1.6.2 Installation Drawings

Submit a minimum of three hard copies of drawings for government approval prior to manufacturing and equipment construction or integration. Submit site plan drawings and riser diagram and general notes at a minimum of 24 by 36 inches. Submit installation and assembly details at a minimum of 24 by 36 inches. Submit at minimum scale of 1/2 inch per foot for overview and 2 inches per foot for detail.

In addition to requirements in Section 01 33 00 SUBMITTAL PROCEDURES, include the following:

a. All details legible and all text no smaller than 0.1 inches in height on any drawing. As needed, provide enlargements to ensure clarity of intent.

b. Submit shop drawings at a minimum of 11 by 17 inches in size using a minimum scale of 1/4 inch per foot, for the exception of drawings not required scale. Shop drawings must include wiring diagrams and installation details of photovoltaic (PV) system equipment indicating location as proposed in design drawings, layout and arrangement of PV modules, support and mounting mechanism, inverters, combiner boxes, AC and DC disconnects, equipment enclosures, conduits, monitors, meters, security systems, and all other accessories associated with the installation of the PV system. Wiring diagrams must identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each equipment item.

c. Shop drawings may include legible copies of manufacturer's product literature, with selected items and specifications highlighted thereon.

d. Modifications to original drawings made during installation must be immediately recorded for inclusion into the as-built drawings. When items have changed relative to the approved design, the designer must provide certification indicating that the changes will not negatively affect the system's operation or the structure supporting the system.

1.6.3 System Operation

Provide a complete description of the function of each component including PV modules, DC wiring, combiner boxes, inverters, AC wiring, AC and DC disconnect switches, and monitoring system. Provide a discussion of the overall system operation.

1.6.4 Installer

Submit NABCEP (North American Board of Certified Energy Practitioners) PV Installation Professional certification, and a resume with references that details least four successful projects that, in aggregate, equal or exceed the size of the proposed project. Provide references for each of these referenced projects.

1.6.5 Standard Materials and Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Submit proof of compliance with requirements of UL, where material or equipment is specified to comply. The label of or listing in UL Electrical Construction Directory will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved nationally recognized testing laboratory (NRTL) equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of Underwriters Laboratories may be submitted.

1.6.5.1 Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of solar photovoltaic products for a minimum of 5-years. Similar photovoltaic products must have been in satisfactory commercial or industrial use for 5-years prior to bid opening and must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 5-year period.

1.6.5.2 Material and Equipment Manufacturing Date

Products manufactured more than 1 years prior to date of delivery to site must not be used, unless specified otherwise.

1.6.6 Cybersecurity Equipment Certification

Furnish a certification that control systems are designed and tested in accordance with DoD Instruction 8500.01, DoD Instruction 8510.01, and as required by individual Service Implementation Policy.

1.6.7 Operation and Maintenance Data

Submit Solar Photovoltaic Systems data package for the following items in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA.

a. Troubleshooting guide.

b. Warranty.

c. Operation instructions.

d. Preventive maintenance and inspection data, including a schedule for system operators.

1.6.7.1 Electrical Systems

Submit operation and maintenance data in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. In addition to requirements of Data Package 5, include the following for the actual solar photovoltaic (PV) system provided:

a. Service and maintenance information including preventive maintenance, assembly, and disassembly procedures.

b. Complete operation, repair, and maintenance information, detailed to the smallest replaceable unit.

c. Adjustment, trouble-shooting, configuration, tuning, and system calibration instructions.

d. Programming information for the communications and monitoring interface.

e. An instruction manual with pertinent items and information highlighted.

f. A layout drawing showing locations as well as views of equipment; front, top, and side views.

g. A one-line drawing showing all components and interfaces to the electrical system.

h. Prices for spare parts and supply list including spare modules and inverters.

i. Inverter efficiency report and field acceptance test reports.

j. Actual nameplate diagram.

k. Date of purchase.

1.6.7.2 Training Course

Provide training by a factory trained instructor to provide full instructions to designated Government personnel in the operation, maintenance and programming of the specified systems and equipment. Include safety training for first responders including fire department. The proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of safety and routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered. The proposed Training Course must be video-recorded and provided with any PowerPoint slides as part of the final documentation for those that cannot attend. .

1.6.8 Bill of Materials

Submit a Bill of Materials listing each product being incorporated into the system. Bill of Materials includes a general description of the product, quantity, and exact manufacturer's model number. Where the manufacturer's model number does not fully identify the product, list options, accessories, or custom features by additional descriptions.

1.6.9 Qualified Testing Organization

Comply with requirements specified in Section 26 08 00 APPARATUS INSPECTION AND TESTING. Engage the services of a qualified testing organization, NABCEP-certified professional, or licensed electrician to provide inspection, testing, calibration, and adjustment of the solar photovoltaic electrical distribution system and equipment listed herein. Organization must be independent of the supplier, manufacturer, and installer of the equipment. The organization must be a first tier contractor.

