



TS 03762:1.0
EP 01 00 00 03 SP
Specification

11 kV AC Ring Main Unit Switchgear

Issue date: 24 June 2024

Effective date: 24 June 2024

Disclaimer

This document has been prepared by Transport for NSW (TfNSW) specifically for its own use and is also available for use by NSW public transport agencies for transport assets.

Any third parties considering use of this document should obtain their own independent professional advice about the appropriateness of using this document and the accuracy of its contents. TfNSW disclaims all responsibility and liability arising whether directly or indirectly out of or in connection with the contents or use of this document.

TfNSW makes no warranty or representation in relation to the accuracy, currency or adequacy of this document or that the document is fit for purpose.

The inclusion of any third party material in this document, does not represent an endorsement by TfNSW of any third party product or service.

For queries regarding this document, please email Transport for NSW Asset Management Branch at standards@transport.nsw.gov.au or visit www.transport.nsw.gov.au

Document information

Owner: Director Energy Networks and Systems
Asset Management
Safety Environment and Regulation

Mode: Heavy rail, Metro

Discipline: Electrical

Document history

Revision	Effective date	Summary of changes
4.1	1 May 2013	Previous issue with designation number EP 01 00 00 03 SP <i>11kV AC Switchgear – RMU Suitable for Indoor and Kiosk Installation</i>
1.0	24 June 2024	First issue with the new designation TS 03762:1.0. Revision numbering recommenced in line with the new designation. Change to previous content in EP 01 00 00 03 SP are: <ul style="list-style-type: none">• updated references to the current versions of relevant standards• Short-time withstand current rating requirement has been reduced from 20 kA to 16 kA for the TfNSW metropolitan heavy rail network• Inclusion of requirements for the 1500 V dc metro network.

Preface

This specification is the first issue with new designation TS 03762:1.0 and supersedes EP 01 00 00 03 SP *11 kV AC Switchgear – RMU suitable for indoor and kiosk installation* version 4.1 and TN 058:2014 *Amendment to internal arc classification*.

This document provides requirements for the procurement of ring main unit (RMU) switchgear rated for 11 kV system voltage for use in the TfNSW metropolitan heavy rail network and 1500 V dc metro network distribution networks.

All information required to ensure that the 11 kV RMU switchgear is electrically suitable for the TfNSW metropolitan heavy rail network and 1500 V dc metro network is contained in this document or referenced by this document.

The terms 'normative' and 'informative' are used in AMB documents to define the application of the appendices to which they apply. A 'normative' appendix is an integral part of an asset standard, whereas an 'informative' appendix is only for information and guidance.

The change from the previous content includes the following:

- updated references to the current versions of relevant standards
- short-time withstand current rating requirement has been reduced from 20 kA to 16 kA for the TfNSW metropolitan heavy rail network
- inclusion of requirements for the 1500 V dc metro network.

Table of contents

1	Scope	7
2	Application	7
3	Referenced documents	7
4	Terms, definitions, and abbreviations	9
5	Transport for NSW type approval	9
6	Functional requirements	10
7	Switchboard requirements	10
7.1	General	10
8	Insulating medium	13
8.1	Insulating gas requirements	14
9	Switch disconnecter requirements	14
9.1	General	14
10	Circuit breaker requirements	14
10.1	General	14
10.2	Circuit breaker operating mechanism	15
10.3	Protection and current instrumentation requirements	15
11	Switch-fuse requirements (heavy rail)	16
11.1	General	16
11.2	Switch-fuse combination requirements	16
12	Interlocks	17
13	Indications	18
13.1	Switch disconnecter	18
13.2	Circuit breaker	18
13.3	Switch-fuse combination	18
13.4	Live line indications	19
13.5	Fault indicators	19
13.6	Insulating gas monitoring	19
14	Earthing arrangement	19
14.1	Ring main unit earth bar	20
15	HV cable interface	20
16	Circuit test facilities	20
17	Padlocking	21
18	SCADA Indications	21
18.1	Indications	21
18.2	Auxiliary contacts	22
19	Testing requirements	22
19.1	Type tests	22
19.2	Factory acceptance tests	23

19.3	Routine tests	23
19.4	Site acceptance tests	23
20	Human factors	24
20.1	Controls and display	24
20.2	Information content	24
Appendix A	Technical schedule (normative)	25
A.1	11 kV ring main unit technical schedule	25
A.2	Supply history	32
A.3	Reliability data	33
Appendix B	Data set associated with the equipment (normative)	34
B.1	Drawings and information	34
B.2	Technical schedule	34
B.3	Life cycle costing	34
B.4	Test results	35
Appendix C	Integrated system support requirements (normative)	36
C.1	Integrated support objectives	36
C.2	Equipment supplier deliverables	36
Appendix D	Whole-of-life cost (normative)	37
Appendix E	Information for request for tender (informative)	38

1 Scope

This document provides the specification for type tested ring main unit (RMU) switchgear designed for indoor and kiosk installations on railway distribution systems operating at a nominal 11 kV ac three-phase, 50 Hz.

The RMUs covered within this specification feature the following:

- a single busbar that is not divided into sections
- interrupters can be either a switch fuse or a circuit breaker
- disconnecter earth switch for feeder connection.

Certain RMUs may:

- be SCADA connected for indications only
- contain a self-powered protection relay.

This specification does not apply to 11 kV switchboards fitted with SCADA control; for requirements on SCADA controlled switchgear, refer to TS 03760.

2 Application

The requirements of this specification apply to the purchase of 11 kV RMU switchgear for the TfNSW metropolitan heavy rail network and 1500 V dc metro network. These requirements are applicable from the date of issue of this specification.

