Specification – MV Switchboard

Standard Number: HPC-8DJ-23-0001-2013

Issue Date: 5th November 2022

Document Number:

Print Date: 5/12/2022

Uncontrolled document when downloaded. Refer to Horizon Power's website for most current version.

Document Control			
Author	**Name:**	Paul Savig	Digitally signed by Paul Savig Date: 2022.12.05 13:15:00 +08'00'
	Position:	Senior Engineer Standards	
Reviewed By	**Name:**	Tadeusz Bloch	Digitally signed by Tadeusz Bloch Date: 2022.12.05 13:23:47 +08'00'
	Position:	Senior Electrical Engineer	
Document Owner *(May also be the Process Owner)*	**Name:**	Johnathan Choi	Johnathan Choi 2022.12.05 13:40:18 +08'00'
	Position:	Plant and Standards Manager	
Approved By *	**Name:**	Victor Cheng	Digitally signed by Victor Cheng Date: 2022.12.06 12:15:59 +08'00'
	Position:	Manager Engineering and Project Services	
Date Created/Last Updated	5 December 2022		
Review Frequency **	3 yearly		
Next Review Date **	5 December 2025		

** Shall be the Process Owner and is the person assigned authority and responsibility for managing the whole process, end-to-end, which may extend across more than one division and/or functions, in order to deliver agreed business results.*

*** Frequency period is dependent upon circumstances– maximum is 5 years from last issue, review, or revision whichever is the latest. If left blank, the default shall be 1 year unless otherwise specified.*

Revision Control		
Revision	**Date**	**Description**
2	5/12/2022	Reformatted document, standards dated and referenced
1	23/06/2021	Updated for comments provided
0	21/01/2014	First Issue

STAKEHOLDERS *The following positions shall be consulted if an update or review is required:*	
Manager Engineering & Project Services	Asset Managers
Manager Systems & Network Planning	Manager Assets Services
Manager Health and Safety	

TABLE OF CONTENTS

1 SCOPE

This specification covers Horizon Power's requirements for new factory-assembled medium voltage (MV) switchboard including circuit breakers, instrument transformers, protection relays, auxiliary equipment and circuitry for rated voltages from 6.6 kV up to and including 33 kV. Specifically primary substation equipment only.

Tests prescribed will evaluate the performance of the switchgear, and shall comply with this specification.

Approval in terms of this specification shall be obtained by one or a combination of the following:

a) successful completion of the appropriate tests required by this specification by an independent and accredited test authority.

b) provision of test certificates from an independent and accredited test authority based upon an alternative specification, with test requirements at least equivalent to this specification.

NOTE: Verification of accreditation of the test authority shall be provided by NATA (National Association of Testing Authorities) accredited test house or by a test house possessing accreditation from a NATA MRA (Mutual Recognition Agreement) partner.

Tenderers must state any non-compliance with the specification in any tender submission and any alternative offers must be submitted in full and separately from any main offer.

2 NORMATIVE REFERENCES

2.1 Standards

2.1.1 Horizon Power Standards / Documents

[1]. *Horizon Power Environmental Conditions*, standard number HPC-9EJ-01-0001-2013, available at http://horizonpower.com.au/contractors-suppliers/contractors/manuals-and-standards/ under the 'Standards' heading.

[2]. *Horizon Power Panel Wiring and Terminals standard*, HPC-9DJ-23-0001-2016, available in DM# 4741129.

[3]. *Horizon Power 22 kV Reactor Circuit Design Review report*, HPC-10-DE-23-0001-2020, available in DM# 19766496.

2.1.2 Australian Standards

The following standards are available at http://www.saiglobal.com.

[4]. *AS/NZS 1102.107, Graphical symbols for electrotechnical documentation – Part 107: Switchgear, controlgear and protective devices*, Standards Australia, 1997

[5]. *AS/NZS 1243, Voltage transformers for protection and measurement*, Standards Australia, 1982

[6]. *AS 2067, Substations and high voltage installations exceeding 1 kV a.c.*, Standards Australia, 2016

[7]. *AS/NZS 2312.1, Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Paint coatings*, Standards Australia, 2014

[8]. *AS 2700, Colour standards for general purposes*, Standards Australia, 2011

[9]. *AS/NZS 3000, Electrical installations -Wiring Rules*, Standards Australia, 2018

[10]. *AS/NZS 5000.1, Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV*, Standards Australia, 2005

[11]. *AS/NZS 5000.2, Electric cables - Polymeric insulated - For working voltages up to and including 450/750 V*, Standards Australia, 2005

[12]. *AS/NZS 60137, Insulated bushings for alternating voltages above 1000 V*, Standards Australia, 2020

[13]. *AS/NZS 60265.1, High-voltage switches – Part 1: Switches for rated voltages above 1 kV and less than 52 kV*, Standards Australia, 2001 (R2016)

[14]. *AS 60270, High voltage test techniques – Partial discharge measurements*, Standards Australia, 2001 (R2015)

[15]. *AS/NZS 60529, Degrees of protection provided by enclosures (IP Code)*, Standards Australia, 2004

[16]. *AS 60947.2, Low voltage switchgear and controlgear – Circuit breakers*, Standards Australia, 2015

[17]. *AS 60947.3, Low voltage switchgear and controlgear – Switches, disconnectors and switch-disconnectors*, Standards Australia, 2018

[18]. *AS 60947.5.3, Low voltage switchgear and controlgear – General rules*, Standards Australia, 2021

[19]. *AS 61869.1, Instrument transformers – Part 1: General rules*, Standards Australia, 2021

[20]. *AS 61869.2, Instrument transformers – Part 2: Additional requirements for current transformers*, Standards Australia, 2021

[21]. *AS 61869.3, Instrument transformers – Part 3: Additional requirements for inductive voltage transformers*, Standards Australia, 2021

[22]. *AS 62271.1, High voltage switchgear and controlgear – Common specifications*, Standards Australia, 2019

[23]. *AS 62271.100, High voltage switchgear and controlgear – Part 100: High-voltage alternating-current circuit-breakers*, Standards Australia, 2019

[24]. *AS 62271.110, High voltage switchgear and controlgear – Part 110: Inductive load switching*, Standards Australia, 2019

[25]. *AS 62271.200, High-voltage switchgear and controlgear – Part 200: Metal-enclosed - Rated voltages above 1 kV up to and including 72.5 kV*, Standards Australia, 2019

[26]. *AS 62271.201, High-voltage switchgear and controlgear – Part 200: Solid insulation enclosed -Rated voltages above 1 kV up to and including 72.5 kV*, Standards Australia, 2019

[27]. *AS 62271.301, High voltage switchgear and control gear – Dimensional standardisation of terminals*, Standards Australia, 2005 (R2016)

2.1.3 International Standards

The following standards are available at http://www.saiglobal.com.

