

Substation Maintenance Instruction

33kV–132kV Indoor air and gas insulated switchgear

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51 Huntingwood Drive, Huntingwood NSW 2148

Postal address: PO Box 811 Seven Hills 1730

Phone: 131 718 Fax: (02) 9853 6000



SUBSTATION MAINTENANCE INSTRUCTION

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SMI 210 33kV – 132kV Indoor air and gas insulated switchgear

Contents

1.0	PURPOSE.....	3
2.0	SCOPE.....	3
3.0	REFERENCES.....	3
4.0	DEFINITIONS AND ABBREVIATIONS.....	3
5.0	ACTIONS.....	3
5.1	General.....	3
5.2	Post-fault maintenance.....	4
5.3	Documentation of maintenance.....	4
5.4	Regulations for maintenance.....	4
5.4.1	General.....	4
5.4.2	High pressure GIS.....	5
5.5	Routine and post-fault/operation maintenance schedules.....	5
5.5.1	High Pressure Gas Insulated Switchgear.....	6
5.5.2	Low Pressure Gas Insulated Switchgear.....	10
5.5.3	Air Insulated Switchgear.....	14
6.0	AUTHORITIES AND RESPONSIBILITIES.....	16
7.0	DOCUMENT CONTROL.....	16

1.0 PURPOSE

To set out in detail the broad maintenance requirements for 33kV -132kV indoor air and gas insulated switchgear.

2.0 SCOPE

This instruction is to be read in conjunction with SMI 100 for transmission and zone substation equipment.

3.0 REFERENCES

- Company Policy 9.2.5 - Network Asset Design
- Company Policy 9.7.1 - Network Asset Construction
- Company Policy 9.9.1 – Network Asset Maintenance
- Substation Design Instruction SDI 505 – Minimum design and construction requirements for transmission and zone substations and switching stations
- SDI 545 - Acceptable limits for new and reclaimed SF₆ gas
- Substation Maintenance Instruction SMI 100 – Minimum requirements for maintenance of transmission and zone substation equipment
- SMI 122 - Use and handling of sulphur hexafluoride (SF₆)
- ENA National Electricity Network Safety Code (Doc 01-2008)
- Endeavour Energy Network Management Plan (2013 Review)
- *Work Health and Safety Regulation 2011*
- *Work Health and Safety Act 2011*
- AS 2467 Maintenance of electrical switchgear
- AS 62271.203 Gas insulated switchgear above 52kV
- IEEE C37.122 Standard for Gas insulated substations

4.0 DEFINITIONS AND ABBREVIATIONS

Ellipse	Endeavour Energy asset database
High pressure GIS	Gas-insulated metal-enclosed switchgear containing gas-filled compartments whose design pressure exceeds 300 kPa (relative pressure).
SF ₆	Sulphur hexafluoride
DRM	Dynamic resistance measurement

5.0 ACTIONS

5.1 General

33kV - 132kV indoor air and gas insulated switchgear equipment, by design, generally requires very little maintenance. Functional and visual inspections can be carried out without the need to open the gas-filled compartments.

Routine maintenance comprises an inspection, minor overhaul. The maintenance intervals are included in SMI 100 - Minimum requirements for maintenance of transmission and zone substation equipment.

Inspections and minor overhauls are time based and do not require entry into the gas compartments.

Major overhauls, based on normal operation cycles and fault operations, require intrusive maintenance. Whenever intrusive maintenance is to be carried out on any component within the SF₆ chambers, it shall be assumed that the SF₆ gas is contaminated and the procedures listed in SMI 122 - Use and handling of sulphur hexafluoride (SF₆), shall be adopted.

The number of fault ops under which the major maintenance is triggered is determined by the condition set out in section 5.2.

The quality of SF₆ gas (especially purity and dew point) to be used in SF₆ enclosures must always be tested to confirm that the gas quality is within acceptable limits specified in SDI 545 - Acceptable limits for new and reclaimed SF6 gas before filling.

Routine maintenance schedules given in section 5.5 are for guidance only. Maintenance must always be carried out in accordance with the manufacturer's recommendations unless otherwise specified.

All defect found during routine maintenance shall have a separate defect work order raised in Ellipse.

