Technical Specification - HV Switchgear

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Revision details

Version No.	Clause	Description of revision
1.0	All	General revision
2.0	All	General revision
3.0	All	General revision
4.0	All	Format update, changing ‘shall’, ‘should’ and ‘may’ to must where relevant, to Sydney Water, ‘approved’ replaced with ‘accepted’, minor editorial changes elsewhere.

Introduction

This Specification is for the design, supply and installation of HV Switchgear for Sydney Water assets.

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Acronyms

The following terms maybe used in this specification:

Term	Definition
AC (ac)	Alternating Current
AI	Analogue Input
AIS	Air Insulated Switchgear
ANSI	American National Standards Institute
AO	Analogue Output
AS	Australian Standard
AUD	Australian Dollars

Term	Definition
CB	Circuit Breaker
CT	Current Transformer
c/w	complete with
DC (dc)	Direct Current
DI	Digital Input
DO	Digital Output
ELV	Extra Low Voltage (i.e. ≤ 50 V AC or ≤ 120 V DC)
EN	European Normalised Standard
ESW	Earth Switch
FVC	Fused Vacuum Contactor
GA	General Arrangement (drawing)
GIS	Gas Insulated Switchgear
HMI	Human Machine Interface
HV	High Voltage (i.e. > 1000 V AC or > 1500 V DC)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronic Engineers
I/O	Inputs/Outputs
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LV	Low Voltage (i.e. greater than ELV but ≤ 1000 V AC or ≤ 1500 V DC)
MCB	Miniature Circuit Breaker
MSDS	Material Safety Data Sheet
MV	Medium Voltage (note this term is not used in this specification)
PF	Power Factor
PLC	Programmable Logic Controller
pu	per unit

Term	Definition
RMU	Ring Main Unit
SAA	Standards Association of Australia
SF_6	Sulphur Hexafluoride
Sec.	second
SLD	Single Line Diagram
TBA	To Be Advised
TBC	To Be Confirmed
TCS	Trip Circuit Supervision
VC	Vacuum Contactor
VCB	Vacuum Circuit Breaker

1. General

1.1 Introduction

This specification defines the minimum technical requirements for the design, manufacture, supply and delivery of High Voltage (HV) Switchgear.

1.2 Scope

This specification ensures that Sydney Water will be delivered outdoor switchgear and associated equipment to the minimum acceptable requirements.

Key stakeholders for this specification include the Sydney Water Electrical Operations team, maintenance providers and delivery partners.

This specification does not apply to the installation / erection, commissioning or performance testing of the equipment.

1.3 Proprietary items

Nomination of a proprietary item by Sydney Water does not imply preference or exclusivity for the item identified.

Alternatives that are equivalent to the nominated items can be submitted to Sydney Water for acceptance. The submission must include appropriate technical information, samples, calculations and the reasons for the proposed substitution, as appropriate.

Technical requirements – general

1.4 Environmental requirements

The HV Switchgear must be designed to suit the following environmental conditions.

Environmental conditions		
Maximum ambient temperature		+ 45 ºC
Maximum ambient temperature (when installed in an outdoor enclosure)		+ 60 ºC
Maximum 24 hr average temperature		+ 35 ºC
Minimum ambient temperature (corresponds to “minus 5ºC indoor class”)		- 5 ºC
Maximum relative humidity	For one month	90%
	For 24 hours	95%

The switchgear must be suitable for installation and service up to an elevation of 1000 m above sea level.

1.5 Key ratings and features

The key ratings and features of the HV switchgear must be as follows:

Ref	Rating or feature	Requirement
1	Construction	Fully type tested enclosed modular switchgear (Withdrawable or Fixed type, preferably one gas tank per switchgear panel)
2	Class	Indoor (primary switchgear only) Indoor and Outdoor (secondary switchgear)
3	Access	Front access
4	Material of enclosure	Zinc annealed sheet steel /Stainless Steel/ Aluminium (Marine Graded)
5	Insulation medium	Air / SF_6
6	Conductor material	Tinned copper for Air insulated conductors Bare copper for gas insulated conductors
7	Mounting arrangement	Free standing floor mounted (on a 100 mm hot dipped galvanised plinth for fixed and secondary GIS switchgear if a plinth is not an integral part of the switchgear from manufacture)
8	Loss of Service Continuity category	AIS withdrawable switchgear – LSC2B GIS Fixed switchgear – Not Applicable

Ref	Rating or feature	Requirement
9	Partitions and shutters	Class PM – Metallic partitions
10	Minimum short time withstand	25 kA 3 s (primary switchgear) 20 kA 3 s (secondary switchgear)
11	Minimum Internal Fault Protection Classification	IAC A FLR 25 kA 1s (primary switchgear) IAC A FLR 16 kA 1s (secondary switchgear)
12	Accessibility of compartments	Busbar - Interlocked / Tool-based CB/Switchgear – Interlocked tool-based Cable – Interlocked tool-based
13	HV Cable connection	Preferable front connection, with bushing / bolted
14	HV Cable entry	Bottom
15	HV Gland Plate	6 mm aluminium (undrilled)
16	LV and ELV cable entry	Bottom / Top (Indoor) Bottom (Outdoor)
17	LV and ELV Gland Plate	3 mm aluminium (undrilled)
18	Minimum degree of protection	Switchgear Enclosure (Indoor) – IP4X Switchgear Enclosure (Outdoor) – IP54 Inside compartments – IP2X
19	Circuit Breaker	Vacuum / SF_6
20	HV Contactor	Vacuum / SF_6
21	Maximum overall height	2300 mm (Indoor) 2500 mm (Outdoor)
22	Height to centreline of highest equipment on LV compartment door	Maximum: 1850 mm (for indication devices) 1680 mm (for devices which require hand operation)
23	Gas discharge tunnel	Required as per section 2.1
24	Control supply voltage	48 V DC
25	Trip/close coil voltage	48 V DC
26	Spring charge motor voltage	48 V DC
27	Racking motor voltage	48 V DC

Ref	Rating or feature	Requirement
28	Anti-condensation heater voltage	240 V AC ± 10%
29	Capacitive voltage indicators with test points	Required on all circuits (cable side)

- Note: Indoors refers to inside a pressurised switchroom. All other environments are to be treated as outdoors.

1.6 Standardisation

Equipment must be designed with standard parts and components readily available within Australia. Parts and components must be standardised as much as possible. All replaceable and consumable equipment must be standard supply equipment. The use of “one off” special designs is not permitted.

2. Technical requirements – construction

2.1 General

The switchboard enclosures must comply with the latest AS 62271.200.

The switchboard panels must have front access and be of the same height to provide a uniform profile along the switchboard.

The design of the switchboard should be such that the incomers are on the ends of the switchboard and enable extension at either end with the minimum of disturbance to the installed equipment.

Separate compartments must be provided within each panel of the switchboard for:

a) Interconnecting busbar system (Main busbar)

b) Circuit Breaker, isolators or starter units

c) Cable termination means and cable-side CTs and VTs

d) Control, metering, protection devices and communication equipment.

The floor of the Switchroom is not considered to be part of the enclosure. The bottom of the switchboard must be closed off, sealed, dust and vermin proof.

All non-withdrawable switchgear must be supplied and mounted on an adequate 100 mm height plinth if this plinth is not an integral part of the switchboard from the manufacture. The plinth must be typically of hot dipped galvanised construction.

All gas insulated switchgear should have one dedicated gas tank per switchgear panel.

The switchboard must have internal arc withstand to Class A-FLR with minimum time duration of one second. The switchboard must have an integrated, type tested pressure relief ducts to ensure operator safety. The venting should be designed such that there is no damage to ancillary equipment (e.g. cables) or pose a hazard to personnel.

The switchboard internal arc withstand must be verified according to the criteria of the standard, class A accessibility. The tests must be carried out, for each type of cubicle and for each of the three power compartments, with the LV compartment door open.

Arc fault tunnels must be provided if there is insufficient height above the switchboard or the switchroom has not been designed to dissipate arc fault gases without danger to personnel.

A separate LV compartment for LV/ELV control, monitoring, protection and indication should form part of each panel located above the relevant HV panel with access for ELV/LV wiring.

All LV and ELV contactors, relays, instruments and other similar items must be arranged so that they may be removed and replaced with complete safety when the associated HV circuit is de-energised but the other HV circuits on the rest of the switchboard are energised.

Each HV functional unit must be installed in a separate panel. All equipment associated with an individual functional unit must be accommodated in the respective panel.

Only cables associated with a functional unit may enter the cable termination chamber of that functional unit. Under no circumstances must cables from other functional units pass through the cable termination chamber of another functional unit.

Each panel in the switchboard must be wired so it can be independently fully isolated of all auxiliary power supplies for protection, control and metering functions. There must be no inter-panel bus wiring for power supplies. Only communication cable inter-panel wiring is permitted.