Submit name and qualifications of organization. Organization must have been regularly engaged in the testing of electrical materials, devices, installations, and regularly engaged in solar PV systems for a minimum of five years.

Organization calibration program requirements:

a. Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

b. Accuracy: Traceable to the National Institute of Standards and Technology.

c. Instrument calibration frequency schedule: Less than or equal to 12 months for both test floor instruments and leased specialty equipment.

d. Dated calibration tables: Visible on all test equipment.

e. Calibrating standard: Higher accuracy than that of the instrument tested.

f. Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:

    (1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.

    (2) Identify the third party laboratory calibrated instrument to verify that calibrating standard is met.

1.6.10 System Performance Calculations

Submit system performance calculations to show that the components provided will produce the minimum required production of power in accordance with PERFORMANCE REQUIREMENTS paragraph.

1.7 DELIVERY, STORAGE, AND HANDLING

a. Store solar PV modules in their original packaging according to the manufacturer's guidance, and do not remove from packaging until day of installation.

b. If a solar PV module is removed from its packaging, store it according to the manufacturer's guidance.

c. Do not store solar PV modules on-site for more than 12 months.

1.8 WARRANTY

Provide a list of all applicable warranties for all equipment and components. Include warranty information, names, addresses, telephone numbers, and procedures for filing a claim and obtaining warranty services. The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.8.1 Solar Photovoltaic Modules

Furnish the solar photovoltaic module manufacturer's written warranty. The warranty must be a 25-year linear 80 percent (minimum) power warranty (at the end of the 25th year after purchase an actual minimum power output of 80 percent based on the nameplate rating must be achieved) and not less than 10-years for workmanship material and manufacturing defects from the date of manufacture.

The warranty must state that the malfunctioning solar photovoltaic module must be exchanged by the manufacturer and promptly shipped to the using Government facility. The replacement solar module must be identical to, or an improvement upon, the original design of the malfunctioning solar module. Provide an extra 10 percent of spare modules in the event of necessary replacement of malfunctioning installed module.

1.8.2 Inverters

Furnish the inverter manufacturer's warranty. Inverter to be free from defects in material and workmanship for a minimum of 20 years from the date of manufacture. Inverter device installation, transportation, and on-site storage must not exceed 12 months, thereby permitting 19 years of the 20 year warranty to be in service and energized.

The warranty must state that the malfunctioning inverter must be exchanged by the manufacturer and promptly shipped to the using Government facility, and arrive in no more than ten days. The replacement inverter must be identical to, or an improvement upon, the original design of the malfunctioning inverter. Provide an extra 2 spare inverters in the event of necessary replacement of malfunctioning installed inverter.

1.8.2.1 Inverter Software Updates Title

Provide, at no cost or charge, any inverter software upgrades that become available during the warranty period.

1.8.3 Combiner Boxes

Combiner boxes to be free from defects in material and workmanship for a period of 5 years.

1.8.4 Mounting System

Provide PV mounting system warranty of minimum 15 years.

1.8.5 Warranty Exclusion

The warranty must cover all system malfunctions and failures except those resulting from misuse, abuse, neglect, fire, vandalism, acts of nature, or other causes beyond the control of the Contractor or manufacturer.

1.8.6 Cybersecurity During Warranty Period

All work performed on the control system after acceptance must be performed using Government Furnished Equipment or equipment specifically and individually approved by the Government.

1.9 CALCULATIONS

If construction deviates from design, provide relevant calculations to demonstrate that new design is satisfactory and approved by a licensed professional engineer.

1.10 HEALTH AND SAFETY RECOMMENDATIONS

Section 01 35 26.00 06 GOVERNMENT SAFETY REQUIREMENTS, applies to this section with additions and modifications specified herein.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

a. The PV system described in this document is a facility-scale less than 1 megawatt with system voltage not exceeding 1,000 VDC, multiple PV systems with a single service, and is of the grid-connected type which provides a direct interconnection of PV system and grid power service supplying building PV system feeds AC power into the local services when solar energy is available and immediately disconnects from the grid upon loss of grid power to the service in accordance with IEEE 1547and local utility regulations.

b. PV system must comply with these specifications, all applicable construction document drawings, all applicable codes, and all local authorities having jurisdiction. System must comply with all policies and standards required by the electrical utility having jurisdiction and all applicable incentive program guidelines. PV system equipment includes, but is not limited to, PV modules and electrical insulating components such as encapsulants and backsheets, raceways, inverters, combiner boxes, disconnect switches, wire, conduit, junction boxes, mounting hardware, mounting structure for modules (racking), monitoring and communication equipment.

