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 MN000301R165: 8 Level Field Test Competency.

These competencies can be gained from, but not limited to any or all of the following:-

- Qualifying as an Electrical Fitter Mechanic
- Qualifying as a Technical Service Person
- 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 Electrical Work).

All resources are required to:

- Have appropriate Switching and Access authorisations for the roles they are required to perform and have the ability to assess and maintain relevant exclusion zones from exposed live electrical apparatus
- 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.

3. DOCUMENTATION

CS000501F115. Daily/Task Risk Management Plan

ES000901R102. Health and Safety Risk Control Guide

SP0515R01. Bus Assembly Testing Job Safety Analysis

SP0515C02. Bus Assembly Testing Competency Assessment

SP0515C04. Bus Protection Primary Injection Test Report

SP0515R02. Earth Frame Leakage Protection

SP0515R03. Earth Frame Leakage Field Testing

SP0515C06. Construction Tool – Bus Assembly

SP0515C05.Commissioning Tool – Bus Assembly

SP0506. Substation Primary Plant and Secondary Systems Field Testing SWP

STNW1117. Standard for Handling of Sulphur Hexafluoride

STNW1160.Standard for Maintenance Acceptance Criteria

MN000301R172. Doble DLA Testing

MPD 600 Test Procedure

P53. Operate the Network Enterprise Process

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AS 1931.1 – High Voltage Test Techniques - General Definitions And Test Requirements

AS 1931.2 – High Voltage Test Techniques - Measuring Systems

AS 2650 – 2005 – Common specifications for High Voltage AC Switchgear and Controlgear standards

AS 2067 – 2008 – Substations and High Voltage Installations Exceeding 1kV

AS 2467 – 2008 – Maintenance of Electrical Switchgear

Test Equipment Manual

Switchgear Manual / Manufacturer's Drawings

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 risk 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 **Daily / Task Workplace Risk Management Plan** (CS000501F115) and using the **Health and Safety Risk Control Guide** reference document (ES000901R102).

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

5.2. All work to be done 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 P53 Operate the Network Process is applicable at all times for isolation and earthing.

Issue a Test Permit and follow the requirements of P53 Operate the Network Process.

As described in Substation Primary Plant and Secondary Systems Field Testing SWP SP0506 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 STNW1160 Standard for Maintenance Acceptance Criteria 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 Table 1 for a duration of 1 minute, and is to be applied to each phase in turn with the other two phases earthed.

Refer to STNW1160 Standard for Maintenance Acceptance Criteria for minimum acceptance values.

Table 1. Applied Voltages for IR Tests:

Primary Voltage Rating	Test Voltage in kV (DC)
Up to 1kV	1
Above 1kV to 3.6kV	2
Above 3.6kV to 12kV	5
Above 12kV	10

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 STNW1160 Standard for Maintenance Acceptance Criteria 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 SP0515R03 Earth Frame Leakage Field Testing.

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

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unaltered during assembly on site, there is no requirement to repeat this test.

Typically, the resistance of a bolted joint should be less than 100μΩ. 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.

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

AS 2067 specifies that a 90% power frequency withstand test be carried out on site after erection. 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) – 90%.

c) Where HV testing has been carried out at the manufacturer's works and no on-site assembly of the insulating component is required – No HV withstand test.

d) If the bus assembly is aged or refurbished – 75%.

Where U_m<=66kV the value of voltage applied shall be as per AS 2650 as listed in the table below. Refer to AS 2650 for voltages U_m>66kV.

Note that the test voltage used may be limited by the output capability of the test equipment. In this case a reduced test voltage for an extended duration as specified in Table 11.1 of AS 2067 may be used.

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%	**90%**	**75%**
3.6kV	10kV	9kV	7.5kV
7.2kV	20kV	18kV	15kV
12kV	28kV	25.2kV	21kV
24kV	50kV	45kV	37.5kV
36kV	70kV	63kV	52.5kV
72.5kV	140kV	126kV	105kV

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 x 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 SF_6 Testing

For SF_6 insulated equipment, carry out testing for the following parameters as specified in STNW1117 Standard for Handling of Sulphur Hexafluoride:

- Purity of SF_6
- Dew point
- Acidity
- Concentration of hydrolysable fluorides.

Refer to STNW1160 Standard for Maintenance Acceptance Criteria for minimum acceptance values.

5.13. Carry out DLA Testing

If required, carry out Dielectric Loss Angle measurements on the bus as per MN000301R172 Doble DLA Testing.

Refer to STNW1160 Standard for Maintenance Acceptance Criteria for minimum acceptance values.

5.14. Carry out Partial Discharge Testing

If required, carry out offline Partial Discharge measurements as per the MPD 600 Test Procedure.

Refer to STNW1160 Standard for Maintenance Acceptance Criteria for minimum acceptance values.

5.15. Schedule of Tests

The table below details the circumstances in which different tests are carried out:

Test	New Isolator/Earth Switch	Aged or refurbished Isolator/Earth Switch
Insulation Resistance	On-site test required.	
Frame Leakage	On-site test required if applicable.	
Connection Resistance	On-site test required.	
Main Earth Connection Resistance	On-site test required.	
High Voltage Withstand	As per 5.10 (a) to (c)	As per 5.10 (d)
SF_6 Tests	On-site test required if applicable.	
DLA	At Asset Manager discretion.	
Partial Discharge	At Asset Manager discretion.	

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.