Amendment no. 1

Substation Design Instruction

Commissioning of permanently connected diesel generator sets

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SUBSTATION DESIGN INSTRUCTION

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SDI 112 Commissioning of permanently connected diesel generator sets

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1.0 PURPOSE

To set out in detail the requirements for the on-site commissioning of diesel generator sets that is connected to the Endeavour Energy's distribution network.

2.0 SCOPE

This commissioning instruction is intended to cover package generator sets driven by a diesel engine and having a low voltage synchronous generator rated up to a nominal 1000 kVA. It is assumed that the generator set is radiator cooled and that there is no heat recovery plant.

The generator set may be capable of being operated in parallel with the mains or in an isolated mode.

This document is generic and there may be references to equipment or facilities that may not be relevant in all cases. Reference must be made to the specific design drawings and operating and maintenance manuals for each generator set.

It is assumed that the generator set will have passed a FAT (factory acceptance test) and that some tests that were performed as part of the FAT (such as noise levels and full load heat run) will not need to be repeated on site.

It is also assumed that a technical representative of the generator set supplier will be on site for the duration of this testing. The generator set must always be operated within the limitations established by the manufacturer.

3.0 REFERENCES

- Company Policy 9.2.2 - Network protection
- Company Policy 9.2.5 - Network Asset Design
- Company Policy 9.2.10-Network Asset Rating
- Company Policy 9.7.1 - Network Asset Construction
- Company Policy 9.8.3 - Network Asset Operations
- Division Procedure GNV 1039 – Acceptance of New Distribution Transformers.
- Division Procedure GNV 1044 - Commissioning network electrical assets
- Branch Procedure PAE 1004 - Product approval process
- Earthing Design Instruction EDI 100 - Distribution earthing design, construct and test
- Protection Design Instruction PDI 5000 - Protection of embedded generation systems
- Protection Maintenance Instruction PMI 4110 – Commissioning of protection schemes
- Substation Maintenance Instruction SDI 111 - Mobile generator connection and operation standard
- Substation Maintenance Instruction SMI 113 - Distribution and field transmission data asset structure and nameplate details
- Company Network Management Plan December 2013 Review
- Electrical Safety Rules
- Annexure 1 – Commissioning Checklist and Records
- AS 3000 - Electrical installations
- ENA Substation Earthing Guide - EG1-2006
- ENA Power System Earthing Guide - EG0-2010
- ENA National Electricity Safety Code (Doc 01-2008)

4.0 DEFINITIONS AND ABBREVIATIONS

AVR	Automatic Voltage Regulation
FAT	Factory acceptance test
Generator set	A packaged assembly consisting of a diesel engine mechanically coupled to a synchronous generator, together with associated switchgear, control and protection equipment.
Grid	Endeavour Energy's network and its connections to the National Electricity Grid.
Islanding	Islanding occurs when a private generator or generating system remains connected to a portion of the network and continues to supply electricity to that portion of the network, but is disconnected from the general electrical network or main source of generation.
Megger	Insulation resistance and continuity tester.
NEC	National Electricity Code.
Network connection point (NCP)	The point of electrical connection between the apparatus owned by the Network Service Provider (Endeavour Energy) and the apparatus owned by the customer.
Point of common coupling (PCC)	Point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected.
SCADA	Supervisory Control and Data Acquisition – computer program for remote control of the supply network.
Synchronism	Synchronism occurs when two (2) a.c. voltages are of the same frequency and magnitude, and have zero phase difference.

5.0 ACTIONS

5.1 Responsible officer

The responsible officer, as defined in Division Procedure GNV 1044 - Commissioning network electrical assets, shall check that all equipment to be installed in a project has Endeavour Energy **product approval,** and that tests/checks specified in this standard are carried out.
Note: Endeavour Energy's responsible officer must be provided with the test reports and the qualified assessors must satisfy themselves of the authenticity and adequacy of tests to make an informed assessment. This may necessitate that they witness the tests. The test reports must have the actual tester's signature and the qualified assessor's signature indicating the tests are true and correct.