Cut-outs in the sheet metal through which wiring passes must be bushed with male and female screwed bushes. If cut outs are greater than 50 mm in diameter or of a non-circular shape, the edges must be fitted with a neoprene extrusion having a return of not less than 10 mm on each side. Such bushings must be neatly fitted to cover the metal completely and must be securely cemented into position.

Type test certificates for the switchboard, switchboard enclosure (for outdoor installation), incorporating cable boxes and all other accessories must be supplied by the Contractor.

2.2 Sheet metal work

The switchboard must be fabricated such that the framework is sufficiently rigid and stable to withstand all normal operating, handling and shipping forces without deformation, misalignment or damage. Removable sections of the enclosure must not be used to obtain such rigidity. Rivets can only be used in the assembly of steel sections with prior approval from Sydney Water.

Where applicable equipment rolling or wheel mechanisms must be such that the withdrawable part can be re-inserted smoothly and gently.

All steel panelling must be of folded construction, utilising 2 mm (minimum) zinc annealed sheet steel. All corners must be machine folded and raw edges must be de-burred and smoothed.

Adequate lifting facilities must be provided on each major shipping section.

The enclosure design must incorporate the following features:

2.3 Compartment doors

All compartment doors must be suitably designed and braced to prevent sagging or drumming taking into account the weight all the instruments and equipment mounted on them. All panel seams and joins must be continuously welded.

All compartment doors must have earth studs welded on the back of the doors and be equipotentially bonded to the switchboard frame with minimum 4 mm^2 earth conductors.

All compartment doors must have a continuous neoprene seal around the perimeter in order to achieve the required IP classification (the seal must be glued or fixed to the door). Instruments and electrical equipment mounted through panels must be sealed to conform to the specified IP classification.

All full height cubicle doors must be provided with a three point latching system.

All compartment doors must be accessible via the front of the panel and must be fitted with door handles that have padlocking facilities.

2.4 Surface preparation and painting

All exposed stationary metal surfaces must be prepared and painted to provide adequate protection against the adverse effects of the site conditions specified in Section 1.4.

Surface preparation and paint systems must be selected to give a life of not less than 15 years to first maintenance.

All Metal finishing, the preparation, pre-treatment of surfaces and painting must be carried out strictly in accordance with Sydney Water Standard specification WSA201 – Manual for selection and Application of Protective Coatings and WSA201 - Sydney Water Supplement and PCS100 – Protective coating standard.

Preferred paint colours	
Electrical Cabinets (Indoor)	RAL7035 (Light Grey) for external surfaces N14 (White) for internal surfaces

Preferred paint colours	
Electrical Cabinets (Outdoor)	G66 (Environmental Green) for external surfaces N14 (White) to AS2700 for internal surfaces

2.5 Fixings

All metal handles, hinges, screws and nuts must be of manufacturer's standard finish and suitably protected against corrosion.

Externally fitted fixings must be hot dipped galvanised.

Cadmium plated fixings must not be used.

All current carrying connections must be with conical washers. Bolt length is to be selected so that approximately two threads protrude on final installation.

All equipment located on equipment mounting plates must be fixed via drilled and tapped holes in the mounting plates.

2.6 HV cable termination

The switchgear must be designed for high voltage cable termination using either bolted air insulated connections or plug and socket connection.

The HV cable terminations, including all necessary accessories, must withstand the voltage impulse test applied to the switchboard.

The HV cable terminations must be designed to ensure thermal, mechanical, electrical and dielectric compatibility with the switchgear.

When the switchboard is located in a fire rated switchroom in accordance with NCC and Sydney Water HV switchrooms specification DOC0018, the switchboard design must make provision for the installation of fire stopping material to provide respective fire rating between the switchboard and the cable basement or subfloor of the switchroom.

Adequate space must be provided within each cable termination compartment for entry, dressing and termination of cables, including sufficient space for safe access by technicians for initial cable termination and subsequent testing and inspection.

Cables termination facilities must be suitable for use with termination kits readily available within Australia.

Cable connection points must be located directly above the corresponding cable entries.

Cable entries for single core cables must be designed to minimise the possibility of eddy current heating.

All HV cables must be bottom entry through earthed, removable gland plates. Adequate support must be provided for cables, terminals must not be used to support cables.

2.7 Low voltage (LV) cable termination

All LV cables must be bottom or top (bottom entry only for outdoor switchboard) entry through earthed, removable gland plates. The LV gland plates must be suitable for the fitting of cable glands for the nominated cable types.

Where LV cables do not enter directly into the bottom of the LV equipment compartment, a separate LV cable box must be provided with terminals for termination of the cables or they must be easily routed through full length metal ducting from the cable entry point to LV compartment to ensure complete separation from other compartments.

2.8 Busbars

Busbars must be housed in a separate compartment and must be sized in accordance with the relevant type test certificate.

Busbars and busbar connections must be capable of carrying rated normal current, rated short-time withstand current and rated peak withstand current compatible with the highest rating of the circuit breaker which form an integral part of the switchboard without:

a) Causing mechanical damage to any part

b) Causing flashover between phases or phase to earth

c) Exceeding a temperature rise which when added to the maximum temperature obtained when carrying the rated normal current continuously is likely to damage the insulation.

All busbars must be rectangular (with radius edges) or circular sections of hard drawn high conductivity electrolytic copper. Single bolt busbar connections will not be acceptable.

All air insulated busbar must be electro-tinned plated.

Adequate provision must be made for the extension of the switchboard at both ends. Where bolted connections are required, busbars must be made with bolt holes for future additions. Access plates must be provided at both ends of the switchboard for access to the busbars for future additions.

For air insulated withdrawable switchgear each panel must be fitted with shutters which automatically cover the busbar spigots and circuit apertures when the truck is removed. Padlocking facilities must be provided to lock the shutters when they are covering the apertures.

For gas insulated fixed switchgear separate sealed chambers must be provided for main busbar and circuit breaker. The switchboard bus and subsystems must be able to provide the rated insulation level with the insulating gas at atmospheric pressure. Visual gas pressure monitoring for each sealed chamber with a low pressure voltage free contact for remote monitoring must be provided.

Busbar connection colour coding		
Supply	L1 L2 L3	Red White Blue
Apparatus	Phase 1 Phase 2 Phase 3	Red White Blue
Neutral	N	Black
Earth	E	Green / Yellow

Busbar layout must not impede the removal and replacement of other equipment in the cubicle.

2.9 Earthing and earth bars

The frame of the switchboard must be provided with reliable earth connections to a common connection point permanently and indelibly marked in accordance with AS 62271.1.

The earth connections must have a rating suitable for the maximum earth fault current and earth fault duration, with minimum physical dimension of 30 mm x 10 mm.

The earth bar must consist of one tinned copper bar extending the full length of the switchboard. Pre-drilled holes at each end of the earth bar must be provided to allow for future extension of the switchboard.

Pre-drilled holes and fasteners for terminating screens must be provided for all incoming power cables.

Earthing switches must be provided as detailed in Section 3.6 – Earthing Switches.

2.10 Compartment for withdrawable parts

Compartments for withdrawable parts such as circuit breakers, vacuum contactors for motor starters and voltage transformers must be provided with shutters, draw-out mechanisms, connection/disconnection facilities and interlocks.

Cable and metering compartments must be interlocked to prevent energisations when covers are removed, cable and metering compartment covers must not be able to be removed until the relevant panel(s) or bus is isolated.

2.11 Shutters

Busbar shutters must be painted R13 (Signal Red) and must be clearly and indelibly labelled “BUS-BAR” in large white letters. Circuit shutters must be painted Y12 (Lemon). Circuit shutters must not be lettered except when they are for circuits that can be made live from the remote end in which case they must clearly and indelibly be labelled “DANGER LIVE CABLES” in large red letters.

For bus-tie (interconnecting) switching devices, both sets of shutters must be painted R13 (signal red) and labelled “BUS-BAR” in large white letters. In addition, an arrow must be painted in white on each shutter pointing towards the busbar with which the shutter is associated.

Voltage transformer spout shutters must be painted Y12 (Lemon).

Additional requirements:

a) Shutters must close and open automatically by positive mechanical action of the withdrawable part when the latter is being racked out of or racked into the service position.

b) Each set of shutters must be padlockable in its closed position and able to be performed whilst standing in front of the panel without encroaching minimum safe working distance in accordance with Sydney Water HV Operating Procedure.

c) To facilitate testing, a manually operated device must be installed to permit the opening and fixing, but not padlocking, of each set of shutters in the open position. The device must be designed in such a way that it will be overridden by the withdrawable part of the switching device, restoring the automatic features of the shutters. The manually operated device must be operable whilst standing in front of the panel, this manual operation must not make operator need to encroach the minimum safe working distance.