[28]. *IEC 60255, Measuring relays and protection equipment*, International Electrotechnical Commission, 2009

[29]. *IEC 60269.1, Low voltage fuses – General requirements*, International Electrotechnical Commission, 1968

[30]. *IEC 60812, Failure modes and effects analysis (FMEA and FMECA)*, International Electrotechnical Commission, 2018

[31]. *NFPA 70E, Standard for electrical safety in the workplace*, National Fire Protection Association - USA, 2021

2.1.4 Compliance with Standards

Various Standards are referenced in this Specification. The Standards have reference to the year they were published. If over the life of the Tender the Standards change, the Vendor is required to conform to the new edition of the Standard.

Unless otherwise specified herein, the *Equipment* shall be designed, manufactured and type and routine tested in accordance with the referenced Australian Standards, including all amendments. Where there is no Australian Standard equivalent, International Standards or Codes as defined in this specification shall be used. The specified documents contain provisions that, through reference in the text, constitute requirements of this Specification. At the time of publication of this Specification, the editions indicated were valid. Information on currently valid national and international standards may be obtained from the Australian Standards website. http://saiglobal.com.

2.2 Definitions and Abbreviations

For the purposes of this specification, definitions shall apply as in the relevant Australian Standards including AS 62271.1 [22] with the addition of a few general definitions listed below in alphabetical order.

2.2.1 Definitions

1) ***Equipment*:** shall collectively refer to various components (circuit breakers, instrument transformers, protection relays, ancillary equipment and circuitry) that form the switchboard unit.
2) **Onboard protection:** means all protection and control relays are housed within the auxiliary compartment located on the switchboard.
3) **Off board protection:** means all protection and control relays and associated circuitry are housed away from the front of the switchboard in a separate room.

4) **Protection and control schemes:** means a selection of protection and control relays as well as associated circuitry that is housed in a designed box/container that can easily inserted into a protection panel or switchgear auxiliary compartment.

2.2.2 Abbreviations

1) CB: Circuit Breaker
2) CT: Current Transformer
3) IAC: Internal Arc Classification
4) kV: kilo Volts (1,000 volts)
5) LED: Light Emitting Diode
6) LV: Low Voltage <1000 volts AC
7) MV: Medium Voltage >1000 volts AC; <36 000 volts AC
8) MVAr: Mega Volt Amp reactive (1,000,000 Volt Amp reactive)
9) MW: Mega Watts (1,000,000 Watts)
10) pf: power factor
11) SCADA: Supervisory Control and Data Acquisition
12) VT: Voltage Transformer

3 REQUIREMENTS

3.1 Power System Particulars

The *Equipment* shall be suitable for continuous connection to a power system with the characteristics covered below.

3.1.1 Design Fault Levels

The Maximum short circuit withstand currents are as follows:

North West Interconnected System:

1) 16 kA rms / 3 second for 33 kV systems
2) 25 kA rms / 3 second for 22, 11 kV and 6.6 kV systems

Non Interconnected System:

Individual fault levels vary for the different networks. The short circuit fault requirement will be specified in Schedule A of the document (see note below).

NOTE: A minimum fault level of 16 kA for 22 kV is acceptable for systems with very low fault current.

3.1.2 Nominal System Frequency

The nominal system frequency is 50 Hz.

3.1.3 System Insulation Levels

The system Basic Impulse Insulation Levels (BIL) are as follows:

Table 1: System Insulation Levels

Nominal System Voltage (kV $_{rms}$)	System Highest Voltage (kV $_{peak}$)	Lightning Impulse withstand Voltage (kV $_{peak}$)	Power Frequency withstand Voltage (kV $_{peak}$)
6.6	7.2	60	20
11.0	12.0	75	28
22.0	24.0	125	50
33.0	36.0	170	70

Equipment rated at 24 kV (Does not apply to VT's) need to be capable of being continuously operated at 6.6 kV and 11 kV nominal voltages without any restrictions. If any extra provisions are required for 24 kV rated *Equipment* to be operated at 6.6 kV or 11 kV, details of such shall be provided by the Vendor in the Proposal.

3.1.4 Environmental Conditions

The performance of the *Equipment* must meet the requirements set out in Section 4.1 of the *Horizon Power Environmental Conditions* and shall be suitable for continuous operation under the service conditions for indoor switchgear as per AS 62271.1 [22].

3.1.5 Clearances & Insulation

The minimum electrical clearance in air to earth for all high voltage parts of the *Equipment* shall be not less than that specified in AS 2067 [6].

Vendors that offer *Equipment* with cast resin (or similar material) encapsulated current carrying MV conductors as per AS 62271.201 [26] shall provide test reports to demonstrate that the cast resin or similar material shall not be affected by the operation of the *Equipment* under the service conditions detailed in this Specification. In particular, load cycling due to the different coefficient of expansion of the metallic conductor and the insulation material at different temperatures over time.

3.1.6 Dimensions

Preference shall be given to *Equipment* having dimensions that do not exceed the maximum height of 2300 mm.

In addition, the switchgear must also meet the dimension requirements for specific compartments as described in the different sections of this specification.

NOTE: The height of the *Equipment* does not include the explosion exhaust chamber/ducts that may be installed for arc venting purposes.

4 SWITCHBOARD DESIGN AND CONSTRUCTION

4.1 General Requirements

The complete switchgear shall be of a metal clad design in accordance with AS 62271.1 [22] and AS 62271.200 [25].

All circuit breakers shall be fully withdrawable. Fixed breakers shall be considered however Horizon Power will evaluate the information and make a determination to accept or reject the proposal.

Oil shall not be used either as an insulating or interrupting medium.

The switchgear will be complete with circuit breakers, protection relays, ancillary equipment and circuitry as defined by the specification.

The vendor shall ensure that the switchgear is designed to readily facilitate installation without the need for special blanking plates, fittings, temporary secondary wiring arrangements or other accessories.

4.1.1 Partition Class

The switchgear shall adhere to partition class PM. All open compartments must be surrounded by earthed metallic partitions and/or metallic shutters.

4.1.2 Loss of Service Continuity

The switchgear must comply with category LSC2B-PM as defined by AS 62271.200 [25]. When any accessible compartment in a functional unit is open, all other functional units must remain energized and operate normally. Access to individual compartments shall be such that work may be carried out safely in that compartment while all other adjacent circuits are in service.

Trained and authorized persons shall be able to carry out the following operations on energised switchboard, without danger of direct contact with live parts:

1) control and reset of relays and disconnecting switch, inspection of signalling devices and instruments;
2) working and testing with breaker in test / service condition;
3) replacement of auxiliary fuses, lamps, and;
4) voltage, current measurements and location of failures, carried out with the proper instruments adequately insulated.

4.2 Switchboard Layout

4.2.1 Rated Parameters and Performance

The *Equipment* shall meet the rated parameters specified in Appendix D Schedule A included with this document.

4.2.2 Enclosure

The entire switchboard enclosure shall be free standing, floor mounted and be designed to ensure maximum safety during all operation conditions, inspection and or maintenance activities. Vertical units shall be assembled to form a continuous line up of uniform height and depth.

It shall be possible to bolt the structure of the switchboard to beams, which are cast-in or are part of the station floor.

The design of the switchboard and control gear assembly shall make it possible to install extension panels at either end without shutting down the switchgear until bus bar connection is required. Extension shall be possible without the need to drill holes in the connecting surfaces or in the structural frame. Ends of bus bars shall be suitably modified for this purpose.

