Substation Design Instruction

Alarm and tripping requirements in SF$_6$ and dry air equipment

IMPORTANT DISCLAIMER

As the information contained in this publication is subject to change from time to time, Endeavour Energy gives no warranty that the information is correct or complete or is a definitive statement of procedures. Endeavour Energy reserves the right to vary the content of this publication as and when required. You should make independent inquiries to satisfy yourself as to correctness and currency of the content. Endeavour Energy expressly disclaims all and any liability to any persons whatsoever in respect of anything done or not done by any such person in reliance, whether in whole or in part, on this document.

Document no. SDI 547
Amendment no. 1

51 Huntingwood Drive, Huntingwood NSW 2148
Postal address: PO Box 811 Seven Hills NSW 1730
Phone: 131 318 Fax: (02) 9853 6000

Copyright © Endeavour Energy 2014
SDI 547 - Alarm and tripping requirements in SF₆ and dry air equipment

Contents
1.0 PURPOSE........................................................................................................... 3
2.0 SCOPE................................................................................................................ 3
3.0 REFERENCES.................................................................................................... 3
4.0 DEFINITIONS AND ABBREVIATIONS............................................................... 3
5.0 ACTIONS ............................................................................................................ 4
  5.1 General........................................................................................................... 4
  5.2 Requirements for gas monitoring device ......................................................... 4
  5.3 Alarm and tripping requirements for SF₆ or dry air equipment...................... 5
6.0 AUTHORITIES AND RESPONSIBILITIES......................................................... 8
7.0 DOCUMENT CONTROL ..................................................................................... 8
Annexure A:..................................................................................................................... 9
1.0 PURPOSE
To set out in detail the minimum alarm and tripping requirements for SF₆ and dry air equipment for use in transmission/zone substations and switching stations.

2.0 SCOPE
This Standard specifies the alarm and tripping requirements for indoor GIS switchgear and outdoor CB using SF₆ either for electrical insulation or combined electrical insulation and arc interruption or for outdoor CB using dry air as electrical insulation installed in transmission/zone substations and switching stations.

This instruction shall be read in conjunction with SDI 505 - Minimum design and construction requirements for transmission and zone substations and switching stations.

3.0 REFERENCES

- Company Policy 4.0 – Environment
- Company Policy 9.2.2 - Network Protection
- Company Policy 9.2.5 - Network Asset Design
- Company Policy 9.9.1 - Network Asset Maintenance
- Company Procedure GSY 1066 - Worksite Coordination/Hazard and Risk Assessment
- Electricity Supply Act 1995 (as amended)
- ENA National Electricity Network Safety Code (DOC 01-2008)
- Network Management Plan 2011-2013
- Work Health and Safety Act 2011 (NSW)
- Substation Design Instruction SDI 502 - High voltage GIS equipment
- SDI 505 - Minimum design and construction requirements for transmission and zone substations and switching stations
- SDI 535 - Testing and commissioning
- AS 62271.200-2005 – High-voltage switchgear and control gear – A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
- AS 62271.203-2012 – High-voltage switchgear and control gear – Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV
- IEC 60529 - Degrees of protection provided by enclosures (IP Code)

4.0 DEFINITIONS AND ABBREVIATIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB</td>
<td>circuit breaker</td>
</tr>
<tr>
<td>DC</td>
<td>direct current</td>
</tr>
<tr>
<td>Critical network elements</td>
<td>Network elements such as busbars, GIS switchgear, outdoor CBs, power transformers and the like that are considered critical, in respect of their design, construction, operation and network requirements.</td>
</tr>
<tr>
<td>GIS</td>
<td>Gas-insulated metal-enclosed switchgear in which the insulation is obtained, at least partly, by an insulating gas other than air at atmospheric pressure.</td>
</tr>
<tr>
<td>High pressure dry air</td>
<td>Pressurised dry air comprising of nitrogen and oxygen gases. The acceptable ratios of the gases in the dry air are set at: Oxygen between 20% to 22% and remaining contents are Nitrogen.</td>
</tr>
<tr>
<td>High pressure GIS</td>
<td>Gas-insulated metal-enclosed switchgear containing gas-filled compartments whose design pressure exceeds 300 kPa (relative pressure).</td>
</tr>
</tbody>
</table>
Low pressure GIS  
Gas-insulated metal-enclosed switchgear containing gas-filled compartments whose design pressure is limited to a maximum of 300 kPa (relative pressure).

Minimum functional level  
The absolute gas pressure or density at which the circuit breaker/switchgear is capable of:
1. successfully interrupting current under network fault conditions; and
2. maintaining its rated BIL level.

SCADA  
Supervisory Control and Data Acquisition

SF₆  
sulphur hexafluoride

5.0 ACTIONS

5.1 General
The insulation level and the making and breaking capability of GIS and outdoor CBs using SF₆ or dry air are associated with the gas density or the absolute gas pressure in each gas compartment.