The requirements of this specification are not applicable to existing 11 kV RMU currently in service.

3 Referenced documents

The following documents are cited in the text. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document applies.

International standards

IEC 62271-213 *High voltage switchgear and controlgear – Part 213: Voltage detecting and indicating system*

Australian standards

AS 1033.2 *High Voltage Fuses (for Rated Voltages Exceeding 1000 V) – Part 2: Current-Limiting (Powder-Filled) Type*

AS/NZS 60265.1 *High-voltage switches – Switches for rated voltage above 1kV and less than 52kV (IEC 60265-1 1998, MOD)*

AS 61869.1 *Instrument transformers – Part 1: General Requirements (IEC 61869-1:2007 (ED.1.0) MOD)*

AS 61869.2 *Instrument transformers – Part 2: Additional requirements for current transformers (IEC 61869-2:2012 (ED 1.0) MOD)*

AS 61869.10 *Instrument transformers – Part 10: Additional requirements for low-power passive current transformers (IEC 61869-10:2017 (ED 1.0) MOD)*

AS 62271.1:2019 *High voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear (IEC 62271-1:2017, MOD)*

AS 62271.100 *High voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers (IEC 62271-100:2008+AMD1:2012+AMD2:2017 CSV (ED. 2.2)/COR1:2018, MOD)*

AS 62271.102 *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches (IEC 62271-102:2018, MOD)*

AS IEC 62271.105 *High-voltage switchgear and controlgear – Part 105: Alternating current switch-fuse combinations for rated voltages above 1 kV up to and including 52 kV*

AS 62271.200:2019 *High voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (IEC 62271-200:2011/COR1:2015, MOD)*

Transport for NSW standards

TS 00011 *Common Requirements for Electric Power Equipment*

TS 01505 (T MU AM 01001 ST) *Life Cycle Costing*

TS 01517 (T MU AM 01002 MA) *Maintenance Requirements Analysis Manual*

TS 03736 (T HR EL 19002 ST) *Protection System Requirements for the High Voltage Network*

TS 03744 (EP 00 00 00 13 SP) *Electrical Power Equipment – Design Ranges of Ambient Conditions*

TS 03756 (T HR EL 20009 ST) *Testing of HV AC and 1500 V DC Cables*

TS 03760 *11 kV AC Indoor Switchgear – SCADA Controlled*

TS 03865 *Electrical SCADA Interface Requirements*

TS 04978 (T MU HF 00001 ST) *Human Factors Integration – General Requirements*

TS 06178 (T MU MD 00005 GU) *Type Approval of Products*

4 Terms, definitions, and abbreviations

The following terms, definitions and abbreviations apply in this document:

ac alternating current

ACCB alternating current circuit breaker

AMB Asset Management Branch

CT current transformer

dc direct current

ELV extra-low voltage; a voltage not exceeding 50 V ac or 120 V ripple-free dc

HV high voltage, a voltage exceeding 1000 V ac or 1500 V dc

LV low voltage, a voltage exceeding 50 V ac or 120 V ripple-free dc but not exceeding 1000 V ac or 1500 V dc

metro a mass transit infrastructure system, and associated facilities, that—

- a. provides high-frequency, high-capacity passenger services, and
- b. is operated using automated or partly automated systems from one or more central control points. (Source: Transport Administration Act 1988)

RFT request for tender

RMS root-mean-square, refers to the most common mathematical method of defining the effective voltage or current of an ac wave

RMU ring main unit

RTU remote terminal unit

SCADA supervisory control and data acquisition

SF₆ sulphur hexafluoride

TAO Technically Assured Organisation

TfNSW Transport for NSW

5 Transport for NSW type approval

All 11 kV RMU switchgear and associated protection relays procured in accordance with this document requires type approval by the AMB prior to being connected to the TfNSW metropolitan heavy rail electrical network or 1500 V dc metro electrical network.

The type approval process is contained in TS 06178.

6 Functional requirements

The 11 kV RMU switchgear shall provide for the following:

- connection of feeders and distribution transformers to the 11 kV busbar
- isolation and earthing of feeders and distribution transformers
- protection for distribution transformer circuits
- means to perform testing on the HV cables without disconnecting the HV cables from the RMU
- remote indication.

7 Switchboard requirements

7.1 General

The 11 kV RMU switchgear and associated equipment shall be designed and manufactured in accordance with the standards stated in Table 1.

Table 1 – Switchboard standards

Equipment	Standard
Switchgear (Common specifications)	AS 62271.1
Circuit breakers	AS 62271.100
Switch disconnecter & earthing switch	AS 62271.102
Switch-fuse combination	AS IEC 62271.105
Metal enclosed switchgear	AS 62271.200
Switch disconnecter	AS 62271.102 & AS/NZS 60265.1
Fuse	AS 1033.2
Current transformers	AS 61869 (Parts 1, 2 & 10)
Degrees of protection	AS 60529

Table 2 provides details of general requirements for 11 kV RMU switchgear.

Table 2 – Switchgear general requirements

Parameter	Designation
Switchgear type	Metal enclosed, non-extensible
Class	Indoor and outdoor – suitable for use within kiosk enclosures
Partition class	PM
Type of system neutral earthing	Effectively earthed and non-effectively earthed (see Note 1)
Insulation medium	Pressurised gas, air or solid insulation – see Section 8
Ambient temperature range	In accordance with TS 03744 (See Notes 2)
Maximum altitude	1000 m (See Note 3)
Interrupting medium	SF ₆ , vacuum or alternative dielectric gas – see Section 8
<u>Operating device:</u>	
Feeder	Switch disconnecter
Transformer:	
Rated below 200 kVA	Switch-fuse combination
Rated 200 kVA and above	Circuit breaker
Operating device type	Non-withdrawable

Note 1: The TfNSW metropolitan heavy rail network has both effectively earthed and non-effectively earthed systems.

