Specification

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.
5.0	Acronyms Introduction 1.1 2.1 2.2 Table 2 2.3 3.1 3.3 3.4 3.5 3.6 3.9 3.11 3.14 4.2 4.3 4.4 4.7 and 4.8 4.9 4.10 4.14 5.2 5.3 6.4 5.6 5.13 5.14 5.15 5.16 6 7 8 10 12	Minor updates Minor updates Minor updates Major updates environmental requirements Updates on item 3,5,10,12,13,19,20, and 22 Update on standardisation requirement Minor updates on general requirements Major updates on compartment doors Minor updates on painting Minor updates on fixings Minor updates on HV cable termination Minor updates on Earthing Minor updates on Shutters Minor updates on Operation Major updates on dielectric medium Minor updates on Circuit Breakers Minor updates on A-FLR requirements Minor updates on VT & CT Reference to regulatory standard added Minor updates for height requirements Minor updates on LLI’s requirements Minor updates on equipment layout Minor update on equipment Major updates on selector switches Minor updates on indicating lights Minor updates on Anti-condensation heaters Minor updates on wire references Minor updates to include IEC61850 Major updates on remote switching panel Minor updates on labelling Minor updates on Testing Minor updates on Spare parts Major updates Minor updates

Introduction

This Specification outlines the minimum acceptable technical requirements for the design, supply, manufacturing, delivery and testing of HV Switchgear for Sydney Water assets.

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Acronyms

Acronym	Definition
AC (ac)	Alternating Current
AI	Analogue Input
AIS	Air Insulated Switchgear
ANSI	American National Standards Institute
AO	Analogue Output
AS	Australian Standard
A-FLR	Authorised personnel access only, all sided switchgear (Front, Lateral, Rear) protection for users
CB	Circuit Breaker
CT	Current Transformer
DC (dc)	Direct Current
DI	Digital Input
DO	Digital Output
ELV	Extra Low Voltage: Not exceeding 50 V AC or 120 V ripple-free DC
ES	Earth Switch
FVC	Fused Vacuum Contactor
GIS	Gas Insulated Switchgear
HMI	Human Machine Interface
HV	High Voltage (i.e., > 1000 V AC or > 1500 V DC)
IAC	Internal Arc Classification

Acronym	Definition
IED	Intelligent Electronic Device
I/O	Inputs/Outputs
IICATS	IICATS Integrated Instrumentation, Control, Automation and Telemetry System
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)
NATA	National Association of Testing Authorities
NO, NC	normally open, normally closed (contacts)
PLC	Programmable Logic Controller
RMU	Ring Main Unit
SCADA	SCADA Supervisory control and data acquisition
SF_6	Sulphur Hexafluoride
SLD	Single Line Diagram
TCS	Trip Circuit Supervision
VCB	Vacuum Circuit Breaker
VT	Voltage Transformer

1. General

1.1 Scope

This Specification outlines the minimum acceptable technical requirements for the design, supply, manufacturing, delivery and testing of HV Switchgear for Sydney Water assets. This document does not cover HV overhead equipment, which is covered under Sydney Water DOC0017 HV Overhead Line Equipment

Where conflicts exist between this specification and any statutory requirement (e.g., the Work Health and Safety Act and Regulations), the statutory requirement prevails.

Where conflict exists between this specification and any other nominated source document, SWC must be notified in writing to nominate which will take precedence.

1.2 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.

2. Technical requirements – general

2.1 Environmental requirements

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

Table 1. Environmental requirements

Environmental conditions		
Maximum ambient air temperature for indoor equipment		+ 45 ºC
Maximum ambient air temperature for outdoor equipment		+ 50 ºC
Maximum daily 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.

SF_6 and any other high greenhouse emission gas insulation media are prohibited. The terminology of “gas” and “GIS” referred in this document must NOT be related to product associated with those gases.

