

BUS ASSEMBLY TESTING SWP

1. PURPOSE AND SCOPE

The purpose of this Standard Work Practice (SWP) is to standardise and prescribe the method for testing high voltage bus assemblies. This includes air insulated busbars and enclosed busbars (such as an oil insulated RMU).

2. STAFFING RESOURCES

Adequate staffing resources with the competencies to safely complete the required tasks as per Substation Commissioning and Testing - 21173495. These competencies can be gained from, but not limited to any or all of the following:

- Electrical Fitter/Mechanic & Competent Assistant with Switching & Access authorisations* for the roles they are required to perform and instructed.

NOTE: Electrical work may only be performed by a person if the person

(a) The holder of an appropriate electrical licence authorising the work; or

(b) Is otherwise authorised to perform the work under the Act.

- Training in the safe use of relevant test equipment.

Requirement for all live work:

- Safety Observer (required for all “live work” as defined in the ESO Code of Practice for [Managing electrical risks in the workplace](#)).

All resources are required to:

- Hold current licences for any vehicles and equipment they may be required to operate.

Required Training

Staff must be current in all Statutory Training relevant for the task.

All workers must have completed Field Induction or have recognition of prior Ergon Energy Field Experience.

Contractors must have completed Ergon Energy's Generic Contractor Worker Induction.

Additional Training

Training Course Description for Authorisations or Certificates
Course ID 1082 - Fire Safety, General Evacuation and First response
Course ID 1084 - Hazardous Manual Tasks
Course ID 1863 - Safe Work at Heights on Substation Structures
Course ID 1022 - Heat Stress Awareness
Course ID 1876 - Elevating Work Platform Operation
*Individual of a Work Group (minimum requirement)

3. DOCUMENTATION

EQL SWMS - Safe Work Method Statements
 HazChat - On-Site Hazard Assessment
 Electrical Safety Rules - 6503074
 Environmental Management Standard - 2947192
 Equipment Catalogue
 Fire Protection Systems at EQL Sites - 3322520
 First Aid Management R255 - 691001
 Gravitational Hazards - 3330498
 Guideline for Apprentice Supervision R061 - 690503
 Hazardous Manual Tasks R243 - 692111

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Joint Asset Management Inspection Tool (JAMIT) - Home Queensland Electricity Entity Standard for Safe Access to High Voltage Electrical Apparatus (SAHV - Orange Book) - 2904212
Safe Entry to High Voltage Enclosures - 2888222
Safety Observer Roles and Responsibilities - 3333651
Standard for Fatigue Management S009 - 692143
Standard for Handling of Sulphur Hexafluoride (SF6) - 2949681
Standard for Maintenance Acceptance Criteria - 2928929
Standard for Minimum Commissioning Test Requirements - 3061890
Standard for Personal Protective Equipment (PPE) S031 - 691352
Standard for Remote and Isolated Work S054 - 1876763
Standard for Substation Earthing Devices - 3057007
Substation Commissioning and Testing - 21173495
Testing Procedure Manual R270 - 692468
Tools and Equipment Safe Operating Procedures - 3070197
Working with Secondary Systems Switching - 21579677
Working with Substation Test Equipment - 2902800
Working With Substation Wiring and Circuitry - 13764022
Construction Tool - Bus Assembly - 2946153
Commissioning Tool - Bus Assembly - 2948460
Earth Frame Leakage Protection Reference Document - 2938224
Earth Frame Leakage Field Testing Reference Document - 2948546
JSEA: Access and Entry - Safe Entry to HV Enclosures
JSEA: Working with Electricity - Working on or Near Energised Equipment
JSEA: Working with Electricity - Testing Using Lethal Current and or High Voltages

4. KEY TOOLS AND EQUIPMENT

- Test Equipment within calibration date, tested and tagged: Insulation Resistance tester, Micro-ohmmeter and High Voltage test set.
- Safety Barriers and warning signs.
- HVIA Operating Equipment: PEDs, Live Line Tester, Class '0' gloves. All equipment to be inspected and confirmed within test date prior to use.
- Standard PPE: Full-length high visibility protective cotton clothing, safety footwear and helmet.
- Additional PPE as required: Leather work gloves, class 00 gloves, hearing protection, safety eyewear. All PPE to be inspected and confirmed within test date (where applicable) prior to use.
- Sun protection to be used when working outdoors.

