Substation Design Instruction

Control cabling, panels and terminations

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SDI 526  Control cabling, panels and termination

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1.0 PURPOSE

To set out in detail the minimum requirements for control cables, indoor panels and associated cable terminations used in transmission and zone substations and switching stations.

2.0 SCOPE

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

It defines the requirements for control cables, indoor panels and associated cable terminations used in transmission and zone substations and switching stations. This SDI does not cover the requirements for protection devices.

3.0 REFERENCES

• Company Policy 4.0 - Environment
  • Company Policy 9.2.1 - Network Planning
  • Company Policy 9.2.2 - Network Protection
  • Company Policy 9.2.5 - Network Asset Design
  • Company Policy 9.2.10 - Network Asset Ratings
  • Company Policy 9.7.1 - Network Asset Construction
  • Company Policy 9.9.1 - Network Asset Maintenance
• Company Procedure GSY 1066 - Worksite Coordination/Hazard and Risk Assessment
• Network Management Plan December 2013 Review
• Earthing Design Instruction EDI 516 - Major substation earthing design, construct and commissioning
• Equipment Technical Specification ETS 0014 - Protection and control panels
• Substation Design Instruction SDI 505 - Minimum design and construction requirements for transmission and zone substations and switching stations
• SDI 503 - Transmission and zone substation fire detection, control and suppression
• SDI 510 - Buildings
• SDI 531 - Installation of conduits in transmission/zone substations and switching stations
• SDI 538 - Supervisory Control and Data Acquisition (SCADA)
• Protection Design Instruction PDI 4003 - Protection CT and link design layout and wiring specification
• ENA National Electricity Network Safety Code (Doc 01-2008)
  • Work Health and Safety Act 2011
  • AS 2067:2008 - Substations and high voltage installations exceeding 1kV a.c.
  • AS 2650:2005 - Common specifications for high-voltage switchgear and controlgear
  • AS 2700:2013 - Colour standards for general purposes
  • AS/NZS 2344:1997 - Limits of electromagnetic interference from overhead a.c power lines and high voltage equipment installations
  • AS/NZS 3000:2007 - Electrical Installations
  • AS 4437:1996 - Solderless crimped connection - general requirements, test methods and practical guide
  • AS 4506:2005 - Metal Finishing -Thermoset Powder Coatings
  • AS 60529:2004 - Degrees of protection provided by enclosures for electrical equipment - IP code
  • AS 60947.1:2004 - Low voltage switchgear and control gear Part 1: General rules
  • AS 60947.7.1:2004 - Low voltage switchgear and control gear Part 7.1: Ancillary equipment - Terminal blocks for copper conductors
• IEC 60445:2010 - Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals and conductor terminations
• IEEE C37.2.2008 - Standard electrical power system device function numbers and contact
designations

4.0 DEFINITIONS AND ABBREVIATIONS

AC alternating current
CT current transformer
cable entry Part with openings, which permit the passage of cables into enclosure.
control cables Cable connections between the switchgear and any remote apparatus or between two (2) or more separate switching installations for control, protection, indication, metering and communication circuits.
control panel (control gear) General term covering switching devices and their combination with associated control, measuring, protective and regulating equipment.
DC direct current
Ellipse Endeavour Energy asset database
PE protective conductor Conductor provided for purposes of safety, for example protection against electric shock
PEN conductor Conductor combining the functions of both a protective earthing conductor and a neutral conductor
SCADA Supervisory Control And Data Acquisition
SO Socket outlet. Single (1Ø) or three phase (3Ø)

5.0 ACTIONS

5.1 Wiring, cable terminations and termination types

All control cable terminations including internal panel wiring and external control cables shall be carried out in accordance with Equipment Technical Specification ETS 0014 - Protection and control panels. Reference shall also be made to Annexure 1 of Equipment Technical Specification ETS 0014 - Protection and control panels for examples of acceptable and non-acceptable terminations. An exception to the requirement shall be given to terminations and equipment that is type tested for endurance in accordance with Australian or IEC Standards.

Where terminals carry 230V AC wiring they shall be shrouded by a non-conducting material to prevent accidental contact, and they shall have a warning label fitted either on the terminals or adjacent to the terminals in accordance with Equipment Technical Specification ETS 0014 - Protection and control panels.