2.2 Key ratings and features

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

Table 2. Key ratings and features

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	Primary Switchgear: Indoor only Secondary Switchgear: Indoor and outdoor
3	Access	Front access (operation and maintenance) Rear access (for maintenance only)
4	Material of enclosure	Zinc annealed sheet steel /Stainless Steel/ Aluminium (Marine Graded)
5	Insulation medium	Air (SF6 and Oil are prohibited)
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
9	Partitions and shutters	Class PM – Metallic partitions

Ref	Rating or feature	Requirement
10	Minimum short time withstand	25 kA 3 s (primary switchgear) 17.5 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	Refer to Section 2.3
13	HV Cable connection	Preferable front connection, with bushing / bolted Rear connection can be accepted when adequate permanent access is provided, 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
20	HV Contactor	Vacuum
21	Maximum overall height	2300 mm (Indoor) 2500 mm (Outdoor)
22	Height to centreline of highest equipment on LV compartment door	Refer to Section 4.2
23	Gas discharge tunnel	Required as per section 3.1
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
28	Anti-condensation heater voltage	230 V AC ± 10%
29	Capacitive voltage indicators with test points	Required on all circuits (cable side)

Note: Indoors refers to a space enclosed within external walls and roof. All other environments are to be treated as outdoors.

2.3 Standardisation

Equipment must be designed with standard parts and components having a minimum of 10 years remaining of their product manufacturing lifecycle. 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. Installing new and replacing existing HV switchgear must consider standardisation of equipment at the existing facility and other Sydney Water sites.

3. Technical requirements – construction

3.1 General

The switchboard enclosures must comply with the latest AS 62271.200. Switchgear must be metal enclosed.

The switchboard panels must have front access for all operation and maintenance tasks. A minimum of 1000 mm rear access must be provided for all switchboards except for kiosk substation. The switchboard panels must be of the same height to provide a uniform profile along the switchboard.

The switchboard must have a modular design, explicitly enabling future extensions at either end. The incomers must be positioned at the ends of the switchboard, ensuring minimal disruption to the existing equipment during extension. Where different bus section of a switchboard is installed in different switchroom, meaning each bus section of the switchboard is physically separated, the inter-connecting bus section should have:

a) Bus-tie panel on both side of the bus connected to each other

b) The bus-tie panels are to be connected with cables

c) Each bus section is to be installed in separate enclosed switchroom sections.

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

a) Interconnecting busbar system and bus VTs (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 gas insulated switchgear must 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 to minimise damage to ancillary equipment (e.g. cables) or pose a hazard to personnel. Arc discharge tunnels maybe considered if there is insufficient height above the switchboard or the switchroom has not been designed to dissipate arc fault gases safely, the arc discharge tunnel design must have prior approval from SW.

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, preferably with the LV compartment door open.

A separate LV compartment for LV/ELV control, monitoring, protection, and indication must form part of each panel located above the relevant HV panel with access for ELV/LV wiring. For an outdoor switchboard, if the height of the operatable and maintainable components exceeds AS 4024 maximum height requirements, it is permitted to design and install the LV compartments of the switchgear in a more suitable location subjected prior review and approval from Sydney Water.

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, with the exception of arc flash sensors, current transformer and voltage transformer cables.

Only cables associated with the specific switchgear panel may enter the HV cable termination compartment of that panel. Under no circumstances must cables from other switchgear panel pass through the cable termination compartment of another switchgear panel.

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 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.

3.2 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.

3.3 Compartment doors

All compartment doors must be suitably designed and braced to prevent sagging or drumming taking into account the weight of 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 equipotential bonded to the switchboard frame with minimum 4 mm^2 earth conductors.

All compartment doors must be appropriately sealed to achieve the required IP classification (if door seal is use, 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 compartment doors must be accessible via the front of the panel and must be equipped with padlockable door handle.

a) LV compartments must have side hinged doors.

b) For bus bar compartment doors and covers, they must either be interlocked in closed position (preferred) with respective earth switches OFF position or be able to open by using tools.

c) For HV CB/vacuum contactor/ VT compartment doors and covers, for withdrawable type switchgear, side hinged compartment doors must be provided, and the doors must only be able to be opened when the CB is racked out in withdrawn position. For fixed type switchgear the CB compartment covers must only be able to be opened by tools.

d) For HV cable termination compartment doors, the compartment doors must be interlocked in closed position with respective earth switches OFF position. For withdrawable switchgear, side hinged panel doors must be used. For fix switchgear, both lifted out panel doors and side hinged panel doors are acceptable, for lifted out panel door option, appropriate lifting handles must be provided, and the panel must only be opened by tools after the interlock is released. Also, the earthing cannot be removed when the respective panel cover is not put back on.

