Section G5: ENERGIZATION AND SYNCHRONIZATION REQUIREMENTS FOR TRANSMISSION GENERATION ENTITIES

PURPOSE

The following is PG&E’s procedure for performing pre-parallel inspections and preparing to energize and synchronize the generator to the PG&E transmission system. All time requirements must be met for PG&E to provide the Generation Entity with timely service.

Any inspections required by local government agencies must be completed and permits signed off prior to the pre-parallel date. Failure to meet the succeeding requirements within the timeframes specified may result in a delay to successful operations parallel to the PG&E system.

G5.1. TEST RESULTS AND/OR INFORMATION REQUIRED PRIOR TO PRE-PARALLEL INSPECTION (PPI)

All tests outlined through sections G5.1.1- G5.1.8. must be complete and an electronic or hard copy of the test reports submitted to a PG&E representative a minimum of thirty (30) business days before the requested pre-parallel inspection date. All test reports require header information reflecting the equipment identification matching the one or three line diagrams. DC schematics, one line and three line diagrams of the facility are required with the test reports. Pre-parallel inspection dates will be scheduled a minimum of ten (10) business days after all test reports are approved by PG&E. Failure to meet PG&E approved test requirements will result in delay of pre-parallel inspection and testing of generation entity’s equipment.

G5.1.1. Proving Insulation

For any of the megger tests referred to below, a 2,500 volt DC megger or a hi-pot is preferred, but a 1,000 volt DC megger is acceptable.

- All transformers connected to the primary bus and the main transformer must be meggered winding to winding and each winding to ground. For purposes of this document, “primary bus” is defined as the source-side bus or conductor from the primary interrupting device to the generating plant.

- All circuit breakers and circuit switchers connected to the primary bus and at the interconnection point must be meggered in the following manner: Breaker open - each pole to ground, pole 1-2, pole 3-4, pole 5-6; breaker closed - pole 1-ground, pole 3-ground, pole 5-ground and if the poles are in common tank or cell, pole 1-3, pole 3-5, pole 5-1.

- All buses and cables shall be meggered phase-to-phase and phase-to-ground.
• The main transformer(s) and main breaker(s) shall have a dielectric test performed on the insulating medium (gas or oil). This does not apply to factory-sealed circuit switcher interrupters.

• The generator(s) must be meggered or hi-pot tested phase-to-phase and phase-to-ground.

G5.1.2. Proving Ratios
All ratios of transformers connected to the primary bus must be proven using either a turns ratio tester or a voltage ratios test. The main transformer must be tested on the final operating tap. This tap shall be recommended by PG&E to best match current transmission system operating voltages.

G5.1.3. Circuit Breakers and Circuit Switchers
• A minimum to trip at 70 percent or less of the nominal DC control voltage must be performed on all circuit breakers and/or circuit switchers that are operated by PG&E-required relays.

• A Micro-Ohm test must be performed on all circuit breakers and circuit switches.

• A timing test showing the time from trip initiation to main poles opening is required.

• A timing test showing the time from close initiation to main poles closing is required.

G5.1.4. Current Transformers and Current Circuits
• A saturation check should be made on all current transformers (CTs) associated with the required PG&E relays. If this is not possible, a manufacturer's curve is acceptable.

• The connected ratio of all CTs must be proven either by using current (primary to secondary) or voltage (secondary to primary).

• CT circuits must be checked for proper connections and continuity by applying primary or secondary current and reading in the relays. Each test (primary or secondary) must be performed in all combinations to prove proper connections to all phase and ground relays. Current must be applied or injected to achieve a secondary reading of 5 amps in each relay to ensure that no loose wiring or parallel current paths exists.

• A single-phase burden check must be made on each phase of each current circuit feeding PG&E-required relays.