5. WORK PRACTICE STEPS

5.1. Carry out an on-site hazard assessment

Prior to performing this activity any hazards associated with prerequisite tasks at the worksite shall be identified and assessed with appropriate control measures implemented and documented in accordance with the HazChat and using the EQL SWMS.

If any risks cannot be managed or reduced to an acceptable level, do not proceed with the task and seek assistance from your WGL.

NOTE: When workers are required to perform electrical work on or near (within 3m) of exposed live parts, workers shall ensure appropriate controls are implemented as prescribed under Working On or Near Exposed Live Parts SWMS R323 - 1887674

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and Safety Observer Roles and Responsibilities - 3333651.

5.2. HV Switching and Access

CAUTION: All work shall be carried out with busbar de-energised

All of the tests described in this SWP should be carried out with the bus assembly de-energised and appropriate control measures in place (eg barriers, matting) to prevent inadvertent contact with adjacent live plant or breaching exclusion zones. Furthermore, the Electrical Safety Rules - 6503074 is applicable at all times for isolation and earthing.

Issue a Test Permit and follow the requirements of the Electrical Safety Rules.

As described in Working with Substation Test Equipment - 2902800 particular safety risks applicable to bus assemblies include:

- Contact with high voltage at primary connections.
- High fault current at primary connections.
- Induced voltages and currents from nearby energised / loaded plant.

5.3. Assessment Criteria

Unless stated, refer to Standard for Maintenance Acceptance Criteria - 2928929 for minimum acceptance values for each test.

5.4. Record Identification Details

Record identification details:

- Manufacturer's name, manufacturer's type description and manufacturer's serial number.
- Plant/Asset number.
- Rated voltage.
- Rated nominal and short-circuit current and duration.
- Insulating medium.

5.5. Visual Inspection of Bus Assembly Condition

Inspect the plant for any sign of damage. Confirm that the insulating medium level/pressure is correct before commencing tests and that assembly is complete and no transport bracing has been left in place.

Inspect the external surfaces and ensure the plant is clean and dry.

5.6. Measure Insulation Resistance

DC insulation tests are to be carried out on the completed bus assembly. The voltage applied will be as per Standard for Maintenance Acceptance Criteria - 2928929 for a duration of 1 minute and is to be applied to each phase in turn with the other two phases earthed.

Refer to Standard for Maintenance Acceptance Criteria - 2928929 for minimum acceptance values.

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5.7. Measure Frame Leakage Insulation Resistance

Where frame leakage insulation is installed, it shall also be subjected to an insulation resistance measurement at 1kV.

Refer to Standard for Maintenance Acceptance Criteria - 2928929 for minimum acceptance values.

If it is found that the frame leakage insulation has a low IR value, there may be inadvertent alternate paths to earth that need to be corrected. Such paths may exist via HV cable sheaths, control cable sheaths, VT primary star point, VT or CT secondary earths, data cable connections to protection relays etc.

For in-service testing refer to Earth Frame Leakage Field Testing Reference Document - 2948546.

5.8. Measure Connection Resistance

Measurement shall be made using DC current of at least 50A (100A preferred) and less than the nominal current rating of the bus assembly. The test shall be conducted as close as practical to ambient temperature.

A four wire micro-ohmmeter should be used for measuring the resistance of each bolted connection. Where a connection has been previously tested at the manufacturer's works and has been unaltered during assembly on site, there is no requirement to repeat this test.

Typically, the resistance of a bolted joint should be less than $80\mu\Omega$. In particular, there should be minimal variation between phases and between like connections.

