

**AES Indiana**  
**AES Indiana – Petersburg BESS**

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**Exhibit F – Attachment 5**  
**Project Testing and Commissioning Requirements**

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## 1.0 INTRODUCTION

- 1.1 The following testing and commissioning specification is general in nature and intended to provide the requirements for developing the detailed Commissioning Plan. The Commissioning Plan shall cover all Project scope including all labor, equipment, activities, tests, and procedures required to comprehensively execute the Commissioning Requirements. Commission Plan and Requirements shall cover the Project apparatus, equipment, devices and auxiliary systems and their associated protection, control, and instrumentation schemes/systems required prior to energization, energization and phase-in activities, subsequent in-service checks and testing, and commissioning close-out. All equipment, devices, components and materials specific to the Project shall be included.
- 1.2 Typical testing & commissioning activities may include visual and mechanical inspections, insulation resistance, continuity and line "End to End" testing, ratio and polarity, equipment setting and calibration, verification of operability, system functionality, and placement of the equipment into service. In addition to equipment testing the Contractor will be required to perform ground grid testing, DC battery testing, protective relay testing, perform SCADA controls testing, and phase in verification.
- 1.3 Contractor shall assure that all protection schemes and electrical equipment tested for the Project are operational and within Owner's, industry and manufacturer's tolerances and are installed in accordance with Contract documents, Contractor's Issued for Construction (IFC) design specifications and drawings, and manufacturer's requirements.
- 1.4 Contractor shall coordinate all applicable testing and commissioning activities with Transmission Owner.
- 1.5 The contractor shall provide testing and documentation required to trouble shoot any relay or equipment malfunctions that would prevent the site from meeting the criteria to safely energize.
- 1.6 Contractor shall coordinate with Owner to support any Owner related tasks once the lines and stations are placed in service, in order to provide troubleshooting assistance when required.
- 1.7 All scope covered in this specification is subject to Owner oversight or witness of testing, and review of test documentation, before a specific test or activity may be accepted.

## 2.0 CODES, STANDARDS, AND REFERENCES

- 2.1 Development of the Commissioning Plan and execution of the Commissioning Requirements shall be in accordance with the manufacturer's recommendations and requirements and the applicable requirements of the industry codes and standards including those listed below.
  - 2.1.1 NETA – International Electric Testing Association
    - 2.1.1.1 ATS – Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
    - 2.1.1.2 ECS – Standard for Electrical Commissioning Specifications for Electrical Power Equipment and Systems
  - 2.1.2 NEC – National Electric Code
  - 2.1.3 NESC – National Electric Safety Code
  - 2.1.4 OSHA – Occupational Safety and Health Organization

- 2.1.5 ANSI – American National Standards Institute
- 2.2 Direct references to standards provided herein are provided for clarity. It is the Contractor’s responsibility to ensure all applicable standard and code requirements, in addition to the manufacturer’s recommendations and requirements, are met.
- 2.2.1 Standards and codes referenced within the above referenced standards and codes shall be considered as applicable to the Commissioning Requirements
- 2.3 The latest edition of the Industry Standards as detailed in the Contract and Contract Exhibits shall be used.
- 2.4 As available, use the manufacturer’s instruction manuals applicable to each piece of equipment or system component tested. Wherever the provisions of said publications are in conflict, the more stringent requirements shall apply.

### 3.0 DEFINITIONS

- 3.1 The following definitions shall apply to this document and any reference Contract document. Capitalized terms used and not defined in this document have the meaning ascribed to such terms in the Contract. Unless otherwise expressly stated, the provisions of Article 2 of the Contract relating to interpretation shall apply to this document
  - 3.1.1 “Commissioning Plan” means the detailed acceptance testing and commissioning requirements, approach, and execution planning document that shall be developed by Contractor as described herein and agreed to by Owner.
  - 3.1.2 “Commissioning Requirements” has the meaning set forth in Section 1.1 herein.
  - 3.1.3 “Commissioning Tests” means the tests described herein and those included in the Contractor developed Commissioning Plan.
  - 3.1.4 “Commissioning Test Report” means the final report documenting the results from the Commissioning Tests.
  - 3.1.5 “Commissioning Sponsor” means Contractors Commissioning Representative(s) charged with managing the execution of Commissioning Plan, who are competent and qualified and having the authority to validate witness tests and sign-off on testing, commissioning and turnover documentation.
  - 3.1.6 “IR” means infrared.
  - 3.1.7 “LOTO” means lock-out, tag-out.
  - 3.1.8 “Off-Grid Commissioning” has the meaning set forth in Section 4.5 herein.
  - 3.1.9 “PPE” means personal protective equipment.
  - 3.1.10 “SCADA” means the supervisory control and data acquisition system installed as part of the Project.

### 4.0 GENERAL REQUIREMENTS

- 4.1 Testing shall be conducted in accordance with any instructions provided by the equipment manufacturer in addition to the requirements provided herein, in the Commissioning Plan to be provided by Contractor in accordance with the Contract, NETA ATS and ECS requirements, and any other applicable Industry Standards. Any conflict between these requirements shall be brought to the Owner’s attention for resolution.

