

Substation Design Instruction

Auxiliary AC supplies and switchgear

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Document no. SDI 511

Amendment no. 4

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SUBSTATION DESIGN INSTRUCTION

ASSET STANDARDS AND DESIGN	Document no. Amendment no. Approved by Approval date	SDI 511 4 MASD 12/05/16
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SDI 511 Auxiliary AC supplies and switchgear

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1.0 PURPOSE

To define the design requirements for auxiliary AC supplies and associated switchgear in transmission/zone substations and switching stations.

2.0 SCOPE

This instruction shall be read in conjunction with SDI 505.

This instruction defines the requirements for auxiliary AC supplies and associated switchgear in transmission/zone substations and switching stations.

3.0 REFERENCES

Internal

- Company Policy 4.0 - Environment
- Company Policy 9.2.5 - Network Asset Design
- Company Policy 9.7.1 - Network Asset Construction
- Company Policy 9.9.1 - Network Asset Maintenance
- Company Procedure GSY 1066 - Worksite Hazard and Risk Assessment
- Earthing Design Instruction EDI 516 - Major substation earthing design, construct and commissioning
- Equipment Technical Specification ETS 0068 - Distribution indoor and padmount substation 12-24kV switchgear
- Mains Design Instruction MDI 0011- Underground distribution cables - continuous current ratings
- Substation Design Instruction SDI 501 - Network Configuration
- Substation Design Instruction SDI 505 - Minimum design and construction requirements for transmission and zone substations and switching stations
- Substation Design Instruction SDI 510 - Buildings
- Substation Design Instruction SDI 529 - Light and power
- Substation Design Instruction SDI 532 - Plumbing and drainage
- Substation Design Instruction SDI 540 - Transformer oil containment
- Endeavour Energy Electrical Safety Rules
- Company Network Management Plan 2011-2013

External

- ENA National Electricity Network Safety Code (Doc 01-2008)
- Work Health and Safety Act 2011 (NSW)
- AS 1940:2004 - The storage and handling of flammable and combustible liquids
- AS 2067:2008 - Substations and high voltage installations exceeding 1 kV a.c.
- AS 2374 - 1 to 8 - Power transformers
- AS 60947.2:2005 - Low voltage switchgear and controlgear - Circuit breakers
- AS/NZS 3012:2010 - Electrical installations: Construction and demolition sites

4.0 DEFINITIONS AND ABBREVIATIONS

ACO	auto changeover control panel
AFIC	audio frequency injection control
CB	circuit breaker
DB	distribution board
Ellipse	Endeavour Energy asset database
HV auxiliary switchgear	Auxiliary switches, switch fuse units and circuit breakers used on the 11kV and 22kV system.

LV switchgear	Switches, switch fuse units and circuit breakers used on voltages less than 1000 Volts.
RCD	Residual current device, used to isolate supply if a current flow to earth exceeds a predetermined value.
RMU	Ring main unit
SCADA	Supervisory Control and Data Acquisition
SO	Socket outlet, single phase or three phase

5.0 ACTIONS

5.1 General

Auxiliary supplies are to provide power to frequency injection systems, oil filtering, battery charger(s), pumps, fans, lights and small power, as well as other AC control circuits and equipment.

5.2 Auxiliary equipment

5.2.1 Transmission substations

Transmission substations shall have duplicate low voltage auxiliary supplies that are supplied from the power transformer tertiary windings through auxiliary transformers. Auxiliary transformers shall be connected directly to the power transformer tertiary windings due to the high fault levels associated with the tertiary winding and the unavailability of switchgear at these fault levels. Reference shall be made to Figure 1 in Annexure 1.

5.2.2 Switching stations

Low voltage auxiliary power shall normally be supplied from the street supply (if available) in accordance with clause 5.11 and as shown in Figure 2 in Annexure 1.

Where street supplies are unavailable, switching stations shall have an auxiliary transformer connected to a high voltage feeder, as shown in Figure 3 in Annexure 1.

If an auxiliary transformer is required, the Protection Manager shall be consulted in regard to the primary winding configuration, impedance and special protection considerations.

The use of a second low voltage auxiliary supply at switching stations preferably connected to two independent feeder CBs from different busbars or zone substations; or other alternative power source (for example a solar panel) can be considered subject to the successful completion of a comprehensive assessment of cost and risk benefits, based on all possible operational configurations. Alternative power sources require prior approval from the Network Substations Manager.

5.2.3 Zone substations

400V/230V auxiliary distribution systems:

Zone substations shall have 400V/230V auxiliary distribution systems.