If the gas density or absolute gas pressure drops below the minimum functional level, the rated insulation level and/or the rated making and breaking capability of pressurised GIS and outdoor CB will be compromised. This may result in damage to the GIS and outdoor CB and adjacent equipment, prolonged system outages and, at worst, injuries to people in the vicinity.

To ensure the gas density or absolute gas pressure in SF₆ or dry air equipment is not below the minimum functional level, a gas density monitoring device shall be installed in each gas segregated compartment. The gas monitoring device shall provide the required signals for the alarm, tripping and lockout before the gas density or gas pressure drops below the minimum functional level.

5.2 Requirements for gas monitoring device
The gas monitoring device used for SF₆ or dry air filled equipment shall be capable of monitoring gas density in each gas compartment.

The device shall also clearly display the following three (3) gas density ranges on front dial:

- Normal - between stage 1 low gas density and overpressure density.
- Stage 1 low - between stage 1 low gas density and stage 2 low gas density.
- Stage 2 low - below stage 2 low gas density.

The gas monitoring device shall be hermetically sealed, maintenance free and suitable for the service conditions specified for the SF₆ or dry air filled equipment. It shall have excellent vibration resistance, and ingress protection IP65 as specified in IEC 60529.

The device shall be capable of providing two (2) types of output contacts for stage 1 low gas density alarm and/or stage 2 low gas density tripping and lockout, as required in clause 5.3, for each type of SF₆ or dry air equipment.

The output contact used for stage 1 low gas density alarm shall be closed at pressures above the manufacturer’s recommended alarm gas density, and open when the gas density drops to the alarm density. The schematic diagram of this contact is shown in Annexure A.
5.3 Alarm and tripping requirements for SF₆ or dry air equipment

Generally, the alarm and tripping requirements for SF₆ or dry air equipment include stage 1 low gas density alarm function is required for gas topping up, and stage 2 low gas CB tripping and lockout function is required for de-energising the low gas compartment in the GIS or outdoor SF₆ circuit breaker.

Detailed alarm, tripping and lockout requirements for different types of SF₆ or dry air equipment are shown in Tables 1 and 2. Table 2 presents mandatory tripping requirements of stage 2 low gas density conditions for various chambers in GIS switchgear.

Refer Figure 1 in Annexure A for typical single bus GIS SF₆ management diagram. The figure shows various chambers of the GIS and typical alarm and protection schemes.

---

1 AS 62271.203-2012
Table 1: Alarm, tripping and lockout requirements for SF₆ and dry air equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Stage 1 low gas density alarm</th>
<th>Stage 2 low gas density tripping and lockout</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alarm</td>
<td>Tripping and lockout (see note 1)</td>
</tr>
<tr>
<td></td>
<td>Secondary contacts</td>
<td>Secondary contacts</td>
</tr>
<tr>
<td>High pressure GIS (using SF₆ for insulation and arc interruption)</td>
<td>SCADA alarm to control room</td>
<td>A minimum of one (1) contact shall be provided by the gas monitoring device.</td>
</tr>
<tr>
<td></td>
<td>See note 2</td>
<td>SCADA alarm to control room</td>
</tr>
<tr>
<td>Low pressure GIS using (using SF₆ for insulation only and vacuum for arc interruption)</td>
<td>SCADA alarm to control room</td>
<td>A minimum of one (1) contact shall be provided by the gas monitoring device.</td>
</tr>
<tr>
<td></td>
<td>See note 2</td>
<td>SCADA alarm to control room</td>
</tr>
<tr>
<td>Outdoor CB (using SF₆ for insulation and arc interruption)</td>
<td>SCADA alarm to control room</td>
<td>A minimum of one (1) contact shall be provided by the gas monitoring device.</td>
</tr>
<tr>
<td></td>
<td>See note 2</td>
<td>SCADA alarm to control room</td>
</tr>
<tr>
<td>Outdoor CB (using SF₆ or dry air for insulation only and vacuum for arc interruption)</td>
<td>SCADA alarm to control room</td>
<td>A minimum of one (1) contact shall be provided by the gas monitoring device.</td>
</tr>
<tr>
<td></td>
<td>See note 2</td>
<td>SCADA alarm to control room (where contacts are available)</td>
</tr>
</tbody>
</table>

**Note 1:** Some critical network elements should not be de-energised automatically. At the design stage, consultation is required with the Operational Planning section, Network Control to determine whether or not the low gas compartment/CB can be automatically de-energised, and the function of CB self tripping shall be designed to be selected through an accessible link.

**Note 2:** Once the stage 1 low gas alarm is raised, gas topping up shall be arranged with a minimum of delay to restore low gas density to the rated filling gas density.