2.12 Draw-out mechanism

The draw-out mechanism must enable the inserting and removal of the withdrawable part. The mechanism must be constructed so that the proper alignment of the part is assured through all positions, inserting and withdrawing. The draw-out mechanism must provide for the following positions of the withdrawable part as defined in AS 62271.200. It must be possible for the withdrawable part to be racked in and out by either an electrical operated racking motor allowing remote operation or by a locally operated manual racking mechanism. All racking functions must be done with the switchgear doors securely closed.

The draw-out mechanism must have a minimum of five thousand (5000) operations prior to needing major maintenance.

a) Service (connected) position

b) Earthing position*

c) Test position (of withdrawable part)*

d) Disconnected position (of the withdrawable part)

e) Removed position (of withdrawable part).

* Not required for voltage transformers

Withdrawable switching devices must be lockable in the ‘service’, ‘test’, ‘cable earth’, ‘bus earth’ and ‘disconnected’ positions.

2.13 Connection / disconnection facilities

For primary circuits the engagement of the withdrawable part with the stationary line and load terminals must take place automatically using self-aligning disconnection devices. Secondary control, metering and protection circuit connections must be made by means of self-aligning plug and plug socket contacts or a multi core cable with a plug and plug socket arrangement. The voltage-carrying part of the fixed gear must be of the female type, while the withdrawable part must be of the male type.

2.14 Operation

It must be possible for one operator to perform all switchgear operations including bus disconnection, earth switch operation, and circuit breaker open and close with all compartment doors closed and secured.

The switching components must be rated for a minimum of three thousand (3000) operations.

The switchboard must be designed for remote operation and local operation. All local operating functions must be capable of being carried out by an operator whilst standing in front of switchboard at floor level.

2.14.1 Local operation

The control circuit of the HV switchgear must be complete with an anti-pumping device to ensure the complete execution of initial operation and suitable interlocks to prevent simultaneous local and remote initial of operation commands.

For withdrawable voltage transformers it must be possible to rack-in, rack-out and lock any isolating bus shutters by the operator whilst standing at floor level. Where operation of any equipment whilst standing in front of switchboard at floor level is not achievable the contractor must provide a suitable means of safe access to operate the equipment.

All operating mechanisms, including circuit breaker closure control, must be pad-lockable.

A “test” mode must be provided to enable the switch unit to be operated when isolated from the supply busbars (i.e. with bus disconnected). This must allow the testing of all auxiliary circuits and mechanical functions and enable the circuit breaker to be operated.

I switchgear design must provide effective arc barriers on enclosed switches and circuit breakers, where the operating handle can be operated through a slot in the enclosing case. Design must provide protection for personnel, particularly when located at the front of the switchboard, and must maintain compartment segregation under fault conditions.

The contractor must address the issues outlined in Annex A1, 2, 3, 4, 5, 6, 7 and 8 of AS62271.200 in demonstrating the arc containment capabilities of the switchgear offered.

2.14.2 Remote operation

Switchgear remote operation is to operate HV switchgear outside HV area via a remote switching panel or a computer based operating platform. Remote switching must only be enabled or disabled via designated selector switches on the HV switchgear panel. When the switchgear is in remote operation mode, the relevant panels should be available to be operated via the remote operating device or at the switchgear panel(s), when the switchgear is in local operation mode, the relevant panels must only be available to be operated at the switchgear panel(s). Both remote operation and local operation must not defeat switchgear mechanical and electrical interlock arrangement.

2.15 Lifting lugs

Removable lifting lugs must be provided for transportation and erection purposes.

2.16 Foundations, fixing bolts and packers

The contractor must provide dimensions and loadings of the equipment to allow for the design and construction of the foundations.

All necessary floor frames, rails, foundation and fixing bolts, must be furnished by the contractor in sufficient time to be incorporated in the foundations.

3. Technical requirements - HV switchgear and equipment

3.1 General

Circuit breakers (Vacuum or SF_6) must be utilised for:

a) Incoming feeder circuits

b) Transformer Feeder circuits

c) Bus Interconnector circuits

d) VSD Feeder circuits.

Fused vacuum contactors must be used for:

a) Direct on-line motor starting circuits.

Each switchgear unit or combination must be capable of making, carrying and breaking the circuit load current or switch rated current, whichever is the greater. The switchgear must also be capable of making, carrying for the specified time and breaking full prospective fault currents corresponding to the nominated symmetrical fault level of the system.

Each switchgear unit must be arranged such that it may be maintained without interfering with power supply to other switchgear units forming part of the switchboard.

Switchgear must be metal enclosed. Isolation must be by either circuit breakers or fault make, load break switches, or bus disconnectors.

The switching device must open simultaneously 3 poles of a 3 phase, 50 Hz circuit with rated voltage between phases equal to the nominated system voltage. The temperature rise of switching devices of any voltage must be subject to the limitation of Table 3 of AS 62271.1. Temperature rises must be maintained within the specified limits with the switching device mounted within the switchboard enclosure.

The breaking current rating must be as specified in AS/NSZ 60265.1 and AS2024 as appropriate. The prospective symmetrical fault levels applicable must be calculated by the Contractor. The switching device must withstand the forces due to maximum fault.

3.2 Switchgear dielectric medium

Air or sealed low pressure SF_6 gas must be used for the dielectric medium for withdrawable or fixed type switchgear. Oil will not be considered. Where SF_6 gas is used for the filling of the switchgear it must be in accordance with IEC 376.

It is preferable to fit an absorption material in the tank to absorb the moisture from the SF_6 gas and to regenerate the SF_6 gas following arc interruption.

The SF6 insulating medium must be constantly monitored via a gas pressure indicator offering a simple go, no-go indication and alarm output contact.

3.3 Circuit breakers (CBs)

Circuit breakers must be designed in accordance with AS 62271.100.

Circuit breakers must be capable of breaking both the symmetrical and asymmetrical rated short-circuit “breaking” current.

CB mechanisms must be stable and not operate due to vibrations or impact.

CB mechanisms must be designed to prevent "slow open" or "slow close" while in normal service due to failure to latch correctly or for any other reason.

The designer must select circuit breaker endurance ratings and rated operating sequence based on the load and expected mode of operation.

3.3.1 Closing

Switchgear closing must be available by an electrically charged spring with manual and electrical release to allow local and remote operation. The spring must be automatically charged following initial connection of supply voltage and must recharge following a closing operation of the switching device and capable of being left in the charged position for an indefinite period.

CB mechanisms must be designed in such a manner that no damage will be caused to any part of the CB if, while charged, the closing spring is released when the CB is already CLOSED. CB mechanisms must be designed to prevent reclosing against a collapsed mechanism.

The following must apply:

a) It must not be possible for the circuit breaker to close while the spring is being charged

b) It must be necessary for the spring to be fully charged before it can be released to close the circuit breaker

c) It must be possible to charge the spring when the circuit breaker is open or closed

d) The closing mechanism must not be dependent upon one spring only

e) A mechanical indicating device must be provided to indicate the state of the spring and inscribed "spring charged" when the mechanism is in the condition to close the circuit breaker and "spring discharged" when in any other condition

f) A limit switch must be provided for remote spring charged indication. Minimum of 2NO + 2NC contacts must be provided

g) must be possible to manually charge the closing spring mechanism.

Where closing is specified as being by a hand charged spring with manual release the speed of operation of the circuit breaker must be entirely independent of the speed of operation of the operating handle.

3.3.2 Tripping

Tripping must be possible by both:

Local mechanical trip method (for maintenance purposes)

Local and remote electric trip methods.

Remote operation must not affect the integrity of the protective device tripping circuits.

The tripping mechanisms must be of a type that acts directly on the circuit breaker mechanism

Trip coils must be continuously rated.

All CB’s must have mechanical latching with electrical and mechanical tripping and must automatically open if a reduction in switching medium occurs. Local and remote indication must be provided to confirm such an event. The operating mechanism must be trip-free and include an anti-pumping device.

3.3.3 Operating voltages

All switching devices must be able to meet their rated making duty for closing circuit voltages from 80% to 120% of nominal and their rated breaking capacity for the trip circuit voltages from 50% to 120% of nominal.

Switchgear Auxiliary Switches and Indications

Sufficient auxiliary switches must be provided to meet the control circuit and monitoring circuit requirements and three spare contacts of each type.

Contacts must be individually adjustable for early or late operation.

A mechanical “OPENED-CLOSED” or “ON-OFF” indicator must be provided that is directly driven by the operating mechanism to avoid incorrect indication in the event of linkage failure.

Mechanical interlocking must be provided between different components of the equipment for reasons of safety and for convenience of operation in accordance with AS 62271-200.

A mechanical operations counter must be provided to monitor the main switching unit.