5.2 Post-fault maintenance

The fault operation limit for a circuit breaker, as detailed in SMI100, is based on individual characteristic of the circuit breaker type and the fault current that is interrupted. The fault cycle for each of these circuit breakers has been determined by using the maximum fault level at the substation where the type of circuit breaker is located. The fault cycle for a circuit breaker may be reviewed if the fault level for a substation significantly changes (for example, due to changes in network configuration).

For SF6 and vacuum circuit breakers, post-fault maintenance shall be performed once the permissible number of fault operations is reached. However, it should be noted that when the fault cycle limit is reached, the fault history (for example, through SCADA) shall be examined to identify and exclude:

- Faults incorrectly registered (such as protection maintenance trips), or
- Fault currents below normal rated load (such as sensitive earth faults).

Furthermore, it should be noted that the fault cycle limit applies to each pole/phase individually. Where the fault history data provides details of the phases involved in the 4.5fault, this can be taken into account to determine a fault count per phase. Where this data is not available, the fault is assumed to affect all phases. Maintenance is only required if one phase has reached the fault cycle limit.

For SF6 circuit breakers, dynamic resistance measurements (DRM) shall be taken where possible to further assess the condition of the contacts.

All the above checks shall be made before intrusive maintenance is carried out.

5.3 Documentation of maintenance

The following shall be recorded in Ellipse:

- Maintenance activities.
- Operation cycle readings for various components.

5.4 Regulations for maintenance

5.4.1 General

All safety precautions shall be taken when maintaining circuit breakers. Potential hazards include charged springs in circuit breaker mechanisms; asbestos, possible X-ray

emission from vacuum interrupters when subjected to the test voltages in excess of rated voltage, and SF₆ contaminated products in arcing chambers.

5.4.2 *High pressure GIS*

5.4.2.1 *Working within compartments*

When work is to be carried out within a gas compartment, the pressure within adjacent chambers must be decreased in accordance with the manufacturer's manual.

5.4.2.2 *Circuit breaker*

Circuit breakers shall be operated only when filled with SF₆ to the minimum recommended functional pressure.

The circuit breaker shall be isolated and earthed on both sides during a major overhaul.

Circuit breakers that have been in service will usually contain traces of toxic SF₆ by-products in varying quantities (see SMI 122).

5.4.2.3 *Fault making earth switch*

Fault making earth switches that have been subjected to load or fault current making or breaking will contain traces of SF₆ by-products in varying quantities (see SMI 122).

5.5 **Routine and post-fault/operation maintenance schedules**

Where applicable, the requirement set for maintenance of circuit breakers in the maintenance schedule below shall be met.

5.5.1 High Pressure Gas Insulated Switchgear

5.5.1.1 ABB ELK

EXERCISE
Trip and close CB electrically.
INSPECTION
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Test and record the "as found" and "as left" open and close timing using CB timing tester. Opening time to be < 18ms and closing time to be < 36ms. Variance between phases to be < 1.5ms. An "as left" test is to be performed after all mechanism tasks are completed. Compare the "as found" with "as left" test results.
Examine cubicle and gas piping for rust and damage.
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage.
Examine the auxiliary switch position indicator/semaphore.
Examine low voltage wiring and terminals for signs of damage.
Measure length of carbon brushes (must be greater than 11mm).
Examine hydraulic pump for damage (for example, leaking)
Earth Switch / Disconnecter – Operating Mechanism
Open and close the switch electrically.
Check the condition and alignment of contacts through the viewing window.
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Inspect limit switches, crank locking switches, and position indicators.
Inspect centre-position lock
Inspect crank lock and end position lock
Examine carbon brushes.
Measure motor current.
Check operation of heater (if applicable).
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and inspecting/replacing the interrupter).
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Check the condition of the contact system and replace as required. - Refill with new gas.
Carry out tasks in the Minor Maintenance .
MAJOR MAINTENANCE – Disconnecter / Earth Switch
Major maintenance involves replacing the contacts of the disconnecter / earth switch. This shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.