An auxiliary transformer shall be used to provide the primary supply to the auxiliary transformer distribution board. A secondary supply (backup) shall also be provided from a street supply through a change over switch in accordance with clause 5.11.

11kV (or 22kV) auxiliary supply:

Where dedicated feeder CB's have been made available for the purpose of an auxiliary supply – they shall direct connect onto the AFIC and these cells shall be protected by the feeder CB protection relay.

Where dedicated feeder CB's for auxiliary supplies are not available, cells shall be doubled onto an existing feeder but have separate (toroidal) CT's installed for protecting the AFIC independently.

In each of these cases the auxiliary transformer can be doubled onto an existing CB (feeder or cell supply) as long as its supplies are off a separate 11kV (or 22kV) busbar to the substation LV backup supply. A dedicated CB to supply the auxiliary transformer shall be utilised where available but this can be ultimately used as a feeder.

In arrangements where additional operational flexibility is required or there are physical constraints; auxiliary switchgear can be used subject to the approval of the Network Substations Manager. Switchgear shall be of the standard distribution RMU type arranged in a *switch-CB-switch* configuration with motorised capability on switches located indoors and connected to cells.

When a single AFIC cell is installed at a zone substation with multiple sections of main busbars, then auxiliary switchgear shall be installed to provide alternative injection paths during main busbar outage.

To supply the auxiliary transformer, outdoor auxiliary switchgear shall be a standard distribution RMU type arranged in a *switch-fuse-switch* configuration and not motorised.

Refer to figures 4, 5 and 6 in Annexure 1 for typical arrangements.

Motorised switches shall have adequate load break capacity, with facilities for remote opening and closing.

Local / remote/maintenance switches shall be provided on the switchgear for maintenance.

5.3 Ratings of HV auxiliary switchgear (11kV or 22kV)

Where 11kV and 22kV auxiliary switchgear is used, the fault rating shall be a minimum of 16kA and its current rating shall be typically 630 Amperes - refer also to ETS 0068.

The switchgear shall have motorising facility available and sufficient auxiliary contacts to determine the suitable gas density and the state of the switch, circuit breaker and fuse indication.

The internal arc classification type shall be IAC in accordance with ETS 0068 with the switchgear vented at the rear.

5.4 Auxiliary transformers

Auxiliary transformers are used to provide the 400V/230V AC requirements of the substation. In the event of a failure of the auxiliary transformer, the substation shall be automatically supplied from the backup supply.

The auxiliary transformer rating shall be in accordance with clause 5.4.3.

5.4.1 Auxiliary transformers for transmission substations

Transmission substations with YNyn0d1 power transformers shall use auxiliary transformers with Yyd configuration (11kV/400V with a delta tertiary winding).

5.4.2 Auxiliary transformers for zone substations

Auxiliary transformers shall be sourced from the Hoxton Park Transformer Workshop.

The auxiliary transformer voltage tapping shall be set to a tap position which will provide a nominal voltage of 411V. For the purposes of this Standard, all low voltage levels are referred to as 400V.

Only sealed auxiliary transformers shall be installed.

5.4.3 Auxiliary transformer rating

Auxiliary transformers in substations shall be sized according to the substation's firm capacity in accordance with SDI 501.

Zone/transmission substation capacity (MVA)	Auxiliary Transformer size (kVA)
Less than 70	315
≥ 70	500

Switching station auxiliary transformers shall be typically rated at 315kVA.

5.4.4 Cabling

LV cables from the auxiliary transformer to the auxiliary transformer distribution panel shall be suitable for the total load of the selected auxiliary transformer, but the minimum size shall be 95mm² (4 x 37/1.78) copper or equivalent current rated aluminium cable.

LV cables from the auxiliary transformer distribution panel to the ACO control panel, and from the street supply to the ACO control panel, shall be suitable for the maximum calculated load, but the minimum size shall be 35mm² (4 x 19/1.53) copper or equivalent current rated aluminium cable.

Refer also to MDI 0011.

5.4.5 Ancillary items for auxiliary transformers

The 11kV or 22kV connections shall be either cable entry or plug-in terminations.

Low voltage connections shall be cable entry.

Cables shall not be supported by the transformer bushings.

5.5 400V/230V AC distribution equipment

Low voltage equipment shall be selected to suit the fault levels indicated in Table 1.

Table 1: Fault levels and equipment ratings for LV distribution

	Fault level and equipment ratings	
Auxiliary transformer size kVA	315	500
Fault level on 400V bus when supplied from 11kV supply in kA	10.2	15.9
Fault level on 400V bus when supplied from 22kV supply in kA	10.3	16.3
Required minimum kA rating of circuit breakers and residual current devices for 0.5 seconds	14	18

Fault level data from Network Configuration Standard SDI 501.