The enclosure covering plates shall be fixed such that an internal explosion shall never cause any movement of these plates. Removable cover plates shall be fixed with bolted connections only. Any other construction using ''hook on'' or fixing by means of swivels is not acceptable. When removing bolted panels, it shall not be necessary to first gain access behind the panels to hold bolts or nuts. The weight of the panel should not have to be relieved from the bolts when loosening them.

The switchgear and control gear panel shall have a minimum degree of ingress protection **IP54** as per AS/NZS 60529 [15]. If necessary, opening for natural ventilation / exhaust ducting shall be provided. These shall be louvered with wire mesh. However the IP rating shall not be affected due to this.

Suitable eye bolts for lifting of panel shall be provided. If eyebolts are removable caps shall be provided to seal any opening on the surface of the switchboard.

4.2.3 Compartments

4.2.3.1 General Requirement

The switchgear shall be made up of individual switchgear panels. The individual switchgear panels shall be fully segregated into four compartment types as follows:

1) The main switching devices that is the circuit breakers;
2) Components connected to one side of the main switching device, which is the external cable circuit and current transformers;
3) Components connected to the other side of the main switching device, that is the busbars; and
4) Auxiliary equipment compartment to house Control and Protection equipment (on-board protection) or Indication circuits (off-board protection), (Section 4.4 for details) etc.

Compartments shall be of a fabricated, rigidly braced, structural steel framework. Where compartment walls or doors have cut-outs for the mounting of Protection, Control and Supervisory equipment, the thickness of sheet shall be increased or stiffeners provided to maintain panel rigidity equivalent to the uncut sheet, if required.

The compartmenting shall be designed so that the separation between the adjacent busbar, and or circuit breaker/ starter, and or the cable termination compartment is retained when the circuit breaker is withdrawn.

Compartment for cable connection shall only allow cable pulling, termination and connection work with switchgear de-energised, via mechanical interlock with earth applied. Vendor shall offer suitable method for access to rear covers.

The Auxiliary equipment compartment shall be mounted directly above its associated circuit breaker compartment, and be accessible from the front of the switchboard. Particular attention should be taken to ensure that the protection relay or any other device does not foul the opening of the compartment.

Access to CT's within compartments shall be easily accomplished by removing the bolted cover, it shall not be necessary to disconnect any of the primary or secondary cables to gain access.

4.2.3.2 Doors

Door seals shall comprise a neoprene or identical non sticking poly material section held in a metal channel on the door and compressed by a dished edge on the fixed enclosure, when the door is closed. All doors shall be equipped with a lockable latch; high doors shall have a dual latching system.

All doors shall be able to open to at least 120°, regardless of the status of adjacent doors, handles, levers or accessories.

Auxiliary equipment compartment doors shall be provided with "stay bars" which positively locate them when open, and not foul wiring or equipment when closed.

All doors shall be hinged on the left side of their associated compartment. Doors greater than 1200 mm high shall have three hinges.

In addition the circuit breaker doors shall comply with the following requirements:

1) Access to any equipment, items, locks, levers or devices associated with circuit breaker carriage racking operations shall be accessible from the front or right hand side of the breaker carriage. That is, with the door open and located to the left side of the carriage, the operator shall enjoy complete freedom of access to all items at the front and right hand side of the carriage.
2) The door, if removable shall have lift off chrome plated hinges with stainless steel pins, one pin longer than the others and shall be designed to meet the requirements of Section 4.2.6.1 and interlock requirements of Section 4.2.8.
3) Doors of primary equipment compartments shall, regardless of height, have chrome plated handles operating top, centre and bottom locking bars to provide an even seal compression when closed. The handles shall be substantial and comfortable to grasp and operate with the whole hand. Specifically, handles, knobs, or knurled screws, operated by fingers shall not be accepted.
4) Inspection windows if provided shall meet requirements of AS 62271.200 [25].

4.2.4 Shutters

Independent metal automatic shutters shall be provided to separate the busbar and the incoming or outgoing stationary MV contacts from the circuit breaker compartment, when the breaker is in the "TEST", or "ISOLATED" position, or is completely removed.

The shutters shall be mounted inside the circuit breaker compartment (switching) on the stationary part; installation inside the busbar compartment is not permitted.

Shutters mechanisms shall be padlockable, both the busbar shutter and the outgoing shutter shall have separate locking facilities. Padlocks must remain locked with the circuit breaker in all positions other than "SERVICE" and prevent the breaker being racked into service. Both shutters shall be closed completely before the 'TEST" position of the circuit breaker is reached.

The shutters for the busbar side, the incoming or the outgoing circuits which can be subject to feedback, shall be coloured red (R13), the outgoing circuit shutters shall be colour wattle (Y12) to AS 2700 [8] respectively.

Earthed metal shutters may also be provided in the withdrawable Voltage Transformer (VT) compartments as described in Section A.2.

In addition, self-adhesive plastic stickers giving a clear distinction between the live and outgoing contacts shall be provided.

4.2.5 Fixing of Equipment on Side Walls

Adjacent panels shall not be opened to fasten screws and/or nuts, in particular when the side walls of the panels are used to mount certain equipment (for example limit switches or shutter operating mechanisms).

Mounting of limit switches, or the like, directly against a sheet steel partition is not acceptable.

4.2.6 Venting

The design of the finished switchgear and individual circuit breaker panels shall provide a high degree of protection for personnel as well as adjacent compartments in the event of arcing and overpressure occurring inside any compartment.

Designs offering an ARC duct exhaust system exhausting to the outside of a switchroom are preferable.

4.2.6.1 Internal Arc Classification (IAC)

The switchgear shall be designed to conform to the requirements of arc-fault venting in accordance with AS 62271.200 [25] Annex A.2 Accessibility Type A.

Operators of the *Equipment* shall be protected against the effects of an arcing fault in any of the MV compartment at all times, including during any racking operations. Full arc containment shall be possible under these conditions.

The *Equipment* must be designed to handle arc containment for the maximum design fault current as per Section 3.1.1 for a duration three (3) sec.

All HV switchgear shall be labelled with their arc flash (AF) incident energy level and AF Hazard Risk Classification (HRC) level for personnel to wear the appropriate arc rated PPE for operator safety, in accordance with NFPA 70E [31].

The Vendor shall provide in the Proposal the IAC accessibility type including sides (Front, Lateral & Rear) and internal arc current and duration with supporting test reports demonstrating IAC compliance. The *Equipment* must meet all IAC test criteria as defined by AS 62271.200 (A-6) [25].

4.2.6.2 Explosion Relief Chamber and Ducting

An explosion exhaust chamber shall be incorporated, such that the gases resulting from the internal arcing in the compartments always escape in a direction, away from the operator standing in front of switchboard. Each MV compartment shall have its own relief facility and designed such that the hot ionized gases from the compartments are directly conducted to the outside of the switchboard into the exhaust chamber, without reaching any other compartments of the switchboard. All relief valves shall be vermin proof.