5.5.1.2 Areva F35

EXERCISE
Trip and close CB electrically.
INSPECTION
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Test and record the "as found" and "as left" open and close timing using CB timing tester. Opening time to be 25-31ms and closing time to be 85-100ms. Variance between phases to be < 1.5ms. An "as left" test is to be performed after all mechanism tasks are completed. Compare the "as found" with "as left" test results.
Examine cubicle and gas piping for rust and damage.
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine the auxiliary switch position indicator/semaphore.
Examine auxiliary contacts for signs of damage.
Examine low voltage wiring and terminals for signs of damage.
Earth Switch / Disconnecter – Operating Mechanism
Open and close the switch electrically.
Check the condition and alignment of contacts through the viewing window.
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Inspect limit switches, crank locking switches, and position indicators.
Inspect centre-position lock
Inspect crank lock and end position lock
Examine carbon brushes.
Check motor running time is less than 5.5 seconds
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and inspecting/replacing the interrupter).
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Check the condition of the contact system and replace as required. - Refill with new gas.
Carry out tasks in the Minor Maintenance .
MAJOR MAINTENANCE – Disconnecter / Earth Switch
Major maintenance involves replacing the contacts of the disconnecter / earth switch. This shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.

5.5.1.3 Hyosung HLSP

EXERCISE
Trip and close CB electrically.
INSPECTION
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Test and record the "as found" and "as left" open and close timing using CB timing tester. Opening time to be < 35ms and closing time to be < 120ms. Variance between phases to be < 3.3ms (opening) and < 5ms (closing). An "as left" test is to be performed after all mechanism tasks are completed. Compare the "as found" with "as left" test results.
Examine cubicle and gas piping for rust and damage.
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage.
Examine low voltage wiring and terminals for signs of damage.
Check oil level in dashpot.
Earth Switch / Disconnecter – Operating Mechanism
Open and close the switch electrically.
Check the condition and alignment of contacts through the viewing window.
Check interlocks where applicable.
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Inspect limit switches and position indicators.
Measure motor current.
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and inspecting/replacing the interrupter).
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Check the condition of the contact system and replace as required. - Refill with new gas.
Carry out tasks in the Minor Maintenance .
MAJOR MAINTENANCE – Disconnecter / Earth Switch
Major maintenance involves replacing the contacts of the disconnecter / earth switch. This shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.

5.5.1.4 Hyundai 145-SP-1

EXERCISE
Trip and close CB electrically.
INSPECTION
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Test and record the "as found" and "as left" open and close timing using CB timing tester. Opening time to be < 24±10ms and closing time to be 86±10ms. Variance between phases to be < 3.3ms (opening) and <5ms (closing). An "as left" test is to be performed after all mechanism tasks are completed.
Compare the "as found" with "as left" test results.
Examine cubicle and gas piping for rust and damage.
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage.
Examine low voltage wiring and terminals for signs of damage.
Examine shock absorber for signs of damage.
Earth Switch / Disconnecter – Operating Mechanism
Open and close the switch electrically.
Check the condition and alignment of contacts through the viewing window.
Check interlocks where applicable.
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Inspect limit switches and position indicators.
Measure motor current.
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and inspecting/replacing the interrupter).
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Check the condition of the contact system and replace as required. - Refill with new gas.
Carry out tasks in the Minor Maintenance .
MAJOR MAINTENANCE – Disconnecter / Earth Switch
Major maintenance involves replacing the contacts of the disconnecter / earth switch. This shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.

5.5.2 Low Pressure Gas Insulated Switchgear

5.5.2.1 TAMCO GV3

EXERCISE
Trip and close CB electrically.
INSPECTION
Test operation of lamp indication. Voltage check of voltage detector.
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Carry out profile or timing test to assess condition of the mechanism.
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Examine cubicle and gas piping for rust and damage
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage (discolouration, burning, and the like).
Examine low voltage wiring and terminals for signs of damage.
Check the operation of limit switches.
If the profile/timing test or visual inspection indicates poor lubrication, remove old grease and apply new grease.
Measure and record the wipe gap (less than 1mm indicates that the interrupter may need to be replaced). See figure 1 on next page.
Earth Switch / Disconnecter – Operating Mechanism
Verify operation through the viewing monitor.
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Check the operation of limit switches.
Measure motor current.
If visual inspection indicates poor lubrication, remove old grease and apply new grease.
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and replacing the interrupter).
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Replace the interrupters. - Refill with new gas.
Carry out tasks in the Minor Maintenance .
MAJOR MAINTENANCE – Disconnecter / Earth Switch
Major maintenance involves replacing the contacts of the disconnecter / earth switch. This shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.