2.1.1 System Requirements

Conform electrical installations to IEEE C2, NFPA 70, and requirements

specified herein.

a. Solar photovoltaic system characteristics as indicated on the design drawings.

b. All equipment must be listed and labeled in accordance with NFPA 70 and OSHA-listed nationally recognized testing laboratories (NRTL) and installed in accordance with the listing requirements and the manufacturer's instructions.

c. Provide all accessories needed for a complete, secure, operational grid-tied PV system.

d. Wiring and connections of inverters, PV source circuits, AC branch circuits, and all interconnections must be rated at a minimum for IP65 in accordance with NEMA IEC 60529.

2.1.1.1 System Wiring

System wiring must conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM and must be in accordance with Section 690 of NFPA 70. Cabling exposed to sunlight must be UV resistant. All wiring must be copper conductor.

Provide conduits in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Use galvanized rigid steel conduit above grade and mount on UV resistant high-density polyethylene (HDPE) supports. Conduit below grade must be as required by Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

2.1.1.2 Site Design

Provide adequate space for personnel, vehicles and equipment throughout the PV array to facilitate installation, inspection and maintenance access to all modules.

2.1.2 Performance Requirements

System components provided must be selected to achieve a minimum calculated energy production as required by ICC IgCC, and minimum AC power output as indicated on the design drawings.

2.2 PHOTOVOLTAIC MODULES

a. PV modules must be listed to UL 1703, and manufactured in an ISO 9001 certified facility.

b. PV modules must be of monocrystalline technology and

(1) for carport.

d. PV module efficiency must be greater than 15 percent for crystalline technology.

e. PV modules must be of the same manufacturer and model number and consistent sub-components.

f. Submit on cutsheets PV module performance data from the manufacturer that must include a flash test data in accordance with IEC 61853-1,

and temperature coefficients at: STC, nominal operating cell temperature (NOCT), low irradiance conditions (LIC), high temperature conditions (HTC), and low temperature conditions (LTC).

g. PV module bypass diodes must be inside the solar PV module's single conductor cable junction box.

h. Photovoltaic wire, wiring methods, and utilization of locking-type connectors must comply with the requirements of NFPA 70 and UL 6703. Provide USE-2 or RHH or RHW-2 wire, and sunlight-resistant wire when exposed to sunlight.

2.2.1 Crystalline Photovoltaic Module Backsheet

a. Backsheet component must consist of a tri-layer construction (minimum thickness of 9.8 mils) with outer layers of polyvinyl fluoride (PVF) and an inner layer of polyester for crystalline-silicon modules with a maximum system voltage of 1000 VDC.

b. Alternate polymeric backsheets consisting of different chemical composition, thickness, or construction must fulfill the safety and performance specifications and acceptance criteria in Table 1. The required component properties in Table 1 must be verified by a test report provided by an OSHA-listed nationally recognized testing laboratory (NRTL) and a cutsheet submitted.

TABLE 1 - PV MODULE BACKSHEET COMPONENT SAFETY AND PERFORMANCE

Items	Test Methods	Specification
Tensile Strength (MPa)	ASTM D882	>=100 (TD) >=100 (MD)
Elongation at Break (percent)	ASTM D882	>=80 (TD) >=100 (MD)
Dimensional Stability (percent, 150 degrees C, 0.5 h)	ASTM D882	<=1.0 (TD) <=1.0 (MD)
Breakdown Voltage (kV)	ASTM D149	>=18
WVTR (g/m^2 day, 37.8 degrees C, 100 percent RH)	ASTM F1249	<=2.5
Interlayer Peeling Strength (N/cm)	ASTM D1876	>=4
Peeling Strength with EVA (N/cm)	ASTM D903	>=40

TABLE 1 - PV MODULE BACKSHEET COMPONENT SAFETY AND PERFORMANCE		
Damp Heat (85 degrees C, 85 percent RH, 1000 hrs) -Color Change delta b -Elongation Retention (percent) -Appearance	ASTM E1171 ASTM E308/ASTM D2244 ASTM D882/ASTM D5870	<=2.5 >=70 No cracking or delamination.
UV Exposure Irradiance of 0.55 W/m^2 at 340 nm (61 W/m^2) using a xenon lamp with a daylight filter (outer layer). Exposure is 4200 hours (260 kWh/m^2 total UV (300-400 nm)) -Color Change delta b -Elongation Retention (percent) -Tensile Retention (percent) -Appearance	ASTM G155 ASTM E308/ASTM D2244 ASTM D882/ASTM D5870 ASTM D882/ASTM D5870	<=2.0 >=70 >=70 No cracking or delamination.

2.2.2 Crystalline Photovoltaic Module Encapsulent

a. Encapsulant component must consist of ethyl vinyl acetate (EVA) with a total nominal (prelamination) thickness of 35 mils or greater in the completed module. The EVA must have a minimum of 28 percent VA content. Through statistical process control, the module manufacturer must ensure that the cured EVA has a minimum of 70 percent gel content per ASTM D7567 or ASTM D2765. The EVA must have a UV cutoff wavelength of 360 nm as measured according to ASTM E424. The EVA must have a minimum volume resistivity of 1X10^15 ohm-cm per ASTM D257.

b. Thermoplastic encapsulants consisting of different chemical composition, thickness, or construction must fulfill the safety and performance specifications and acceptance criteria described in Table 2. The required component properties described in Table 2 must be verified by a test report provided by an OSHA-listed nationally recognized testing laboratory (NRTL) and a cutsheet submitted.