The vendor shall make recommendation on the design of the explosion chamber. If the danger exists that gases of an internal explosion, released in the switchroom space can harm the operator, for instance because of its limited dimensions, additional ducting shall be quoted for separately, to conduct the gases to the outside of the building. Vendor shall state when this facility is required, free height of ceiling, free space over and to the rear of the switchboard.

Designs offering an explosion exhaust system exhausting to the outside of the switchroom are preferable.

4.2.7 Earthing

All earthing must comply with the requirements as defined in AS 62271.1 [22] and AS 62271.200 [25] in addition to the following:

4.2.7.1 Earthbar

The completed switchgear shall have an earth bar with a minimum cross section of 40 mm x 5 mm and shall be rated to carry the maximum fault current running throughout the length of the switchboard. It must be made of hard drawn high conductivity copper and should have provision for a minimum of 4 connections to the distribution substation earth.

The earth bar shall not be insulated. It shall have branches to all circuit breakers, starter units or and other main electrical equipment such as but not limited to: current transformers, earthing switches and the switchboard structure and enclosure itself.

4.2.7.2 Accessory Earthing

All doors shall be grounded by means of a flexible, stranded copper wire (see Panel Wiring and Terminals standard HPC-9DJ-23-0001-2016 [2] for wiring requirements), and connected to the stationary part of the switchboard. Earthing connections through the hinges are not acceptable.

Panel mounted equipment with exposed metal parts such as indicating lights, push buttons and relays shall be separately earthed.

Earth wiring connecting electrical equipment and exposed metal parts to the earth bar or metal enclosure frame shall be sized in accordance with AS/NZS 3000 [9] in relation to the size of the largest active conductor.

All metal shutters shall be earthed to the earth bar of the switchboard, using a flexible connection which will not hamper the operating mechanism.

4.2.7.3 Circuit Breaker Earthing

The trucks of the circuit breakers shall have a direct connection with the earth bar, both in the test position and the fully engaged position, as well as during travelling to and from these positions.

All circuit breakers shall be grounded by means of a copper brush or sliding contact, which shall be mounted on the switchboard structure and connected to the earth bar.

The fixed earthing part shall be silver-plated to prevent corrosion.

4.2.7.4 Cable Earthing

An earthing strip of 25 mm x 5 mm size connected to the distribution substation earth bar shall be installed inside the cable compartment for earthing the cable screen and shall be insulated from the switchgear frame earth. It shall be clearly labelled as being the cable screen earthing bar. The switchboard shall be provided with one separated earthing screw for each cable to connect cable armour earthing where applicable.

4.2.7.5 Bus Duct Earthing

The structure of the bus duct shall be connected through a flexible braiding, having the same cross section as the main earth bar, to a copper branch of the main earth bar, having the same dimension as the main earth bar.

The connection point shall be at the connecting flange. The flexible braiding is part of the switchboard supply.

4.2.7.6 Earthing Switches

All panels in the switchgear with MV cable circuits shall include a suitable fault making earthing device to earth its MV cable circuit. Vendors shall state clearly what types of earthing devices are proposed.

An earthing switch as per AS/NZS 60265.1 [13] shall be capable of making the full short circuit current, the operating mechanism shall be charged spring operated in both directions.

The operating mechanism of the earthing switch shall be accessible from the front only, with all doors or covers closed. Preferably access to operating shafts shall be prevented when the circuit breaker is closed, this is to avoid damage to the interlocking mechanism.

The contacts of the earthing switch shall be directly connected through a copper connection with main earthing bar; the flexible braided conductor shall jump the shaft mechanism.

The earthing switch shall be interlocked mechanically with its upstream circuit breaker such that mutual inadvertent closing is impossible.

All earthing devices must either be capable of being viewed so that visible indication of earthing is given or indicating devices must be positively linked to the earth switch operating mechanism. The position of each earthing switch shall be visible from the front, without opening doors or covers. Two spare auxiliary switches shall be provided on each earthing device which can be used for remotely indicating the operating position of the earth switch. Each switch shall be wired out to the terminal block strip in the associated auxiliary equipment compartment.

If the circuit breaker is used to provide the earth connection it shall not be possible to electrically trip the circuit breaker whilst in the earthed position. Breakers used for earthing shall only be manually tripped using the circuit breakers mechanical trip pushbutton.

The earth switch shall be capable of at least two operations at rated fault-make current before repair or replacement becomes necessary. Each switch shall be capable of being locked with a padlock in either the open or closed position.

4.2.8 Interlocks

Interlock mechanisms shall be mechanical and manually operated. They shall be provided with permanently lasting labels which are readily visible and which contain clear and concise instructions to operators.

Interlocks shall be provided to prevent the following operations:

1) The truck portion from being withdrawn from or inserted into the “SERVICE” position when the circuit breaker is closed. Attempted withdrawal shall not trip a closed circuit breaker.
2) The closing of the circuit breaker unless the truck portion is correctly positioned in the selected location, or fully isolated or withdrawn from the equipment.
3) The circuit breaker being closed in the ‘SERVICE” position without completing the appropriate auxiliary circuits between the fixed portion and the circuit breaker truck.
4) The circuit breaker truck being plugged into the fixed portion unless it is correctly positioned.
5) Between the circuit breaker assembly and the control cable plug if required so that that the plug only can be removed in the test position of the circuit breaker and prevent moving of the circuit breaker to the engaged position without the plug locked in.
6) The fault-make earthing switch from being closed unless the associated circuit breaker is in the “ISOLATED” position.
7) Bus earth switches shall incorporate a blocking magnet interlock to all panels on that Bus.
8) The circuit breaker from being closed while in the “SERVICE” position when its associated fault-make earthing switch is in the closed position.
9) The auxiliary circuits being disconnected with the circuit breaker closed in the “SERVICE” position.
10) The circuit breaker of a lower current rating from being inserted into the fixed portion of a higher normal current rating.
11) The fault-make earthing switch from being closed on a live busbar.
12) The front door (if applicable) of the circuit breaker compartment shall not be opened until the circuit breaker is in the “ISOLATED” position.

Vendors shall provide full details of *Equipment* interlocks. Interlock schemes which result in tripping of the circuit breaker while attempting an illegal operation are not preferred.

Interlock mechanisms shall function positively without the need to physically manipulate them to achieve the desired result.

Dead front protection shall be maintained throughout the withdrawal operation. Such interlocks shall not prevent the circuit breaker being fully functional in the "TEST" position.

4.2.9 Busbars and Primary Connections

The busbars shall be designed and constructed in accordance with AS 62271.1 [22] and be of hard drawn, high conductivity copper of uniform cross section throughout the switchgear.

The busbar system includes the connections to and from the horizontal conductors and the incoming and the outgoing cables, both to or from the fixed contacts of the switching device.

Joints shall be bolted and have provision to maintain contact pressure. Busbars should be supplied complete with bridging pieces for connection of transportable sections and provision made to accommodate any thermal expansions. Bolted joints shall be silver surfaced; ring-plating will not be permitted. Bolts and associated hardware shall be of non-magnetic, corrosion-resistant material. Any busbar bolt holes shall be drilled. Punching shall not be accepted, as this is known to lead to point or line contacts and bus bar failure. All related fixing torques shall be indicated in the maintenance manual.