• A megger check of the total circuit with the ground wire lifted must be done to prove that only one ground exists.
G5.1.5. Relays
All relays\(^1\) must be field tested on site to their specified settings to verify the following:

- Minimum operating point at which relay picks up (minimum pickup).
- Time delay at three different current test points, in integral multiples of minimum pickup, that closely characterize the relay time-current curve.
- Phase angle characteristic of directional relay.
- Pickup points at maximum torque angle (MTA) and ±30 degrees of MTA on impedance relays using the approved settings.
- Slip frequency, voltage matching, phase angle acceptance and breaker compensation time on synchronizing relays.
- PG&E tolerances are listed below:
  - Current/Voltage/Time: ± 10 percent
  - Impedance/Phase Angle: ± 5 percent
  - Frequency: ± 0.05 Hz

If a pilot relay system is required by PG&E, signal level checks must be performed to PG&E standard.

G5.1.6. Primary Disconnect Switch
The primary disconnect switch at the point of interconnection shall be assigned a PG&E number by PG&E. The switch, platform, and switch number plate bracket must be constructed to PG&E’s Engineering Standard 034851 and Engineering Design Standard 454092, see Appendix D. A switch number plate bracket shall be furnished by PG&E (Appendix D).

G5.1.7. RTU/RIG/DPU
The final RIG/DPG/RTU database shall be provided to PG&E at least 30 calendar days prior to scheduled energization date.

G5.1.8. Station Battery
When a battery is installed, proof of discharge testing is required to ensure that the battery has the capacity to support the load and trip (see Appendix T).

G5.2. PRE-PARALLEL INSPECTION (PPI)
The Generation Entity is responsible for ensuring that all relays, data telemetry and other protective devices are adjusted and working properly, as approved by PG&E, prior to the pre-parallel inspection. The relay settings submitted to and approved by PG&E

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\(^1\) Please see Section G-2 specifically Table G2-5 for information on relay requirements.
must be demonstrated. If problems arise with equipment during testing, the PG&E protection representative may elect to cancel the PPI and reschedule.

All pre-parallel inspections should be scheduled to begin at 8:00 AM and completed by 6:00 PM, Monday through Friday only. Functional tests shall be performed by the Generation Entity and all tests shall be observed by PG&E as outlined below. The Generation Entity shall provide all test equipment and qualified personnel to perform the required tests. PG&E recommends third party testers to be InterNational Electrical Testing Association (NETA) certified. PG&E shall be there strictly as an observer. Form G5-1 shall be completed by the PG&E representative on site at the time of the pre-parallel inspection.

Before the unit is paralleled to the System to complete tests that require parallel operation, a "permission to parallel for test purposes" letter must be obtained from PG&E’s Grid Operations department. This letter would typically be issued after the tests as described in Section G5.2 sub-sections are completed, but before the remaining tests that require the unit to be paralleled begin.

G5.2.1. Functional Tests
The following functional tests shall be performed after the equipment has been energized, but before the generator is paralleled with PG&E’s system:

- Check that each protective relay trips the appropriate generator breaker and/or main breaker. This may require injecting a signal. Jumpering across contact on the back of the relay is not acceptable.
- When first energized, check that proper secondary potential is applied to all voltage and frequency relays.
- Check the synchronizing meter, synchronizing equipment and phasing panel (if used) with the paralleling breaker closed and the generator off-line. This typically requires lifting the generator leads. The equipment should show an "in-phase" condition.
- Check the generator phase rotation. (PG&E’s phase rotation is A-C-B counterclockwise). All three phases must be checked using hot sticks with a phasing tool or a phasing panel provided by the Generation Entity. The synchronizing equipment typically checks one phase only. Any other method of demonstrating correct phasing and phase rotation shall be approved by PG&E in writing prior to conducting the test. Alternative methodologies to check phasing and phase rotations must be submitted to PG&E fifteen business days in advance of scheduled pre-parallel test. PG&E must approve the methodology three business days in advance of pre-parallel test date.