The responsible officer shall be responsible for checking that the equipment is safe to energise, pre-commissioning tests and checks are carried out immediately prior to energisation of the newly installed equipment or system, the relevant forms are completed, and the test results are satisfactory for the newly installed assets to be energised or made available for service.

5.2 Design and documentation review

Pre-commissioning tests and checks are designed to confirm that newly installed distribution equipment or a newly constructed distribution system of components is safe and fit for energisation.

Post-commissioning checks are carried out to confirm equipment once energised, is operating as expected.

Copies of the following documentation shall be available for reference during the commissioning:

a) FAT reports and checklists.

b) Drawings.

c) Operating and maintenance manuals.

All necessary statutory approvals shall be available. This shall include any approvals needed for the safe storage and handling of diesel fuel.

All relevant design drawings shall be reviewed to check that the installation complies with the drawings.

If equipment is not to be commissioned within four weeks of completion of these tests, then the tests shall be repeated, immediately prior to the commissioning of the equipment.

Also, if the equipment is to be commissioned after the day of installation but before the four weeks is completed, a visual inspection of the equipment shall be carried out. If any work has been carried out on the equipment, or if there has been any damage from adjacent works and the like that is evident in the area of the equipment, the tests shall be repeated.

AUPs are responsible for confirming that any commissioning tests or checks specified throughout this document are carried out in accordance with Endeavour Energy's requirements and supplied to the responsible officer.

Where required, AUPs must arrange, were necessary, an Access Authority for Test in accordance with the requirements specified in Endeavour Energy's *Electrical Safety Rules* prior to commencement of the tests.

All test equipment and instrumentation used for commissioning must have been calibrated and traceable to a NATA approved laboratory; and shall have a current test sticker affixed. AUPs are responsible for checking that test equipment and instrumentation used is correctly calibrated and traceable.

5.3 Records

In addition to the normal asset information, as required in Substation Maintenance Instruction SMI 113 - Distribution and field transmission data asset structure and nameplate details, AUPs must record at least the following information:

d) Testing organisation name, testing officer and any witnesses.

e) Test date, time, location, temperature and humidity.

f) All ratings for current, voltage, power, vars, and the like.

g) Accurate description of power plant, generator or equipment tested.

h) Generator or equipment *passed* or *failed* tests.

i) Details of test completed and result expressed as a value at a reference temperature.

j) Instrument numbers and calibration dates.

k) Test equipment numbers and calibration dates.

Within one week of the tests, AUPs must provide Endeavour Energy's responsible officer with a test report covering items (a) to (h) inclusive.

The responsible officer shall check that the test results are retained in Endeavour Energy's project file for future review. For contestable projects this will be held in the CAM system. An electronic copy of all test results shall be placed in the network drive G:\TIS under a suitable sub folder with an appropriate project name.

Caution: When carrying out insulation tests on HV equipment carrying electronic/control/telecommunication sub-systems, care shall be taken to follow the manufacturer's instructions and check whether these sub-systems could be affected by test voltages.

5.4 Pre-commissioning checks and tests - overview

Pre-commissioning checks and tests shall be performed on each piece of significant distribution equipment, power plant, generator, fuel tank, cables, switchgear and the like.

These tests shall be performed after installation of the equipment, where possible, to check all forms of transit to site and installation damage is covered. Where the tests cannot practically be carried out after installation, **the tests may be carried out after transit to site and just prior to installation**.

These tests not only provide a smooth passage through commissioning, but help prevent undue delays and costs in the event of failures once the whole system is installed.

The tests are described below and checklists are provided in Annexure 1 - Commissioning Checklist and Records. AUPs shall have documentary evidence to indicate that the tests have been carried out for individual items of equipment mentioned above. As required by Division Procedure GNV 1044 – Commissioning Network Electrical Assets, at the start of any project an inspection and test plan is to be developed by the responsible officer of the project to provide and manage the process effectively.

Checks and tests that need to be performed as pre-commissioning tests can be broadly categorised into three stages. While the tests set out below are not necessarily in strict order, nevertheless all checks and tests shall be performed.