TABLE 2 - PV MODULE ENCAPSULANT COMPONENT PROPERTIES		
Items	Test Methods	Specification
Appearance	Visual Examination	No bubble, crack, or delamination.
Gel Content (percent)	ASTM D7567/ASTM D2765	>=70
UV Cutoff Wavelength (nm)	ASTM E424	>=360
Volume Resistivity (ohm-cm)	ASTM D257	>=1X10^15

2.2.3 Electrical Characteristics

Provide high-power type PV module(s), with typical peak power of not less than 305 watts, plus or minus 3 percent power tolerance, under Standard

Test Conditions (STC). The AC output must not be less than 80 percent of the DC kWp rating. The individual current harmonics and TRD shall not exceed the limits specified in IEEE 1547.

The operating voltage corresponding to the power output mentioned above must be at least 32.73 volts. The open circuit voltage of the PV modules under STC should be at least 40.79 volts. Operate PV module at an ambient temperature range of minus 40 degrees F to plus 185 degrees F with 100 percent relative humidity.

2.2.4 Terminal Box

Include a terminal box on the module having a provision for opening for replacing the cable, if required.

2.2.5 Nameplate

Include the following on the module nameplate so as to be clearly visible:

a. Name of the Manufacturer or distinctive logo;

b. Model or Type Number;

c. Serial Number;

d. Year of make;

e. Peak wattage rating;

f. Peak voltage; and

g. Peak current.

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2.3 INVERTERS

a. Array-to-inverter kW ratio must not exceed manufacturer recommendations. Inverter must be IEEE 1547 compliant, listed to UL 1741, comply with the latest applicable ANSI and FCC standards and addenda, and inspected before commissioning, testing, and operation of the system. Submit documentation validating system performance requirements.

b. Inverter must be approved by FCC Part 15, Class A as an unintentional radiator.

c. All same-sized inverters supplied must be of the same manufacturer and model number.

d. Provide inverter utilizing a support structure mount system.

e. Provide inverter utilizing a NEMA 4X enclosure in accordance with NEMA 250.

f. Provide inverter with anti-islanding protection to prevent back-feeding inverter generated power to the grid in the event of a utility outage. Anti-islanding protection must be listed to UL 1741 and IEEE 1547.

g. Overcurrent protection, ground fault protection, arc fault circuit interrupter (AFCI), and rapid shutdown must comply with the requirements of NFPA 70.

h. Provide inverter with self-diagnostics routines, and remote and local display of operating status and remote monitoring capabilities. Provide inverter compatible with monitoring system and metering system. If capability for remote monitoring and control does not exist, then it must be added.

i. Provide inverter with integrated monitoring system. Data monitoring equipment must be able to sustain an overload across its output terminals up the 150 percent load, while supplying any load within its rating and without reducing its output voltage. Fuse power semiconductors in the inverter with fast acting fuses to prevent cascading failures. Provide each fuse with a blown fuse excluding String and Micro inverters and alarm indicating diodes on the control panel.

j. Rate inverters output as 60 AC kW at unity (1), 3 phase, 480 volts, 422-528 maximum power point tracking (MPPT) voltage range. The peak inverters power conversion efficiency must be 96 percent or greater.

k. Match inverter DC input to the design of the PV module array outputs and account for the following:

(1) The inverter low voltage is 50 percent of the maximum system voltage, to account for 25 year degradation.

(2) Voltage decrease due to high temperatures at project site. Operate inverter at an ambient temperature range of minus 22 degrees F to 140 degrees F with 95 percent humidity (non-condensing).

l. Inverter must include AC and DC disconnecting means. DC and AC disconnecting means must be listed with ratings suitable for the intended use and purpose. System disconnecting means must meet the requirements of NFPA 70.

2.3.1 String Inverters

a. Submit String Inverter Efficiency of having a weighted average inverter power conversion efficiency of 96 percent or greater.

b. Allow the use of DC optimizers provided that a design which coordinates the DC optimizers and the inverter(s) is approved by the Contracting Officer.

c. Inverter must feature maximum power point tracking (MPPT).