3.3.4 Fixed CBs

Each circuit must be provided with fault-make, load break switches to disconnect the circuit from each bus. The disconnectors must be electrically and mechanically interlocked with the circuit breaker and be both electrically operable via remote and local operation and also manually operable locally.

For manual operation, the disconnectors must be mechanically interlocked so the manual operation is only possible with the circuit breaker open. Manual operation must also be possible in the absence of the auxiliary supply.

The position of the disconnectors must be indicated on the front panel. The disconnection of the circuit from bus must be viewable (visible break). Details of how this is achieved must be included in tender.

Where disconnectors require locking in accordance with AS 2067, provision must be made for application of padlocks.

3.3.5 Withdrawable CBs

It must be possible for the withdrawable circuit breaker to be racked into and out of the service, disconnect and test position both remotely by electrical operation and locally by mechanical and electrical operation. All racking operations of the withdrawable CB must be possible with the compartment door securely closed and mechanical interlocked to prevent inadvertent operation. Electrical and mechanical position indication of the withdrawable CB must be provided.

Withdrawable circuit breakers and its operating mechanism must have a minimum three thousand (3000) operations prior to needing major maintenance.

Padlocking facilities must be provided for each position

SERVICE in which the main and secondary circuits are connected

TEST in which the main circuit is isolated, but the secondary circuits connected

ISOLATED in which both the main and secondary circuits are isolated

All withdrawable CB trucks must be earthed via spring-loaded sliding connection or a plug and socket connection such that the earth connection makes before and breaks after the main circuit connections.

3.3.6 Sulphur hexafluoride (SF_6) CBs

The interrupting portion of each pole must preferable be comprised of single low-pressure units in modular form designed for easy removal and replacement.

The unit must be capable of interrupting fault current with no adverse effects on loss of SF_6 pressure down to atmospheric pressure. Means must be provided to check the SF_6 gas pressure during maintenance periods.

The circuit breaker must be designed to avoid condensation of SF_6 gas caused by arcing.

Means must be provided to protect the main contacts from burning during the operation of the circuit breakers.

3.3.7 Vacuum CBs

The interrupter units in each pole must be readily accessible for inspection and the assembly designed for convenient removal and replacement of the vacuum units.

Means must be provided to protect the contacts from burning or welding during the operation of the circuit breakers.

The contacts of the circuit breaker must be held open by a positive fail-safe mechanical latch. The closing arrangement must be designed to give a positive closing action whilst overcoming the contact hold open device and must in no way be dependent on interrupter vacuum.

3.4 Fused vacuum contactors (FVCs)

HV FVCs must be designed in accordance with AS 604–0 - 2001.

Vacuum contactors must have minimum utilisation category AC4 and duty of 12 operating cycles per hour, Class12.

Control supply for FVC units must be a single mounted VT supply of adequate rating for unit.

The rating selected for a contactor must be based on uninterrupted duty. Rating selection based on intermittent or 8-hour duty is not acceptable. Contactors must be capable of making and carrying for a specified time at least 10 times rated current and must be capable of breaking at least eight times rated current.

All FVCs must be of withdrawable construction.

It must be possible for the withdrawable FVC to be racked into and out of the service, disconnect and test position both remotely by electrically operation locally by mechanical and electrical operation. All racking operations of the withdrawable FVC must be possible with the compartment door securely closed and mechanical interlocked to prevent inadvertent operation. Electrical and mechanical position indication of the withdrawable FVC must be provided.

All withdrawable FVC trucks must be earthed via spring-loaded sliding connection or a plug and socket connection such that the earth connection makes before and breaks after the main circuit connections.

Closing

Vacuum contactors must be electromagnetic operation and must be electrically held unless otherwise specified in site specific specification.

Tripping

Tripping must open the contactor when supply to the holding coil is interrupted.

Striker Pin Operation

Where HV fuses are used in conjunction with vacuum contactors, the fuses must incorporate striker pins. When activated, the striker pin must operate a latching switch with minimum 2 N/C and 2 N/O contacts. The N/O contact will trip the contactor if direct mechanical operation is not possible. The other N/O contact and one N/C contact will be used for remote indication purposes.

3.5 Disconnector switches

Disconnectors must be double break designed in accordance with AS 62271.102.

Disconnector switch mechanisms must be stable and not operate due to vibrations or impact.

Disconnector switch mechanisms must be designed to prevent "slow open" or "slow close" while in normal service due to failure to latch correctly or for any other reason.

The switches must be of the “increased operating frequency” in accordance with the standards. They must be constructed in such a way that natural interlocks prevent incorrect operation. Padlocking facilities must be provided for each position.

Mechanical endurance must be a minimum of M2 as per AS 62271.102

3.5.1 Closing and opening

Closing and opening should be possible by both:

a) Local mechanical method (mandatory)

b) Electric methods (local and remote).

Local and remote indication must be provided to confirm such an event.

3.5.2 Operating voltages

All switching devices must be able to meet their rated making duty for closing circuit voltages from 80% to 120% of nominal and their rated breaking capacity for the open circuit voltages from 50% to 120% of nominal.

3.5.3 Switchgear auxiliary switches and indications

Sufficient auxiliary switches must be provided to meet the control circuit and monitoring circuit requirements and three spare contacts of each type.

Contacts must be individually adjustable for early or late operation.

A mechanical indicator must be provided that is directly driven by the operating mechanism to avoid incorrect indication in the event of linkage failure.

Mechanical interlocking must be provided between different components of the equipment for reasons of safety and for convenience of operation in accordance with AS 62271-200.

A mechanical operations counter must be provided to monitor the main switching unit.

3.6 Earthing switches

All incoming and outgoing circuits must be provided with a suitable method of earthing the HV cables for maintenance purposes. Actual earthing must be carried out by a fault-make load-break switch. All earth switches must be provided with mechanical interlocks to ensure that the earth switch cannot be closed onto a ‘Live’ circuit.

Where access to the exposed bus is required for maintenance purposes or to access any metering instrument transformers for regulatory testing, the bus must be earthed by an earth switch. Interlocks must be provided between bus earth switches and switchboard incoming circuits to ensure bus earth switches are not possible to be closed on to a live bus.

Switchgear panel cover and metering panel cover must also be interlocked to ensure the panel cover can only be opened when the respective earth switch is applied. Also, the earthing cannot be removed when the respective panel cover is not put back on.

Earthing switches must be preferably electrically operable to allow for remote control. Where remote switching cannot be provided, the manufacturer must provide a solution that applies an earth that will remove the operator from the vicinity of any potential arc fault.

Manually operable earth switches must be from outside the equipment enclosure. The speed of operation of the earth switch contacts must be independent of the rate of movement of the operating handle.

Electrical (via auxiliary contacts) and mechanical position indication of the earth switch must be provided. The mechanical position indicators must be visible at the point of operation.

All earth switches must have provision for padlocking the switch in the open and closed position.

Where earthing is achieved through the circuit breaker, the circuit breaker must not be able to be tripped by any protection device and can only be opened by the operator.

Earthing switches must comply with AS 1306, AS/NZS 60265.1and AS 62271-102.

3.7 Voltage transformers (VTs)

Voltage transformers must be designed in accordance with AS 60044.2 and must have phase-to-phase secondary terminals of 110 V. Voltage transformers must have appropriate number of secondary winding(s) required by the design.

For primary switchgear, VTs must be of the withdrawable type with HV fuse and LV miniature circuit breaker mounted on the withdrawable carriage. Auxiliary contacts from the LV MCB must be wired to the LV compartment / cable box.

For secondary switchgear, VT's are preferred to be withdrawable type with HV fuse and LV miniature circuit breaker mounted on the withdrawable carriage. Fixed type VTs may be accepted with prior approval from Sydney Water. Auxiliary contacts from the LV MCB must be wired to the LV compartment / cable box.

Operation to withdraw the voltage transformer and locking of any isolation shutters must be possible by the operator from floor level.

VT secondary wiring must be same colour as the respective primary phase conductors.

Partial discharge tests must be performed on every VT. Acceptable values for partial discharge must be in accordance with AS 60044.2. NATA test certificates must be supplied.

VTs for power monitoring purposes are preferred to be on the lineside of incomers for a switchboard.

3.8 Current transformers (CTs)

CTs must comply with AS 60044.1-2003 and be designed with insulation and fault level ratings compatible with the switchgear.

CTs must be mounted within the confines of the switchboard, i.e. it must not be necessary to mount CTs in the cable basement below the switchboard.

CTs must preferably not be mounted in spaces containing the insulating gas (other than air).

CT secondary wiring must be the same colour as the respective primary phase conductors.

CT rating plate details must be duplicated on the outside of the circuit chamber housing the CT.

All CT tappings must be wired to slide test link terminals in the LV compartment / Cable box of the switchgear.