The 400V/230V AC supply panel (located in the control building) shall be supplied through a 160 amp fault current limiting fuse or fault current limiting circuit breaker located in the auxiliary transformer distribution panel. The fault current limiting fuse or circuit breaker shall limit the fault current to a value that is within the capability of the downstream devices.

5.6 Auxiliary transformer distribution board

The auxiliary transformer distribution board shall be located as close as possible to the auxiliary transformer. Where the transformer distribution board is not located in the LV end of a padmount cubicle, it shall be mounted in a weatherproof enclosure with a minimum ingress protection rating of IP34. The enclosure shall be made from corrosion resistant material such as aluminium or stainless steel and it shall be erected on a concrete pit suitable for allowing the laying and termination of supply cables while the other cables are connected.

Access shall be made available to all the fuses and cable terminations from the front of the cubicle by doors or easily removable panels, which can be padlocked shut.

The auxiliary transformer distribution board shall have current ratings as follows:

If supplied by auxiliary transformer rated at:	315kVA	500kVA
Main incomer	450A	750A*
Busbars	450A	750A
Generator connection	450A	750A
SFU supply	200A	350A
Streamline filter supply	250A	250A
Supply to 400V auto-change over panel	160A (fault current limiting)	160A (fault current limiting)

Note: Component sizes in the above table are based on the standard transformer sizes as specified in this document. If larger transformers are used, component sizes shall be adjusted accordingly.

* Refer to the Protection Manager for the main incomer overcurrent protection details.

5.7 400V/230V AC supply panel

A 400V/230V AC supply panel, preferably located within the substation building, shall be used to supply the battery chargers, pumps, fans, and other essential small power systems within the substation.

All SOs and lighting shall be protected by residual current devices (RCDs) in accordance with SDI 529.

5.8 Low voltage (400V/230V) primary and backup supply

In transmission substations, the primary supply is from one (1) auxiliary transformer, while the backup supply is from a second auxiliary transformer.

The zone substation primary supply shall be provided from one (1) auxiliary transformer, which is totally dedicated to all of the substation functions. The backup supply shall be provided from a street supply, where available; however, if a street supply is not available, a second auxiliary transformer can be installed and this shall be supplied from a different section of the 11kV (or 22kV) busbar.

Whenever the primary or backup supply is compromised for periods longer than one (1) day, alternative supplies, such as portable generators shall be used to provide N-1 capability of the 400V/230V auxiliary power supply system.

There shall be complete isolation (including isolation of neutrals) between primary and backup supplies so that the supply that is not in use can be maintained safely whilst the other supply is in use.

5.9 Low voltage (400V/230V) neutral earthing

LV neutrals shall be earthed in accordance with EDI 516.

5.10 Auto changeover system (400V/230V)

Two (2) 400V/230V AC supplies shall enter the automatic changeover (ACO) control panel. Each 400V/230V AC source on the ACO panel shall be fitted with lamps to indicate the availability of the normal supply and backup supply.

Each source shall be fitted with switches for isolation purposes. Changing from primary supply to backup supply, or vice versa, shall be done with a *break before make* operation to prevent paralleling of the supplies and to overcome problems associated with phase shift.

Automatic changeover operations shall allow all conductors (including neutrals) on the isolated section to be safe to work on.

The 400V/230V AC supply shall automatically switch between primary and backup supplies through a mechanically and electrically interlocked auto-changeover system. Where three (3) supplies are available, the auto-changeover system needs only to operate between two (2) supplies, with the third supply either being manually or automatically switched in to replace one of the other two supplies in an emergency.

The low voltage AC detection and changeover initiation relay shall be suitable for detecting and setting as set out in the clauses below.

5.10.1 Out of balance

- Detection range is to be adjustable from 5 to 15% of nominal phase to phase voltage.
- Normal setting will be 5% of nominal phase to phase voltage.
- Nominal phase to phase voltage is 400V.

5.10.2 Ripple signal rejection

- Insensitive to ripple signals generated from AFIC equipment and to spurious harmonics of the 50Hz voltage.

5.10.3 Under-voltage setting

- Fixed or variable to 80% of the phase-to-phase nominal voltage.
- Setting will usually be at 80% of nominal phase to phase voltage.

5.11 Street supply

The street supply shall be adequate to supply the substation battery chargers, tap changers, pumps, fans, heaters, oil-water separators and emergency lighting load, and it shall be a minimum of 40kVA continuous rating.

The LV service and associated neutrals from the street supply shall be through isolating transformers unless the earthing design identifies otherwise in accordance with EDI 516.