- 4.2 The Commissioning Plan shall be developed and executed in accordance with NETA ATS and ECS requirements, Manufacturers requirements, the Contract and the Interconnection Agreement. For the purposes of the Commissioning Plan development and execution, the following NETA ECS terms shall have the following understanding:
- 4.2.1 Owner’s Representative: Contractor shall be understood to be responsible for the requirements of Owner’s Representative
- 4.2.2 Commissioning Organization’s Responsibilities: Contractor shall be responsible to self-perform, where qualified, or subcontract the Commissioning Organization’s responsibilities.
- 4.2.3 Owner’s Project Requirements: The Contract and its Exhibits shall define the Owner’s Project Requirements
- 4.2.4 Basis of Design: Contractor’s engineering, design, and procurement selection, Work along with any Owner supplied components shall define the Basis of Design.
- 4.3 The Commissioning Plan shall include all relevant testing required to demonstrate compliance with the Owner’s testing obligations under the Interconnection Agreement
- 4.4 Where witness testing is required as part of the Commissioning Requirements, Contractor shall provide Owner with Notice at least five (5) Business Days prior to testing. Contractor shall keep Owner continuously apprised of any changes to the schedule for such testing and shall give and shall give Owner at least two (2) Business Days advance Notice of the re-scheduling of any such test; provided that any such period of advance Notice may be reduced if the applicable Owner’s representative is at the Site and Owner approves such reduction.
- 4.5 Contractor shall furnish all labor, equipment, tools, and materials required to execute the Contractor developed Commissioning Plan safely, successfully and on schedule.
- 4.6 Contractor may elect, prior to or following Mechanical Completion, to use grid emulators and/or external generators to facilitate commissioning of the BESS including for the performance of functional testing (“Off-Grid Commissioning”). Contractor’s election to conduct Off-Grid Commissioning shall be in its sole discretion and Contractor shall not be required to be conduct Off-Grid Commissioning.
- 4.7 Contractor shall properly protect equipment which has been checked and tested, so that there is no adverse impact to this equipment by subsequent testing of other equipment and systems

## **5.0 QUALIFICATIONS OF COMMISSIONING PERSONNEL**

- 5.1 Contractor shall submit the resumes of qualified technicians assigned to the Project for Owner review and approval. The resumes should include similar projects executed and should show completion of at least one project of similar scope for the team position being proposed, and preferably include at least 3 years of similar work experience.
- 5.2 Technicians performing the Commissioning Requirements work shall be qualified by virtue of training and experience for the type of work performed and shall be familiar with the equipment under test. They shall be trained in the nature of the hazards involved and shall be capable of judging the serviceability of the equipment.
- 5.3 Once the resumes are submitted and approved, these assigned resources may not be substituted without prior approval from Owner.

- 5.4 Any requested changes to the resumes of the personnel anticipated to work on these projects shall be submitted to Owner for review no later than three (3) weeks prior to mobilization.
- 5.5 Contractor's Commissioning Team shall perform a thorough review of the Commissioning Plan, and ideally shall be involved in the development. Commissioning team shall review and be familiar with all applicable Project documents, single lines and schematics, commissioning forms and procedures related to the Commissioning work.
- 5.6 Contractor shall assign Commissioning Sponsor(s) who shall be competent individuals responsible for all aspects of the safe and complete execution of the Commissioning Plan

## **6.0 COMMISSIONING PLAN**

- 6.1 Contractor shall develop the Commissioning Plan (Commissioning Plan) with schedule which shall describe the planned activities, processes, procedures, and deliverables as well as describe the sequence required to prove the function and performance and fully commission, energize, functionally test, and make safe and ready for operation the complete Project. Execution of this Commissioning Plan shall be completed in a safe manner and while meeting the project schedule.
- 6.2 The draft Commissioning Plan shall be submitted ninety (90) days prior to the start of any testing or commissioning activities onsite, with the final approved plan being provided to Owner thirty (45) days prior to start of any testing or commissioning activities onsite.
- 6.3 The draft testing & commissioning template shall include, at a minimum:
  - 6.3.1 Division of responsibilities matrix for the activities including dedicated support of any Owner activities.
  - 6.3.2 Commissioning Safety Plan covering all activities included in the Commissioning work.
  - 6.3.3 Testing schedule, coordination plan, mitigation plans and an energization procedure, inclusive of all required Owner coordination activities.
  - 6.3.4 Commissioning Plan templates which are tied to the Project one-line diagrams
  - 6.3.5 Details of all testing and commissioning activities being performed, inclusive of a detailed listing of each device or piece of equipment, and quantity, to be tested, with associated check-out, acceptance testing, and commissioning activities assigned to each, including gassing of the breakers.
  - 6.3.6 Examples of all test data sheets, and procedures and sequencing of the scheduled tests.
  - 6.3.7 Templates of Test Reports for each device type included for the Project.
  - 6.3.8 Templates of all 'Ready for Energization' and 'Testing and Commissioning Complete' turnover reports and verification forms.

## **7.0 SAFETY REQUIREMENTS**

- 7.1 The purpose of the Commissioning Specific Safety & Environmental Plan is to ensure that the safety and environmental requirements of the Project are communicated in a consistent manner, which in turn will ensure the safety and environmental compliance of all Project stakeholders to the job site. The goal is to complete the Project with zero accidents / incidents. This section provides minimum requirements that must be met.