A magnetisation curve must be obtained from the manufacturer for each CT in order to:

a) Detect damage in transit or installation

b) Prove that the correct cores have been wired out to the relevant terminals.

The DC resistance of each CT secondary winding must be measured and also (where possible) the DC resistance of the transformers and connecting leads, each item being recorded separately.

The insulation resistance of all secondary circuits must be measured at 1000 V DC and recorded.

Primary current injection tests must be conducted on all CTs using adequate primary current to prove correct ratio, polarity and for differential protection schemes, to prove the correct relative polarities of all CTs of each scheme.

Partial discharge tests must be performed on every CT. Acceptable values for partial discharge must be in accordance with AS 60044.1.

Records of all such tests by the CT manufacturer(s) must be collated by the Contractor for review during the auxiliary transformer factory tests (refer Section 6.2 - Routine (Factory) Testing).

3.9 Instrument transformers for revenue metering

For VTs and CTs used for the revenue metering purposes, they design must ensure they can been safely accessed for NATA certificate calibration and replacement. Test links or bars should be considered to facilitate instrument transformer testing and removing instrument transformers for maintenance must not be cause major alteration to the equipment they connected with. For dual power supply facility, working instrument transformers on one power supply must not be required to isolate other power supplies to the site.

3.10 Other safety related requirements for switchgear assembly

In accordance with AS 4024, Instruments, control switches, hand operated devices, and components that require to be seen and operated must be installed with a centre line between 200 mm and 1680 mm from the floor. The centre line of all indication devices must be mounted no taller than 1850 mm from the floor.

The design must eliminate the need for a worker to access this equipment while adjacent equipment is energised and has the potential to cause electric shock due to unintentional inadvertent contact.

3.11 Bushings

All bushings rated at > 1 kV must be designed to meet the requirements of AS/NZS 60137 and the rated voltage, current and environmental conditions as specified in section 2.1 of this Specification.

3.12 Station insulators

All station insulators rated at 1 kV must be porcelain type designed to meet the requirement of AS 4398.1 and the rated voltage, current and environmental conditions as specified in section 3.1 of this Specification.

3.13 Busbar and connections

Busbars and busbar connections must be capable of carrying rated normal current, rated short-time withstand current and peak withstand current without:

a) Causing mechanical damage to any part

b) Causing flashover between phases or phase to earth

c) Exceeding a temperature rise which when added to the maximum temperature obtained when carrying the rated normal current continuously is likely to damage the insulation.

3.14 Live line indication

Capacitive voltage detecting systems must be fitted to all HV switchgear. These must be installed in locations which verify safe isolation of supply of all incoming feeders, outgoing feeders, and bus bars. The system must include the following features:

a) LCD or LED voltage indication

b) Integrated test sockets with the ability for connection of a phase comparator

c) Testing points (100 V).

3.15 Operating tools

Two complete set of operating tools must be supplied for the HV switchboard including:

a) Manual spring charge handle

b) Earth switch operating handle

c) CB racking handle

d) FVC racking handle

e) Three-phase HV test plugs for insertion into busbar or cable-side spouts

f) Trolley for CB truck

g) Trolley for FVC truck

h) CB truck test leads

i) FVC truck test leads.

Notes:

Where the CB and FVC use the same truck or test leads then only two sets of trucks or test leads required in total. The Trolley for CB trucks or FVC trucks must be lockable to the switchboard (during the insertion or removal of a truck).

4. Technical requirements - LV and ELV control and protection equipment

4.1 General

All control equipment must be equipment with IP2X terminals. If this cannot be achieved the Contractor must manufacture removable shrouds.

Where applicable, miscellaneous control equipment such as non-protection type control relays and signal transducers must be selected for mounting on TS35 rail.

Non-protection type control relays must include an onboard mechanism indicating when the relay coil is energised (e.g. mechanical flag or LED).

Equipment mounted directly onto the back pane of the low voltage compartment must be done so using tapped machine screws. Self-tapping screws will be rejected.

4.2 Equipment layout

Within the limitations of the standard size low voltage control compartment, observe the following:

a) Duct work must be at least 50 mm from any terminal insertion point

b) Duct work must be at least 50 mm from any rail mounted device

c) Duct work must be at least 50 mm from any other component not mentioned in b) or c) above.

Wiring work at the back of the LV compartment door should not make contact with the installation inside the LV compartment during the LV compartment door opening or closing.

4.3 Control and protection equipment on LV compartment door

As a minimum, the LV compartment door of each tier of HV switchgear must be fitted with the following control and protection equipment:

a) Digital protection relay(s) incorporating HMIs for CB

b) Test block for secondary injection testing of digital protection relay(s) for CB

c) Pilot lights indicating CB, FVC and Disconnector Switch status (OPENED and CLOSED)

d) Pilot lights indicating Protection trip for CB

e) LOCAL-REMOTE control selector switch for CB and Disconnector Switch

f) TRIP-N-CLOSE control switch with spring return to the centre position for C/B

Pilot lights indicating FVC or Disconnector Switch status (RUNNING and STOPPED or OPENED and CLOSED)

START and STOP pushbuttons

Pilot Lights indicating circuit earth or bus earth is applied (Bus Earth On or Circuit Earth on)

Common push to test button to test all indication lamps on the LV compartment door.

Note: Signal lights on protection relays are not deemed as pilot indication light in this specification, all indication lights must comply with requirements in section 5.6.

Trip and Close / Start and Stop functions must be able to be performed remotely using two different methods. Separate terminals are to be provided for each method. These are:

a) Hard wired from a remote control panel external to the building housing the switchgear

b) Via an external PLC.

4.4 Control switches and control selector switches

Each switchgear low voltage control compartment must be provided with:

a) A two position (REMOTE, LOCAL) selector switch, providing selection of remote or local operation of the switchgear. When the switch is selected in remote, only remote open and close operation must be possible with local functions locked out. When the switch is selected in the local, only local open and close operation must be possible with remote operational functions locked out. Protection tripping must not be affected by which position the selector switch is in.

b) A three position (TRIP, NEUTRAL, CLOSE) control switch with spring return to neutral action, for local trip/close operation of the switchgear.

The mechanical endurance of all control switches must be at least 100,000 operations.

Each control selector switch must be provided with a teardrop style operating handle and an escutcheon or label plate of engraved plastic laminate material having white letters on a black background.

Selector switches must comply with the following minimum requirements:

a) IP54

b) Engraved escutcheon plate mounted above the switch

c) Contacts rated 240 V AC, 5 A AC, utilisation category AC14, silver plated.

4.5 Pushbuttons

Pushbuttons must be dust proof and arranged to prevent the ingress of dust into the switchboard. The colours of pushbuttons must comply with IEC60073.

Pushbuttons must not have exposed live terminals.

Emergency stop pushbuttons must be shrouded to avoid accidental trip and must comply with SCW Emergency Stops Policy.

Pushbuttons must comply with the following minimum requirements:

a) IP54

b) 22 mm diameter body

c) Engraved escutcheon plate mounted above the pushbutton

d) Contacts rated 240 V AC, 5 A AC, utilisation category AC14, silver plated.

4.6 Indicating lights

Indication lights must operate on the switchboard at the auxiliary supply as specified in section 1.5 of this specification. The colours of indication lights must typically comply with IEC60073.

Indication lights must comply with the following minimum requirements:

a) IP54

b) 22 mm diameter body

c) LED cluster type

d) Lamp replacement from the front only

e) RED lens for CLOSED

f) GREEN lens for OPENED

g) AMBER lens for ABNORMAL CONDITIONS

h) WHITE lens for NORMAL CONDITIONS

i) Engraved escutcheon plate mounted above the lens.

Indicating lamps must be suitable for lamp replacement from the front of the panel without the use of tools.

Indication lights must not have exposed live terminals.

4.7 Lamp test pushbutton must be installed, push to test indicating lamp must not be used. Fuses and links

Fuses and links must be of the cartridge, high rupturing capacity type generally complying with the requirements of AS 60269 and AS 60818.

All LV fuses and links must be installed with appropriate facilities for isolation lockout with a standard isolation padlock.

4.8 Miniature CBs

MCBs must be provided for isolating all auxiliary power supplies in the LV compartment of each tier of all HV Switchboards.

MCBs must comply with the following minimum requirements:

a) Compliant with AS/NZS 60898 series and AS 3111

b) DIN-style

c) Fault breaking and fault making capacity of not less than 10 kA

d) Appropriate facilities for isolation lockout with a standard isolation padlock.

4.9 Miniature relays

Miniature relays must comply with the following minimum requirements:

a) Compliant with AS 60947series

b) Plug-in flat-pin style

c) DIN rail mounted base

d) 48 V DC coil voltage complete with in-built suppression and diode protection

e) Integral LED indication

f) Contacts rated 240 V AC 5 A

g) Comply with all other requirements in Sydney Water Technical Specification - Electrical.