G.5.2.2. Data Telemetry Tests
PG&E Grid Operations must verify the following prior to Pre-Parallel Operations.
• Communications circuits meet Appendix F specifications and are functioning properly.
• RIG/DPG/RTU data is mapped correctly to PG&E EMS and SCADA systems.
  o Scaling on all analog data points is correct.
  o Point to Point check on all status points is verified at PG&E electric control centers.

Typically, pre-parallel inspections can be performed within a normal working day. PG&E shall dedicate one full work day to observe the test. If a test cannot be completed by 6:00 PM, the PG&E representative may cancel the remainder of the test and reschedule it. In this case, the Generating Entity shall incur additional costs for the pre-parallel inspection.

G5.3. REQUIREMENTS FOR PARALLEL GENERATOR OPERATION

G5.3.1. Clearance for Parallel Operation (For Testing Purposes Only)
Generating Entity shall certify that it has met all pre-parallel requirements ten business days before paralleling to the grid. The PG&E representative shall notify the California Independent System Operator and Transmission Operations Engineering in writing that the Generating Entity has met all the requirements to synchronize to the grid at least 7 calendar days before the pre-parallel inspection and prior to obtaining a clearance for parallel operation for testing purposes only.

The PG&E representative shall contact the designated PG&E Grid Control Center at least 72 hours before the pre-parallel inspection and obtain a clearance for parallel operation for testing purposes only. The PG&E representative shall provide the designated PG&E Electric Control Center a drawing indicating which PG&E circuit the generation facility will be connected to, and which PG&E operated disconnect will be identified with a PG&E designated number. When the pre-parallel inspection is passed, the generator may at PG&E’s discretion be allowed to operate in parallel with PG&E for testing purposes only. This should not be mistaken as an official release for parallel operation. Once this testing-only permission is granted, the generator may operate in accordance with the previously executed Generation Interconnection Agreement for a maximum of 14 days, or a period previously approved by PG&E.

If applicable, firm capacity performance testing of new generators cannot begin until the Generation Entity receives written permission from PG&E.

G5.3.2. Impedance and Directional Relay Tests
During the Parallel Operation for Testing period direction check all PG&E required impedance and directional relays by doing the following:
• Bring up load on the plant and/or generator.
• Verify direction of power flow.
• Measure the phase angle between the current and potential applied to the relay.

• Observe the current action of the directional contacts according to the direction of power flow. Reverse either the potentials or current to prove contact operation for reverse power flow.

G5.3.3. Generator Load Tests

For generators, the following load tests shall be performed after the generator picks up load:

• For synchronous generators, verify operation of the generator at 90 percent lagging power factor and at 95 percent leading power factor at rated output measured at the generator terminals.

• For asynchronous generators, verify operation of the generating facility meets power factor requirements specified in the Interconnection Agreement (IA). If the CAISO phase II study identifies a need to maintain +/- 0.95 power factor at the POI, the IA will invoke the requirement. Verification in such cases is at 95 percent lagging power factor and at 95 percent leading power factor at rated output measured at the point of interconnection (POI). If the IA does not require a +/- 0.95 power factor at the POI, verify operation of the generating facility at unity power factor at rated output measured at the POI.

• Verify operation of the generator at 95 percent and 105 percent of per unit voltage while delivering rated output measured at the generator terminals or the low side of the GSU bank.

• Load check all PG&E required differential relays. The load current must balance to zero in all differential relays.

• Load check voltage restraint overcurrent relays to prove correct connection of currents and potentials (Form G5-2).

The generator(s) may have to be paralleled temporarily with PG&E’s system to run the load tests. Permission to do this shall be given by the PG&E Transmission System Operator.