Where an isolating transformer is used, its LV neutral shall be earthed on the substation side of the isolation transformer (the street side of the star/star isolation transformer shall not be earthed) in accordance with EDI 516.

Isolating transformers shall be in accordance with the following requirements:

- Three (3) phase
- Two winding 1:1 ratio
- Vector group YNyn0

- Lightning impulse withstand voltage 40kV peak
- Power frequency withstand 15kV (rms) for 1 minute
- Dry type transformer
- Minimum 40kVA continuous rating

Isolating transformers shall not be located in basements.

Where the isolating transformer is located outdoors, it shall be mounted in a weatherproof enclosure with a minimum ingress protection rating of IP34. The enclosure shall be made from corrosion resistant material such as aluminium or stainless steel and it shall be lockable when it is not enclosed within the intruder resistant fence.

5.11.1 Isolation panel

Two insulated panels fitted with four (4) fuse fittings (3 phases - fused, and one neutral link) shall be installed adjacent to the isolation transformer to isolate both sides and provide a visible break when work is performed on the isolation transformer.

5.11.2 Services isolation

Substation plumbing, telephone and any other services shall be isolated from the street services in accordance with SDI 532 and EDI 516.

5.12 Switchroom

Where auxiliary switchgear is required subject to the approval of the Network Substations Manager, the auxiliary switchroom shall have adequate space to install and operate all of the switchgear required for the ultimate arrangement of the substation. All auxiliary switchrooms shall be designed and constructed to comply with SDI 510. There shall be no obstructions that could prevent staff from entering and leaving the room in a safe manner.

A combination of indoor units (in auxiliary switchroom) and outdoor units (in cubicle) will provide the ultimate 11kV (or 22kV) arrangement as shown in figure 5 in Annexure 1.

All cabling and terminations shall be easily accessible at all times.

6.0 AUTHORITIES AND RESPONSIBILITIES

The **General Manager, Asset Management** has the authority and responsibility for approving this instruction.

The **Manager Asset Standards and Design** has the authority and responsibility for making recommendations to the **General Manager, Asset Management** in respect to this instruction.

The **Network Substations Manager, Asset Standards and Design**, is responsible for keeping the content of this instruction up to date.

All **Endeavour Energy employees and/or contractors** are responsible for:

- Meeting the requirements of this instruction and SDI 505.
- Working in accordance with local and statutory requirements.
- Maintaining public safety.
- Working in accordance with Endeavour Energy's Electrical Safety Rules.
- Updating the Endeavour Energy Ellipse database.

All **Project Managers** are responsible for:

- Meeting the requirements of this instruction within their area of responsibility.
- Overseeing that Endeavour Energy staff and/or contractors engaged to perform the work have appropriate qualifications.

- **Overseeing** that appropriate equipment details are entered into the Ellipse database as part of the work.