4.10 Digital energy metering

Each incoming circuit must be provided with a digital power and energy metering unit monitoring the incoming side of the circuit. Unconventional voltage and current sensing devices may be accepted for power monitoring purposes only, the application will be subjected to Sydney Water's prior approval. The unit must have a LED display where the following power parameters can be displayed. The unit must also be compatible with IEC 61850 communication protocol which can then be utilised by Sydney Water SCADA/IICATS.

a) Voltage L-N (average, per phase)

b) Voltage L-L (average, per phase)

c) Frequency

d) Current (average, per phase)

e) kW/MW (total, per phase)
f) kVAr/MVAr (total, per phase)
g) kVA/MVA (total, per phase)
h) kWh/MWh (total, per phase)
i) kVArh/MVArh (total, per phase)
j) kW/MW (demand, peak)
k) kVA/MVA (demand, peak)
l) Current demand (average, per phase)
m) Current peak demand (average, per phase)
n) Power Factor (total, per phase)
o) Voltage THD (per phase)
p) Current THD (per phase).

4.11 Protection relays

All Protection Relays must be in accordance with Sydney Water Standard specification DOC0014 - Protection Relays.

Each incoming and outgoing circuit must be provided with a protection relay appropriate to the nature of the protected circuit.

4.12 Trip circuit supervision (TCS)

Each CB trip coil must be equipped with trip circuit supervision (ANSI 74TC).

This must be achieved integrally within the digital protection relay (preferred) or via a separate trip circuit supervision relay.

4.13 Anti-condensation heaters

Separate anti-condensation heaters should be provided within each HV cable compartment and must be provided for each LV compartment of each switchboard tier.

The auxiliary supply voltage for anti-condensation heaters must be 240 V AC ± 10%.

Anti-condensation heaters must be sized appropriately with the consideration of all possible impacts and variables, such as: ambient temperatures, spatial dimensions, heat generated from electrical loads, etc.

Anti-condensation heaters must be controlled by means of individual adjustable thermostats within each compartment.

Isolating circuit breakers within each LV compartment are to be provided for the anti-condensation heaters within that tier.

The anti-condensation heaters, thermostats, and wiring terminations must be guarded and/or shrouded to prevent inadvertent personnel contact with hot surfaces or live terminals during testing, commissioning or routine service and maintenance activities.

Anti-condensation heaters must include a method of indicating unit failure. The indication signal must be connected to relevant monitoring interface to alarm purposes.

4.14 LV and ELV wiring

All LV and ELV wiring is to be installed in a neat and logical manner following standard industry practices.

All LV and ELV wiring must fully comply with the requirements of AS 3000 Wiring Rules.

All conductors must be FLEXIBLE stranded tinned copper wire.

Minimum conductor sizes must be:

Item	Wire type	Wiring and/or Conductors	Colours
Extra Low Voltage (AC or DC)	1.5 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147	Active/Positive Neutral/Negative	Light Grey (LtG)
240 V AC control when supplied from same compartment or SCA	2.5 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147	Active Neutral	Brown (BN) Black (BK)
In all other cases		Active Neutral	Orange (O) Black (BK)
CT and VT secondaries	4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V105 to AS 3147	Red Phase White Phase Blue Phase Neutral	Red (R) White (W) Blue (B) Black (BK)
Core Balance toroids	4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V105 to AS 3147	S1 S2	Black (BK) Black (BK)
Earth conductors	Minimum 4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147		Green-Yellow (G-Y)
Instrumentation twisted pair conductors		Positive Negative	White (w) Black (BK)
Ethernet	CAT 6		Blue
Conductors connecting voltage free relay contacts where the voltage is undefined	1.5 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147	Active/Positive Neutral/Negative	Violet (V)

All LV and ELV wiring is to be installed in plastic cable duct with clip-on covers, strapped looms or flexible conduit is to be provided from panel to door. Cable ducts are to have 30% spare capacity. Panel to door wiring must include a loop to relieve stress and must be anchored at the panel and the door.

No joints in runs of wiring (i.e. at locations other than at terminals) must be permitted.

All LV and ELV wiring is to be arranged so that the line side is connected to the top of the respective device.

Adhesive wiring supports are unacceptable.

Where wiring is to pass through cut-outs in panelling, the hole must be bushed.

All terminal strips and individual terminal blocks must be labelled using proprietary labelling/numbering systems.

All conductors must be terminated at both ends with pre-insulated crimp terminations. They must be of the correct size for the conductor and must be applied with the terminations manufacturer's tool.

- Ring type termination lugs must be used for terminating to stud-type terminals
- Lip blade termination lugs must be used for terminating to rail-type terminals
- U shaped termination lugs must be used on selector switches and similar small equipment.

Solder connections are not acceptable.

All conductors must be uniquely numbered at both ends in accordance with the respective schematic diagrams.

All field wiring must be marshalled at terminal strips.

Terminals must comply with the following requirements:

a) Tunnel type connectors

b) Disconnect terminals must be provided for all CT and VT secondary wiring in addition to the protection relay test blocks

c) Only one conductor must be terminated on each side of each terminal

d) All terminal strips must maintain a degree of protection of IP2X

e) All field cabling must be terminated on one side of each terminal strip and all panel wiring must be terminated on the other side of the terminal strip

f) For clarity, provide barriers between groups of terminals having different functions (e.g. between terminals for protection and terminals for CT secondaries)

g) Provide a separate earth terminal for each field cable

h) All terminal blocks must be uniquely numbered in accordance with the respective schematic diagrams

i) All terminals must be uniquely numbered in accordance with the respective schematic diagrams

j) MCB's must be provided for isolating all auxiliary power supplies in the LV compartment of each tier of all HV Switchboards.

4.15 Interfaces with external systems and equipment

Interfaces between the Switchboard and external systems and equipment must be provided in accordance with Sydney Water SCADA/IICATS requirements.

All hardwired CT and VT secondary signals to external systems must be provided with disconnect/test terminals.

All hardwired VT secondary signals to external systems must be provided with a suitably rated MCB for protection and isolation of the external equipment.

The following signals must be included as a minimum for each circuit:

a) CB or FVC racked out (for withdrawable switchgear only)

b) CB or FVC racked in (for withdrawable switchgear only)

c) Isolator opened (for fixed switchgear)

d) Isolator closed (for fixed switchgear)

e) CB or FVC opened
f) CB or FVC closed
g) CB or FVC tripped
h) Earth switch opened
i) Earth switch closed
j) Trip circuit healthy
k) Protection relay operated
l) Protection relay healthy
m) Supply Authorities supply healthy.

4.16 Remote switching panel

Remote Switching Panel must be provided for switchboard capable of carrying out motorised remote operation for Circuit Breakers, Disconnector Switches and Earth Switches. Remote switching panel must also be able to demonstrate the mimic of the HV system it is representing with real time equipment status indication.

Remote Switching Panel must be either a hardwired signalling control panel or an HMI computer based terminals.

Remote Switching Panel must be fitted in a Control Cabinet preferable to be housed in LV building or structure adjacent to HV switchroom or switchyard, if LV building or structure is not available, the Remote Switching Panel must be installed on a free-standing pedestal no closer than 10 meters to the HV switchgear. Additional LED lighting in the remote switching panel must be considered to aid the operation. For detail requirement of a Control Cabinet, please refer to Sydney Water Technical Specification - Electrical.

Where the switchboard design has included provision for future expansion, the design of the respective remote switch panel should consider space for additional controls.

5. Identification and labelling

All electrical equipment forming part of the switchboard must be readily identified in the English language by a label in accordance with the relevant standard and this Specification.

All labelling and nameplates must be in accordance with nomenclature used on the relevant electrical Drawings and Schedules provided by Sydney Water.

All labels must be permanent, free from fading, engraved, embossed or pressed multi-layered thermosetting plastic or metal. Labels must be secured suitable coated machine screws into tapped holes. Departures from these requirements must require the written pre-approval of Sydney Water.

All equipment labels must be mounted on a fixed portion of the enclosure directly adjacent to the device.

Terminal block group labels must be manufactured of the material and mounted in accordance with the standard procedures adopted by the terminal strip manufacturer. Terminals must not be made of brittle material.