Note 2: Where the switchgear does not meet the ambient temperature requirements of TS 03744 the applicable derating factors will be provided by the manufacturer.

Note 3: Locations west of Penrith on the Blue Mountains line have a maximum altitude of 1200 m. Where applicable, derating factors will be provided by the manufacturer.

Table 3 provides switchgear and specific equipment rating requirements.

Table 3 – Switchgear ratings

Parameter	Rating
Number of phases	3
Nominal system voltage	11 kV
Rated voltage (U_r)	12 kV (minimum)
Rated frequency (f_r)	50 Hz

Parameter	Rating
Busbar	Single
Rated normal current (I_r) – see Notes 1 and 3: Busbar Feeder switch disconnecter Transformer switch fuse Transformer circuit breaker	(For heavy rail) 630 A 400 A 200 A 200 A
Rated normal current (I_r) – see Notes 1 and 3: Busbar Feeder switch disconnecter Transformer circuit breaker	(For metro) 630 A /1250 A 630 A 200 A, 630 A, and 1000 A
Rated lightning impulse withstand voltage (U_p) Common value – see Note 2 Across the isolating distance	95 kV (peak) 110 kV (peak)
Rated short-duration power-frequency withstand voltage (U_d): Common value Across the isolating distance	28 kV (RMS) 32 kV (RMS)
Rated short-time withstand current (I_k): (for main and earthing circuits) Rated duration of short-circuit (t_k) (for main and earthing circuits)	16 kA 1 s (minimum)
Rated peak withstand current (I_p) (for main and earthing circuits)	40 kA
Rated short-circuit breaking current (I_{sc}) (for circuit breaker)	16 kA
Rated short-circuit making current (I_{ma}) (for switch disconnecter and earthing switch)	40 kA (peak)
Internal arc classification (IAC) – see Note 4 Arc fault current Arc fault duration	AFLR 16 kA 1 s

Note 1: Switchgear rated normal current (I_r) requirements are specified in accordance with ambient conditions listed in AS 62271. Where the switchgear does not meet the ambient temperature requirements of TS 03744, the applicable derating factors will be provided by the manufacturer. For metro requirements the busbar rating is dependent on transformer ratings and specific load details.

Note 2: The rated lightning impulse withstand voltages specified are specific to Australian conditions and compatibility with the existing TfNSW electrical networks. These values are not from the current version of AS 62271.1.

Note 3: Where the circuit breaker does not meet the ambient temperature requirements of TS 03744, the applicable derating factors will be provided by the manufacturer.

Note 4: AFL is acceptable when there is no available product and the RMU is to be located where rear access is not required (for example inside a kiosk arrangement). TfNSW shall be contacted where an AFL RMU is proposed to be installed.

Table 4 details the minimum electrical and mechanical endurance class for the circuit breaker, disconnecter and earth switch associated with the switchgear.

Table 4 – Mechanical and electrical endurance class

Designation	Class
Feeder switch disconnecter	E3, M1
Transformer circuit breaker	E2, M1
Transformer switch-fuse disconnecter	M1
Earth switch	E2, M0

8 Insulating medium

At the time of publication of this standard there are alternate insulating gases to SF₆ being developed and trialled in industry.

For TfNSW air insulated 11 kV RMU switchgear should be used. The use of any other insulating mediums is subject to TfNSW type approval. The procurement of 11 kV RMU switchgear to this specification requires the assessment of commercially available and proven equipment: both switchgear with insulating medium of SF₆ and switchgear with alternate insulating gasses or solid insulation.

The design TAO shall provide an assessment with detailed technical analysis and comparison between products and a detailed life cycle costing in accordance with TS 01505 for each option. Life cycle costing for the switchgear shall include the disposal, management and environmental costs.

TfNSW, as part of the type approval process, shall review and advise its preference in line with NSW Government and TfNSW policies in place at that time.

Where the insulating medium is SF₆, the supplier of the switchgear shall have a policy to accept responsibility for disposal of the SF₆ and any remaining SF₆ gas or by-products. The supplier shall also accept SF₆ gas, if evacuated during maintenance for the whole life of the switchgear. SF₆ management, environmental and disposal costs will be considered in the evaluation process.

8.1 Insulating gas requirements

End of life gas recovery shall be provided by the manufacturer.

The switchgear shall be factory sealed to not require any routine gas replenishment during installation or in normal service.

The design, construction and sealing of gas compartments shall be such that the gas is maintenance free for 30 years.

9 Switch disconnecter requirements

9.1 General

Switch disconnecter functional units shall comprise of a switch disconnecter and an interlocked earthing switch.

Switch disconnectors shall comply with the requirements of AS 62271.102.

There is no requirement for motorised operation of switch disconnectors.

Each switch disconnecter shall consist of three separate pole units mounted on a single piece frame and shall be mechanically interconnected.

Any part of the switch disconnecter mechanism that requires routine inspection and maintenance shall not be enclosed in any gas tight compartment.

The switch disconnecter shall be manually operated for opening and closing.

The interrupting medium of a switch disconnecter shall be either vacuum, SF₆ or alternate insulating gas, see Section 8 for requirements on the insulating medium.

10 Circuit breaker requirements

10.1 General

Circuit-breaker functional units shall comprise a fixed circuit breaker, a switch disconnecter and an interlocked earthing switch.

Circuit breakers shall comply with the requirements of AS 62271.100.

Circuit breakers shall be used for distribution transformers in the range 200 kVA to 1 MVA inclusive. For metro, circuit breakers shall be used for distribution transformers up to 2.2 MVA.