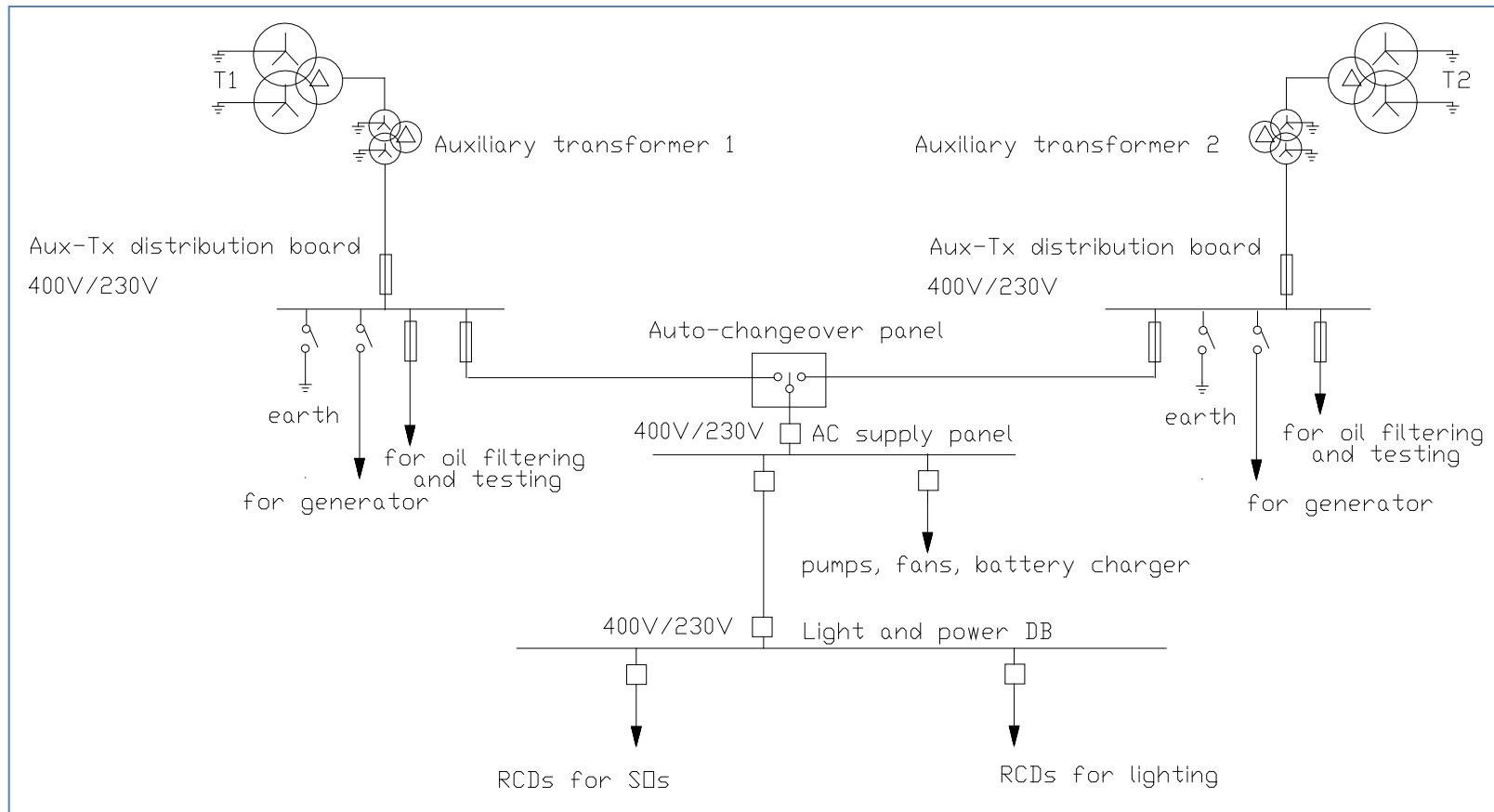
7.0 DOCUMENT CONTROL

Documentation content coordinator: Network Substations Manager, Asset Standards and Design

Documentation process coordinator: Branch Process Coordinator

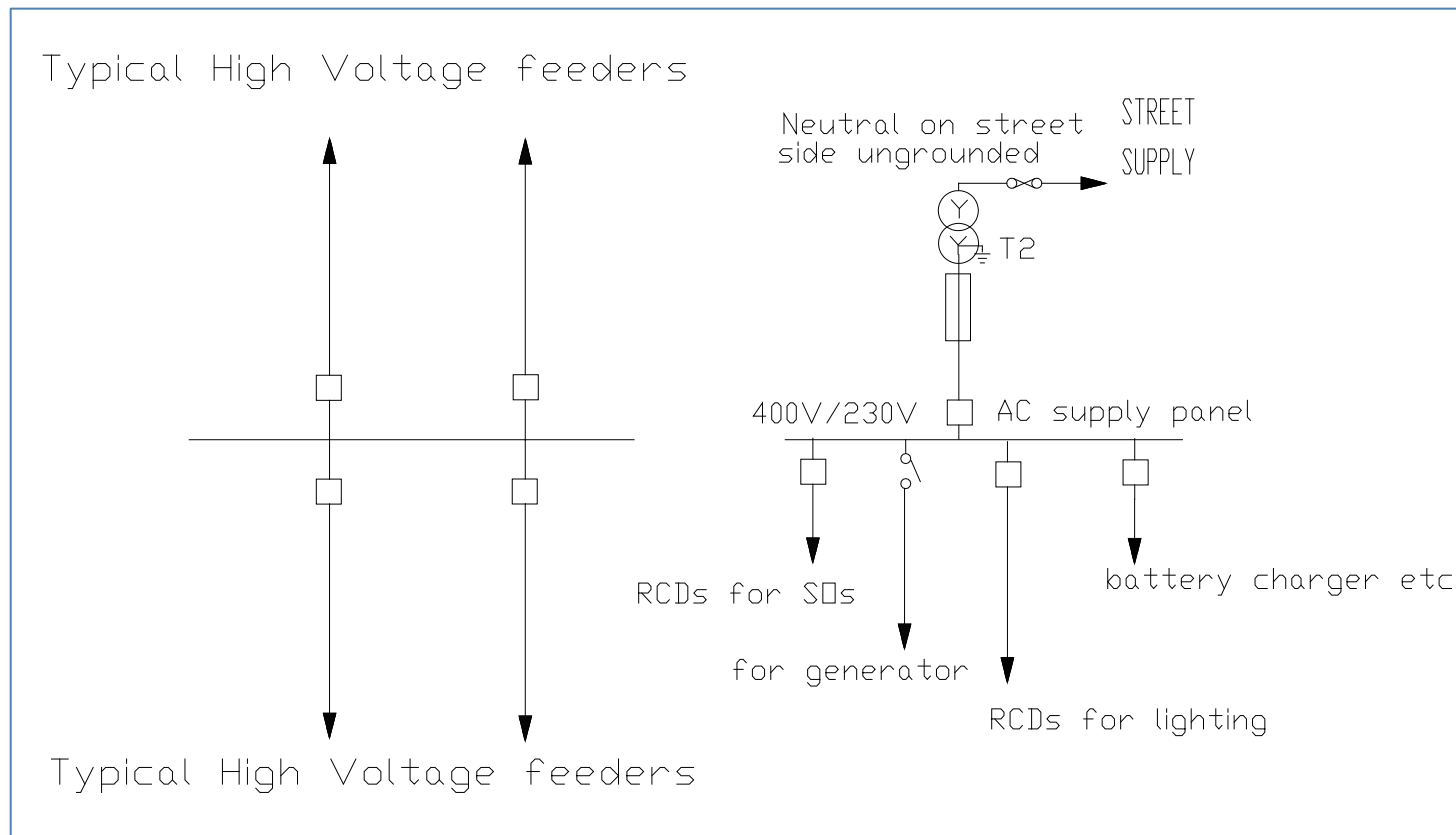
Annexure 1: Typical auxiliary supply arrangements