2.4 COMBINER BOXES

a. All combiner boxes must be listed to UL 1741, and inspected before commissioning, testing, and operation of the system.

b. Provide combiner boxes support structure mount, NEMA 4/4X outdoor enclosures in accordance with NEMA 250.

c. Supply combiner boxes designed for use with the inverter provided, and coordinated to the specific PV source circuit design.

d. Include in the combiner boxes fuses and a bus to combine the outputs of the strings. Each combiner box must be UL 1741 listed and operate at an ambient temperature range of minus 13 degrees F to plus 135 degrees F. Provide combiner box capable of at least 12 inputs and an input fuse rating of 20 amps.

e. Provide combiner box output terminals for paralleling two conductors for the PV positive and negative, as well as the equipment ground conductors. Run set of wires from the combiner box to the inverter. Provide overcurrent protection and output disconnecting means listed for intended use and purpose that comply with the requirements of NFPA 70.

2.5 **PV ARRAY** MOUNTING STRUCTURE

a. PV array, including modules, hardware, **racking,** and attachments, must withstand gravity loads, seismic loads, snow loads, ice loads and wind loads as required by ASCE 7-16 and ICC IBC. **Racking system may be omitted where PV module attachments fasten directly to carport framing. Use same type of PV module mounting system for each carport.** Coordinate with structural engineer to **carport** roof will withstand the PV array loads.

b. **Carport** must be suitable for Seismic Design Category B as defined by ASCE 7-16 and ICC IBC.

c. Submit gravity, seismic, wind, ice and snow load design calculations for the array mounting system and its attachment to the structure showing compliance with gravity, seismic, wind, ice and snow requirements while supporting the PV modules.

d. Provide the mechanical hardware for mounting the PV arrays and all other hardware required for assembling the PV modules, and the attachments to the **carport** structure.

e. Use array mounting hardware compatible with the site considerations and environment. Select mechanical hardware for corrosion resistance and durability. Use a stainless steel, galvanized steel, or aluminum support structure. Do not use wood or plastic components for support.

f. Use cathodic protection compatible with the site considerations and environment. Utilize galvanized anchor encased in concrete driven into ground.

2.5.1 Mounting System Supports

Fabricate with fastening points integral to the mounting structure. Mounting system supports must be **fastened** to the carport structure.

Comply with requirements specified in Section 13 34 19 METAL CARPORT SYSTEMS.

P2: 505014, Microgrid Design 750KWDC Conroe ARC
Conroe, TX

2.5.2 **DELETED**

2.5.3 **DELETED**

2.5.4 **DELETED**

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2.5.5 Framing

Provide with wall thickness as determined by structural calculations.

2.5.6 Hardware

Bolts, nuts, washers, and screws must be 18-8 stainless steel.

2.6 PV SYSTEM MONITORING

a. Provide a PV system monitoring panel mounted as indicated.

b. The following quantities must be viewable from a touch screen display mounted at location as indicated:

(1) DC Input Voltage from PV array

(2) DC Input Power from PV system

(3) DC Input Current from PV system

(4) AC Phase Current from inverter (average)

(5) AC Voltage from inverter (average)

(6) AC Real Power from inverter

(7) Daily, Weekly, Monthly, Yearly, and Cumulative Energy Production

(8) Fault Status Report

(9) DC Ground Current Report

(10) AC Neutral Current from inverter

(11) AC Reactive Power from inverter

(12) AC Apparent Power from inverter

(13) AC Power Factor

(14) AC Phase Current from inverter (A, B, C)

(15) AC Voltage from inverter (A, B, C)

(16) AC Voltage and Current Balance.

c. Provide additional data acquisition sensors to measure irradiance wind speed ambient temperature PV module temperature. Any additional data acquisition sensors require a conduit separate from the current conductor conduit.

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2.7 PV SYSTEM METERING

a. Provide a revenue-grade Interval Data Recording (IDR) meter complete with industry standard telemetry for communications with Ethernet, cellular, or other common output capabilities. Conform to CSI requirements and electrical utility requirements.

b. Connect to a monitoring/data collection recording solar production through time increments applicable to installation and utility standards, with a minimum of 15-minute intervals and 30-day memory.

c. UL listed and conform to ANSI C12.1.

d. Measure kWh, demand, instantaneous power, volts, amps, and watts.

e. Provide UL listed communication and annunciator panel.

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2.8 POSTED OPERATING INSTRUCTIONS

Provide for each system and principal item of equipment as specified in the technical sections for use by the operation and maintenance personnel. The operating instructions include the following:

a. Wiring diagrams, schematic diagrams, interconnection diagrams, control diagrams, and control sequence for each principal system and item of equipment.

b. Array layout showing the locations of all DC and AC disconnects.

c. Start up, proper adjustment, operating, and shutdown procedures.

d. Safety precautions.

e. The procedure in the event of equipment failure.

f. Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions do not fade when exposed to sunlight and secure to prevent easy removal or peeling.

2.9 MANUFACTURER'S NAMEPLATE

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. For PV modules, a label on the back of the module is acceptable.

2.10 FIELD FABRICATED NAMEPLATES

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified. Each nameplate inscription identifies the function and, when applicable, the position. Nameplates are of melamine plastic, 0.125 inch thick, white with black center core. Surface is of matte finish. Square corners. Accurately align lettering and engrave into the core. Minimum size of nameplates is 1 inch by 2.5 inches. Lettering is a minimum of 0.25 inch high normal block style.