- 7.2 All parties involved must be cognizant of applicable Human Performance procedures, policies and practices. This document does not include any procedures, including specific safety or human performance procedures. It is recognized that an overwhelming majority of the tests and inspections recommended in these specifications are potentially hazardous. Individuals performing these tests shall be capable of conducting the tests in a safe manner and with complete knowledge of the Commissioning Plan's requirements and the hazards involved.
- 7.3 Contractor shall develop a Commissioning Specific Safety & Environmental Plan which is in compliance with the referenced standards herein, and all applicable laws.
- 7.4 Contractor shall observe and follow the site safety specific guidelines. A copy of the Safety Book for the project will be provided prior to coming on site.
- 7.5 Contractor will be responsible for the safety of all personnel and equipment during the testing and commissioning activities.
- 7.6 A safety lead person shall be identified prior to commencement of work. Note, this may be the assigned Lead Technician.
- 7.7 A documented job tailboard / safety briefing meeting shall be performed before the start of each workday and whenever scope and/or conditions change significantly.
- 7.8 Suitable PPE, barricades and warning signs shall be used for all activities.
- 7.9 All testing activities shall be coordinated with all other activities and parties on site.
- 7.10 All commissioning tests shall be made with proper regard for the protection of both the equipment, commissioning personnel, other onsite personnel not directly involved in commissioning activities, and any station operating personnel.
- 7.11 No commissioning test shall be performed without the knowledge and consent of the Owner.
- 7.12 All tests shall be performed by or under the direct supervision of the designated competent person / qualified individual.
- 7.13 Identify areas of hazard and erect physical barriers to prevent or restrict access. Provide personnel in the vicinity of the test area during the periods of high voltage application specifically assigned the duty of ensuring unauthorized personnel cannot enter the test area.
- 7.14 Follow the local, state and National safety rules and the site-specific safety rules.
- 7.15 All tests shall be performed with the apparatus de-energized and grounded except where otherwise specifically required to be ungrounded or energized for certain tests.
- 7.16 Contractor shall submit two Certified Test Reports for all equipment and systems indicating equipment or system is ready for safe energization. A preliminary copy shall be available for review by Owner. Contractor's Commissioning Sponsor shall verify and sign-off on each report prior to energization of any equipment or systems.
- 7.17 Fully ground equipment after medium and high voltage testing for sufficient time to fully discharge any static charge.
- 7.18 Properly protect all equipment tested and checked for operation, to ensure that any subsequent testing of other equipment or system does not disturb, damage, or otherwise interfere with the functional capability of the equipment.

- 7.19 Additional safety practices shall include, but are not limited to, requirements provided in the below referenced documents:
  - 7.19.1 All applicable provisions of the Occupational Safety and Health Act, particularly OSHA 29CFR 1910.
  - 7.19.2 Accident Prevention Manual for Industrial Operations, National Safety Council.
  - 7.19.3 ANSI/NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.
  - 7.19.4 NETA ATS and ECS safety requirements
  - 7.19.5 Applicable state and local safety operating procedures.
  - 7.19.6 Site Specific and Commissioning Specific (as applicable) Safety Plans and Exhibit S

## **8.0 VEHICLES, TOOLS AND EQUIPMENT**

- 8.1 Contractor shall provide all transportation, insulated small tools & consumables, test sets and tools, hardware and software, material, equipment, labor and technical supervision required to execute the Commission Plan.
- 8.2 All test equipment required for commissioning should be used in accordance with the manufacturer's recommendations and with applicable NEC, NESC, NETA, ANSI, or OSHA guides.
- 8.3 All test equipment shall be properly calibrated, well maintained and in good working order.
- 8.4 Contractor shall have a calibration program based on the National Institute of Standards and Technology (NIST).
- 8.5 All test equipment shall be designed specifically for the electrical power system testing and for the specific purpose that it is being used for.
- 8.6 Dated calibration labels shall be visible on all test equipment with calibration occurring within six (6) months for analog devices and twelve (12) months for digital devices, or in accordance with the manufacturer's recommended calibration frequency for the instrument.
- 8.7 Calibration of any test instruments that will be permanently installed shall not expire within one year of installation.
- 8.8 Calibration records shall be maintained and shall be made available to the Owner upon request.
- 8.9 Calibration accuracy shall be directly traceable to the National Institute of Standards and Technology (NIST).
- 8.10 Test equipment shall be of the highest class available and in good mechanical and electrical condition and shall be inspected prior to use.
- 8.11 All meters shall be true RMS reading devices.
- 8.12 Contractor shall be experienced in the use of appropriate relay test equipment. Contractor shall use approved relay testing tools which shall meet the requirements of the Transmission Owner. Contractor shall propose software for Owner's Protection Relay Testing Software and database, which shall be compliant and compatible with the Transmission Owner's system. Contractor shall use the latest version of manufacturer's required software to communicate and set relays.



## 9.0 PROJECT SCHEDULE

- 9.1 Commissioning Plan and schedule shall support the overall Project Schedule and shall account for all coordination requirements with Owner and Transmission Owner.
- 9.2 Acceptance Testing and Commissioning Plan shall account for Project work not being completed in a linear fashion and allow for check-out, testing and commissioning of components, equipment and systems as they are completed.
- 9.3 Contractor shall schedule and coordinate a site walk down with Owner's technicians and supervision at the completion of the testing and commissioning, i.e., Field Hand-off Meeting. The site walk down shall be scheduled for a minimum of one full day or longer if needed to completely review the facilities.

## 10.0 QUALITY ASSURANCE

- 10.1 All testing and commissioning activities will be planned in advance, thoroughly reviewed and completed under strict Quality Control / Quality Assurance ("QA/QC") procedures.
- 10.2 Reviews and checks will be completed through each phase of the project and are documented for future reference.
- 10.3 In addition to adherence to the quality procedures, all testing and commissioning deliverables will undergo stringent reviews by Owner oversight to ensure completeness and accuracy.
- 10.4 The QA/QC documentation process is designed to remind each person involved to pay attention to the details beyond the procedures and documentation and ensure that strict commissioning procedures are followed by every member the Commissioning Team.

## 11.0 REPORTING

- 11.1 Contractor shall provide, for Owner review and approval, a complete set of commissioning test forms at least thirty (30) Business Days prior to commencing the Commissioning Tests.
- 11.2 Contractor shall provide periodic reporting as described below to report the status of testing activities, to verify testing is proceeding in accordance with the project schedule, and to document the results of all testing performed:
  - 11.2.1 Weekly look-ahead of tests planned for the upcoming two-week period
  - 11.2.2 Weekly reports summarizing the tests performed during the current week
  - 11.2.3 Draft report forms for tests performed shall be submitted on a weekly basis following completion of tests
- 11.3 Documentation shall be maintained on a real time basis and provided to the Owner daily. Prior to energization a hard copy of all test results must be provided to the Owner. All documentation shall be produced and submitted by Contractor in both hard copy and electronic form.
- 11.4 Preliminary copies of all test record forms, together with a detailed written report, shall be packaged and provided to the Owner's representative within ten (10) Business Days after the conclusion of each Commissioning Test. Final copies shall be included in the Commissioning Test Report.