For outdoor enclosure containing the HV switchgear, the enclosure doors must be provided with a three-point latching system.

3.4 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 2.1. Surface preparation and paint systems must be selected to give a life of not less than the design life of the switchboard.

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. External surfaces of the switchboard must be RAL 7035 (Light Grey).

3.5 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.

The use of fixings must not impair the internal arcing fault rating provided by the switchgear.

3.6 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.

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, subsequent testing, inspection and routine maintenance.

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.

3.7 Low voltage (LV) cable termination

All LV cables must be bottom or top entry (bottom entry only for outdoor switchboard) 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.

3.8 Busbars and Connections

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 monitoring for each sealed chamber with a voltage free contact for remote monitoring must be provided.

Table 3. Busbar colour coding

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

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

3.9 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.

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.

3.10 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.

3.11 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, each shutter must be clearly identified with which the bus is associated.

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

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. Each shutter must be close and open by its own independent mechanism and must not be latched with other shutter’s operation.

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.

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.

3.12 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.

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.

It must be possible for the withdrawable part to be racked in and out by either an electrically 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.

3.13 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.

3.14 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. 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.

3.14.1 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.

All operating mechanisms, including circuit breaker closure control, must be padlockable.

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.

3.14.2 Remote operation

Switchgear remote operation is to operate HV switchgear outside HV area via a remote switching panel, a computer based operating platform, or via automated switching operation sequences. Remote switching must only be enabled or disabled via designated selector switches on the respective HV switchgear panel. Both remote operation and local operation must not defeat switchgear mechanical and electrical interlock arrangement.

3.15 Lifting lugs

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

3.16 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.

4. Technical requirements - HV switchgear and equipment

4.1 General

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

Isolation must be made by either circuit breakers or load-break and fault-make rated 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. 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. The prospective symmetrical fault levels applicable must be calculated by the Contractor. The switching device must withstand the forces due to maximum fault.

4.1.1 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 65% to 120% of nominal.

4.1.2 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.

4.2 Switchgear dielectric medium

Air or gas must be used for the dielectric medium for withdrawable or fixed type switchgear. Oil and SF_6 must not be considered.

The gas insulating medium must be constantly monitored and equipped with a simple go, no-go indication and alarm output contact.

4.3 Circuit breakers (CBs)

Circuit breakers must be utilised for:

a) Incoming and outgoing feeder circuits

b) Transformer Feeder circuits

c) Bus Interconnector circuits

d) HV Motor Starter Feeder circuits.

CBs must be designed in accordance with AS 62271.100. CBs 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.

4.3.1 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.

4.3.2 Tripping

Tripping must be possible by both:

a) Local mechanical trip method (mandatory)

b) 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.

4.3.3 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 disconnectors are allowed to be single break design when they are part of the fix CB assembly.

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.

4.3.4 Withdrawable CBs

It must be possible for the withdrawable circuit breaker to be racked into and out of the service, disconnect and test positions 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.

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.

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, and able to OPEN and CLOSE the CB

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.

4.3.5 Gas insulated CBs

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

The unit must be capable of interrupting fault current with no adverse effects on the insulation gas. Means must be provided to check the gas conditions during maintenance periods.

The circuit breaker must be designed to avoid condensation of gas caused by other factors including arc.

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

4.3.6 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.

4.4 Fused vacuum contactors (FVCs)

FVCs must only be used for Direct on-line motor starting circuits.

HV FVCs must be designed in accordance with AS 60470. The HV FVC panel must be fully tested to A-FLR for internal arcing fault protection.

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 positions both remotely by electrical operations 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.

4.5 Disconnector switches

Disconnectors must be load-break and fault-make rated and 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 interlocks prevent incorrect operation. Padlocking facilities must be provided for each position.