Each circuit breaker shall consist of three separate pole units mounted on a single piece frame and shall be mechanically interconnected.

There is no requirement for motorised operation of circuit breakers used in RMU configurations.

The interrupting medium of a circuit breaker shall be either vacuum, SF₆ or alternate insulating gas, see Section 8.

10.2 Circuit breaker operating mechanism

The circuit-breaker operating mechanism shall be an integral part of the circuit breaker.

Any part of the circuit breaker mechanism that requires routine inspection and maintenance shall not be enclosed in any gas tight compartment.

All circuit breakers shall be equipped with a mechanism which upon closing with a manual operating handle in the one-movement charges the opening mechanism for the circuit breaker. Opening may be actuated either by a mechanical push button or by the self-powered protection device.

The circuit breaker in the closed position shall be able to trip using its self-powered mechanism before the mechanism needs to be charged again.

10.3 Protection and current instrumentation requirements

The protection equipment shall be located for front access and be logically associated with the relevant circuit breaker functional unit.

Circuit breaker protection relays shall be self-powered from CTs, or low power current sensors specifically designed for use with the relay.

The protection relays shall not require internal or external batteries for protection functions and operation. However, the circuit breaker protection relays may use batteries for programming, maintenance, testing or recording purposes.

The circuit-breaker functional units shall be provided with either of the following:

- three phase sets of protection CTs in compliance with AS 61869 (Parts 1 and 2) and TS 3736
- three phase sets of low power current sensors in compliance with AS 61869 (Parts 1 and 10).

The protection relay shall have as a minimum the following features:

- inverse definite minimum time and definite time trip curves suitable for overcurrent protection of transformers
- inverse definite minimum time and definite time trip curves for earth faults
- trip settings for both the overcurrent and earth faults, adjustable in steps. This adjustment to the settings shall be able to be made from the front of the protection relay

- indicators on the front of the relay that reflect any protection functions that causes the ACCB to trip. The relay may require power from internal or external batteries to display the indicators.

The relay should have selectable trip curves (for example, SI, VI, LT, RI). The trip output from the self-powered relay shall be matched to the tripping requirement of the circuit breaker.

11 Switch-fuse requirements (heavy rail)

11.1 General

Switch-fuse combinations shall be used for protection of transformers when the transformer is below 200 kVA in size.

Switch-fuse combination functional units shall comprise a fixed switch disconnecter, a fuse and interlocked earthing switches. The fuses shall be easily accessible through the front and interlocked with the earth switch.

Switch-fuse combinations shall comply with the requirements of AS IEC 62271.105.

The fuses shall comply with AS 1033.2. The fuse holder and fuse shall be suitable for the prospective fault rating. The fuse holder shall suffer no degradation following rated fault currents with rated duration times.

Fuse blown indication shall be provided. Voltage free auxiliary contacts shall be wired to terminals for remote indication purposes – see Section 18.

If the fuse ruptures for any one of the phases, the switch disconnecter shall open all three phases immediately.

Earthing shall be made simultaneously on both sides of the fuse link where required for the safe replacement of the fuse.

There is no requirement for motorised operation of switch-fuse disconnectors when used in RMU configurations.

The interrupting medium for the switch disconnecter within the switch-fuse functional unit shall be either vacuum, SF₆ or an alternate insulating gas – see Section 8. The switch disconnecter used in the switch-fuse combination shall comply with Section 9 of this document.

11.2 Switch-fuse combination requirements

Each switch fuse disconnecter shall consist of three separate pole units mounted on a single piece frame. The pole units shall be mechanically interconnected.

Three separately mounted fuses shall be mounted after the switch disconnect unit. An earth switch unit shall be mounted after the fuse between the cable and the fuse. The earth switch shall be mechanically interlocked with the switch disconnecter earth position.

Any part of the switch mechanism that requires routine inspection and maintenance shall not be enclosed in any gas tight compartment.

12 Interlocks

Facilities provided for operational access to parts of the switchgear functional unit that contain live components shall be mechanically interlocked so that access to such parts is not possible unless all live parts have been rendered safe, either by an applied earth connection or by being positively disconnected and screened from the remaining live parts.

Mechanical interlocks shall be provided to ensure positive and substantial protection against malfunction. The design and construction shall facilitate dependable fail-safe operation.

Mechanical interlocks shall be provided in compliance with Section 5.11 of AS 62271.200:2019 to prevent unsafe operation, including:

- automatic opening of a circuit-breaker when it is used to earth a circuit or the busbar
- closing of an earthing switch unless the circuit-breaker is in the open position
- opening or closing a switch disconnecter associated with a circuit breaker unless the circuit breaker is open
- closing the cable earth switch while the associated switch disconnecter is closed.

Positive mechanical interlocking shall be provided to prevent inadvertent switching from the ON position to the EARTH position without a definite stop in the OFF position, or from the EARTH position to the ON position without a definite stop in the OFF position.

Access to the test terminals shall only be possible when the associated earth switch is in the EARTH position.

When the circuit test facility is in use, it shall not be possible to close the disconnecter.

The making of the disconnecter contacts in the EARTH position should be directly observable by the operator.

If the earthing of a circuit-breaker or switch fuse combination or switch disconnecter functional unit is not visible from the operating position, the corresponding indication shall be directly coupled to the earthing mechanism, to ensure fail-safe indication.

An analysis shall be provided detailing the integrity of the interlocking system. The analysis shall include all possible failure modes and the controls employed to prevent an unsafe operation.

A table shall be produced of all possible and inhibited states the switchgear may occupy.