Figure 1: For transmission substations



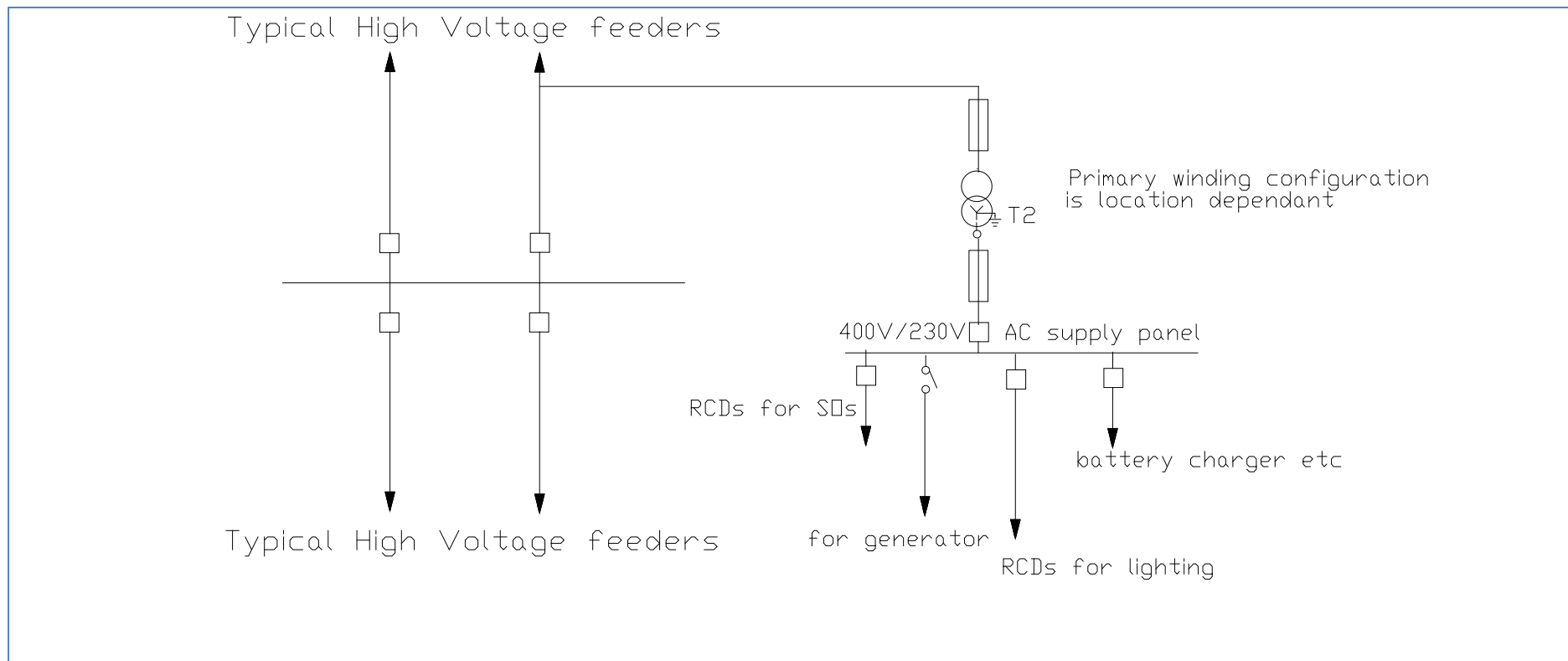
Annexure 1 - Typical auxiliary supply arrangements (cont.)