- 11.5 Contractor shall provide the Final Testing & Commissioning Report containing all test reports and forms for all equipment and systems tested. The Report will document that all equipment and systems were tested in accordance with the project requirements and as specified. The draft final report will be submitted within two weeks following completion of testing and commissioning activities and before the Commissioning Team demobilizes from the site. Report shall be delivered per Exhibit P requirements and as a minimum, shall include all information described in NETA-ATS section 5.4, copies of all testing records, and the following:
- 11.5.1 Summary of project.
  - 11.5.2 Description of equipment tested.
  - 11.5.3 Description of tests.
  - 11.5.4 Test data.
  - 11.5.5 Analysis, explicit statement of all pass / fail for each test and commissioning activity, conclusion and recommendations.
- 11.6 Preliminary and final test reports shall indicate all deficiencies found during the testing, include a description of the corrective action taken to remedy and the results of re-testing verifying resolution of deficiencies.
- 11.7 Final Commissioning Plan shall indicate all pass/fail criteria and basis for criteria. In general test results that fall within the guidelines of NETA Testing and Commissioning Standards are considered acceptable, unless otherwise specified.
- 11.8 Raw test results and RTS test routines and reports are to be supplied Owner the same day the test is conducted for review. Any failed test should be reported immediately to Owner, and field inspector. Test data records shall be per the Contractor proposed and agreed to standard and include the following minimum requirements:
- 11.8.1 Relay test reports (PDF format);
  - 11.8.2 Protection Suite test plan (.db format or equivalent);
  - 11.8.3 Identification of the testing organization.
  - 11.8.4 Equipment identification.
  - 11.8.5 Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
  - 11.8.6 Date of inspections, tests, maintenance, and/or calibrations.
  - 11.8.7 Identification of the testing technician(s).
  - 11.8.8 Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
  - 11.8.9 Indication of expected results when calibrations are to be performed.
  - 11.8.10 Indication of "as-found" and "as-left" settings and results, as applicable.
  - 11.8.11 Sufficient spaces shall be provided to allow all results and comments to be indicated clearly
- 11.9 Contractor shall provide all point-to-point "yellow-lining" of all circuits.

- 11.10 Red line drawings with all 'as built' changes made by the Contractor shall be provided to Owner prior to Commissioning Team leaving site. A station copy shall remain in the Contractor's trailer during the project phase and shall be stored in the substation control house once the Project is turned over to Owner as an accurate set for operations personnel.
- 11.11 The drawing mark-up standard to be used for this project is as follows:
  - 11.11.1 'red' for drawing additions
  - 11.11.2 'green' for removals, and
  - 11.11.3 'blue' for commenting and
  - 11.11.4 'yellow' highlighting for verification of drawing items or for wire point to point tracing and verification.

## 12.0 SCOPE OF WORK REQUIREMENTS

- 12.1 Contractor shall test and commission all electrical equipment and protection devices to NETA ATS - Acceptance Test Specifications and NETA ECS - Electrical Commissioning Specifications unless otherwise stated by the manufacturer's recommended acceptance test.
- 12.2 In addition to the requirements provided and referenced herein, following the erection of the BESS and auxiliaries, a systematic, comprehensive commissioning program shall be completed by Contractor, with technical direction provided by the BESS equipment supplier. The BESS equipment supplier shall provide a commissioning manual which shall include all necessary commissioning procedures, instructions, drawings and test forms for their equipment.
- 12.3 Contractor is ultimately responsible for testing and commissioning all Project equipment in the proposed scope, energizing, verifying functionality of all equipment, systems, protection and controls, and turning over a functioning product ready for operation upon completion of the Commissioning Requirements.
- 12.4 Contractor shall perform all acceptance testing of all systems, equipment, apparatus and materials installed under the scope of this project. Acceptance tests shall include all testing and equipment inspections in accordance with the manufacturer's recommendations and the requirements and requirements provided herein, as well as (at minimum), activities as outlined in the latest version of the ANSI/NETA Acceptance Testing Specifications.
- 12.5 Contractor shall perform all electrical verification testing of the installed equipment and facilities under the scope of each project, to ensure proper operation of the complete Project at commissioning. Electrical Verification Testing shall be performed to ensure the new facilities are ready for upload of final relay settings and performance of final functional testing. At a minimum, testing shall include operational testing and energization of all equipment and systems, including testing activities as outlined in the latest version of the ANSI/NETA Acceptance Testing Specifications. The scope includes filling out the required Equipment Ratings Notification ("ERN") forms as part of this effort.