13 Indications

13.1 Switch disconnecter

Switch disconnecter functional units shall have indication clearly visible from the front of the functional unit. The following definite indications shall be provided:

- switch disconnecter position (that is, open or closed)
- earth switch position.

13.2 Circuit breaker

Circuit-breaker functional unit shall have indications clearly visible from the front of the functional unit (that is, either on the circuit breaker or on the circuit-breaker functional unit).

A mechanically operated indicator, indelibly marked, to show whether the circuit breaker or disconnecter is open or closed. The word OPEN shall be visible only if the circuit breaker is in the open position. The word CLOSED shall be visible only if the circuit breaker is in the closed position. An alternative may be to replace the word OPEN by 'O' and the word CLOSED by 'I'. If colours are used in addition, then the colour green shall indicate the open condition and the colour red shall indicate the closed condition.

The following definite indications shall be provided:

- circuit-breaker open/closed
- switch disconnecter open/closed
- earth switch position
- stored energy device charged/discharged
- non-resettable mechanical operation counter.

13.3 Switch-fuse combination

Switch-fuse combination functional unit shall have indication clearly visible from the front of the functional unit. The following definite indications shall be provided:

- switch disconnecter open/closed
- earth switch position
- fuse blown.

13.4 Live line indications

Live line indicators shall be provided for each of the three phases on each circuit and the busbar. Live line indicators shall comply with the requirements of IEC 62271-213.

13.5 Fault indicators

All RMU feeder switch units shall be equipped to interface with a fault indicator such as Easergy Flair 22D or equivalent.

The wiring (for SCADA indication interface and remote reset) shall be fitted to all units.

13.6 Insulating gas monitoring

This clause is only applicable to switchgear that utilise dielectric gas for insulation.

A gas density gauge, indicating the gas density within each compartment while in service shall be provided. The gauge shall be clearly visible to the operator from the operating side of the switchgear functional unit. The gauge shall be marked with minimum permissible pressure level for safe operation. The gauge shall have a green indicator area for gas pressure safe for operation and red indicator area for low gas pressure.

14 Earthing arrangement

To assist with stray current mitigation measures from the dc traction system, it may be necessary to connect 11 kV cable screens to a separate cable screen earth bar. This arrangement shall facilitate future installation of a transient earth clamp.

The transient clamp acts as a dc decoupler to provide dc isolation between earthing systems (for example, a local earth system and a remote earth system). Under an ac earth fault, the clamp impedance momentarily changes state to a virtual short circuit, acting to provide a direct connection of HV cable screens to the switchboard earth bar.

Note: some HV panels and HV functional units require all HV earth screens to be directly connected to the switchboard earth bar.

Each feeder functional unit shall include two copper earthing bars, rated for maximum fault levels and not less than 120 mm² cross section area to facilitate earthing.

A separate cable screen earth bar shall be provided for each feeder functional unit. This shall be connected to the switchboard earth bar via removable links and be isolated from similar bars in adjacent functional units. It shall be insulated from the frame of the switchboard by insulated mounts that have been rated for maximum earth potential rise and tested to 15 kV for not less than 1 minute. The cable screen earth bar shall provide for connection of the two removable links, four HV cable screens and mounting holes for a transient earth clamp.

14.1 Ring main unit earth bar

The earth bar shall provide:

- for all switchgear bonding
- for two cable connections to the main substation earth grid
- for two removable links per functional unit for connection to the insulated cable screen earthing bar.
- for connection of four HV cable screens
- mounting holes for a transient earth clamp.

To provide for mounting of the transient earth clamp to the two earth bars, that is, the ring main unit earth bar and the cable screen earth bar, the earth bars shall be vertically separated as far as possible to provide sufficient space for future insertion of the transient earth clamps.

Earth termination requirements are provided in TS 00011.

15 HV cable interface

Each circuit-breaker, switch disconnecter and switch-fuse combination, functional unit shall be equipped with a HV cable compartment providing a dead-break, separable, fully insulated and shielded system for connection of HV cables. The separable insulated shielded connection system shall be compliant with AS 2629 and relevant ratings specified in Section 7.

The HV cable compartment shall be suitable for connection of single and 3 core XLPE insulated 11 kV cables up to a maximum size of 240 mm².

Feeder and circuit breaker units shall use Elastimold, bolted, field disconnectable type 400TB (or equivalent to be approved by AMB).

Switch fuse units shall use Elastimold type 158LR (or equivalent type approved item by AMB).

The cables shall enter the cable compartment from below. Details of the cable connections shall be nominated in the Technical Schedule at Appendix A.

The cable termination shall be capable of withstanding the power frequency test voltages as specified in Table 1 of AS 62271.1:2019. The cable termination shall also comply with requirements in Section 16.

16 Circuit test facilities

Each functional unit shall incorporate an integral type circuit test facility.

All test facilities shall be suitable for the application of test voltages associated with the after-installation testing of HV ac cables. Test facilities shall be rated for the same system voltage as the switchgear. Refer to TS 03756 for details on required tests.

The test facility shall facilitate the connection of test equipment with the circuit earthed and then allow the earths to be removed with the test equipment still connected.

17 Padlocking

Facilities shall be provided to padlock:

- the circuit breaker in the open position and the closed position while the disconnecter is in the earthed position, and the disconnecter in the closed, open and earth positions
- The switch-fuse combination in the open position and the earth position while the cable earth switch is in the earthed position and the switch-fuse combination in the closed position while the cable earth switch is not in the earth position
- the switch disconnecter in the closed, opened and earth positions
- the disconnecter in the closed, opened and earth positions
- the circuit test facility, if applicable (see Sections 12 and 16).

All padlocking facilities shall be suitable for padlocks with a 6 mm shank diameter.