Generally, labels must be manufactured to the following specification:

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
Switchboard main label - Mounted in centre of fully assembled switchboard	400 L x 100 H	Black / White	Switchboard Number Switchboard Name	40 20
Switchboard rating plate - Mounted on the centre panel LV compartment door of the fully assembled switchboard	120 L x 100 H	Black / White	Sellers/manufactures name Purchase order number Year of Manufacture Type and serial number Switchboard voltage, current, and fault rating	10 10 10 10 10
Circuit number (Sydney Water Number plate style) -mounted on LV compartment door of panel, Withdrawable compartment door of panel and, rear cover of panel - Mounted on the front of the CB or FVC	100 L x 100 H	Black/Yellow	Switch Number	80
Circuit name -mounted on LV compartment door of panel, Withdrawable compartment door of	100 L x 60 H	Black / White	Circuit Name	40

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
panel and, rear cover of panel				
FVC MV fuse rating label - Mounted on Withdrawable compartment door and the front of FVC	50 L x 30 H	Black / White	Fuse Fuse rating / Holder rating	10 10
HV compartment label - Mounted on all compartment doors that provide access to HV		White / Red / Black	DANGER HIGH VOLTAGE (to AS 1319)	
All other removable cover labels that provide access to high voltage equipment - Mounted on all covers that provide access to HV		White / Red / Black	DANGER HIGH VOLTAGE (to AS 1319)	
Current transformer - Mounted on side wall in the LV compartment of specific circuit	50 L x 30 H	Black / White	Circuit Number Function e.g. metering Cores ratio Class	5 5 5 5
Voltage transformer and reactor labels - Mounted on side wall in the LV compartment of specific circuit	50 L x 30 H	Black / White	Circuit Number Function e.g. metering winding ratio Class / VA	5 5 5 5
Busbar Shutter label -Mounted on all shutters that provide access to HV main Busbar		White / Red	BUS-BAR	40
Circuit Shutter label (for circuits with cables that can be made live from remote end only) -Mounted on circuit shutters		Red / Yellow	DANGER HIGH VOLTAGE	40
All compartment door mounted equipment labels		Black / White		3

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
(e.g. Controllers, indication lights, selector switches, pushbuttons etc) - Mounted on front and rear of LV compartment door below equipment				
All compartment internally mounted equipment labels (e.g. control relays, control MCBs, Terminals etc) - Mounted below equipment		Black / White		3

5.1 Label schedule

A label schedule showing details of each label must be submitted for approval prior to manufacture of the relevant labels.

6. Testing requirements

6.1 Type testing

Type test reports must be provided by the Contractor for the switchboard enclosures, VCBs, FVCs, and earth switches for all type tests listed within:

AS 60044.1	Instrument transformers - Current transformers
AS 60044.2	Instrument transformers - Voltage transformers
AS 62271.100	HV switchgear and control gear - HV AC circuit-breakers.
AS 62271.102	HV switchgear and control gear - AC disconnectors and earthing switches.
AS 62271.200	HV switchgear and control gear - AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.
AS 60470	HV AC contactors and contactor-based motor-starters.

A covering report must be provided by the Contractor that includes:

a) Details of the design of the type tested equipment (including drawings).

b) An explanation why any differences do not affect the integrity of the type tests.

c) Full copies of the type test report(s).

If new type tests are performed, Sydney Water must be given the option of witnessing all inspections and tests. Sufficient notice (14 calendar days for tests on site, 42 calendar days for test elsewhere in Australia, 42 calendar days for tests outside Australia) must be given to enable the necessary travel arrangements to be made.

Copies of all type test reports (whether previous or new) must be submitted by the Contractor to Sydney Water.

Applicable type tests reports for other equipment, components, protection relays, etc must be provided by the Contractor upon request by Sydney Water.

6.2 Routine (Factory) testing

Perform routine (factory) tests on each tier of switchgear prior to shipment to site. Such tests must include all routine tests listed within:

AS 62271.100	HV switchgear and control gear - HV AC circuit-breakers.
AS 62271.102	HV switchgear and control gear - AC disconnectors and earthing switches.
AS 62271.200	HV switchgear and control gear - AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.

Routine (factory) tests must include:

a) Detailed mechanical inspection

b) Detailed electrical inspection

c) Verification of correct labelling

d) Mechanical tests on all mechanical interlocking, key interlocking and padlocking systems

e) Mechanical tests on all CBs earth switches

f) Mechanical tests on all FVCs earth switches

g) Electrical tests on all electrical interlocking and synch-check systems

h) Review of setup parameters for all digital protection relays

i) Functional tests on all operations counters, position indicators, capacitive voltage indicators, etc

j) Functional testing of all control and indication circuits. Functional testing of all protection circuits via secondary injection

k) **Note** - secondary injection testing must be carried out at a minimum of three current settings to verify correct operation of protection relays

l) Functional testing of all metering circuits

m) Insulation resistance tests (before dielectric withstand tests)

n) Dielectric withstand tests (power frequency tests)

o) Insulation resistance tests (repeated after dielectric withstand tests)

p) LV wiring flash tests (insulation resistance/dielectric withstand/insulation resistance)

q) HV circuit resistance (“Ductor") test between main busbar tags and outgoing cable tags

r) Inspection of all loose-supplied equipment

s) Verification of all CT ratios and polarity of all CT connections

t) Partial discharge tests on all CTs and VTs (if not already performed at the place of manufacture)

u) Magnetisation tests on all CT’s (if not already performed at the place of manufacture)

v) Review of routine test certificates for CBs, FVCs, CTs and VTs (from place of manufacture)

w) Review of routine test certificates (to IEC 60255) for digital protection relays (from place of manufacture)

x) Review of manufacturing inspection and test documentation and records

y) Review of manufacturing defect lists / punchlists.

Sydney Water must be given the option of witnessing all inspections and tests including type tests, (routine) factory tests and site tests. Sufficient notice (14 calendar days for tests onsite, 42 calendar days for test elsewhere in Australia, 42 calendar days for tests outside Australia) must be given to enable the necessary travel arrangements to be made.

The results of all factory tests must be available for review during the tests.

A comprehensive Factory Test Report must be submitted to Sydney Water for approval within five working days of completion of the tests for that switchboard or prior to shipment (whichever is the earlier). The Factory Test Report must include:

a) Results of all tests

b) Copies of any test oscillograms, graphs, printouts, etc

c) Copies of all routine test certificates (from place of manufacture) for CBs, FVCs, CTs and VTs

d) Copies of all routine test certificates (from place of manufacture) for digital protection relays

e) Copies of manufacturing inspection and test documentation and records, follower cards, etc

f) Copies of factory defect lists / punchlists

g) Copy of the completed Factory ITP

h) Statement confirming compliance with the specified requirements.

Unless agreed otherwise by Sydney Water, all defects arising prior to or during the factory tests must be rectified to the satisfaction of Sydney Water prior to the respective equipment being shipped to site.

6.3 Site testing

After assembly at site, the Contractor must perform detailed site tests to verify that each HV switchboard is fully complete and ready for energising. The Contractor must complete a copy of their Pre Commissioning Checks, for each panel incorporated within the HV switchboard.

Such site tests must comply with the applicable requirements of:

AS 62271.100	HV switchgear and control gear - HV AC circuit-breakers
AS 62271.102	HV switchgear and control gear - AC disconnectors and earthing switches
AS 62271.200	HV switchgear and control gear - AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
AS 60470	HV AC contactors and contactor-based motor-starters.

As a minimum, the following tests must be performed:

a) Detailed mechanical inspection
b) Detailed electrical inspection (including termination of inter-tier wiring)
c) Mechanical tests on all mechanical interlocking, key interlocking and padlocking systems
d) Mechanical tests on all CBs, earth switches
e) Mechanical tests on all FVCs, earth switches
f) Electrical tests on all electrical interlocking and synch-check systems
g) Check of setup parameters for all digital protection relays
h) Functional tests on all operations counters, position indicators, capacitive voltage indicators, etc
i) Functional testing of all control and indication circuits
j) Functional testing of all protection circuits via secondary injection
k) **Note** - secondary injection testing must be carried out at a minimum of three current settings to verify correct operation of protection relays
l) Functional testing of all metering circuits
m) Insulation resistance tests (before dielectric withstand tests)
n) Dielectric withstand tests (power frequency tests)
o) Insulation resistance tests (repeated after dielectric withstand tests)
p) LV wiring flash tests (insulation resistance/dielectric withstand/insulation resistance)
q) HV circuit resistance (“Ductor") test between main busbar and outgoing cable tags
r) HV circuit resistance (“Ductor") along main busbars
s) Inspection of all loose-supplied equipment
t) Review of assembly inspection and test documentation and records
u) Review of assembly defect lists / punchlists.

Sydney Water must be given the opportunity to witness the site tests. A minimum of 14 calendar days’ notice must be given. The results of all site tests must be available for review during the tests.

A comprehensive Site Test report must be submitted to Sydney Water for approval within five working days of completion of the tests (or on handover, whichever is the earlier). The Site Test Report must include:

a) Results of all tests

b) Copies of any test oscillograms, graphs, printouts, etc

c) Copies of site defect lists / punchlists

d) Copy of the completed Site ITP

e) Statement confirming compliance with all specified and legislated requirements.