2.11 PV EQUIPMENT MARKING AND WARNING LABELS

Provide PV equipment listed or be evaluated for the application and have a field label applied in compliance with NFPA 70.

Provide warning signs for the enclosures of electrical equipment having a nominal rating exceeding 600 volts.

a. Provide PV equipment with UL 969 weather-resistant marking and warning labels in compliance with NFPA 1 and NFPA 70.

b. When such equipment is guarded by a fence, mount signs on the fence. Provide metal signs having nominal dimensions of 14 inches by 10 inches with the legend "DANGER HIGH VOLTAGE KEEP OUT" printed in three lines of nominal 3 inches high white letters on a red and black field.

c. Provide warning signs for arc flash protection in accordance with NFPA 70Eas indicated for all electrical equipment and components that are requiring examination, adjustment, servicing, or maintenance while energized. Provide field installed signs to warn qualified persons of potential electrical arc flash hazards when warning signs are not provided by the manufacturer. Provide marking that is clearly visible and readable from each accessible side to qualified persons before examination, adjustment, servicing, or maintenance of the equipment.

2.12 CABLE TAGS IN MANHOLES, HANDHOLES, AND VAULTS

Provide tags for each power cable or wire located in manholes, handholes, and vaults. The tags must be polyethylene or sheet lead. Do not provide handwritten letters. The first position on the power cable tag denotes the voltage. The second through sixth positions on the tag identify the circuit. The next to last position denotes the phase of the circuit and must include the Greek "phi" symbol. The last position denotes the cable size.

2.13 GROUNDING AND BONDING

a. Provide properly sized equipment grounding conductors. Equipment grounding conductors must be insulated stranded copper, except that sizes 10 AWG and smaller must be solid copper. Insulation color must be continuous green for all equipment grounding conductors, except that wire sizes 4 AWG and larger shall be identified per NFPA 70.

b. Provide grounding lugs for aluminum PV solar module frames of either stainless steel or tin-coated copper.

c. Bonding conductors must be bare stranded copper, except that sizes 10 AWG and smaller must be bare solid copper. Bonding conductors must be

stranded for final connection to motors, transformers, and vibrating equipment.

d. Provide bonding fittings on concentric/eccentric knockouts with metal conduits for circuits over 250 volts in accordance with NFPA 70.

e. Provide bonding fittings for ferrous metal conduits enclosing grounding electrode conductors in accordance with NFPA 70.

2.14 PV LIGHTNING PROTECTION SYSTEM

Provide PV Lightning Protection for electrical and mechanical systems in accordance with Section 26 41 00 LIGHTING PROTECTION SYSTEM and NFPA 780.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTALLATION INSTRUCTIONS AND INSTALLATION DRAWINGS

a. Complete all electrical work in accordance with NFPA 70.

b. Provide all permanent and temporary shoring, anchoring, and bracing required by the nature of this work in order to make all parts absolutely stable and rigid, even when such shoring, anchoring, and bracing are not explicitly called for.

c. Install the solar PV system in accordance with this section, installation drawings, and the printed installation instructions of the manufacturer.

d. Follow the manufacturer's installation recommendations to ensure no electricity is being fed to the grid and that all available disconnects are in the open position and fuses are not installed during wiring operations. Utilize on-site measurements in conjunction with engineering designs to accurately cut wires and layout before making permanent connections. Locate wires out of the way of windows, doors, openings, and other hazards. Ensure wires are free of snags and sharp edges that have the potential to compromise the wire insulation. If the system is roof-mounted, it must have direct current ground fault protection in accordance with NFPA 70. Ensure breakers in combiner box are in the off position (or fuses removed) during combiner box wiring. Ensure wires and conduit are not installed as a trip hazard.

e. Attach solar PV modules to the mounting structure according to the manufacturer's instructions and approved plans.

f. Install instrumentation according to the manufacturer's instructions, with control panels located as indicated.

3.1.1 Wiring Methods

Furnish and install conductors required to connect incoming and outgoing circuits. Install conductors with conduits, boxes, and terminal cabinets in a totally enclosed installation. Install wiring in accordance with NFPA 70 and Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

3.1.2 Electrical Connections

a. Use twist on wire connectors listed for the environment (i.e. wet,

damp, direct burial) and installed per manufacturer's instructions.

b. Use listed power distribution blocks.

c. Use terminals containing more than one conductor listed for multiple conductors.

d. Use connectors and terminals used for fine strand conductors that are listed for use with such conductors.

e. Utilize appropriate tools for connector type as recommended by the manufacturer.

f. Tighten and secure module connectors.

g. Provide corrosion protection in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM, and by adding a stainless steel isolating washer between components of incompatible metals on the racking structure.

h. Rate all enclosures for electrical connections and interconnections for NEMA 6 in accordance with NEMA 250 or IP67 in accordance with ANSI IEC 60529.