18 SCADA Indications

This clause is only applicable if the RMU Switchgear is required to be connected to SCADA for *indications and monitoring* only. If SCADA *control* is required, then refer to TS 03760 for SCADA control requirements.

18.1 Indications

Indications shall be conveyed to the SCADA RTU in accordance with TS 03736 and TS 03865.

A set of terminals shall be used for the termination of the auxiliary wiring for indications. The terminals shall be mounted in a LV area of the RMU.

The indications shown in Table 5 shall be implemented for the respective switchgear functional units specified:

Table 5 – Indications to be implemented for SCADA monitored RMU switchgear.

I/O point description	Switchgear functional unit
Earthing switch position (Open, Closed)	All
Isolator position (Open, Closed)	All
Fault indicator alarm	All
Circuit breaker (Open, Closed)	Circuit breaker
Protection relay watchdog alarm	Circuit breaker

I/O point description	Switchgear functional unit
Overcurrent trip alarm	Circuit breaker
Earth fault trip alarm	Circuit breaker
Switch position (Open, Closed)	Switch-fuse combination
Fuse blown alarm	Switch-fuse combination

18.2 Auxiliary contacts

Each switchgear functional unit (that is, switch disconnecter, switch-fuse, circuit breaker) shall be fitted with two normally open, and two normally closed voltage free auxiliary contacts of Class 2 in accordance with AS 62271.1. These auxiliary contacts shall be provided in addition to those essential to the operation.

A set of terminals for the termination of auxiliary wiring associated with the auxiliary contacts, fault indicators, fuse blown, or transformer protection relay outputs shall be provided.

19 Testing requirements

The switchgear testing requirements are split into three distinct categories as follows:

- type tests
- factory acceptance tests (FAT)
- site acceptance tests (SAT).

Testing requirements shall be read in conjunction with the specification TS 00011.

19.1 Type tests

The type tests as required in the following standards and their relevant parts shall be completed with copies of type test certificates, test results and reports submitted as part of the tender documentation:

- AS 62271.1
- AS 62271.102
- AS 62271.200
- AS 62271.100 (for switchgear with a circuit breaker)
- AS IEC 62271.105 (for switchgear with a switch-fuse combination).

Type test certificates for each of these tests shall be accepted where it can be demonstrated that the equipment supplied is of a similar design to previously type tested circuit breakers or CTs.

19.2 Factory acceptance tests

FAT shall be completed at the manufacturers' premises unless agreed by TfNSW.

Where a TAO is witnessing the FAT on behalf of TfNSW, they are responsible for witnessing and providing engineering assurance on the tests and requirements.

TfNSW shall be notified of the FAT schedule and will advise if attending.

19.3 Routine tests

Routine tests shall be completed as part of the FAT at the manufacturers' premises unless agreed by TfNSW. Routine test reports shall be provided to the AMB.

Switchgear routine tests as listed in the following standards shall be carried out:

- AS 62271.1
- AS 62271-200
- AS 62271-100 (for switchgear with a circuit breaker).

Dielectric dissipation factor and partial discharge testing shall be performed.

Certain routine tests shall be completed as part of the SAT see Section 19.4.

19.4 Site acceptance tests

Certain routine tests required shall be repeated once the equipment is installed at site.

The TAO is responsible in conjunction with the manufacturer to determine the exact routine tests that require to be repeated based on the hazards and risk analysis of transporting the switchgear from the factory to site and the installation activities required.

The switchboard shall be tested following installation and before commissioning into service to check the correct operation of the equipment including the interlocking system and the dielectric strength of the equipment.

On site tests shall include but not be limited to the following to locate any defects or damages during handling, transportation, storage and erection:

- dielectric test on main circuits
- dielectric tests on auxiliary circuits (if applicable)
- measurement of resistance of main circuit
- gas leakage tests (if applicable)
- measurement of moisture content of insulating gas (if applicable)
- operation of all devices.

For switchgear configurations with a circuit breaker and protection relay, the following additional tests shall be performed:

- timing of circuit breaker operation
- insulation resistance of all wiring
- continuity of all wiring
- secondary injection of protection schemes. Primary injection shall be carried out where secondary injection is not feasible
- full operation checks of all protection schemes.

20 Human factors

The design of the 11 kV RMU switchgear shall incorporate the principles of human factor integration as described in TS 04978.

Human factors aspects to be considered relate to controls and displays, information content, alarms and alerts. All equipment shall be designed to minimise safety hazards to operating personnel and prevent accidental short circuits due to human error.

20.1 Controls and display

Human factors shall be taken into account in the design of all operational facets of the switchgear. This includes aspects such as the following:

- location of the local controls
- position of indications
- accessibility of the fault indicators, live line indicators, protection relays (if installed) and gas density gauge (if required). The location is critical to ensure suitability for use by the operator or maintainer.

20.2 Information content

The correct labelling of all controls and indications is critical to reduce the likelihood of operator error while switching.

Appendix A Technical schedule (normative)

This appendix has the technical schedule which shall be completed at the time of tender. The schedule details the descriptive information that shall be submitted at the time of tender.