5.5 Stage 1 - compliance with Standards

1. Check that the installation meets the approved design and that the construction complies with Endeavour Energy's construction Standards.
2. Check that the earthing of the installation meets the approved design, and that the construction complies with Endeavour Energy's construction Standards and Earthing Design Instruction EDI 100 – Distribution earthing design, construct and test. Verify the common or separate earthing status.
3. Check the connection of the neutral to the MEN network and other LV connections recommended by the earthing design.
4. Check that all equipment and material used in the project is new and approved, or approval to utilise used equipment has been given from the substation Primary Systems manager. Significant network assets are listed in Endeavour Energy's approved products database and carry an Endeavour Energy product approval number.
5. Check all equipment and material used, but not covered by point 4 above, still comply with the relevant Australian or IEC standards.

5.6 Stage 2 - visual inspection and tests

5.6.1 General inspection all areas

Before commencing any testing there shall be a complete visual inspection of the facility which shall cover at least the following areas:

1. Inspection of all equipment for any damage, corrosion, leaks abnormal uncleanliness or any other visible abnormalities. All paintwork shall be free of scratches and defects.
2. Visual check and, if necessary, measurements to confirm safety clearances, creepage distances, flashover clearances, setback (for noise and fire) from properties and the like meet relevant standards and equipment specifications.
3. Check that all machinery guards are securely fixed in place. This particularly applies to fan guards around the radiator fan and coupling guards on driven equipment.
4. Check that heat shields are in place around any surfaces that will operate at an elevated temperature, such as exhaust manifolds and water piping.
5. Check that the generator set is mounted in accordance with the manufacturer's recommendations and that, where provided, anti-vibration mounts are installed correctly.
6. Check for any workmanship issues, such as level footings, sharp edges, poor fitted doors, doors can open, close and latch shut or misaligned cable terminations.
7. Check that the installation complies with relevant environmental standards and has no visible environmental issues, for example, piles of dirt, excavations, or potholes.
8. Check right of way clearances, operation and maintenance clearance and access, and any likely impact on safe motor vehicle operation.
9. Carry out earthing system visual checks.
10. Check that asset numbers are affixed as required by Endeavour Energy Standards.
11. Check all equipment fitted with a manufacturer's nameplate for compliance against the project design drawing specification.
12. In addition to the previous points, it is necessary to carry out general risk checks, including:

- Assess fire risks, and check that fire extinguishers are installed, alarms fitted and operational.
- Ventilation is installed and operating according to design standard.
- Check there are no access issues due to stairs or doors not installed according to the building code.
- Emergency exit signs or lighting installed and working.
- All cable penetrations are sealed.

5.6.2 Air intake system

Check that there are no obstructions to the flow of cooling and combustion air to the generator set and that all construction debris and rubbish is removed.

Inspect the air cleaners to check that the internal areas are clean and that the proper air filter elements are installed.

5.6.3 Radiator cooling system

Inspect the fan drive belts and check that there is no wear, and that the belts are correctly installed and tensioned.

Verify that the radiator has the correct level of coolant and that the radiator cap is correctly installed and tightened.

5.6.4 Exhaust system

Check that the exhaust system is correctly installed and that there is provision for thermal expansion. Check that there is a rain cap on the exhaust stack.

5.6.5 Fuel system

Check that the fuel system complies with the following:

- The bulk fuel storage tank is bunded or is of a double skin design to satisfy Australian Standards AS1692 and AS1940.
- Visually inspect the complete installation for any signs of leaks.
- Check that the tank is full.
- Check that the fuel level gauge is reading correctly. Where a level transmitter is provided, verify that the transmitter is correctly calibrated and that the signal is available at the SCADA system.
- Check that there are adequate facilities for the safe delivery and transfer of fuel from road transport tankers.
- Check that the fuel tank is vented through an approved flame trap.
- Check that the fuel lines to the generator set skid are of the correct size and material. Flexible connections should be provided at the generator set skid.
- Check that the fuel filters are clean and free from debris.
- Drain any condensate from the bottom of the fuel tank.
- Verify that fuel lines have been flushed out.

5.6.6 Lubrication system

Take a sample of lube oil from the sump for future testing purposes.

Check the oil level using the dipstick, check that the correct calibration mark is used for cold oil.

Check that the oil filters are clean and free of debris.

Visually check for any oil leaks.