The busbar compartments shall be fitted with removable covers to provide access to busbars and joints at all circuit cubicle.

Primary busbar conductors and connections shall be covered with insulation material and coloured red R13 to AS 2700 [8]. Insulators for busbar supports shall be made of high quality non-hygroscopic insulating material, suitable to withstand the occurring dynamic forces. A soft rubber gasket shall be applied between the vertical sections of a busbar compartment.

Materials shall be supplied for insulating the busbars at joints between compartment units separated for shipment. Busbars shall be arranged relative to the front of the switchgear top to bottom/left to right/back to front, as appropriate.

4.2.10 Cable Termination

All switchgear panels requiring MV cable terminations shall be fitted with cable boxes. The boxes shall be suitable for cable sizes specified in Appendix D-Schedule A of the document. Primary cables shall be separated from each other (phase separation) and from the cables of other circuits via barriers.

The cable boxes will be downward pointing. The dimensions of the cable box shall completely contain the cable termination. Vendor shall verify that the cable termination, made according to the installation instructions of its manufacturer, amply fits into the available cable termination space of the switchboard. The termination of cables is to be carried out by Horizon Power's approved contractor.

Cable boxes shall be fitted with windows to allow for in-service thermography. Number and location of windows shall be such that all cable connections are visible. Thermography windows shall be constructed of a suitable material for the environment and shall incorporate a cover to protect the window from damage and shall not detract from the switchgears arc flash rating or type testing certificate.

The cable termination palms should preferably be 1 metre above floor level and suitable for connecting the cables which rise vertically from the switchroom cable trench below.

A metallic cable support system shall be provided to fix and support the weight of all incoming and outgoing cables within and on the outside of the switchboard.

They shall be fitted with an undrilled removable gland plate for each cable to allow the cables to be laid into and removed from the box without the need to thread the cables through the gland entry.

The cable box entry for single core cables shall be designed to minimise the possibility of eddy current heating.

Primary cable compartments shall be large enough to accommodate cable stress cones, and shall include cable connectors and cable supports.

For panels with more than one power cable termination, the set of terminals nearest to the circuit breaker shall be designated 'A' with the next set of terminals designated 'B' and 'C' if applicable. All terminals must comply with dimensions defined as per AS 62271.301 [27].

4.2.10.1 Cable Glands

Where multiple cable glands are fitted to the cable box a minimum clear separation of 100 mm shall be maintained between glands. The minimum distance from the bottom of the cable gland to floor level shall be 300 mm. The gland plates are to have insulated cable glands to suit the cables specified and approved means of supporting the cables. There shall be no damages to the cable due to rough edges of the gland plate. Suitable rubber grommets shall be provided if this is the case.

Attention shall be paid to the insulation and earthing of the gland and the gland plate, if core balance earth fault protection is required. If single core cable or steel tape armour is applied, the cable gland shall be approved for use by Horizon Power.

NOTE: Vendors supplying switchgear for switchrooms **do not** need to maintain the minimum distance required between the cable gland plate and the switchroom floor **if the switchroom is elevated**. The Vendor may utilise cut-outs in the switchroom floor with the switchgear gland plate forming the "floor" if a complete seal is provided. Rubber grommets are not acceptable in lieu of cable glands.

4.2.11 Current Transformers

Refer Appendix C1.

4.2.12 Voltage Transformers

Refer Appendix C2.

4.2.13 Rating Plates and Designation Labels

The rating plates shall be made of stainless steel and fixed to the surface by permanent fasteners. Adhesive fixing is not acceptable.

The rating information shall be engraved on the surface of the plates. Engraving shall be filled with non-deteriorating black paint. The maker's rating plate shall be in accordance with AS 62771.200 [25].

Main circuit labels shall be fixed to the front and rear of each switchgear unit. Such labels shall be approximately 240 mm x 75 mm with 25 mm black lettering on a white background. In addition, the Vendor shall fit an operating label 65 mm x 25 mm immediately above or below the circuit breaker control switch. The labels shall contain the circuit designations of the switchboard single line diagram.

VT marshalling boxes shall be labelled on the external surface of the door so as to clearly identify and associate it with the VT to which it is wired. The label shall include the associated bus bar name (e.g.) Front, Rear, A, B, as appropriate.

The Vendor shall provide and install labels adjacent to every item of equipment (e.g. relays, selector switches, fuses, links, Test Blocks, MCB's, etc.) which contain the circuit designation, function and such other details as may be relevant to facilitate identification from either side of the panel. These labels shall have black letters engraved on a white background, using white - black - white laminated engraving sheets.

Labels shall be fixed to the mounting plate using a suitable adhesive. Embossed, punched and/or self-adhesive labels are not acceptable. Labels should not be mounted on any removable surface or panel cover, which could be removed and then replaced onto another section of the switchgear.

Labels shall be positioned such that they can be read from the front of the switchgear or compartment without parallax error, or confusion of association with the labelled item. For this purpose, labels shall always be as close to their associated item as possible, with at least twice as much space to any other item. The labels shall not be concealed by wiring or any other items.

Fuses and links shall have their identification labels fixed to the mounting plate either above or below the fuse or link. The labels must be easily visible, whether mounted above or below the fuses and links. The rear identification labels, for fuses and links, shall be located between the connection studs and fixed to the mounting plate.

Any relays with LCD displays shall have, immediately below them, a space to allow Horizon Power to mount a label. Horizon Power shall engrave on the label the relevant fault indications likely to appear on the relay LCD. The space shall be at least the width of the relay being labelled, and at least 100 mm in height.

Warning labels shall be provided in those locations where normal isolating procedures may not ensure that the equipment is completely `dead', e.g. at anti-condensation heaters, at compartment mounted terminals where the voltage exceeds 110 volts, and at access covers to high voltage compartments. Such labels shall consist of lettering not less than 6 mm high and shall be red letters on a white background.

The details of all labels shall be submitted to Horizon Power for approval.

4.2.14 Painting

All internal and external surfaces shall be protected against corrosion. All exposed metal surfaces shall be protected by the application of a painting system at least equivalent to ISO Category 4-5 and suitable for severe marine environments as specified in AS/NZS 2312.1 [7]. Colours shall be to AS 2700 [8] or equivalent as below:

External of switchboards	Parchment	Y43.

The manufacturer shall specify in the offer the standard colour offered and the additional cost implied upon for the specified colour code

4.3 Circuit Breaker

Refer Appendix C3.

4.4 Auxiliary Equipment

Protection and control schemes shall no longer be installed on switchboards. They shall be installed "**off-board**" in a separate room to ensure safety of operators.

However, in certain situations where it is physically not possible to provide for off-board protection / control schemes in a separate control room (i.e. extension to existing switchboards), the option for "**on-board**" schemes mounted on the Auxiliary compartment (Low Voltage compartment) may be considered. However the designer must obtain prior approval before employing this scheme into the system.

The method of protection will be specified in Schedule A of the document.

4.4.1 Auxiliary Equipment Compartment

An auxiliary equipment compartment shall be supplied above each circuit breaker and forms part of each circuit breaker panel.