To limit any hazardous voltage rise due to induction, always maintain an operator earth or working earth on one side of the bus during this measurement where there is an adjacent live bus.

For minimum acceptable resistance levels refer to the Standard for Maintenance Acceptance Criteria - 2928929.

CAUTION: Do not pass measurement current through any current transformer connected to the bus (such as a bus coupler CT). A DC current may cause inadvertent protection operation and may leave residual magnetism in the CT which adversely affects CT performance.

5.9. Measure Busbar Main Earth Connection Resistance

Measurement shall be made using a four wire micro-ohmmeter at a DC current of at least 50A (100A preferred). The test shall be conducted as close as practical to ambient temperature.

Where there is a separate earth connection for each bus section, or a separate earth connection associated with frame leakage insulation, each earth connection shall be tested individually.

5.10. Carry out HV Testing

EQL's Standard for Site Acceptance Testing - 3061890 specifies that a power frequency withstand test be carried out on site after erection for voltage up to and including 33kV. The level of high voltage testing to be applied is therefore:

- a) Where no HV testing has been carried out at the manufacturer's works - 100%. This may apply to only a portion of the bus assembly, for example poured insulated joints, however because it is impossible to separate the untested portion from the rest of the assembly a 100% test is required for the entire assembly.
- b) Where HV testing has been carried out at the manufacturer's works but subsequent assembly is required on site (for example connecting tested sub-assemblies together) - 80%.
- c) Where HV testing has been carried out at the manufacturer's works and no on-site assembly of the

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insulating component is required ie. RMUs - No HV withstand test.

The power frequency withstand voltage for selected voltage levels U_m as per AS 2067 are listed below.

The 1-minute power frequency withstand test voltage is to be applied to each phase in turn with the other two phases earthed.

U_m	U_{test}	
	100%	80%
3.6kV	10kV	8kV
7.2kV	20kV	16kV
12kV	28kV	22.4kV
24kV	50kV	40kV
36kV	70kV	56kV

The requirements of the test are satisfied if no disruptive discharge occurs.

An insulation resistance test is to be repeated after the HV withstand test to confirm that no insulation degradation has occurred.

5.11. Check Expansion Joints

Check that sufficient allowance in expansion joints for a 30 degree C temperature rise (typical) has been catered for.

Typical coefficients of expansion are:

- Copper - 0.0000173 mm per degree C.
- Aluminium - 0.000023 mm per degree C.

For example, an aluminium busbar 16 m long subjected to a 30 degrees C temperature rise above ambient will expand by $16 * 1000 * 0.000023 * 30 = 11$ mm. (This equates to an expansion of 0.7 mm per m of busbar for aluminium, and 0.5mm/m for copper).

5.12. Carry out SF₆ Testing

For SF₆ insulated equipment, carry out testing for the following parameters as specified in Standard for Handling of Sulphur Hexafluoride (SF₆) - 2949681:

- Purity of SF₆
- Dew point
- Acidity
- Concentration of hydrolysable fluorides.

Refer to Standard for Maintenance Acceptance Criteria - 2928929 for minimum acceptance values.

5.13. Carry out DLA Testing

If required, carry out Dielectric Loss Angle measurements on the bus. Refer to Standard for Site Acceptance Testing - 3061890.

Refer to Standard for Maintenance Acceptance Criteria - 2928929 for minimum acceptance values.

5.14. Carry out Partial Discharge Testing

If required, carry out offline Partial Discharge measurements. Refer to Standard for Site Acceptance Testing - 3061890.

Refer to Standard for Maintenance Acceptance Criteria - 2928929 for minimum acceptance values.

5.15. Schedule of Tests

Refer to Standard for Site Acceptance Testing - 3061890 for bus assembly testing requirements.

5.16. Complete Pre-commissioning Checklist

A requirement for a bus assembly being placed in service for the first time or after refurbishment is that all checklists nominated in the Construction and Commissioning Tools have been completed.