- 12.6 Contractor shall perform continuity and functional testing of all wiring, schemes and systems installed under the scope of each project to ensure proper operation as defined by the schematics, wiring diagrams and the requirements of the project. Functional operation of schemes and systems shall be verified through energization of all circuits referenced to the schematics and wiring diagrams demonstrating proper operation of the related devices. Installed wiring shall be verified against the project wiring diagrams. Testing shall ensure the facilities are ready for upload of final relay settings and performance of final functional testing.
- 12.7 Contractor shall test grounding system in accordance with the project site and substation grounding study (if required) and IEEE 80 and IEEE 81 requirements. Ground grid tests and fall of potential tests shall be completed prior to primary cable neutrals, transmission line OPGW, & supplemental ground wires to ensure each grounding system, new or existing onsite, is totally isolated from all other new and existing ground grids on site, as well as interconnection ground grid.
- 12.8 Contractor shall provide all documentation in accordance with the NERC Reliability Standards to comply with the GIA and as outlined herein, a minimum thirty (30) days prior to initial energization of the first block.
- 12.9 Contractor shall input Engineer of Record (EOR) supplied relay settings, perform operational/functional tests on all equipment and phase-in all equipment. Contractor is responsible for programming all protective and alarming devices with the proper settings provided by the EOR. Settings shall not be changed or applied to any device without written authorization from the EOR. Contractor shall assume that no remote programming will be allowed.
- 12.10 Contractor shall install and test SCADA, RTUs, BESS communication equipment.
- 12.11 Contractor shall submit testing documentation, functional test procedures, circuit integrity and full relay end-to-end test procedures a minimum of 24 hours prior to energization /phase-In, but no later than is required for Owner to fully review the pre-energization package and provide feedback as appropriate.
- 12.12 Contractor shall immediately, upon the discovery of any defective equipment or incorrect system design or installation, notify Owner and provide corrective action plan.
- 12.13 All buses, cables, and wiring, along with equipment nameplate information shall be compared with the drawings and verified. Contractor shall provide nameplate photos for all BESS equipment and apparatuses and control house equipment. The applicable nameplate information shall be populated into the Owner's asset register or other database format as agreed to by Owner.
- 12.14 Contractor Commissioning Sponsor, who shall be an experienced and competent regarding the work being performed, shall be on-site during all testing and commissioning work, which includes energization and functional testing. Commissioning Sponsor shall fill out the appropriate energization forms and documentation prior to energization after energization.
- 12.15 After energization, relay phase in verifications shall be performed on all relays. This includes calculating expected magnitude and phase angles to compare to actual values. Phase in documentation shall be submitted upon successful verification.
- 12.16 Commissioning Sponsor and Commissioning Team shall at all times be outfitted with appropriate equipment and training to provide assistance in the event of a malfunction during the testing, commissioning and system start-up process.

12.17 Control System Functional Test

12.18 Contractor shall perform a control system functional test upon completion of equipment acceptance tests. The test is to prove the correct interaction of all sensing, processing and action devices.

12.19 Contractor shall develop a test plan and parameters for the purpose of evaluating the performance of the system. Contractor shall perform the following functional tests:

12.19.1 Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.

12.19.2 Verify the correct operation of all sensing devices, alarms, and indicating devices.

12.20 Facility Operability Test

12.20.1 Contractor shall develop a Facility Operability Test procedure for the Facility to validate the full operability as well as BESS functionality requirements of the installed systems. Reference Exhibit F – Attachment 2 for details regarding the functional requirements of the BESS system and required performance test items.

12.21 Contractor is required to perform the following tests, at a minimum, with Commissioning Sponsor and Owner representative, at Owner’s discretion, present to witness. Commissioning manager shall be required to validate the tests. Final testing list requiring validation witness will be agreed to be Parties as part of the Commissioning Plan review process:

12.21.1 Functional test

12.21.2 Circuit integrity test

12.21.3 Relay end-to-end test

12.21.4 Point-to-point checkout (SCADA)

12.22 Insulation Resistance Testing

12.22.1 All underground AC and DC power cables (including individual String circuits) shall have insulation resistance measured.

12.22.2 Test voltage shall be applied as specified in NETA-ATS Table 100.1 and shall be applied for a minimum of one minute or until voltage and resistance stabilizes.

12.22.3 For 600V, 1000V, and over 1000V rated conductors, insulation resistance results greater than or equal to 100MΩ are acceptable. Insulation resistance values less than 5MΩ are considered a failed test.

12.22.4 If the insulation resistance of a 600V or 1000V or over 1000V conductor is less than 100MΩ but greater than 5MΩ, continue to apply test voltage for ten minutes total duration and calculate the Polarization Index:

12.22.4.1 Record the insulation resistance reading after one minute.

12.22.4.2 Record the insulation resistance reading after ten minutes.

12.22.4.3 Divide the 10-minute reading by the 1-minute reading; this is the Polarization Index.

12.22.4.4 If the Polarization Index is greater than or equal to 2.0 and the 1-minute insulation resistance is at least 5MΩ, the result is considered acceptable.

- 12.22.5 The concentric shields of all MV cables shall be tested to ground with a 1000/500VDC megohmmeter at 1000VDC to check the integrity of the outer jacket.
- 12.22.6 Any test results for any component which are outside the acceptable range shall be recorded as a deficiency on the applicable test report with any corrective action or re-testing performed.
- 12.23 Cables – Low Voltage (1000-V Maximum) and Medium Voltage (Cables above 1000-V)
  - 12.23.1 Inspect and test each low voltage cable in accordance with NETA-ATS section 7.3.2 (for 1000V maximum cables) and 7.3.3 (for cables above 1000V).
    - 12.23.1.1 Perform insulation resistance testing.
    - 12.23.1.2 Verify uniform resistance for all parallel conductors.
    - 12.23.1.3 Test values are to be in accordance with NETA-ATS section 7.3.2.3 & 7.3.3.3.
- 12.24 Grounding System
  - 12.24.1 Testing shall be by the fall-of-potential method, in accordance with IEEE-81. Test results shall be compared to the value predicted by the engineer's grounding calculations. If the measured ground resistance exceeds the calculated value, the engineer of record shall be notified and shall assess if the results are acceptable.
  - 12.24.2 Test values are to be in accordance with NETA-ATS section 7.13.3.
- 12.25 Power Conversion System Equipment
  - 12.25.1 Power Conversion Systems (PCS) shall be commissioned and tested using the manufacturer's recommended procedures and results shall meet all manufacturer requirements.
  - 12.25.2 PCS commissioning reports shall utilize reporting forms provided by the PCS manufacturer.
- 12.26 Switchgear and Switchboard Assembly
  - 12.26.1 Inspect and test each switchgear and switchboard assembly in accordance with NETA-ATS section 7.1.
  - 12.26.2 As per NETA-ATS section 7.1.2.11 perform system function tests in accordance with NETA-ATS section 8, which requires interlock system testing.
  - 12.26.3 Perform the insulation-resistance tests on control wiring as per NETA-ATS section 7.1.2.4
  - 12.26.4 Perform any additional testing as recommended by the Manufacturer
  - 12.26.5 Test values are to be in accordance with NETA-ATS section 7.1.3 and per Manufacturer requirements.
- 12.27 Transformers (Liquid Filled)
  - 12.27.1 Inspect and test each transformer in accordance with NETA-ATS section 7.2.2.
  - 12.27.2 Perform the optional core insulation resistance test (if accessible).
  - 12.27.3 Measure the percentage of oxygen in the nitrogen blanket, if applicable.
  - 12.27.4 Perform the optional oil tests for water content, and power factor.