Figure 2 - For switching stations where LV street supplies are available



Annexure 1 - Typical auxiliary supply arrangements (cont.)

Figure 3 - For switching stations where LV street supplies are not available



Annexure 1 - Typical auxiliary supply arrangements (cont.)

Figure 4 – For zone substations without dedicated auxiliary switchgear

Same analogy applies to different numbers of HV sections, and arrangements.

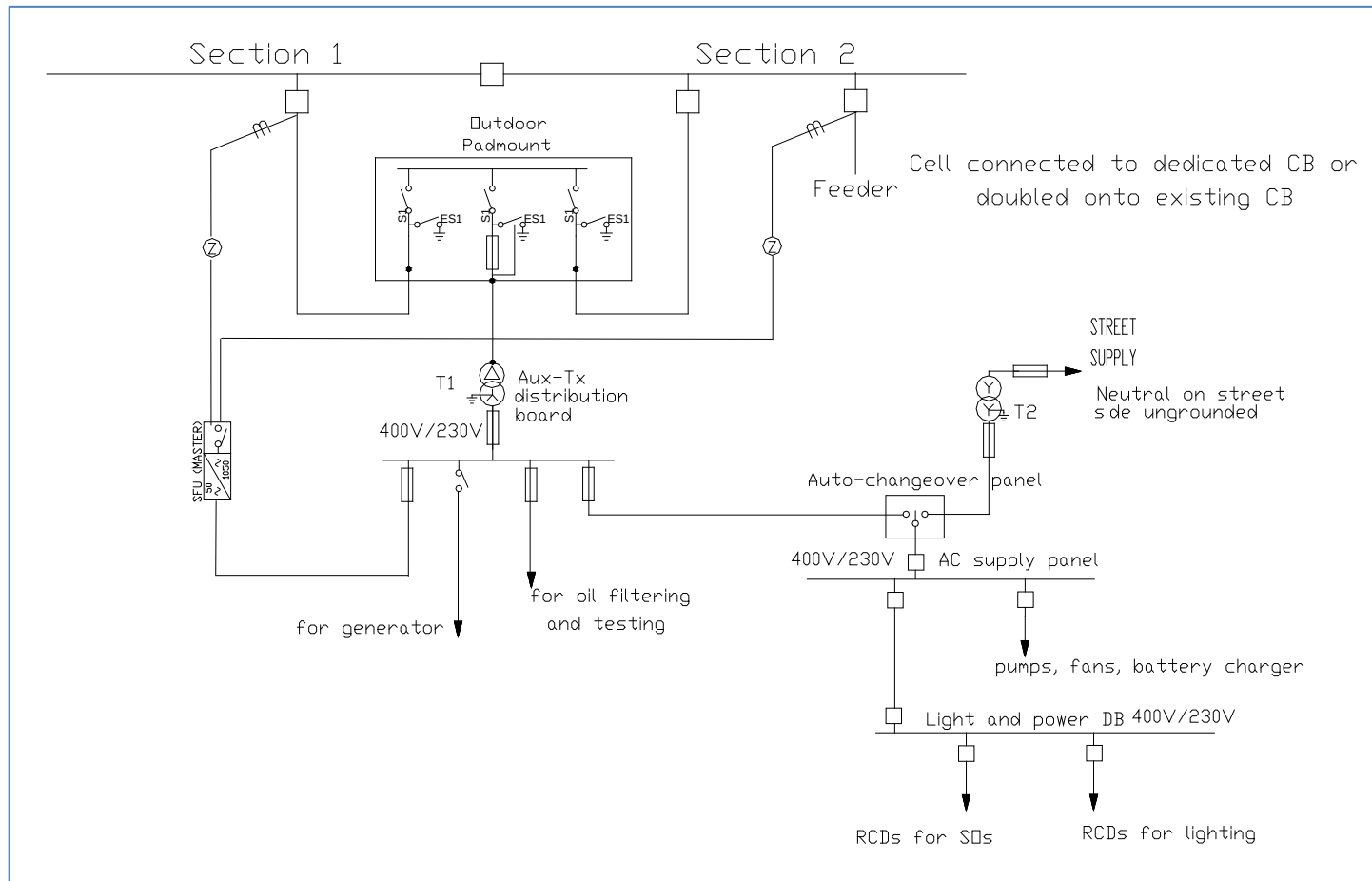


Figure 5 – For zone substations with dedicated auxiliary switchgear – multiple cells

Same analogy applies to different numbers of HV sections, and arrangements.