G5.3.4. Power System Stabilizer (PSS)

During the Parallel Operation for Testing period, the Power System Stabilizer shall be calibrated and tested in accordance with the latest WECC standard calibration and test procedures as outlined in Appendix H. The test report shall be submitted for approval to the following address:

Manager, Transmission System Planning
Pacific Gas and Electric Co., Mail Code N14K
P.O. Box 770000
San Francisco, CA  94177

and emailed to AreaCoordinator@pge.com.
Adequate testing of the PSS can only occur on the generating unit(s) after pre-parallel inspection has been satisfactorily completed and the units are paralleled and supplying load. The generation facility shall not be considered officially operational until this PSS calibration and testing has been done to PG&E’s satisfaction.

Failure of the Generation Entity to maintain its PSS could adversely impact system operation. PG&E reserves the right either to disconnect from, or refuse to parallel with, any Generation Entity which does not operate and maintain its generator control systems in accordance with applicable reliability criteria.

The PSS Reports shall include a minimum of the following:

- Description of unit including ratings.
- Excitation system type and ratings.
- PSS type, inputs, and available setting ranges for adjustable parameters. Include description of failure detection system if provided.
- Modifications required to provide final settings.
- List of final settings, including:
  - Limit settings + and – gain.
  - Lead and lag time constants.
  - Washout time constant.
  - Any included filtering (fixed or settable).
- Models:
  - PSS model and parameters in GE PSLF format, using the latest WECC approved dynamic models.
  - Excitation model and parameters in GE PSLF format, using the latest WECC approved dynamic models.
- Bode plots:
  - Excitation response with unit connected to electrical system without PSS in service (See Figure 7 of Appendix H).
  - PSS response alone (See Figure 8 of Appendix H).
  - Excitation response with PSS in service and unit connected to electrical system. This plot can be either via test or calculated based on previous two plots.
  - If settings are developed through simulations, actual excitation response versus excitation model response used in simulation. (See Figure 3 of Appendix H).
• Time plots:
  - Step response showing generator terminal voltage, field voltage, field current, power, PSS output, AVR output with PSS in service and out of service. (See Figure 5 of Appendix H).

**PG&E will not grant permission for a generating facility to commence commercial operations until PSS has been calibrated to PG&E's satisfaction.**

**G5.3.5. Model Testing and Validation Report**

Following WECC guidelines, generation equipment shall be tested to verify that data submitted for steady-state and dynamics modeling in planning and operating studies is consistent with the actual physical characteristics of the equipment. The data to be verified and provided shall include generator gross and net dependable capability, gross and net reactive power capability, voltage regulator controls, speed/load governor controls, and excitation systems.

**G5.3.6. Signage Requirements**

All signs shall be constructed to be weather proof.

- Disconnect -- The disconnect sign shall have 1 inch wide by 2 inch high, with colors venetian red (#3) lettering on a buff (#1) background (or similar). It shall be attached as shown on Engineering Design Standard 454092 (see Appendix D). If the facility has multiple feeds with multiple separate disconnect switches, then each disconnect requires a separate sign.

- Location -- The location sign shall have 1 inch high venetian red (#3) lettering on a buff (#1) background. PG&E's standard location sign size is 14 inches wide by 7 inches high overall. It shall be posted at each entrance to the facility. If there are other gates or doors to go through, then each one of those shall have a sign as well. For example: One posted at the entrance to the generation facility and one posted on the entrance to the substation within the generation facility.

**G5.4. PERMISSION TO COMMENCE COMMERCIAL OPERATION**

Written permission for commercial operation shall be sent to the Generation Entity via U.S. First Class Mail. The letter shall be issued after PG&E has verified the following:

- All proper contracts and documents have been executed and are in place.
- The pre-parallel inspection has successfully passed.
- The Power System Stabilizer tests and calibration have been completed.
- All other outstanding issues have been resolved, including rights-of-way, deeds of conveyance, insurance verification and operating agreements.
PG&E has received final copies of the single line diagram and elementary diagrams that show "As-Built" changes made during construction, as well as a completed finalized generator data sheet (Appendix M).

If applicable, firm capacity performance testing of new generators cannot begin until the Generation Entity receives written permission from PG&E to parallel.