3.1.3 Disconnects

Provide disconnecting means in accordance with NFPA 70 requirements.

a. Install disconnects for all current carrying conductors of the PV source.

b. Install disconnects for the PV equipment. For inverters and other equipment that are energized from more than one source, group and identify the disconnecting means. Equipment disconnecting means or its remote operating device or the enclosure providing access to the disconnecting means must be capable of being locked in the open position when not within sight or not within 10 ft of the equipment.

c. Install disconnects and overcurrent protection for all ungrounded conductors in ungrounded (transformerless) PV power systems.

d. Install disconnecting means with a rapid shutdown function using the rapid shutdown initiation devices as specified in NFPA 70. Each device's "off" position must indicate that the rapid shutdown function has been initiated for all PV systems connected to that rapid shutdown initiation device.

e. Disconnecting means equipment that performs the rapid shutdown function, other than initiating devices, must be listed for providing rapid shutdown protection.

f. Buildings with rapid shutdown disconnecting means must have a permanent label as specified in NFPA 70.

3.1.4 Overcurrent and Overvoltage Protection

a. Install the PV interconnect overcurrent protective device as indicated in accordance with NFPA 70. Overcurrent devices used in PV system dc circuits must be listed for use in PV systems.

b. Install overvoltage surge protective device (SPD) as indicated and in accordance with NFPA 780 and NFPA 70. PV surge protective devices must be listed for use in PV system and marked "DC" or "PV SPD." If the system inverter is more than 100 ft from the closest combiner or recombiner box, provide additional PV SPDs at the PV output circuit adjacent to the inverter.

3.2 GROUNDING

3.2.1 PV System Grounding

NFPA 70 and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms. Ground according to racking manufacturer's recommendations.

Install grounding lugs in locations on the solar PV module as designated by the module manufacturer, using stainless steel machine screws of the thread size provided in the pre-tapped holes, along with a stainless steel star washer placed between the grounding lug and the solar module frame.

3.2.2 Grounding Electrodes

Provide driven ground rods as specified in Section 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3.3 INSTALLATION OF EQUIPMENT AND ASSEMBLIES

3.3.1 Carport Mounted Systems

a. Install and support PV system on carport structures in accordance with PV system manufacturing requirements.

3.4 WARNING SIGN MOUNTING

a. Display calculated maximum and minimum voltages and their respective amperages on engraved warning labels.

b. Display information on the arc flash warning labels in accordance with NFPA 70E.

c. Provide the number of signs required to be clearly visible and readable from each accessible side. Space the signs in accordance with NFPA 70E.

3.5 CABLE TAG INSTALLATION

Install cable tags in each manhole, handhole, and vault as specified, including each splice. Install cable tags over the fireproofing, if any, and locate the tags so that they are clearly visible without disturbing any cabling or wiring in the manholes, handholes, and vaults.

3.6 FIELD QUALITY CONTROL

Perform in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM

and 33 71 02 UNDERGROUND ELECTRICAL DISTRIBUTION.

3.6.1 Performance of NABCEP Acceptance Checks and Tests

Perform all inspections using a NABCEP-certified professional and in accordance with NABCEP inspection procedures, and in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests.

3.6.1.1 PV Modules

a. Visual and Mechanical Inspection

(1) Solar PV module manufacturer, model, and number of modules must match the approved plans.

(2) Solar PV modules must be in good conditions (including but not limited to no broken glass or cells, no discoloration, frames not damaged).

b. Electrical Tests

(1) Verify output of PV modules according to manufacturer's recommendations and NABCEP practices.

3.6.1.2 Inverters

a. Visual and Mechanical Inspection

(1) Inverter manufacturer, model, and number of inverters must match the approved plans.

(2) Inverters must be in good condition.

b. Electrical Tests

(1) Verify output of inverters according to manufacturer's recommendations and NABCEP practices.

3.6.2 Performance of NETA Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

3.6.2.1 Grounding System

a. Visual and Mechanical Inspection

(1) Inspect ground system for compliance with contract plans and specifications.

b. Electrical Tests

(1) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod, perform tests before any wire is connected. Take measurements in normally dry weather,

not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

(2) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3.6.3 Functional Acceptance Tests

a. Provide final and complete commissioning of the solar PV system in accordance with IEEE 1547.

b. Verify that all electrical components are installed and connected according to the requirements of the PV electrical drawings, specifications, and manufacturer's written instructions.

c. Before starting or operating the system, check continuity of all conductors and grounding conductors to verify that there are no faults and that all equipment has been properly installed according to the manufacturer's recommendations. Check factory instructions to see that installations have been made accordingly. Check equipment for any damage that may have occurred during shipment, after delivery, or during installation. Replace damaged equipment.

d. Before starting or operating the system, obtain a final inspection approval and final inspection from the Contracting Officer. Be present on site for both of these inspections.

e. Make final adjustments to all inverters and monitoring equipment so that they will be placed in an acceptable operating condition. Adjustable parameters must be set so that the PV system will produce the maximum possible amount of energy on an annual basis.