5.2 Control panels (indoor)

5.2.1 General

The requirements for the design, manufacture and testing of protection and control panels for use in transmission and zone substations and switching stations shall be in accordance with Equipment Technical Specification ETS 0014 - Protection and control panels.

5.2.2 Earthing

A minimum 25mm wide x 6mm thick tinned copper earth bar, that is continuous throughout the adjacent panels, shall be provided inside each panel in an easily accessible position, near its base, in accordance with Equipment Technical Specification ETS 0014 - Protection and control panels.
Each end of the control panel earth bar shall be connected to the earth grid in accordance with Earthing Design Instruction EDI 516 - Major substation earthing design, construct and commissioning.

Refer also to clauses 5.4.6 and 5.9.

5.2.3 Fixing

The control panels shall be suitably fixed to the floor to prevent movement.

5.2.4 Cable entry sealing

All cable entries through the wall and/or floor penetrations into the control panels shall be sealed with a fireproof sealant to protect the panels and components from the ingress of moisture, fire and vermin (refer to Substation Design Instruction SDI 503 - Transmission and zone substation fire detection, control and suppression)

5.2.5 Ancillary relays and contactors

For general items of low voltage equipment, earth fault isolation of 2kV is required from other equipment inside the switchyard, unless otherwise indicated.

5.3 Protection equipment and link design

Refer to PDI 4003.

5.4 Control cables

5.4.1 Joints

Inline joints in any internal panel wiring or external control cables are not permitted under any circumstances.

5.4.2 Terminations requiring multiple wires

There shall be no more than two wires in any single termination. Where two ring terminations are used at one terminal, the ring lugs shall be placed back to back; and the equipment terminals shall be designed to allow this to be done in a manner that achieves a secure and reliable termination.

5.4.3 Allowable number of cables in enclosure

The trench or conduit used to enclose cables shall consider the future requirements, by ensuring that the trench or conduit does not exceed half capacity (refer to Substation Design Instruction SDI 531 - Installation of conduits in transmission/zone substations and switching stations).

5.4.4 Segregation of control and HV power cables

For fire segregation purposes, HV power and control cables shall not be installed in the same cable trench, conduit or cable tray run. Cables shall be arranged so that a fire in a power cable does not affect the performance of the control cables.

5.4.5 Control wiring and cable rating

All control wiring and cables, including CT control cabling extended from secondary winding terminals of CTs, shall be adequately rated considering the following requirements:

- Current carrying capacity.
- Voltage drop and current transformer burden.
- Mechanical strength.
- Short circuit temperature conditions.

All cables shall be screened and earthed as indicated in clause 5.4.6.
5.4.6 Screening and earthing of control cables

All control cables shall be fitted with an overall aluminium or copper foil screen, which shall be earthed at one end only. Cables associated with general substation AC light and power need not be screened.

Screen earthing conductors shall be stranded copper with standard green-yellow coloured insulation in accordance with Equipment Technical Specification ETS 0014 - Protection and control panels.

5.4.7 Separation of SCADA wiring

Where twisted pair wiring associated with the SCADA system is installed, analogue and digital signals shall not be mixed in the same twisted pair cable.

To reduce the effect of transients and interference, 230V AC wiring shall be separated from DC control, protection and signaling wiring in accordance with Substation Design Instruction SDI 538 - Supervisory Control and Data Acquisition (SCADA).

5.4.8 Colour code

The following table specifies the standard identification code for AC and DC control cables and conductors. Reference shall also be made to Equipment Technical Specification ETS 0014 - Protection and control panels.

<table>
<thead>
<tr>
<th>Type of conductors</th>
<th>Terminal designation (alphanumeric notation)</th>
<th>Graphical symbols</th>
<th>Colour code</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-phase conductors</td>
<td>L1</td>
<td></td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td></td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td></td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td></td>
<td>Black</td>
</tr>
<tr>
<td>DC conductors</td>
<td>L+</td>
<td>+</td>
<td>Grey</td>
</tr>
<tr>
<td></td>
<td>L-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Protective conductors</td>
<td>PE</td>
<td></td>
<td>Green and yellow combination</td>
</tr>
<tr>
<td></td>
<td>PEN</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 - Standard identification code for AC and DC cables and conductors
5.4.9 Control cable minimum sizes