**G5.5. GENERAL NOTES**

- The PG&E system has A-C-B counterclockwise rotation.

- Any changes to PG&E required protection equipment or major equipment (transformer, breaker, generator, etc.) must be submitted to the PG&E representative for review and approval by the appropriate PG&E engineer prior to the changes being made. In order to energize new equipment, the Generation Entity must follow the pre-parallel inspection process.

- Protective Relays: Routine maintenance on PG&E required protective relays, batteries and breaker(s) must meet PG&E’s maintenance and test practices. After completion of these tests, test reports must be submitted to the PG&E protection specialist for review and approval by the appropriate PG&E engineer. A PG&E technical representative may come to the customer’s facilities and verify the settings.

- Customers who’s load changes due to economic market conditions or any other related condition are still required to maintain their protective devices and can be subject to a pre-parallel inspection upon request by PG&E.

- **Idle Facilities** - If customers are idle for an extended period of time and do not maintain proof of maintenance for their applicable protective equipment they will be required to separate from PG&E and lock the high side disconnect with a PG&E lock. Prior to restoration of transmission service, the customer will must complete a PPI and/or any applicable transmission load reviews deemed required by PG&E.
### PACIFIC GAS AND ELECTRIC COMPANY
### GENERATION PRE-PARALLEL INSPECTION

<table>
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<tr>
<th>Name of Project:</th>
<th>Location:</th>
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<td>PM#</td>
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</table>

Transmission Line No. | Distribution Circuit No.
----------------------|------------------------

1. **Maintenance Data:**
   - **Generation Customer's Maintenance Chief**
   - **Telephone Number**
   - **Generation Customer's Regular Maintenance Interval**
   - **Electrical Contractor**

2. **Test Reports Attached:**
   - Yes ______
   - No ______

   If not, who has the reports:

3. **Generation Facility Manual Disconnect Device for PG&E Line Clearances:**
   - **Manufacturer**
   - **Model Number**
   - **PG&E Device Number**

4. **Designated PG&E Electric Control Center**

5. **PG&E Inspector**
   - **NAME**
   - **PHONE NO.**

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<th>Date Inspection Performed (Witness Testing/PPI):</th>
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<td>Date Load Checks Performed (Energization):</td>
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<td>Date Facility Placed on 30 Day Test Released (Permission to Parallel for Test Purposes):</td>
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<tr>
<td>Date Facility Completed Operational Testing:</td>
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**Distribution:**
- PG&E Designated Electric Control Center (1)
- Division Project Coordinator (1)
- Marketing Services (1)
- Power Contracts (1)
- GM&C Area Engineering (1)
- System Dispatch (1)
Form G5-1

PG&E LOG

JOB ORDER

D&C

PACIFIC GAS AND ELECTRIC COMPANY
GENERATION PRE-PARALLEL INSPECTION

1a. Generator Nameplate: _____ kW _____ Volts _____ Pf _____ 1φ _____ 3φ

b. Generator Type:
   Synchronous
   Induction
   DC w/ Inverter

   Synchronizing:
   Auto
   Manual w/ Relay

   Connection:
   WYE-Ground
   WYE-Ungrounded
   Delta

Manufacturer ___________________________ Serial No. ___________________________

c. Generator Prime Mover:
   Wind _______ Water _______ Steam _______ Solar _______ Fuel Cell _______
   Other, specify ___________________________

d. Generator Breaker or Contactor:
   Manufacturer ___________________________ Serial No. ___________________________
   ___________________________ Thermal/Magnetic Overcurrent
   ___________________________ Undervoltage Release (optional under 40kW)
   ___________________________ DC Shunt Trip (required over 40kW) w/battery ________ Capacitor Trip _______
   ___________________________ Control Voltage ___________________________ 
   (Not acceptable for use)

2. Dedicated Transformer: Yes _______ 3φ _______ 1φ _______ 3-1φ _______ 
   No _______ Bank of 3-1φ

   Customer owned
   Bank Rating: _______ KVA Transformer _______ PG&E owned
   % _______ MVA Base