3.7 COMMISSIONING

Conduct Commissioning, after the system is installed and is ready for operation, in accordance with Section 01 46 00.00 07 COMMISSIONING - MICROGRID, item (6) renewable energy generation, to verify that the completed and installed system meets the requirements of IEEE 1547. Tailor for non-building systems.

3.7.1 Commissioning Agent Qualification

Individual qualified in testing protective equipment (e.g., professional engineer, factory-certified technician, licensed electrician with experience in testing protective equipment) must perform or directly supervise commissioning tests.

3.7.2 Commissioning Plan and Schedule

Develop and implement a commissioning plan and commissioning schedule in accordance with Section 01 46 00.00 07 COMMISSIONING - MICROGRID.

3.7.3 Start-up Pre-functional Checklists

Carry out a checklist of startup requirements and conduct a series of safety tests to ensure proper installation, safe operation, and performance conforming to specification.

3.7.4 Functional Performance Testing

Prepare test procedures and conduct functional performance testing of the installed system. Include the following test requirements:

a. All inverter startup tests as specified by the inverter manufacturer in the inverter operation manual;

b. Actual power;

c. Loss of grid;

d. Grid resume;

e. Data monitoring check out;

f. V_{oc} measurement of every source circuit and log it;

g. Verify tightness of all wiring terminations;

h. Verify proper markings and labeling of all wire terminations and enclosures;

i. Verify startup/shut down procedures;

j. Verify system 5 minutes delay upon restart;

k. Verify PV array quick connectors are fully mated and wires are neatly secured;

l. Verify no debris on the modules, no damaged or broken modules;

m. Verification and inspections (see IEEE 1547.1 7.2)

n. Field-conducted type and production tests (see IEEE 1547 7.3)

o. Unintentional islanding functionality test (see IEEE 1547.1)

p. Cease-to-energize functionality test (see IEEE 1547.1)

q. Unintentional islanding functionality test (see IEEE 1547.1)

r. Cease-to-energize functionality test (see IEEE 1547.1 7.5)

s. Revised settings (see IEEE 1547.1 7.6)

3.7.5 Functional Performance Testing Results

Coordinate, observe and record the results of the functional performance testing. Coordinate retesting as necessary until satisfactory performance is verified. Verify the intended operation of individual components and system interactions under various conditions and modes of operation.

Document items of non-compliance in materials, installation or operation. Immediately address observed non-conformance and deficiencies in terms of notification to responsible parties, and provide recommended actions to correct deficiencies.

3.7.6 Final Commissioning Report

Prepare and submit final commissioning report. Summarize all tasks, findings, conclusions, and recommendations of the commissioning process in accordance with IEC 62446. Include the results of all tests and a listing of the final settings.

3.8 FINAL ACCEPTANCE

The acceptance of the solar PV system occurs only after all deficiencies identified by the functional acceptance tests and commissioning report are corrected, and the system operates successfully during a 30 day initial testing period.

The Contracting Officer must sign appropriate certificates, if equipment and systems are operating satisfactorily in accordance with the specifications, stating the system's operation has been tested and accepted at the end of the final start-up and testing.

3.9 CLOSEOUT ACTIVITIES

3.9.1 Demonstration

Upon completion of the work and at a time approved by the Contracting Officer, provide instructions by a qualified instructor to the Government personnel in the proper adjustment, system operation, and maintenance of the specified systems and equipment, including pertinent safety requirements as required. Government personnel must receive training comparable to the equipment manufacturer's factory training. Instructor must provide a separate training course for the monitoring system.

3.9.2 Instructor's Qualification Resume

Instructor(s) must be employee(s) of installer, manufacturer, or certified solar photovoltaic system training program. Instructors must be thoroughly familiar with all parts of the installation and trained in operating theory as well as practical operation and maintenance work. Submit the name(s) and qualification resume(s) of instructor(s) to the Contracting Officer for approval.

3.9.3 Training

Furnish training service by a factory-trained representative. Document that each qualified employee has received the required training in accordance with 29 CFR 1910. Maintain all training documentation in a central location for the entire employee's employment duration. Minimum documentation data includes employee's name, training name, and date(s) of training.

The training period must consist of a total of 2 hours of normal working time and begin after the system is functionally completed but prior to final acceptance tests. Submit the training course curriculum for approval, along with the proposed training date, at least 14 days prior to the date of proposed conduction of the training course. Instruction must

be given during the first regular work week after the equipment or system has been accepted and turned over to the Government for regular operation. Provide video recording and any PowerPoint slides as part of the final documentation for those that cannot attend. Extend safety training to fire department representatives. Coordinate with Contracting Officer for Fire Department first responder training.

-- End of Section --