For **off- board** protection/control scheme,

1) Terminal blocks, fuses and isolation links shall be mounted within the auxiliary compartment chamber.
2) The door panel shall be used to mount indicating lights only.
3) The following auxiliary supplies shall be provided via ducts/control buses consisting of insulated cables running along the entire length of each switchgear assembly:
   - 110 V DC supply for indicating lights.
   - 240 V AC to supply the anti-condensation heaters, power for the charging motors of the circuit breaker stored energy mechanisms and power to operate elevating mechanisms of vertical lift-type breakers, if applicable.

For **on-board** protection/control scheme,

1) All control and protection equipment are to be housed within the auxiliary equipment compartment in separate areas, with the protection equipment preferably occupying the lower levels.
2) The door panel shall be used to mount protection relays, any meters, indicating lights, control switches, test blocks and earth links. All auxiliary equipment including auxiliary relays, terminals fuses and isolation links shall be mounted within the compartment chamber.
3) The following auxiliary supplies shall be provided via ducts/control buses consisting of insulated cables running along the entire length of each switchgear assembly:
   - 24 V DC for SCADA
   - 110 V DC for alarm circuits, control and protection relays

- 240 V AC to supply the anti-condensation heaters, power for the charging motors of the circuit breaker stored energy mechanisms and power to operate elevating mechanisms of vertical lift-type breakers, if applicable.

4) In general, all test blocks, terminals, fuses, isolation links and earth links shall be accessible with the equipment in service. A minimum vertical distance of 60 mm shall be maintained between the cut-outs of adjacent flush mounted relays to enable device identification labels to be conveniently fixed. The Vendor shall submit panel arrangement drawings for approval by Horizon Power.

NOTE: 230 V AC supply shall not be used for any equipment mounted on the door panel of switchboard.

4.4.2 General Requirements for Control Circuit Elements

Refer Appendix C4.

4.4.3 Wiring

4.4.3.1 General

The Vendor shall make provision for wiring required to connections external of switchboard: Power supplies DC and AC, SCADA and other Horizon Power equipment as necessary. The wiring shall be in accordance with AS/NZS 5000.1 [10]. All wiring to auxiliary compartment and protection control (located separately or within auxiliary compartment) shall also be provided by the vendor and detailed in the submission, this wiring shall be in accordance with AS/NZS 5000.2 [11].

4.4.3.2 Secondary Wiring

Refer Appendix C5.

4.4.4 General Protection Control Requirements

4.4.4.1 General

The Vendor shall use only relays and ancillary devices that are approved by Horizon Power. Approved devices are listed in Appendix D Schedule A.

All relay terminals shall be screw type and not push on.

Each relay shall have an adjacent label indicating its schematic reference code. Relays shall have minimal operating power requirements, shall operate reliably on voltages as per table below and shall be rated for continuous energisation at the upper limit of this working range.

Table 2: Operating Limits of Control Voltages for Protection Relays

Battery Voltage	Upper Limit	Lower Limit
110 V	137.5 V	88.0 V
24 V	29 V	21 V

All protection relays with indications and readouts shall be flush mounted on the front surface of the equipment compartment. Each relay shall have a removable transparent cover or cover with a transparent window making the front of the relay visible.

Protection relays with indicators shall be mounted such that the bottom of such is not lower than 1000 mm and the top not higher than 2000 mm from floor level.

Test facilities for each AC current secondary circuit so as to provide access for testing of the protective relay and its associated circuits. This shall be provided on the terminal block and will consist of isolation links on the current transformer and voltage transformer circuits and suitable terminals for insertion of test leads banana terminals for injection of secondary current and voltage.

The rear terminals of flush mounted protection relays shall have a minimum clearance of 25 mm from any other item (except another relay or test block) or compartment surface when the compartment door is closed.

Control and auxiliary relays without flagging or operation indicators may be mounted on surfaces inside the corresponding compartment.

The control of the switching devices shall be as per control schematics attached to the requisition. This setup shall ensure proper protection tripping and safe interlocking of the operation of the switching device. Adaptations to the given schematics may be required due to particular material requirements, such as the time required for activating of the closing and or tripping mechanisms.

4.4.4.2 Protection Relay

The principal protection relay approved for use in Horizon Power switchboards is the SEL751 relay. This will provide Over Current, Earth Fault, Sensitive Earth Fault, Over & Under Voltage, Frequency, Trip Circuit Supervision and CB fail (local backup) functions. In addition, it can also provide Auto Reclose and Under Frequency Load Shedding which may be required in feeder circuits.

The opto-isolator input of the SEL751 relay shall be used for trip Circuit Supervision. Secondary protection control and indication wiring shall be segregated functionally with both the positive and negative legs being fused. Figure 1 in Appendix C5 provides an example of the segregation requirements.

Arc flash detection option shall be selected for SEL751 relay used in feeder/incoming protection circuits. See Section 4.4.4.5 for details.

The position of the circuit breaker, i.e. racked-in or withdrawn shall be indicated, as well as status, i.e. whether open or closed as well as the status of the earth switch.

General Electric MFAC34 shall be used for bus differential and bus zone protection.

4.4.4.3 Trip and Control Relays

Additional relays shall be selected by the designer for trip supply supervision, trip relays and other control relays. The electrical protective relays shall be of Numeric design and shall comply with IEC 60255 [28]. Each protection relay shall be equipped with adequate electrically independent contacts of adequate rating for Trip and alarm functions.

The relay shall also have adequate number of LEDs to assign each of the available protection functions. Relay operation due to system fault, shall be indicated by a Red LED and the fault details (flags) shall be displayed on the interface. Both the relay fault flags and red LED shall be reset via reset push buttons without opening the relay Cover.

Relays contacts shall make firmly without bounce and the whole of the relay mechanism shall be as far as possible unaffected by vibration or external magnetic fields.

Relays contacts shall be suitable for making and breaking the maximum currents, which they may be required to control in normal service. Where contacts of the protective relays are unable to deal directly with the tripping currents, Auxiliary Trip relays shall be provided. This will ensure safety for the protection relays output contacts.

4.4.4.4 Non Operation for Interruption / Restoration of Measuring or Trip Supplies

As a general policy, the interruption, restoration or disturbance of any protection power supplies or measured quantities shall not result in operation of any protection scheme or device, unless a primary fault condition exists.

This philosophy shall apply to the removal, replacement, or operation of:

- supply fuses;
- isolation links;
- MCB's;
- test blocks; and
- racking operations or disconnection of VT's.

If for any reason this requirement cannot be met, such items shall be prominently labelled with a yellow warning label with black lettering, the wording of which shall be approved by Horizon Power.

In addition, instructions for the correct operation of such items to avoid tripping shall be included in the maintenance and operation manuals.

4.4.4.5 Arc Detection Protection System Equipment

Each switchboard shall make provision for the fitment of arc detection sensors. In the case of on-board protection and control schemes, the arc sensor for each compartment of incomer and feeder panels shall be wired directly to the arc flash card supplied with the SEL751 relay.

For off-board protection a slave relay configuration may be required. In this case, the arc sensor shall be wired to terminals in the auxiliary compartment and then wired to the appropriate arc detection relay.