A.1 11 kV ring main unit technical schedule

Switchgear general details:	
Manufacturer	
Model	
Country of manufacture	
Insulation medium	
IP rating	
Design life	
Partition class	
Ambient operating temperature range	
Maximum operating altitude	
Mass of the complete switchgear	

Switchgear common ratings and details:		
Number of phases		
Rated voltage (Ur)		kV
Rated frequency (fr)		kV
Busbar rated normal current (Ir)		A
Rated short time withstand current (Ik): Main circuit		kA
Earth circuit		kA
Rated duration of short circuit (tk)		S
Rated peak withstand current (Ip)		kA
Rated short-duration power-frequency withstand voltage (Ud) Common value		kV (RMS)
Across the isolating distance		kV (RMS)
Rated lightning impulse withstand voltage (Up) Common value		kV (peak)
Across the isolating distance		kV (peak)

Switchgear common ratings and details:		
Internal arc classification (IAC) Arc fault current Arc fault duration		kA s
Partial discharge level of complete switchboard including all components		pC
Provide derating factors (if applicable) for ambient conditions to a maximum of 60°C (derating factors shall be in a form of table or graph)		
Provide derating factors (if applicable) for altitudes to a maximum of 1200 m (if required) (derating factors shall be in a form of a table or graph)		
Description of all operational and safety interlocking arrangements		
Table of all possible and inhibited states of the switching devices in the switchgear		
Analysis demonstrating the integrity of all interlocking arrangements which includes an analysis of all possible failure modes and the controls in place to manage them		
Ability to motorise switchgear for remote operation after installation		

Circuit breaker details (if required):		
Interrupter medium		
Maximum break time		ms
Circuit breaker mechanical endurance class		
Circuit breaker electrical endurance class		
Rated continuous current (I_r)		A
Rated short time withstand current (I_k)		kA
Rated duration of short circuit (t_k)		s
Rated peak withstand current (I_p)		kA
Rated short circuit making current (I_{ma})		kA
Rated short-circuit breaking current (I_{sc})		kA
Rated line-charging breaking current		A
Type of circuit breaker mechanism		
Rated operating sequence		

Circuit breaker details (if required):		
Rated first-pole-to-clear-factor (kpp)		
Electrical rating of auxiliary contacts		
Number of N/O auxiliary contacts		
Number of N/C auxiliary contacts		
Details of disconnecter associated with the circuit breaker (on-load or off-load, ratings, etc)		

Protection relay details (if required):	
Manufacturer	
Model/catalogue no.	
Country of manufacture	
Minimum current for correct operation of relay	
Number of CTs required for protection relay (including CTs required for powering the relay)	
Details on self-powered tripping of ACCB system	
Details of indications on the relay	
Method of configuring protection settings	
Requirement for battery for the relay: Functions that the battery is required for Type of battery required Number of batteries required Estimated battery life	

Current transformers (if required):	
Detail the following for the CTs:	
Type	
Encapsulation material	
Class	
Burden	
Ratio	
Knee-point voltage	
Secondary winding resistance	

Current transformers (if required):	
Excitation current at knee-point voltage	
Where are the CTs located and how are they mounted?	
Detail the terminal block or connectors for the CTs	
Details of manufacturer's recommended tests for the CTs	

Switch disconnecter ratings:		
Type of switch disconnecter offered		
Is the switch disconnecter 2-way or 3-way?		
Rated continuous current (I_r)		A
Insulation medium		
Rated short-time withstand current (I_k)		kA
Rated duration of short-circuit (t_k)		s
Rated short-circuit making current (I_{ma})		kA
Rated short-circuit breaking current (I_{sc})		kA
Mechanical endurance class		
Electrical endurance class		
Electrical rating of auxiliary contacts		
Number of N/O auxiliary contacts		
Number of N/C auxiliary contacts		

Earth Switch ratings:		
Rated continuous current (I_r)		A
Rated short-time withstand current (I_k)		kA
Rated duration of short-circuit (t_k)		s

Earth Switch ratings:		
Rated short-circuit making current (I_{ma})		kA
Rated short-circuit breaking current (I_{sc})		kA
Mechanical endurance class		
Electrical endurance class		
Electrical rating of auxiliary contacts		
Number of N/O auxiliary contacts		
Number of N/C auxiliary contacts		
Details of the circuit earthing facilities offered		
Method of indicating the position of the earth switch and confirming the integrity of the indication		

Switch-fuse ratings:		
Switch Insulation medium		
Rated continuous current (I_r)		A
Fuse rating		A
Rated short-time withstand current (I_k)		kA
Rated duration of short-circuit (t_k)		s
Rated short-circuit making current (I_{ma})		kA
Rated short-circuit breaking current (I_{sc})		kA
Mechanical endurance class		
Electrical endurance class		
Electrical rating of auxiliary contacts		
Number of N/O auxiliary contacts		
Number of N/C auxiliary contacts		

Fuse ratings:		
Rated normal current (I_r)		A
Voltage rating		kV
Manufacturer		
Fuse type		
Fuse indicator		

Fuse ratings:		
Fuse length		
Fuse diameter		
Fuse curve details		

Insulating gas details:		
Insulating gas		
List of compartments or switching devices insulated by the gas		
Mass of insulating gas		kg
Guaranteed leakage per year (degree of gas tightness) for the switchgear		%/year
Nominal gas pressure		
Minimum gas pressure for operation		
Gas recovery details		
Method of indicating vacuum loss for vacuum type switching devices		
Gas density gauge details:		
Details of the gas density monitoring device		
Details of the markings on the gauge		

11 kV cable interface details:
Provide details of how the HV cables are accessed
Maximum size and number of HV cables that can be terminated in each panel. Clearly specify clearances between each cable termination of each phase. Provision of a detailed dimensioned drawing of the arrangement is required
Type of cable termination offered. Specify manufacturer, model and full details of separable insulated connector and associated detail on the shielding arrangement (if applicable)
Type of circuit test facility offered

11 kV cable interface details:	
Include details of any test plugs	

Live line indicator details:	
Manufacturer	
Model/catalogue no.	
Country of manufacture	
Details on the implementation of the live line indication system	
Details on the indicators	
Accuracy of the indication system	
Any limitations of the system	

Fault indicator details:	
Manufacturer	
Model/catalogue no.	
Country of manufacture	
Details of the CTs required	
Fault detection current threshold ranges	
Number and type of contacts	
Details on local indicators	
Reset details	
Test arrangement details	
Requirement for battery for the relay: Functions that the battery is required for Type of battery required Number of batteries required Estimated battery life	

Condition monitoring devices:	
List of condition monitoring devices integrated within the switchgear	

Condition monitoring devices:	
List of additional optional condition monitoring devices recommended for the switchgear	
Additional information regarding the listed condition monitoring devices	

A.2 Supply history

The manufacturer shall provide the following supply history:

- period (in years) this model or type has been available for purchase
- estimated period before replacement with new model
- number of units in service worldwide
- number of units in service in Australia.