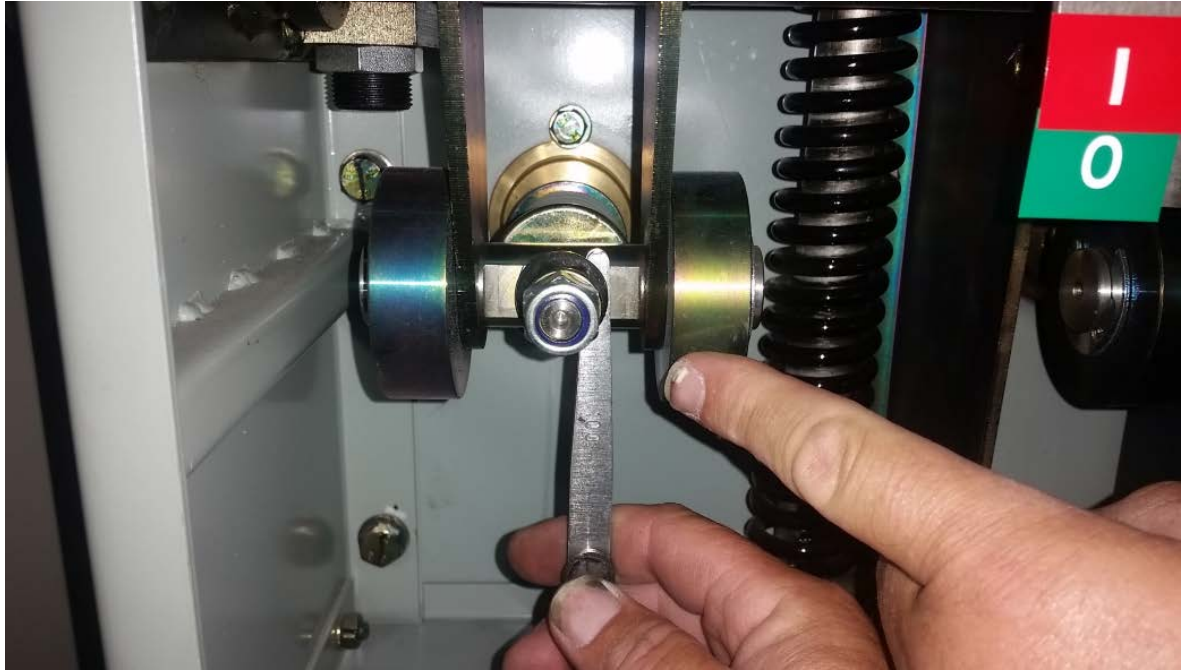


Figure 1: Measuring the wipe gap

5.5.2.2 Areva WS/WSA

EXERCISE
Trip and close CB electrically.
INSPECTION
Test operation of open/close indication.
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Carry out profile or timing test to assess condition of the mechanism (where possible).
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage (discolouration, burning, and the like)
Examine low voltage wiring and terminals for signs of damage.
Check the operation of limit switches.
If the profile/timing test or visual inspection indicates poor lubrication, remove old grease and apply new grease.
Earth Switch / Disconnecter – Operating Mechanism
Verify operation through the indicators.
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Check the operation of limit switches.
Measure motor current.
If visual inspection indicates poor lubrication, remove old grease and apply new grease.
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and replacing the interrupter).
The manufacturer is to be consulted for further advice.
MAJOR MAINTENANCE – Disconnecter / Earth Switch
The manufacturer is to be consulted for further advice.

5.5.2.3 ABB ENK

EXERCISE
Trip and close CB electrically.
INSPECTION
Test operation of open/close indication.
Examine cubicle for rust and damage.
Record number of operations (yearly).
Check the gas pressure.
MINOR MAINTENANCE
Carry out profile or timing test to assess condition of the mechanism.
Test SF6 gas quality (in accordance with SDI 545 – Acceptable purity limits for SF6 gas)
Examine cubicle and gas piping for rust and damage
Circuit Breaker – Operating Mechanism
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage (discolouration, burning, and the like)
Examine low voltage wiring and terminals for signs of damage.
Check the operation of limit switches.
If the profile/timing test or visual inspection indicates poor lubrication, remove old grease and apply new grease.
Earth Switch / Disconnecter – Operating Mechanism
Check security and tightness of fastenings.
Examine low voltage wiring and terminals for signs of damage.
Check the operation of limit switches.
If visual inspection indicates poor lubrication, remove old grease and apply new grease.
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and inspecting/replacing the interrupter).
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Check the condition of the contact system and replace as required. - Refill with new gas.
Carry out tasks in the Minor Maintenance .
MAJOR MAINTENANCE – Disconnecter / Earth Switch
Major maintenance involves replacing the contacts of the disconnecter / earth switch. This shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.