All arc sensors applicable to a particular switchboard shall be fitted by the supplier as per advice from Horizon Power. The switchgear manufacturer shall install the cables between the relays and the sensors in accordance with the relay instructions and the arc detection protection scheme design.

Point sensors shall be installed inside the switchboard on the busbar compartment, MV cable compartment, CT compartment (if separate) and circuit breaker compartment. The sensors shall be mounted flush on the switchgear cabinet wall, using a standard 1/4-inch hole. Wiring shall be done as per Section 4.4.3.

The arc sensor for the VT compartment of the VT panel shall be wired to their respective slave relays in accordance with the arc detection protection scheme design.

Where vacuum circuit breakers are used, the arc sensors shall be positioned such that light emitted from the arc inside the vacuum interrupter during operation does not cause spurious operation of the arc detection protection system.

NOTE: For the arc flash detection inputs to be included in the SEL751 the Fast High Current Interrupting Output mode must be selected while ordering the relay.

4.4.4.6 Masking of Alarm Conditions

An alarm condition arising in any particular circuit of the switchgear shall not mask or prevent alarms arising in other circuits from being annunciated.

4.4.4.7 VESDA Systems

Where use is made of VESDA systems, each auxiliary compartment shall have capillary tubes fitted.

5 PACKAGING REQUIREMENTS

The *Equipment* shall be suitably packaged, such that it is "fit for use" at any location in Horizon Power's operational area and specifically include all accessories needed. Packaging shall be capable of preventing damage whilst in storage and during transit to remote locations. The Vendor is required to nominate standard pack quantities and standard packs shall be clearly marked with the following information:

1) Manufacturer's name;
2) Manufacturer's part reference number;
3) Horizon Power Order Number;
4) Horizon Power Stock Number;
5) Gross weight in kg;
6) Nett weight in kg;
7) Date of manufacture; and
8) Manufacturer's Serial Numbers of all packaged *Equipment* (to facilitate traceability)

Very strong consideration shall be given to appropriate packaging provided with any *Equipment* offered under this specification, with respects to satisfying the "fit for use" criteria mentioned above.

In addition the package shall contain:

a) an installation instruction;
b) all necessary components and consumables required to complete the installation in accordance with the instruction;
c) a bill of materials; and
d) Material Safety Data Sheets (MSDS)

Each package is to have an identifying bar code and number which identifies as a minimum the:

- Manufacturer's part number;
- Manufacturer;
- Factory of manufacture; and
- Month and year of manufacture.

The bar code should be code 128 and can be applied either by spray or on a plastic tag. The bar code and number does not have to be indelible beyond installation.

Note: The vendor is required to identify the cost of providing bar coding as specified in this Section separately from the other cost requirements of this specification.

6 STORAGE

The *Equipment* shall be capable of being stored without deterioration within the temperature range of -10 °C to +50 °C for no less than 24 months.

7 RELIABILITY

Vendors shall provide information on the reliability of the *Equipment* and the performance of the materials offered over an **operational life of 30 years** under the specified field of application and conditions of service.

Information provided shall evidence the claimed reliability and performance for the *Equipment* offered, including details on Failure Mode and Effect Analysis, carried out in accordance with IEC 60812 [30]. Failure modes should be described; taking cantilever mechanical failure as an example, the failure may be excessive deflection, or brittle fracture. Electrical failure may be material damage such as puncture, polymer degradation, carbonisation, loss of hydrophobicity, etc.

Vendors may offer their standard *Equipment* but any variation to the foregoing standards must be clearly stated in writing at the time of the proposal. The products offered in the standing offer should be equal to or better in quality and performance than the existing items as listed under this Specification.

8 SAFETY

Material Safety Data Sheets (MSDS) applicable for each different *Equipment* or chemical ingredient in the *Equipment* which is considered harmful to personnel or environment in any manner, shall be supplied with the Proposal.

9 ENVIRONMENTAL CONSIDERATIONS

Vendors are required to provide information on the environmental soundness of the design and the materials used in the manufacture of the items offered. Vendors shall provide a detailed outline of the steps that have been put in place to fulfil any obligations that may be required pursuant to the *Waste Avoidance and Resource Recovery Act 2001* and any amendments. In particular:

- Management of waste reduction;
- The use of re-usable packing; and
- Extended producer responsibility for the safe disposal of materials at the end of their life.

10 ELECTRICAL TESTS

All *Equipment* offered shall have been fully type tested in accordance with AS 62271.200 [25].

Where the Vendor considers that tests previously performed meet the type test requirements of all or of particular tests specified, then these type tests will be acceptable only if the *Equipment* offered to the Specification is of identical design in every detail and to the same material specification as the original *Equipment* on which the type tests were performed.

Where a Vendor offers a switchboard which has not been fully type tested, the Proposal shall state whether the *Equipment* is of identical design and material specification of a switchboard which has previously been fully type tested.

Test procedures are available from Horizon Power on request. Certificates to verify the results of the tests shall be provided and supplied to Horizon Power.

For each relay the test certificates shall describe:

- The date and time of the test
- The type of relay tested
- The serial number of the relay tested
- The tests performed and the methods followed
- The test results in terms of measured quantities (e.g.) pick up in amperes, time delay in seconds. That is, not just 'pass/fail', or 'in accordance with specification' type of results.

If the relay testing is separate from the testing described below, then a Horizon Power Representative will attend the factory for the purpose of inspection and witnessing of tests. Horizon Power shall be given 4 weeks notice of the tests.

10.1 General

10.1.1 Manufacturer's Testing Capabilities

The manufacturer shall be fully responsible for performing or having performed all the required tests as specified. Tenderers shall confirm the manufacturer's capabilities in this regard when submitting tenders. Any limitations shall be clearly stated. The manufacturer shall bear all additional costs related to not being able to test as tendered.

10.1.1.1 Witnessing of Tests

Horizon Power reserves the right to be present at any of the tests specified.

The contractor shall ascertain the sequence of tests required in each particular case and whether witnessing of tests is required, and, after completion of all works preliminary tests, shall then give the purchaser not less than 14 days notice of the firm date when the switchboard and associated apparatus will be ready for the witnessing of testing.

For overseas suppliers the minimum required notification time period is 8 weeks. As many tests as possible shall be arranged to take place on the same day.

No switchboard shall be despatched from the manufacturer's works without the purchaser's approval of its testing and overall quality.

Any costs incurred by the contractor as a result of abortive or protracted visits by the purchaser's representatives, due to poor organisation on the part of the manufacturer or test failures, shall be for the contractor's account.

The purchaser shall be notified as soon as possible of all test failures and corrective measures. This shall take the form of abbreviated reports that shall, upon request, be supported by more detailed reports. It is desirable that the purchaser is notified of test failures to allow in situ inspection if desired.

10.1.1.2 Test Instruments and Apparatus

The testing apparatus shall subject to the purchaser's approval, and, where required, instruments shall be re-calibrated by an agreed independent body at the contractor's expense.

All apparatus shall be arranged and operated with due regard to the safety of personnel and so as to minimize damage to the test object in case of breakdown.