A.2.1 Additional description 11 kV ring main unit detail and information

The following general descriptive detail on the switchgear shall be provided with the tender:

- switchgear operation and maintenance manual
- details on standards that switchgear complies
- copies of all type test certificates and reports
- any departures from the requirements of this specification If there are departures, include details on a separate sheet
- details on the voltage detection system
- details on interlocking between the switching devices and earth switches
- description on the 11 kV cable termination and associated method for testing 11 kV cables
- physical dimensions, weights and required clearances
- detail on maintenance requirements including frequency, type of maintenance, consumables used, estimated duration and requirement for special tools and personnel
- details on manufacturer’s recommended commissioning and routine tests
- details of segregation, mechanical protection of LV wiring in HV compartments
- details on recommended spares.

A.3 Reliability data

Reliability data shall be submitted including, but not limited to, design life, failure modes, mean time between failures and mean time between repairs. Refer to TS 01517 for details of TfNSW maintenance analysis requirements.

This manual supports the TfNSW Asset Management Policy with detailed processes for undertaking a maintenance requirement analysis.

Appendix B Data set associated with the equipment (normative)

The following data shall be supplied by the manufacturer and maintained for the 11 kV RMU. This data will remain the property of TfNSW.

B.1 Drawings and information

The following drawings are required as a minimum set:

- legend and symbols
- equipment list
- arrangement drawings that include the following:
 - dimensions
 - cable termination details including cable trench width and depth of protrusion into cable trench (if applicable)
 - clearances required around and above the switchgear
 - cable trench
- schematic diagrams
- civil drawings and diagrams as required for the installation.

All drawings shall conform to the requirements of TS 01547.1.

Note: This list does not include component drawings which are required as part of the integrated support requirements and inclusion in the operations and maintenance manual.

B.2 Technical schedule

The information listed in the technical schedule in Appendix A, supplied by the manufacturer, shall be maintained for each 11 kV RMU.

B.3 Life cycle costing

All the data and assumptions pertaining to the determination of the whole-of-life cost calculations of the switchgear shall be recorded. See Appendix D. This is prepared by the TAO.

B.4 Test results

The results of all tests, including type, special, routine, acceptance, periodic and corrective maintenance tests shall be recorded and provided.

Routine and type tests certificates showing the results of each test performed shall be supplied in English.

Appendix C Integrated system support requirements (normative)

C.1 Integrated support objectives

The switchgear manufacturer shall establish and provide the information required to operate and maintain the equipment throughout its operational life. This shall be done in a cost effective manner and to a level that is consistent with the planned operational performance and usage of the switchboard.

This includes all of the following:

- specifying maintenance requirements
- spares support (availability of spares – timeframe, where they are held)
- operations and maintenance manuals
- training
- support equipment and tooling.

C.2 Equipment supplier deliverables

The integrated support requirements are a significant deliverable in the procurement of new switchgear. Manuals, training, documentation, and other support deliverables shall comply with TS 03742.

Appendix D Whole-of-life cost (normative)

This appendix is provided to assist TAOs to assess the whole-of-life cost as required by TS 01505.

The selection of the most suitable 11 kV RMU shall be made on the basis of minimising the whole-of-life cost. The following factors shall be assessed when determining the whole-of-life cost:

- cost of changes to the technical maintenance plan and service schedules or the creation of new manuals and schedules
- cost of decommissioning and disposal
- cost of installation
- cost of inventory spares
- cost of maintenance
- cost of modifications to other parts of the installation
- cost of replacement parts
- cost of special tools
- cost of staff training
- discount rate
- environmental costs
- initial purchase price
- lifetime of equipment.

If the 11 kV RMU has not previously been type approved by AMB in accordance with TS 06178, then the costs for this process shall be included in the whole-of-life cost.

Appendix E Information for request for tender (informative)

This appendix contains the information to be provided with the RFT at the time of tender and by the tenderer with the submission.

See Appendix A for the requirements for tenderers to complete and submit the technical schedule.

For procurement of 11 kV RMU switchgear relevant site-specific information and technical information should also be made available to tenderers.

Table 6 provides a list of technical details to be considered for including in the RFT.

Table 6 – List of technical details to include in the RFT

Item	Technical details to include in the RFT
Required RMU configuration	Details of the configuration of the RMU switchgear required including: <ul style="list-style-type: none"> • details of the load functional unit, • protection details required for the load, • any condition monitoring capability required
Technical electrical data	Provide technical data including: <ul style="list-style-type: none"> • Transformer or load size including minimum and maximum load • Feeder data including minimum/maximum load and fault data • Method of neutral earthing of the system
Diagrams	Proposed operating diagrams or single line diagrams for the proposed RMU switchgear
Drawings	Any relevant site available drawings for the installation.
Special service or environmental conditions (where varied from conditions listed in this specification or TS 03744)	Provide any details of any special requirements or conditions required for site such as higher ambient temperature ranges, altitude, moisture or pollution levels