- 12.27.5 Inspect and test the sudden pressure relay, if applicable.
- 12.27.6 Perform any additional testing as recommended by the Manufacturer
- 12.27.7 Test values are to be in accordance with NETA-ATS section 7.2.2.3 and per Manufacturer requirements.
- 12.27.8 Provide factory testing reports in accordance with ANSI/IEEE C57.12.90.
  - 12.27.8.1 Resistance measurements
  - 12.27.8.2 Polarity and phase relation
  - 12.27.8.3 Ratio
  - 12.27.8.4 No-load losses and excitation current
  - 12.27.8.5 Load losses and impedance voltage
  - 12.27.8.6 Dielectric tests – impulse test
  - 12.27.8.7 DGA analysis
    - 12.27.8.7.1 Start of the test
    - 12.27.8.7.2 Start of the heat run
    - 12.27.8.7.3 Completion of the heat run
    - 12.27.8.7.4 Completion of dielectric
    - 12.27.8.7.5 Completion of all tests
  - 12.27.8.8 Partial discharge test recording, inception voltage, and drop-out voltage levels using the procedures in IEEE C57.113, C57.12.90, and with voltages as specified in C57.12.00 for 34.5kV equipment. Partial discharge test acceptable limit shall be 300 pC, notwithstanding a less stringent requirement by IEEE
- 12.28 Cables – Medium Voltage (5,000V – 46,000V)
  - 12.28.1 In addition to requirements of 12.23 for MV cabling above 1000V, MV cabling above 5000V shall be subject to the additional testing requirements of this section.
  - 12.28.2 Inspect and test each medium voltage cable in accordance with NETA-ATS section 7.3.3.
  - 12.28.3 Inspection and testing shall be performed after all splices and cable terminations have been installed. In all cases, the tested sections shall include all cable sizes and shall test the cable insulation, the terminations and the splices (if any) on the cable sections. The acceptable test method for NETA-ATS section 7.3.3.2.4 is the VLF test. The tests shall be performed after cable terminations have been installed. Tan-delta measurement shall be performed in conjunction with the VLF test. Other test methods may be used subject to Owner approval, except that DC dielectric withstand testing shall not be used. Each of the MV collection system cables shall be tested by the partial discharge (PD) method in accordance with IEEE 400.3 and ICEA S-94-649. Each completed collection system feeder shall be tested by the “VLF Hi-Pot” method in accordance with IEEE 400.2.
  - 12.28.4 Field-applied test voltages shall not exceed 80% of the factory test value and shall not exceed the maximum test voltage of NETA-ATS Table 100.6.

- 12.28.5 Verify the proper installation of faulted-cable indicators (if present).
- 12.28.6 Test values are to be in accordance with NETA-ATS section 7.3.3.3. Tan-delta results shall be submitted as a chart of the tan-delta value vs. test voltage.
- 12.28.7 The PD method test voltage shall be a minimum 2.0 times rated voltage ( $2.0U_o$ ), at 60 Hz, with at least 5pC sensitivity and shall include a documented sensitivity assessment performed in accordance with IEEE 400.3 on every cable system to assure the test results are comparable with IEEE and manufacturer levels as specified in the table below. The design of the collection system shall be such that the cables can be sectionalized into lengths of 8,500 feet, maximum, and 1/6th or larger neutral to support PD testing as performed by IMCORP or other service provider who has been previously qualified by the Owner. Cable lengths shall be coordinated with normal splice points and above ground junction boxes with separable connectors used to minimize cable splicing.

Table of Acceptable PD Threshold Levels:

Standard	Thresholds (@50/60Hz)
IEEE 48 Terminations	No PD $\geq$ 5pC up to $1.5U_o$
IEEE 404 Joints	No PD $\geq$ 5pC up to $1.5U_o$
IEEE 386 Separable Connectors	No PD $\geq$ 3pC up to $1.3U_o$
ICEA S-97-683 Metallic Shield MV Cable	No PD $\geq$ 5pC up to $4U_o^*$
ICEA S-94-683 Concentric Wire MV Cable	No PD $\geq$ 5pC up to $4U_o^*$

\*200V/mil

12.29 Switches – Low and Medium Voltage

12.29.1 DC and AC Switches, Low Voltage

- 12.29.1.1 Inspect each switch in accordance with NETA-ATS section 7.5.1.1.
- 12.29.1.2 Confirm proper electrically-bonded equipment ground.
- 12.29.1.3 Confirm that metal-enclosed switches are clean, and debris has been removed.
- 12.29.1.4 Verify that switches used in DC applications are rated and installed accordingly.
- 12.29.1.5 Verify that warning signs where provided are in accordance with NEC.

12.29.2 Medium Voltage Metal-Enclosed Switches

- 12.29.2.1 Inspect and test each air break switch in accordance with NETA-ATS section 7.5.1.2.
- 12.29.2.2 Include testing of the motorized switch operator mechanism (if applicable), in accordance with NETA-ATS section 7.5.1.2.
- 12.29.2.3 Test values are to be in accordance with NETA-ATS section 7.5.1.2.3.