**Note 3:** As the disconnector in this type of GIS is normally non-remote operated, the upstream or downstream circuit breakers may need to be tripped through protection to achieve de-energising of the low gas compartment through protection (System Operations shall transfer load and isolate the
Alarm and tripping requirements in SF₆ and dry air equipment

faulty equipment. This is because it may not be possible to automatically disconnect the low gas compartment from all sources of supply. The tripped circuit breakers can be restored to normal operating status only after the disconnector has been manually operated on-site to de-energise the low gas compartment in lieu of the circuit breaker.

**Note 4:** Some of the older designs of outdoor SF₆ dead tank CBs installed in Endeavour Energy have stage 1 low gas alarm feature only and no provision of low gas density tripping and lockout. These CBs shall have the stage 1 alarm transmitted to the control room through SCADA system.

The associated disconnectors for these outdoor dead tank CB are normally non-remote operated and, may not be possible to automatically disconnect the low gas CB from all sources of supply, hence, the Network Control shall transfer load and isolate the faulty equipment.

The vacuum interrupters fitted in similar circuit breakers are generally fault rated and can remain in service and be manually opened under load as required by System Operations.

### Table 2: Tripping requirements of stage 2 low gas density conditions for various chambers in GIS switchgear:

<table>
<thead>
<tr>
<th>GIS Chamber</th>
<th>Stage 2 low gas density conditions – Mandatory tripping schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busbar chamber (See note 5)</td>
<td>Trip/open all CBs connected in that bus zone via the busbar protection. <em>(See note 6)</em></td>
</tr>
<tr>
<td>Feeder CB chamber (See note 5)</td>
<td>Feeder CB shall be self-tripped, de-energised (locked out) via auxiliary relays. This relay shall initiate the isolation of the bus and line isolator via a SCADA routine.</td>
</tr>
<tr>
<td>Transformer CB chamber (See note 5)</td>
<td>Transformer CB shall self-trip and de-energised (locked out) via auxiliary relays. This relay shall initiate the isolation of the bus isolator and open the transformer LV CB via a SCADA routine. If required, the auto standby SCADA routine shall be initiated.</td>
</tr>
<tr>
<td>Bus section CB chamber (See note 5)</td>
<td>Bus section CB shall self-trip and de-energised (locked out) via auxiliary relays. This relay shall initiate the isolation of the LHS and RHS bus isolators via a SCADA routine.</td>
</tr>
<tr>
<td>Bus section busbar transition chambers</td>
<td>Bus section CB shall self-trip and de-energised (locked out) via auxiliary relays. This relay shall initiate the isolation of the LHS and RHS bus isolators via a SCADA routine.</td>
</tr>
<tr>
<td>Feeder Line isolator and VT chamber</td>
<td>Trip/open feeder CB via SCADA routine. The remote end will be isolated manually by Network Operations.</td>
</tr>
<tr>
<td>Transformer isolator chamber</td>
<td>Trip/open the transformer HV side and LV side CBs via a SCADA routine. If required the auto standby SCADA routine is to be initiated.</td>
</tr>
</tbody>
</table>

**Note 5:** Loss of SF₆ gas density in GIS CB chamber compromises the fault rating of the installed CB. To ensure the CB is disabled for a stage 2 low gas condition, duplicate density relays (auxiliary relays), shall be supplied from separate no.1 and no.2 DC trip circuits.

**Note 6:** For the mass tripping of all CBs within the bus protection zone, no.1 busbar protection multitrip shall be used and coordinated with protection design.
6.0 AUTHORITIES AND RESPONSIBILITIES

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

The **Manager Primary Systems** has the authority and responsibility for making recommendations to the Chief Engineer in respect to this instruction.

The **Network Substations Manager, Primary Systems** is responsible for ensuring that the content of this instruction is kept up to date.

All **Endeavour Energy employees and/or contractors** are responsible for:
- Working in accordance with local and statutory requirements.
- Ensuring that public safety is not compromised.
- Working in accordance with Endeavour Energy’s Electrical Safety Rules.

The **Transmission Substation Electrical Design Manager** is responsible for:
- Ensuring that requirements of this instruction and SDI 505 are met when preparing detailed design documents.

All **Project Managers** are responsible for:
- Meeting the requirements of this instruction within their area of responsibility.
- Ensuring that Endeavour Energy staff and/or contractors engaged to perform the work have appropriate qualifications.
- Ensuring that appropriate equipment details are entered into the Ellipse database as part of the work.

7.0 DOCUMENT CONTROL

**Documentation content coordinator:** Network Substations Manager, Primary Systems

**Documentation process coordinator:** Branch Process Coordinator
Annexure A:

Figure 1: Typical GIS single bus SF₆ management diagram