Check that the crankcase ventilation system is correctly installed.

5.6.7 Electrical installation

Note: This procedure is intended to cover only the installation immediately associated with the generator set. There may be other electrical switchboards and facilities connected to the installation and it is assumed that they are the subject of separate commissioning instructions and checklists.

Carry out a visual inspection of all of the power and control cables and cable terminations and check the requirements of clause 5.1.12 of Substation Design Instruction SDI 111 – Mobile generator connection and operation standard, are satisfied.

Check that the cables are free from any visible damage, all connections are in accordance with the drawings, and that main circuit connections are tight.

Measure, between phases and each phase to earth, the insulation resistance of the alternator stator winding and connections to the circuit breaker using a 1000V *Megger*. Compare the reading with that achieved during the FAT. The insulation resistance should exceed one megohm and should not vary appreciably from the FAT result.

It may be necessary to remove the fuses in the voltage measuring instrumentation circuits for this test. Check that the fuses are correctly replaced.

Measure, between phases and each phase to earth, the insulation resistance of the main circuit connections from the generator set circuit breaker to the point of connection with the load installation using a 1000V *Megger*. The insulation resistance should exceed one megohm.

Check that there are no crossovers within parallel runs of cable.

Verify, using a current injection test, that the earthing system (where the generator neutral is earthed) meets the requirement of clause 5.5 of Earthing Design Instruction EDI 100 – Distribution earthing design, construct and test.

Verify that the generator set is connected to the earthing system in an approved manner.

Verify that the generator set neutral is solidly earthed by connecting to the network earthing system in an approved manner.

Check that batteries have the correct level of electrolyte. Measure and record the float voltage.

Where the generator circuit breaker has adjustable trip settings, verify that the settings are correct.

5.7 Stage 3 - functional testing

Prior to starting any functional testing, check that all necessary commissioning tests on other parts of the system that may be connected to the generator set have been completed, including protection relay testing. Where necessary, check that safety provisions have been planned and implemented, switches are isolated and tagged, and employees have been advised of the testing procedure.

5.7.1 Safety shutdown systems

For all system conditions that are required to cause an engine shutdown, simulate the initiating event and verify that a shutdown signal occurs.

For each emergency stop pushbutton, operate the pushbutton and verify that a shutdown signal occurs.

5.7.2 Remote control, indication and alarm systems

For each status indication connected to the SCADA system, simulate a change of state and verify that the SCADA system receives the event.

For each alarm connected to the SCADA system, simulate a change of state and verify that the SCADA system receives the alarm.

For each analogue signal connected to the SCADA system, simulate the analogue output and verify that the SCADA system receives the signal. Verify that the range is correctly calibrated.

Where remote control from the SCADA system is implemented, force the appropriate output from the SCADA system and verify that the generator set controller receives the signal.

5.7.3 No-load running

Configure the generator set in accordance with the manufacturer's instructions in order to run in isolation from the network.

Start the generator set from the control panel.

Verify that the generator set starts and runs at the correct speed.

Check that there is no unusual noise or vibration.

Measure and record the following:

- No load terminal voltages.
- Frequency.
- Phase rotation.

Verify that the battery charger is operating and that the anti-condensation heaters are off.

Stop the generator set from control panel and verify that the machine coasts to a stop.

5.7.4 Isolated running

Start the generator set from the control panel.

After the generator set has reached normal speed, check that the generator circuit breaker closes and apply a load to the machine.

Measure and record the following:

- Terminal voltages.
- Frequency.
- Load current.
- Load power.

Continue the test for at least 15 minutes and measure and record the following:

- Oil temperature.
- Oil pressure.
- Coolant temperature.
- Ambient air temperature and humidity

Compare the measured values with the display on the generator set control panel and check that they agree.

Measure the transient response of the voltage and frequency and compare with the FAT results for step loading. Adjust the governor and AVR settings if necessary to achieve the fastest response possible with minimal overshoot. Check that the terminal volts and frequency are stable with constant loading.

Stop the generator set from the control panel and verify that the load is automatically disconnected and the machine coasts to a stop.

In addition to the above, it is important when running islanded to know the generators capability to handle cold load pick up and fluctuating loads without protection operation.