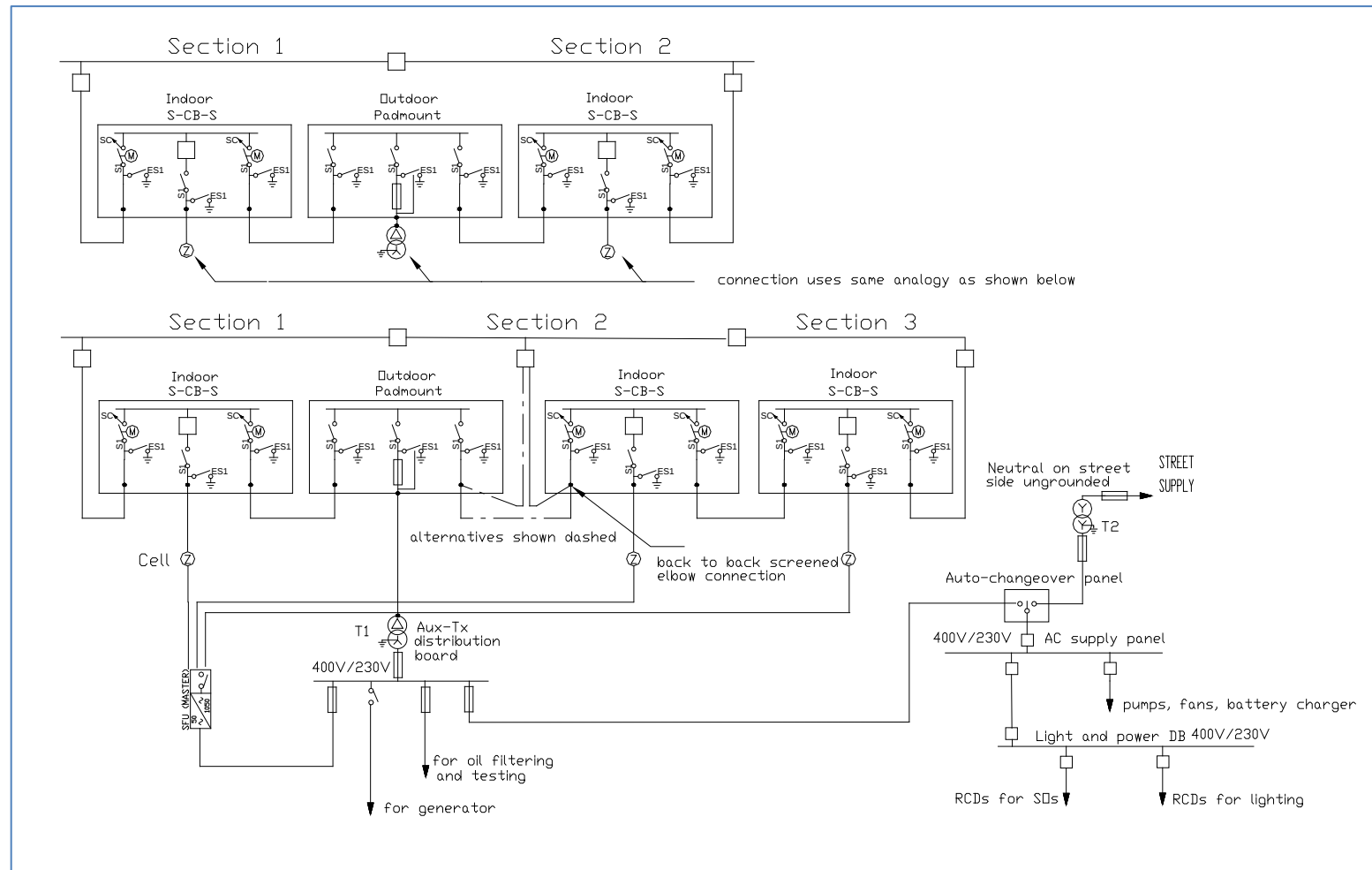


Figure 6 – For zone substations with dedicated auxiliary switchgear – single cell

Same analogy applies to different numbers of HV sections, and arrangements.