   Transformer Connection:
   Primary ___________________________ volts
   Secondary ___________________________ volts

   Protected by: Fuse Size _______ Amps _______ Other _______

3. Ground Protection Required: Yes _______ No _______

   If Yes, type of ground detection (check type):
   Ground Bank with overcurrent relay.
   Broken Delta Ground Bank with low pick up overvoltage relay.
   Ground Overcurrent relay in neutral or dedicated transformer.
   Low voltage pick-up overvoltage relay in elevated neutral of dedicated transformer.
   Other ___________________________

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### PROTECTIVE DEVICES:

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<th>Required Yes/No</th>
<th>Mfr and Model</th>
<th>Settings</th>
<th>Specific Breaker Tripped</th>
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April 1, 2018

G5-12
GENERATION PRE-PARALLEL INSPECTION

SPECIAL INSTRUCTIONS and/or VARIANCES:

(A). Additional information needed for testing: PG&E inspector initials
(B). Additional information needed for testing: PG&E inspector initials
(C). Additional information needed for testing: PG&E inspector initials

GENERATORS OPERATION¹:

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<tr>
<td>(A)</td>
<td>Verify POI Protection is Cut-in and operating properly (Verify at Energization): PG&amp;E inspector initials</td>
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<tr>
<td>(B)</td>
<td>Verify Phase and Rotation, prior to Permission to Parallel (non-inverter): PG&amp;E inspector initials</td>
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<tr>
<td>(C)</td>
<td>Verify Generator Protection is Cut-in and operating properly (Verify at first Sync): PG&amp;E inspector initials</td>
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<tr>
<td>(D)</td>
<td>Verify proper load checks, at ½ amp secondary current: PG&amp;E inspector initials</td>
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<td>(E)</td>
<td>Verify operation of the generator(s) at 0.90 P.F. lag and at 0.95 P.F. lead, while delivering rated output: PG&amp;E inspector initials</td>
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<tr>
<td>(F)</td>
<td>Verify operation of the generator(s) at 1.05 per unit voltage, while delivering rated output: PG&amp;E inspector initials</td>
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<tr>
<td>(G)</td>
<td>Verify generators properly performs anti-islanding operations, in less than 2 seconds: PG&amp;E inspector initials</td>
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¹ See Section G5.3.3, “Generator Load Tests”
SIMPLIFIED FLOW CHART OF PRE-PARALLEL INSPECTION (PPI) / TEST PROCEDURE

- **Submit Relay Test Reports (2 Copies)**
- **Notify Operations Engineering of scheduled Pre-Parallel Inspection date (2 weeks prior to PPI)**
- **PPI Complete by 6pm (normal business hours)**
- **Receive permission letter from EGI (formerly GIS)**
- **Authorization to Parallel Requirements:**
  - PPI complete (successful)
  - EMS/SCADA visibility (if > 1 MW)
  - Relays/DTT approved by Protection (SCADA visibility for any DTT)

- **Export?**
- **No**
- **Yes**
- **Authorization to Parallel to Parallel**
- **“Permission to Parallel for Test Purposes” letter Issued by Grid Operations**
- **Generator contacts Grid Control Center for permission to parallel to grid for testing**
- **Generator testing until test results are approved and PSS test results are approved (if applicable)**
- **“Permission to Commence Commercial Operations” letter issued by Grid Operations**
- **Permission to Parallel for Test Purposes Requirements:**
  - PPI complete (successful)
  - EMS visibility
  - SCADA visibility
  - Relays/DTT approved by Protection

- **Permission to Commence Commercial Operations Requirements:**
  - All Project RNU complete
  - All Project issues resolved
  - AVR testing complete
  - Power Factor testing complete (0.95 lead/0.90 lag)
  - PSS testing & calibration complete
    - (single unit > 30 MVA)
    - (aggregate units > 75 MVA)