5.7.5 Running in parallel with the network

Configure the generator set in accordance with the manufacturer's instructions in order to run in parallel with the network. Disable closing of the generator circuit breaker.

Check and verify the vector group of the step-up transformer is appropriate for the installation

Verify that the HV neutral of the step up transformer is disconnected from earth via the isolating switch provided.

Close the LV isolator of the generator set.

Check that there are volts on the load side of the generator circuit breaker and that the phase rotation is the same as proved in clause 5.7.3 above.

Start the generator set from the control panel.

Verify that the generator set starts and runs at normal speed.

Measure the voltage and frequency difference across the generator circuit breaker while the controller is synchronising and check that the close command occurs at the moment where the generator is fully synchronised with the network supply.

Enable the closing of the generator circuit breaker and repeat the test.

Check that the generator synchronises correctly and that the generator load increases to the set-point.

Verify that the reactive power is correct for the load power factor.

Check that the generator set frequency, terminal voltage and real and reactive power are stable.

Raise and lower the load set-point and check that the generator set smoothly increases and decreases output without any oscillation or hunting.

Verify that fuel is being transferred correctly from the storage tank.

Reduce the load to below 5% and open the generator circuit breaker. Allow the engine to cool down before stopping.

5.7.6 Remote control

Repeat the above tests with start and stop from the SCADA system and check that all operations are correct.

5.7.7 Network protection

The following testing is to be conducted in conjunction with Endeavour Energy's protection technologists as it involves the HV network protection relays and switchgear.

- Protection systems are tested and commissioned in accordance with Protection Maintenance Instruction PMI 4110 – Commissioning of protection schemes.
- Start the generator set and operate in parallel with the network at normal load.
- Simulate operation of the network protection (for example, ROCOF, vector shift). Check that the HV circuit breaker opens.
- With the generator set in operation, test the anti-islanding protection by opening the upstream HV network circuit breaker. Check that the generator set is isolated from the network by operation of one or more of the protection relays. Record the tripping time.

5.8 Maintenance program

As part of the commissioning process it should be checked that there has been a suitable maintenance schedule put in place for continued suitable performance.

Ongoing maintenance shall include periodic inspections and regular servicing intervals as defined by the manufacturer.

The fuel system shall be monitored to prevent it from becoming stagnant or contaminated.

6.0 AUTHORITIES AND RESPONSIBILITIES

Chief Engineer has the authority and responsibility for approving this instruction and approving variations to the requirements of this instruction.

Manager Primary Systems has the authority and responsibility for endorsing and recommending changes and revisions to this instruction.

Network Substations Manager, Primary Systems has the authority and responsibility for revising and updating the substation related information in this instruction in accordance with Company Policies and Procedures.

Regional Managers have the authority and responsibility for:

- appointing a responsible officer to any project when required by this procedure; and,
- developing a process for implementing the requirements of this instruction.

Endeavour Energy Responsible Officer, as defined in Division Procedure GNV1044 – Commissioning Network Electrical Assets has the authority and responsibility for:

- checking that all equipment to be installed in a project has Endeavour Energy product approval, and that tests/checks specified in this Standard are carried out;

  Note: Endeavour Energy's responsible officer, or nominated Endeavour Energy representative, must be provided with the test reports, and the qualified assessor must be a witness to the tests. The test reports must have the qualified assessor's signature indicating the tests are true and correct.

- checking that the equipment is safe to energise; pre-commissioning tests and checks are carried out immediately prior to energisation of the newly installed equipment or system; the relevant forms are completed; and,
- checking that the test results are satisfactory for the newly installed assets to be energised or made available for service.

Contractor Operations Manager, Network Connections Branch has the authority and responsibility for confirming that all new installations are inspected and tested in accordance with this instruction prior to energisation.

Manager Network Connections has the authority and responsibility for confirming that the network installations made by external employees or organisations are checked and tested in accordance with this Standard.

SCADA and Communication Manager has the authority and responsibility for confirming all design aspects have been covered prior to the installation of SCADA equipment.