5.5.3 Air Insulated Switchgear

5.5.3.1 Merlin Gerin FG4/F400

EXERCISE
Trip and close CB electrically.
INSPECTION
Record number of operations (yearly).
Examine cubicle and external structural condition of CB (for example. for rust and damage).
Check the gas pressure.
Check heater and thermostat (if fitted) for correct operation.
CLEAN AND VACUUM
Dust, vacuum and clean throughout the busbar and cable connection compartments.
Check the condition and alignment of earth switch. Lubricate if necessary.
Check and lubricate the earth drive mechanism if necessary.
MINOR MAINTENANCE
Test and record the "as found" and "as left" open and close timing using CB timing tester. Opening time to be <65 ms and closing time to be < 90ms. Variance between phases to be < 2ms. An "as left" test is to be performed after all mechanism tasks are completed. Compare the "as found" with "as left" test results.
Test and record the total resistance of each phase is < 100micro Ohms at 100A using CB micro-ohm meter.
Test and record the "as found" and "as left" IR between phases (CB closed and earth all other phases) of CB is > 5G Ohms using 2.5kV megger.
Measure the degree of contact wear (in accordance with the manual). If the test shows that the arcing contacts are worn, the poles may need to be replaced.
Examine plug-in arms for cleanliness and signs of damage.
Examine primary isolating contacts for damage.
Examine busbar spout bushings for dust and damage.
Examine the racking interlock for damage/misalignment.
Examine plug box and trailing lead for damage
Lubricate operating mechanism.
Lubricate shutters.
Examine bushings for cleanliness and mechanical damage.
Examine cubicle and gas piping for rust and damage.
Check security and tightness of fastenings.
Examine auxiliary contacts for signs of damage.
Examine low voltage wiring and terminals for signs of damage.
Examine shock absorber for signs of damage.
Check that anti-pumping is functioning correctly.
Check operation of motor and limit switches.
Check heater and thermostat (if fitted) for correct operation.
MAJOR MAINTENANCE – Circuit Breaker
IMPORTANT: Refer to clause 5.2 before major maintenance is carried out. This is necessary to confirm that the condition of the circuit breaker warrants intrusive maintenance (that is, requires degassing and inspecting/replacing the interrupter). In addition to the above, measure the degree of contact wear in accordance with the manufacturer's manual. If the test shows that the arcing contacts are worn, all poles must be replaced.
The tasks below which involve degassing and accessing the internal elements of the circuit breaker shall be carried out in accordance with the manufacturer's manual. This may require contacting the manufacturer for assistance.
- De-gas the circuit breaker - Replace all circuit breaker poles. - Refill with new gas.
Carry out tasks in the Minor Maintenance .

6.0 AUTHORITIES AND RESPONSIBILITIES

Chief Engineer has the authority and responsibility for approving this instruction.

Manager Primary Systems has the authority and responsibility for approving this document for minor changes and to make recommendations to the Chief Engineer for major changes.

Network Maintenance Manager, Primary Systems has the authority and responsibility for keeping the content of this instruction up to date.

Regional Transmission Managers have the authority and responsibility for:

- maintaining high pressure GIS equipment at transmission and zone substations in accordance with the requirements of this instruction and SMI 100; and
- engaging Endeavour Energy employees and/or contractors who have appropriate qualifications and are competent to carry out the work.

Endeavour Energy employees and/or contractors have the authority and responsibility for:

- meeting the requirements of this instruction;
- working in accordance with local and statutory requirements;
- upholding a high level of public safety;
- working in accordance with Endeavour Energy's Electrical Safety Rules;
- updating the Endeavour Energy database; and
- communicating abnormalities found to the Regional Transmission Manager and the Network Maintenance Manager.

7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Maintenance Manager

Documentation process coordinator: Standards Process Coordinator