12.29.3 Medium Voltage Air Break Switches



- 12.29.3.1 Inspect and test each air break switch in accordance with NETA-ATS section 7.5.1.3.
- 12.29.3.2 Include testing of the motorized switch operator mechanism (if applicable), in accordance with NETA-ATS section 7.5.1.3.
- 12.29.3.3 Test values are to be in accordance with NETA-ATS section 7.5.1.3.3.
- 12.29.4 Other Switches
  - 12.29.4.1 Inspect and test each switch in accordance with the applicable subsection to NETA-ATS section 7.5.
  - 12.29.4.2 Include testing of the motorized switch operator mechanism (if applicable), in accordance with the applicable subsection to NETA-ATS section 7.5.
  - 12.29.4.3 Test values are to be in accordance with the applicable subsection to NETA-ATS section 7.5.
- 12.30 Circuit Breakers
  - 12.30.1 Low-Voltage Air Breakers – Insulated-Case/Molded-Case
    - 12.30.1.1 Inspect and test circuit breakers in accordance with NETA-ATS section 7.6.1.1.
    - 12.30.1.2 Confirm that if breaker is being back-fed, it is rated accordingly.
    - 12.30.1.3 Test values are to be in accordance with NETA-ATS section 7.6.1.1.3.
  - 12.30.2 Low-Voltage Power Breakers
    - 12.30.2.1 Inspect and test circuit breakers in accordance with NETA-ATS section 7.6.1.2.
    - 12.30.2.2 Confirm that if breaker is being back-fed, it is rated accordingly.
    - 12.30.2.3 Test values are to be in accordance with NETA-ATS section 7.6.1.2.3.
  - 12.30.3 Medium-Voltage Vacuum Breakers
    - 12.30.3.1 Inspect and test circuit breakers in accordance with NETA-ATS section 7.6.3.
    - 12.30.3.2 Perform optional power factor tests on each pole and bushing.
    - 12.30.3.3 Test values are to be in accordance with NETA-ATS section 7.6.3.3.
  - 12.30.4 Other Circuit Breakers
    - 12.30.4.1 Inspect and test circuit breaker(s) in accordance with the applicable subsection to NETA-ATS section 7.6.
    - 12.30.4.2 Test values are to be in accordance with the applicable subsection to NETA-ATS section 7.6.
- 12.31 Protective Relays
  - 12.31.1 Inspect and test each protective relay in accordance with NETA-ATS section 7.9.
  - 12.31.2 Program each device with the recommended relay settings provided by the engineer.
  - 12.31.3 Perform insulation resistance tests only if approved by the relay manufacturers.

- 12.31.4 Verify that grounding pins have been removed from all shorting-type terminal blocks in non- spare current transformer circuits.
- 12.31.5 Verify that all spare current transformers are properly shorted.
- 12.31.6 Perform functional testing of each control scheme, including breaker trip tests, close inhibit tests, 86 lockout relays, alarm functions, and breaker-failure schemes.
- 12.31.7 After the equipment is energized, measure the magnitude and phase angle of voltage and current inputs and compare to expected values.
- 12.32 Instrument Transformers
  - 12.32.1 Inspect and test all voltage and current transformers in accordance with NETA-ATS section 7.10.
  - 12.32.2 Perform the optional dielectric withstand tests on primary windings of all voltage transformers.
  - 12.32.3 Perform the additional tests for capacitor-coupled voltage transformers in accordance with NETA-ATS 7.10.2.3.
  - 12.32.4 Test values are to be in accordance with NETA-ATS section 7.10.3.
- 12.33 Metering Equipment
  - 12.33.1 Inspect and test metering devices in accordance with NETA-ATS section 7.11.
  - 12.33.2 Test Values are to be in accordance with the applicable subsection to NETA-ATS section 7.11.
- 12.34 Surge Arresters
  - 12.34.1 Inspect and test surge arrester in accordance with NETA-ATS sections 7.19.1 and 7.19.2. Perform an insulation resistance test phase terminal to ground. Apply voltage in accordance with manufacture published data. If manufacturer data is unavailable use NETA-ATS Tables 100.1.
  - 12.34.2 Inspect and test each surge arrester and each surge arrester on the collection feeders.
  - 12.34.3 Verify that arrester lead lengths are as short as practical and do not have unnecessary bends.
  - 12.34.4 Test values are to be in accordance with NETA-ATS section 7.19.2.3.
- 12.35 Capacitors and Reactors
  - 12.35.1 Inspect and test capacitors and reactors in accordance with NETA-ATS section 7.20.
  - 12.35.2 Test values are to be in accordance with the applicable subsection to NETA-ATS section 7.20.
- 12.36 Fiber-Optic Cables
  - 12.36.1 Inspect and test the fiber-optic cable system in accordance with NETA-ATS section 7.25.
  - 12.36.2 Perform testing after completion of all splices, terminations, break-out boxes and patch cords.
  - 12.36.3 Test values are to be in accordance with NETA-ATS section 7.21.3.
- 12.37 Low Voltage Auxiliary Equipment