7. Quality assurance and inspection and test plans

The Contractor must implement a quality system that complies with the requirements of ISO 9001 for all work on the HV switchboard.

The Contractor must submit for approval two project-specific ITPs for the HV Switchboard:

a) **Factory ITP** covering all off-site activities i.e. engineering, design, supply, testing, resolution of factory defects/punchlists, release for delivery, preparation for transport, etc

b) **Site ITP** covering all on-site activities i.e. delivery to site, unloading, installation, assembly, site testing, resolution of site defects/punchlists, handover, etc.

The ITPs must identify the standards and/or procedures as well as the acceptance criteria that must apply for each stage in the ITPs.

Unless approved otherwise, all standards, procedures and acceptance criteria included in the ITPs must comply with the requirements defined in this specification.

Perform all work on the HV switchboard in accordance with the approved ITPs.

Sydney Water may apply witness points and/or hold points on various stages of the ITPs.

Sydney Water (or representative) must be given the option of witnessing all inspections and tests including type tests, (routine) factory tests and site tests. Sufficient notice (14 calendar days for tests onsite, 42 calendar days for test elsewhere in Australia, 42 calendar days for tests outside Australia) must be given to enable the necessary travel arrangements to be made. Sydney Water may elect to appoint third party inspector(s) to witness inspections and tests.

All costs associated with attendance by representatives of Sydney Water at inspections and tests must be borne by Sydney Water.

8. Spare parts

8.1 Routine maintenance spare parts and / or tools (for defects liability period)

Provide replacement spare parts and/or tools for the commissioning period and up to end of the defects liability period.

All routine maintenance spares must be provided in advance and held in storage at site.

8.2 Long-term maintenance / strategic spare parts and special tools

Provide a priced list of optional recommended spare parts for long-term maintenance activities and strategic planning, as well as any special tools required to perform long-term maintenance activities.

Sydney Water will confirm if it wishes to purchase some (or all) of these recommended spare parts and tools.

9. Manuals and drawings

Two paper copies of erection, maintenance and operating manuals in accordance with Clause 10 of AS 62271.1 must be supplied.

One electronic copy of all manuals, drawings and test results must be provided on suitable electronic media in PDF file format as a minimum.

Where programmable microprocessor-based equipment is used in the switchboard, the Contractor must provide an electronic copy of any settings files, any proprietary software required to program the equipment and interface cable.

Where a password is required to access the settings, this password must be provided in the manual.

Equipment manuals provided must contain details of all aspects of the operation and maintenance of the supplied equipment, a detailed parts list of all major components and copies of all factory test results.

Electrical circuit diagrams must be supplied either with the manuals or as separate A3 size drawings. All drawings must be supplied electronically in an AUTOCAD compatible format.

Equipment manuals and drawings must not contain descriptions or details of alternative equipment not specifically used in the supplied equipment.

Maintenance manuals and regimes must be specific for each site installation, in particular with respect to the maintenance timeframes required for the environmental conditions of the specific site.

10. Packaging and delivery

The Contractor must pack all equipment for delivery such that it will not be subject to any damage, or deterioration due to any environments through which the equipment may pass during delivery.

The Contractor must make good any damage or deterioration that has resulted from the delivery.

The Contractor must provide for Sydney Water, documents detailing the following information:

a) Number of crates to be delivered

b) Items that are in each crate

c) Total weight of each crate

d) Any special lifting requirements for each crate

e) Any obligation that Sydney Water may have when the items are delivered, such as immediate unpacking, storage requirements etc.

11. Reference documents

The HV Switchgear and all associated equipment and materials must be designed, manufactured and tested in accordance with the latest revisions of the Federal and State statutory requirements, applicable Australian and IEC Standards, as well as the Sydney Water standard specifications.

Document type	Title
Legislation	- The latest edition of the Work Health and Safety Act 2011 - The latest edition of the Service and Installation Rules of New South Wales
Policies and procedures	- WSA201 - Manual for Selection and application of protective coatings - Supplement to WSA201 - Manual for Selection and application of protective coatings - PCS100 - Protective Coatings - Sydney Water Emergency Stop Policy
Other documents	
Standards	- AS ISO 1000: The International System of Units (SI) and its application (ISO 1000) - AS 1033 (IEC 60282.2): High voltage fuses (for rated voltages exceeding 1000V) (Parts 1 and 2) - AS 1170: Minimum design loads on structures (known as the SAA Loading Code). (Parts 2 and 4) - AS 1307 (IEC 60099): Surge arresters (diverters) - AS 1627: Metal finishing - Preparation and pre-treatment of surfaces - AS 1824 (IEC 60071): Insulation coordination (phase-to-earth and phase-to-phase, above 1kV) (Parts 1 and 2) - AS 1852.441: International electrotechnical vocabulary - Switchgear, controlgear and fuses - AS 1931 (IEC 60060): High voltage testing techniques (Parts 1 and 2) - AS 2024 (IEC 62271-105): High voltage AC switchgear and control gear - Switch-fuse combinations - AS 2067: Switchgear assemblies and ancillary equipment for alternating voltages above 1kV - AS 2467: Maintenance of electrical switchgear - AS 2700: Colour standards for general purposes - AS/NZS 3000: Electrical installations (known as the Australian/New Zealand Wiring Rules) - AS/NZS 3008.1.1: Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical Australian installation conditions - AS 3111: Approval and test specification - Miniature overcurrent circuit-breakers

Document type	Title
	- AS 60947 series: LV switchgear and control gear - AS 4243: Additional requirements for enclosed switchgear and control gear from 1 kV to 72.5 kV to be used in severe climatic conditions - AS 60038: Standard voltages - AS 60044.1 (IEC 60044-1): Instrument transformer - Current transformers - AS 60044.2: Instrument transformers - Inductive voltage transformers - AS 60137 (IEC 60137): Bushings for alternating voltages above 1000 V - AS/NZS 60265.1:2001 (IEC 60265-1): High-voltage switches - Switches for rated voltages above 1 kV and less than 52 kV - AS 60269 (IEC 60269): Low-voltage fuses - AS 60470 (IEC 60470): High-voltage alternating current contactors and contactor -based motor-starters - AS 60529 (IEC 60529): Degrees of protection provided by enclosures (IP Code) - AS/NZS 60898.1 (IEC 60898): Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Circuit-breakers for AC operation - AS 60947 (IEC 60947): Low-voltage switchgear and controlgear. Please note: Some parts still exist as AS/NZS 3947 - AS 62053.21 (IEC 61036): Electricity metering equipment (AC) - Particular requirements - Static meters for active energy (classes 1 and 2) (IEC 62053-21 Ed.1.0 (2003) MOD) - AS 62053.22 (IEC 62053-22): Electricity metering equipment (AC) - Particular requirements - Static meters for active energy (classes 0.2 S and 0.5 S) - AS 62054.11 (IEC 62054-11): Electricity metering (ac) - Tariff and load control - Particular requirements for electronic ripple control receivers - AS 62271.1 (IEC 62271-1): High-voltage switchgear and controlgear - Common specifications - AS 62271.100 (IEC 62271-100): High-voltage switchgear and controlgear - High-voltage alternating-current circuit-breakers - AS 62271.102 (IEC 62271-102): High voltage switchgear and controlgear - Alternating current disconnectors and earthing switches - AS 62271.103 (IEC 62271-103): High-voltage switchgear and controlgear - Switches for rated voltages above 1 kV and less than 52 kV - AS 62271.200 (IEC 62271-200): High-voltage switchgear and controlgear - A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV - AS 62271-201 (IEC 62271-201): High-voltage switchgear and controlgear - AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

Document type	Title
	- AS 62271-303 (IEC 62271-303): High-voltage switchgear and controlgear - Use and handling of sulphur hexafluoride (SF6) in high-voltage switchgear and controlgear - IEC 376: Sulfur Hexafluoride - IEC 60073: Basic and Safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators - IEC 60255 series: Measuring relays and protective equipment

11.1 Conflicts between specification, standards and/or codes

Review the above standards and make use of them where they are applicable. Identify any conflicts between the above standards and recommend which criteria to use. The Contractor must refer any conflicts in the information to Sydney Water for clarification.

Ownership

Ownership

Role	Title
Group	Integrated Systems Planning - Liveable City Solutions
Owner	Manager of Urban Design and Engineering
Author	Lead Engineer Electrical

Revision history

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1	Robert Lau / Andrew Manganas / Paul Zhou	05/12/2014	Nobert Schaeper	05/12/2017
2	Robert Lau / Andrew Manganas / Paul Zhou	21/09/2016	Nobert Schaeper	21/09/2016
3	Robert Lau / Paul Zhou	15/09/2018	Ken Wiggins	15/09/2018
4	Paul Zhou	20/02/2020	Steve-Keevil Jones	20/02/2020