Accredited Service Providers have the authority and responsibility for confirming that their employees have available and use the latest issue of this instruction and other related Standards.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Substations Manager

Documentation process coordinator: Standards Process Coordinator

Annexure 1: Commissioning Checklist and Records

	Name	Signature	Date
Qualified assessor			
Tests conducted by			

Equipment location	
Manufacturer	
Model number	
Serial number	
Year of manufacture	
Number of phases	
Gen. vector group	
Rated parameters	
Voltage (V)	
Power (kW)	
Fuel tank size (Ltrs)	
Approx. full load running time/100litres fuel	

Check/test	Acceptable criteria	Result
Design review		
FAT reports and checklists	Available on site	
Drawings	Installation in accordance with drawings.	
Operating and maintenance manuals	Available on site	
Compliance with standards		
Meets approved design and Endeavour Energy construction standards	Yes	
Earthing design	Meets Earthing Design Instruction EDI 100 – Distribution earthing design, construct and test requirements	
Equipment approved for use by Endeavour and accepted as in Division Procedure GNV 1039 – Acceptance of New Distribution Transformer	Mandatory	

Check/test	Acceptable criteria	Result
Visual inspection and tests		
Inspect all equip. for damage, corrosion, leaks, paintwork, abnormalities	None	
Check clearances, setbacks	Comply to standard	
Machinery guards	In place	
Heat shields	In place	
Mounting	Anti-vibration mounts	
Fire protection	In place	
Access doors	Correct operation	
Access for Op. and Maint.	Adequate space	
Signage	In place	
Documentation	In place	
Paintwork	No defects	
Cleanliness and leaks	Clean	
Air intake system		
Intake system	Clear of obstructions	
Air cleaners	Clean	
Radiator cooling system		
Drive belts	Correct tension, no wear	
Coolant level	Correct level	
Radiator cap	Tight	
Exhaust system		
Pipework	Correct	
Rain cap	In place	
Fuel system		
Storage tank bund	Complies	
Fuel Leaks	No visible leaks	
Fuel level	Tank full	
Level gauge	Correct reading	
Delivery system	Acceptable	
Vent and flame trap	In place	
Fuel lines	Correct material and size	
Flush lines	Completed	
Fuel filters	Clean	
Condensate	Drained	

Check/test	Acceptable criteria	Result
Lubrication system		
Oil sample	Sample taken	
Oil level	Check dipstick	
Oil filters	Clean	
Oil leaks	No visible leaks	
Crankcase ventilation	System verified	
Electrical installation		
Check cabling	Connections correct	
Winding insul. resistance	>1 Mohm	
Power cable insul. resistance	>1 Mohm	
Power cable connections	No crossovers	
Current injection test	Meet requirements of clause 5.5 of Substation Design Instruction SDI 111 – Mobile generator connection and operation standard	
Earthing connections	Solidly connected	
Gen. LV Neutral connections	Solidly connected	
Step-up transformer HV neutral earth switch	Opened	
Batteries	Electrolyte level correct	
Battery charger	Correct float voltage	
CB trip setting	Correct trip setting	
Functional testing		
Safety shutdown systems		
Itemise shutdown condition		
Emergency stop button	Operation correct	

Check/test	Acceptable criteria	Result
Remote control, indication and alarm systems		
Itemise each signal tested		
	Operated correctly	
No-load running test		
No load test done	All functions correct	
No load voltage	V	
No load frequency	Hz	
Phase rotation	Clock wise	
Isolated running test		
Isolated running test done	All functions correct	
Load voltage	V	
Load frequency	Hz	
Load current	A	
Load power	kW	
Oil temperature @ 15min	Deg C	
Oil pressure @ 15min	kPa	
Coolant temp. @ 15min	Deg C	
Transient response @ 15min	Attach printout	
Parallel running test		
Parallel running test done	All functions correct	
Synchronising	Successful	
Load voltage	V	
Load frequency	Hz	
Load current	A	
Load power	kW	
Load adjustment	Raise and lower test	

Check/test	Acceptable criteria	Result
Remote control test		
Remote start	Successful	
Remote stop	Successful	
Network protection test		
Simulate protection relay operation	HV CB trips	
Anti-islanding test	HV CB trips	
Generator load pre-trip	kW	
Tripping time after islanding	s	