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

4.5.1 Closing and opening

Closing and opening must 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.

4.6 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 rated 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 bus is required for maintenance purposes or to access any metering instrument transformers for 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.

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 earth switch and CB are on the same panel, they must be designed with independent actuation mechanism. Earthing switches must comply with AS/NZS 60265.1 and AS 62271.102.

4.7 Voltage transformers (VTs)

Voltage transformers must be designed in accordance with IEC 61869.3 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, VTs 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. The VT must be interlocked to prohibit withdraw operation when the VT is connected to live buses or live cables.

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

Partial discharge tests must be performed on every VT as part of the routine test. Acceptable value for partial discharge must be in accordance with IEC 61869.3. NATA or equivalent testing institution's test certificates must be supplied.

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

4.8 Current transformers (CTs)

CTs must comply with IEC 61869.2 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 mounted in the cable basement below the switchboard. CTs must also 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 tapings must be wired to slide test link terminals in the LV compartment / Cable box of the switchgear.

A magnetisation curve must be provided 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, must be 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 as part of the routine test. Acceptable value for partial discharge must be in accordance with IEC 61869.2.

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 7.2 - Routine (Factory) Testing).

4.9 Instrument transformers for revenue metering

For VTs and CTs used for the revenue metering purposes, the design must ensure they can be safely accessed for regulatory compliance routine calibration and replacement. The installation of these instrument transformer must comply with the latest version of Service and Installation Rules NSW. Test links or bars must be provided 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, to perform work on instrument transformers on one power supply must not require isolating other power supplies to the site.

4.10 Other safety related requirements for switchgear assembly

In accordance with AS 4024.1204, Instruments, control switches, hand operated devices, and components that require to be seen, operated and adjusted must be installed with a centre line between 400 mm and 2000 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.

4.11 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 of this Specification.

4.12 Station insulators

All station insulators rated at 1 kV must be porcelain or epoxy type designed to meet the requirement of AS 4398.1 and the rated voltage, current and environmental conditions as specified in section 1.4 of this Specification.

4.13 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 or neon voltage indication

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

c) Testing points (100 V).

d) Work Independently regardless of auxiliary power availability or operate in fail safe manner in absence of auxiliary power supply availability.

4.14 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 kit including test leads.

i) FVC truck test kit including 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).

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

5.1 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.

5.2 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. To work on one component must not require removal of other components to gain access to it.

The design must prioritise placing maintainable, operable, and adjustable components at the lower height position on the LV compartment door to allow ease of access. Components that are only indications can be installed at a higher position.

5.3 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 functional testing (including secondary injection testing) of digital protection relay(s) for CB

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

d) Pilot lights indicating Protection trip for CB

e) REMOTE-ENABLED and REMOTE-DISABLED control selector switch for CB, Earth Switch and Disconnector Switch

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

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

h) 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-N-Close, Open, and Close 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 communication cables from an external platform (such as SCADA, IICATS, IEC61850 substation controller, etc) based on the agreed design with SW.

5.4 Control switches and control selector switches

Each switchgear panel low voltage control compartment must be provided with:

a) A two position (REMOTE-ENABLED, REMOTE-DISABLED) selector switch, providing selection of enabling/disabling remote operation of the switchgear. The selector switch must be able to be padlockable (suitable for 50mm padlock) in the selected position.

   i. When the switch is selected in REMOTE ENABLED, remote operation of switchgear open and close, switchgear withdrawable truck rack in and rack out must be made available. The selection of remote operation status must not impair any other function of the switchgear.

   ii. When the switch is selected in the REMOTE DISABLED, only local operation of the switchgear must be possible with remote operational functions locked out.