- 12.37.1 This section addresses testing requirements for auxiliary power systems for systems such as tracker power, substation equipment, SCADA and meteorological station.
- 12.37.2 Inspect and test dry type transformers in accordance with NETA-ATS section 7.2.1.1.
- 12.37.3 Inspect and test the station auxiliary power transformer in accordance with NETA-ATS section 7.2.2.
- 12.37.4 Inspect and test the fused cutouts for the station auxiliary transformer in accordance with NETA- ATS section 7.5.5.
- 12.38 SCADA Equipment
  - 12.38.1 SCADA equipment shall be commissioned and tested using the manufacturer’s recommended procedures.
  - 12.38.2 Test reports shall utilize manufacturer-provided reporting forms, if available.
  - 12.38.3 Test reports shall include a complete data points list indicating each field data point monitored or controlled by the SCADA. For clarity, the data points list shall include all PCS temperature readings and all fault codes from each PCS.
  - 12.38.4 The data points list report shall indicate the corresponding device, description of the data point and the data point addresses within the device and within the SCADA “master” device.
  - 12.38.5 100% of all data points shall be field verified from the field device to the SCADA “master” device and, if applicable, to the remote monitoring service. Device fault codes do not need to be simulated, except as noted in 29.6.
  - 12.38.6 The following PCS device status and fault codes shall be field verified at each PCS:
    - 12.38.6.1 All operating states, which shall include, but are not limited to, (as available based on PCS used; manufacturer nomenclature may vary):
      - 12.38.6.1.1 Operating modes (e.g. start-up/warm-up, power/current limiting mode, etc.)
      - 12.38.6.1.2 Stop modes
      - 12.38.6.1.3 Wait modes (e.g. waiting for AC)
      - 12.38.6.1.4 Fault/error modes as identified in 29.6.4
    - 12.38.6.2 All integrated DC and AC disconnect switch and circuit breaker positions
    - 12.38.6.3 Cabinet door position, if available
    - 12.38.6.4 Fault and error codes for (the PCS manufacturer shall be consulted for recommended procedures to simulate these fault codes):
      - 12.38.6.4.1 DC overvoltage
      - 12.38.6.4.2 AC overvoltage
      - 12.38.6.4.3 AC undervoltage
      - 12.38.6.4.4 Frequency out of range
  - 12.38.7 All configurable set points shall be documented on the data points list, including but not limited to:
    - 12.38.7.1 Power limit

12.38.7.2 AC grid wait time

12.38.8 Reactive power settings.

12.38.9 Contractor shall develop a SCADA test plan for demonstrating compliance with the requirements of the Interconnection Agreement.

12.39 Thermographic Survey

12.39.1 Perform a thermographic survey in accordance with NETA-ATS section 9.

12.39.2 The survey shall be performed after all other Commissioning Tests, while the Project is operating.

12.39.3 All AC power distribution equipment shall be surveyed if equipped with infrared test windows.

12.39.4 All PCSs shall be surveyed, if equipped with infrared test windows.

12.39.5 Report and investigate temperature differences greater than 3°C between similar components in the same enclosure.

12.39.6 Report and investigate temperature differences greater than 15°C between components and ambient air.

12.40 NERC Reporting Requirements

In accordance with the NERC Reliability Standards outlined below, Contractor shall provide at a minimum the following documentation to Owner, thirty (30) days prior to initial energization of the first block. Owner shall provide the information for Owner Furnished Equipment. Contractor shall perform testing and develop applicable reporting including but not limited to in order to meet facility NERC requirements:

12.40.1 FAC-008 Study (Facility Ratings Methodology)

12.40.1.1 Study to use Owner's documented methodology to establish facility ratings.

12.40.2 PRC-001 (Protection System Coordination)

12.40.3 PRC-005 (Protection System Maintenance)

12.40.3.1 All Equipment O&M Manuals

12.40.3.2 Yellow Lined Schematics verifying control circuitry.

12.40.3.3 Equipment Checklists

12.40.3.4 Instrument test reports (CTs & PTs)

12.40.3.5 Test Reports for any Pressure or Flow devices on BES elements.

12.40.3.6 As-Left Relay Settings in .RDB format

12.40.3.7 Protection Relay Test Reports in .PDF and .PSX (Doble Protection Suite Software) formats

12.40.4 PRC-019 Study (Coordination of Limiters w/ Protection System)

12.40.4.1 Coordination of PCS settings with substation protection relay settings, if applicable.

12.40.5 PRC-024 Study (Generator Frequency & Voltage Protective Relay Settings)

- 12.40.5.1 Documentation of all voltage and frequency elements are outside the No-Trip Zone
- 12.40.6 PRC-025 (Generator Relay Loadability)
  - 12.40.6.1 Table of load-responsive relay elements and calculations showing loadability margin
  - 12.40.6.2 Documentation of PCS skid Low Voltage Circuit Breaker settings.
  - 12.40.6.3 Documentation of any equipment limitations from equipment manufacturers.
- 12.40.7 PRC-026 (Relay Performance During Stable Power Swings)
- 12.40.8 MOD-025 (Verification of Generator Real & Reactive Power Capability)
  - 12.40.8.1 Perform Staged Test and Record Test Data
  - 12.40.8.2 Complete Attachment 2 Forms from Standard.
- 12.40.9 MOD-026 & MOD-027.
  - 12.40.9.1 Deliver dynamic computer models of the facility in PSS/E Format.
  - 12.40.9.2 Models shall use model blocks acceptable by MISO modeling guide.
  - 12.40.9.3 Models shall include a lumped collector equivalent that includes charging susceptance (B), in addition to resistive (R) and reactance elements (X).
  - 12.40.9.4 Contractor shall perform staged test on-site.
  - 12.40.9.5 Contractor to perform study to make computer model adjustments to match actual facility response.
- 12.40.10 BAL-005 – One-line diagram which displays the point of interconnection to the substation. Note: Important to have "unique identifiers" for all feeders
- 12.40.11 COM-002 – Network diagram of voice and data links by Contractor
- 12.40.12 VAR-002 - Transformer information including the following: as applicable by Contractor and O&M Vendor:
  - 12.40.12.1 Tap Settings
  - 12.40.12.2 Available fixed tap ranges
  - 12.40.12.3 Impedance data
  - 12.40.12.4 The + / - voltage range with step-change in % for load-tap changing transformers.
- 12.40.13 CIP-3.7 and CIP-2.5. Contractor shall provide supporting evidence that the design meets CIP-003-8 and CIP—002.5.1a. Please note that these CIP standards call out other CIP standards, including physical security of BES elements. Part of supporting evidence is identification of Bulk Electric System (BES) elements of the project and evidence of the identification methodology.

**End**