<table>
<thead>
<tr>
<th>Min. conductor cross-sectional area (mm²)</th>
<th>Min. stranding/ single conductor size</th>
<th>No. of pairs or cores</th>
<th>Description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.49</td>
<td>7/0.03</td>
<td>4 pair (twisted)</td>
<td>PVC (screened)</td>
<td>Small signal indication and control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 pair (twisted)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>7/0.5</td>
<td>2 core</td>
<td>PVC (screened)</td>
<td>Circuit breaker control and indication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 core</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 core</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>7/0.67</td>
<td>10 core</td>
<td>PVC (screened)</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>7/0.5</td>
<td>2 core + earth</td>
<td>PVC</td>
<td>Panel AC light</td>
</tr>
<tr>
<td>2.5</td>
<td>7/0.67</td>
<td>2 core + earth</td>
<td>PVC</td>
<td>Panel AC power outlet</td>
</tr>
<tr>
<td>2.5 (Indoor substation)</td>
<td>7/0.67</td>
<td>4 core</td>
<td>PVC (screened)</td>
<td>General metering and indication</td>
</tr>
<tr>
<td>4.0 (Outdoor substation)</td>
<td>7/0.67</td>
<td>6 core</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 core</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – Guide to the minimum sizes, stranding, number of cores, description and application of control cables

5.5 Device function numbers

Each device on every circuit diagram in the drawing system shall be given a device function number. This number allows for easy identification of the device through a legend on the diagram and permits the standardisation of circuit diagrams.

All devices including relays, timers, contactors, CTs and operating mechanisms shall be identified.

The standard electrical power system device function numbers and description shown in IEEE C37.2:2008 shall be followed unless otherwise indicated.

5.6 Numbering and identification

All cables shall be clearly and uniquely identified at both ends by an alphanumeric system.

A cable route schedule shall be produced to identify each cable’s location and end connection points.

All devices, cable labeling and numbering shall be in accordance with Equipment Technical Specification ETS 0014 - Protection and control panels.

Reference shall also to be made to Table 1 - Standard identification code for AC and DC cables and conductors.

5.7 Existing wire numbering

When augmentation of existing substation wiring is carried out, the existing wiring system shall be continued, unless the augmentation is major, such as a complete new section of busbar and associated circuit breakers, or similar.
5.8 Cable ladders
Cable ladders shall be used to support all control cables and they shall not be laid on floors or obstruct pathways.

Cable ladders shall be earthed in accordance with Earthing Design Instruction EDI 516 - Major substation earthing design, construct and commissioning and shall not be used to form part of an earthing conductor.

- Reference shall also be made to Substation Design Instruction SDI 510 - Buildings.

5.9 Frame leakage protection
Frame leakage protection shall only have one conductor connecting the frame to the substation earth grid; as more than one earth connection causes the protection scheme to operate incorrectly for faults elsewhere on the network, and also desensitises the protection for the faults it is designed to detect.

All electrical installations, for example lighting, heating and SO power circuits connected to the substation earth grid must be insulated from the frame earth.

6.0 AUTHORITIES AND RESPONSIBILITIES
Chief Engineer has the authority and responsibility for approving this instruction.

Manager Secondary Systems has the authority and responsibility for:
- making recommendations to the Chief Engineer in respect to this instruction; and
- approving minor amendments to this instruction.

Protection Manager, Secondary Systems has the authority and responsibility for:
- keeping the content of this instruction up to date based on industry best practice and consulting changes in accordance with Company Procedure GAM 0001 – Production/Review of Design/Construction/Maintenance/Technical Specifications/Environmental and Metering Standards.

Endeavour Energy employees and contractors are responsible for:
- verifying that requirements of this instruction and SDI 505 are met;
- working in accordance with local and statutory requirements; and
- working in accordance with Endeavour Energy’s Electrical Safety Rules.

Project Managers have the authority and responsibility for:
- meeting the requirements of this instruction within their area of responsibility;
- verifying that Endeavour Energy employees and/or contractors engaged to perform the work have appropriate qualifications; and
- verifying that appropriate equipment details are entered into the Ellipse database as part of the work.

7.0 DOCUMENT CONTROL
Documentation content coordinator: Protection Manager, Secondary Systems
Documentation process coordinator: Standards Process Coordinator