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

c) For switchgear using withdrawable truck, a three position (RACK IN, NEURAL, RACKOUT) control switch with spring return to neutral action, for local withdrawable truck rack in/out operation.

d) Where there is IEC 61850 logic based automatic changeover function used, each switchgear panel associated automatic changeover switching operation must be provided with:

   i. A two position (AUTO ENABLED, AUTO DISABLED) selector switch, providing selection of enabling/disabling automatic switching operation of the designated switchgear.

   ii. When selected automatic changeover switching associated switchgear panels are selected to AUTO ENABLED, the respective automatic changeover switching logic must be activated.

   iii. When the automatic changeover switching associated switchgear panel is selected to AUTO DISABLED, this switchgear panel must be deactivated from the automatic switching sequences.

The mechanical and electrical endurance of all control switches must comply with IEC 60947 standards.

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 utilisation category AC14, silver plated.

5.5 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 SW 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 utilisation category AC14, silver plated.

5.6 Indicating lights

Indication lights must operate on the switchboard at the auxiliary supply as specified in section 2.2 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 and CB truck racked in
f) GREEN lens for OPENED and CB truck racked out (ready to be withdrawn and ready for umbilical cord to be disconnected)
g) AMBER lens for ABNORMAL CONDITIONS and CB truck racked to testing position (with umbilical cord connected)
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.

Lamp test pushbutton must be installed, push to test indicating lamp must not be used.

5.7 Fuses and links

Fuses and links must be of the cartridge, high rupturing capacity type complying with the requirements of IEC 60269 series.

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

5.8 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.

5.9 Miniature relays

Miniature relays must comply with the following minimum requirements:

a) Compliant with IEC 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) Comply with all other requirements in Sydney Water Technical Specification - Electrical.

5.10 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)
c) Frequency
d) Current (average, per phase)
e) kW/MW (total, per phase)
f) kVAr/MVAr (total, per phase)
g) kVA/MVA (Min, average and Max 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).

5.11 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.

5.12 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.

5.13 Anti-condensation heaters

Separate anti-condensation heaters must be provided within each HV cable compartment. Other compartment of the switchgear could be subjected to condensation issue of each switchboard tier.

The auxiliary supply voltage for anti-condensation heaters must be 230 V AC ± 10%. Isolation circuit breakers within each LV compartment are to be provided for the anti-condensation heaters within that tier.

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.

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 associated IED or merging unit for alarm purposes.

The anti-condensation heater must not cause overheating and other potential reliability issues for the rest part of the switchboard.

5.14 LV and ELV wiring

All LV and ELV wiring are 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:

Table 4. LV and ELV wiring requirements

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 V90 to AS/NZS 5000.1	Active/Positive Neutral/Negative	Light Grey (LtG)
230 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/NZS 5000.1	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/NZS 5000.1	Red Phase White Phase Blue Phase Neutral	Red (R) White (W) Blue (B) Black (BK)

Item	Wire type	Wiring and/or Conductors	Colours
Core Balance toroids	4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V105 to AS/NZS 5000.1	S1 S2	Black (BK) Black (BK)
Earth conductors	Minimum 4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V90 to AS/NZS 5000.1		Green-Yellow (G-Y)
Instrumentation twisted pair conductors		Positive Negative	White (w) Black (BK)
Ethernet	Shielded 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 V90 to AS/NZS 5000.1	Active/Positive Neutral/Negative	Violet (V)

All LV and ELV wiring are 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 are 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 have unique numbers and labelled 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.

5.15 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 using IED via IEC 16850 protocol:

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 healthy

l) Supply Authorities supply healthy

m) Anti-condensation healthy

5.16 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 platform.

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.

For hardwired remote switching panel, push buttons or selector switches must be used for switching operation. LED indicating lights must be provided to indicate switchgear status, the LED indication lights must be illuminated when any panel door is opened and must not be illuminated when the panels doors are closed. Lamp test pushbutton must be installed, push to test indicating lamp must not be used. For detail requirement of a Control Cabinet, please refer to Sydney Water Technical Specification – Instrumentation and Control.

For HMI computer based remote operating platform, HMI must be able to view entire distribution network but only be able to perform switching operation on designated HV switchgear near where the HMI is located. The HMI must also present all equipment and functions connected to the same IEC 61850 network at the facility including but not limited to :

- HV switchgear,
- Transformers,
- Battery Chargers
- HV power factor correction units
- HV harmonic filtering units
- HV motors and motor starters
- Permanent generators
- Automatic switching system
- Interlock system
- Low voltage circuit breakers immediately downstream of power transformers connected to the same IEC 61850 network.

The HMI must provide real time energy monitoring function in accordance with section5.10.

The HMI must be able to store past 60 days of time stamped data as minimum including but not limited to:

- Energy monitoring
- Switchgear status changes
- Faults and alarms for the equipment presented.
- Sequence of events

The HMI must be password protected by customisable personalised login details, as a minimum 3 levels of user access must be provided, they are:

- HV operator access level: Be able to perform switching operation, enable/disable automatic switching function and view all information, but not able to alter the rest of the function.
- Engineering access level: In additional to HV operator access, be able to perform protection setting changes, equipment firmware and software updates.
- Administration access level: Access to all functions

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

6. 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. 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:

Table 5. Labelling requirements

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	60
Circuit name -mounted on LV compartment door of panel, Withdrawable compartment door of panel and, rear cover of panel	100 L x 60 H	Black / White	Circuit Name	40
FVC MV fuse rating label	50 L x 30 H	Black / White	Fuse Fuse rating / Holder rating	10 10

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
- Mounted on Withdrawable compartment door and the front of FVC				
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
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

6.1 Label schedule

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

7. Testing requirements

7.1 Type testing

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

AS 61869.2	Instrument transformers - Current transformers
AS 61869.3	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.

The type test 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 certificates.

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 certificates for other equipment, components, protection relays, etc must be provided by the Contractor upon request by Sydney Water.

7.2 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 / punch lists.

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 / punch lists

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.

7.3 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) before energisation. 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.

8. 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 and agreed deviations to this specification.

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

Sydney Water must be provided with opportunities to 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.

9. Spare parts

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

Provide replacement spare parts and 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.

9.2 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 must be provided opportunities the decided whether to purchase some (or all) of these recommended spare parts and tools.

10. Deliverables

10.1 Deliverables during design stages

Following deliverables must be provided at the appropriated design milestones, including but not limited to:

a) Layout drawings

b) Datasheets

a) CT calculations

b) Assembly drawings

c) Assembly manuals

d) Switchgear schematics

e) Logic diagrams

f) Functional design specifications (FDS)

10.2 Post design deliverables

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, and test results must be provided on suitable electronic media in PDF file format as a minimum. Electrical circuit diagrams must be supplied either with the manuals or as separate A3 size drawings. All drawings must be supplied electronically in both PDF and an AUTOCAD compatible format.

Where programmable microprocessor-based equipment is used in the switchboard, the Contractor must provide an electronic copy of any settings files, configuration 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.

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 time frames required for the environmental conditions of the specific site.

11. 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.

12. 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 legislation, regulations, applicable Australian and IEC Standards, policies, 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	D0002010 - Engineering Standard governance
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 60099 (IEC 60099): Surge arresters (diverters) - AS 1627: Metal finishing - Preparation and pre-treatment of surfaces - AS IEC 60060: High voltage testing techniques (Parts 1 and 2) - AS 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 - 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 61869.2 Instrument transformer- Additional requirements for current transformers (IEC 61869-2) - AS61869.3 Instrument transformers - Additional requirements for inductive voltage transformers (IEC 61869-3) - AS/NZS 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

Document type	Title
	- 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/NZS 60947 (IEC 60947): Low-voltage switchgear and controlgear. - AS 62053.21 (IEC 61036): Electricity metering equipment (AC) - Particular requirements - Static meters for active energy (classes 1 and 2) (IEC 62053-21) - 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 - 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 60071: Insulation coordination (phase-to-earth and phase-to-phase, above 1kV) (Parts 1 and 2) - 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 - IEC 60269: Low-voltage fuses

12.1 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	Water and Environment Services – Engineering Modernisation
Owner	Manager of Engineering Modernisation
Author	Technical Director – Electrical Engineering

Change history

Version No.	Prepared by	Date	Approved by	Issue date
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
5	Paul Zhou / Hedi Mahdavi Aghdam	30/09/2024	Nobert Schaeper	4/10/2024