10.1.1.3 Test Certificates

Four copies of test certificates in English shall be supplied to the purchaser within 30 days of the completion of the works tests.

A copy of the test certificate shall be incorporated into each maintenance/operating manual provided for that transformer.

10.2 Type Tests

Certificates of type tests shall be submitted to Horizon Power. These type tests shall include those outlined in AS 62271.100 [23], AS 62271.110 [24], AS 62271.200 [25], and AS 62271.201 [26].

Temperature rise tests will only be accepted where the Vendor can show that the test has been performed either as a complete switchboard or that the test on an individual unit has taken into account the effect of the adjacent units under full load conditions.

The Vendor should also submit evidence of any cyclic loading tests performed on the *Equipment* offered.

10.2.1 Routine Tests

In addition to the routine tests required on the circuit breaker by AS 62271.100 [23] and those normally performed by the Vendor, the switchgear shall also be subjected by the Vendor to the routine tests specified below:

10.2.1.1 Switchgear

Each complete section of switchgear shall be subjected to:

1) Insulation resistance test of all circuits with the associated circuit breakers both open and closed at an ambient temperature not exceeding 45 °C. The insulation resistance, measured at not less than 1 kV to frame, shall be not less than 5000 MΩ for primary conductors and 30 MΩ for secondary wiring grouped together.
2) Power frequency voltage withstand test as prescribed in AS 62271.100 [23] Clause 6.2.6.1.
3) Power frequency voltage withstand test as prescribed in AS 62271.110 [24] Clause 4.4.8.

10.2.1.2 Current and Voltage Transformers

All current transformers shall be routine tested as prescribed in AS 61869.1 [19] & AS 61869.2 [20], and all voltage transformers shall be routine tested as prescribed in AS 61869.1 [19] & AS 61869.3 [21].

10.2.1.3 Insulation Tests

1) Bushing insulation shall be routine tested as prescribed in AS/NZS 60137 [12].
2) All insulation composed of synthetic material shall be subject to tests for the measurement of partial discharge in accordance with the provision of AS 60270 [14]. Such tests shall demonstrate that the insulation is free of discharges of magnitude greater than 20 pC, when subject to a test voltage of 23 kV rms. Reports of these tests shall be supplied with test reports of other routine tests. If the required level of discharge magnitude cannot be achieved, the levels that can be guaranteed shall be stated in.

Horizon Power reserves the right to witness any test. The Vendor shall provide at least 7 days notice of when each and every test is to be carried out.

One certified copy of all test results shall be supplied to Horizon Power immediately after the completion of the tests.

10.2.2 Tests Prior to Completion of Defects Liability Period

Immediately prior to the completion of the Defects Liability Period the switchgear may be subject to an insulation test by means of a 1000 Volts insulation tester, by Horizon Power.

Any piece of apparatus showing an insulation resistance of less than 1000 MΩ will be subject to a high voltage test in accordance with AS 2067 [6]. Any piece of apparatus breaking down on this subsequent test shall be replaced by the Vendor free of cost.

11 DOCUMENTATION AND SAMPLES

11.1 Documentation to be provided with Proposals

Submitted proposals shall provide all documentation and information as requested in this specification, including any further relevant information on the *Equipment* offered. The proposal must be complete in all respects. Failure to comply may cause the proposal to be considered incomplete and hence informal.

The vendor shall provide an electronic version of all documents in Adobe Acrobat (.pdf) format containing the information detailed below with their offer:

- Any non-compliance of the Specification shall be detailed in the Technical Deviation schedule;
- All information provided in Technical Requirements shall be in English and measurement units shall be in metric units;
- Material Safety Data Sheets;
- CAD drawings (Micro station preferred DGN format) of all *Equipment* showing all critical dimensions;
- *Equipment* data sheets showing the weight, material type, protective coatings, mechanical & electrical properties (Combined Load Charts shall be included);
- Installation instructions included in the packaging; and
- A copy of the Vendor's current Quality Assurance accreditation and category.

Should the preferred vendor submit drawings for approval by Horizon Power, this will in no way exonerate it from being responsible for the correct and proper function of the *Equipment*.

11.2 Service History

Vendors shall state:

- Other Australian electricity supply authorities who have a service history of the items offered; and
- Contact details of those supply authorities who can verify the service performance claimed.

11.3 Training Materials

Training material in the form of drawings, instructions and/or audio-visuals must be provided for the items accepted under the offer.

Vendors shall state the availability of training materials which could include but is not limited to the following topics:

- Handling and storage;
- Application (particularly in areas of heavy coastal pollution);
- Installation;
- Maintenance;
- Environmental performance;
- Electrical performance;
- Mechanical performance;
- Disposal at the end of service life; and
- Production process and testing.

12 SPARE *EQUIPMENT*

Separate prices are required with the offer for the following:

1) Any spares necessary for the continuous operation of each item of *Equipment*; and

2) Any special tools or handling equipment required for installation and/or maintenance shall be stated in Appendix F of the enquiry document.

All spares must be labelled with manufacturer's part number.

It is required that the validity period of the Proposal, as far as spares are concerned, be extended until such time as Horizon Power places an order for spares.

APPENDIX A REVISION INFORMATION

(Informative) Horizon Power has endeavoured to provide standards of the highest quality and would appreciate notification if any errors are found or even queries raised.

Each Standard makes use of its own comment sheet which is maintained throughout the life of the standard, which lists all comments made by stakeholders regarding the standard.

A comment sheet found in **DM: 2008484** can be used to record any errors or queries found in or pertaining to this standard, which can then be addressed whenever the standard gets reviewed.

Date	Rev No.	Notes
5/12/2022	2	Reformatted document, standards dated and referenced, Additional requirements (Appendix A) moved to Appendix C
23/06/2021	1	Minor changes to section 4.2.3.2, 4.2.6.2, 4.2.7.6, 4.2.8, 4.2.10, 4.2.13 and 4.4.4 SCADA voltage changed from 50 to 24Vdc. Minor changes to section A.4.5, A.4.6, A.4.7 and A.5.1 & 2 Appendix G- removed tables and text for 1) Size and voltage grade of Wires for Panel Wiring, 2) Terminals, 3) Colours for Small Wiring & 4) Circuit Function Letters and Wire Numbers. Precise details in section 1 of comment sheet No 1 to No 53.
05/07/2013	0	First Issue

APPENDIX B QUALITY ASSURANCE (TO BE COMPLETED BY STORES)

DOCUMENT NUMBER	HPC-8DJ-23-0001-2013			**QUALITY ASSURANCE**		**DM NUMBER**		
DEVICE DESCRIPTION	**LABEL MATERIAL NO.**			**MV SWITCHGEAR PURCHASE**		**ASSET OWNER**		
	ASSET ID/ STOCK NO							
MANUFACTURER			**DIMENSION**					

ITEM	OPERATION/EQUIPMENT/FACILITY	DOCUMENT REF.	WHO CHECKS	INITIAL	DATE/ TIME	QUALITY ASSURANCE CRITERIA	PASS Y/N	COMMENTS
1								
1.1	Name of Manufacturer					*******		
1.2	Week & Year of Manufacture					*******		
1.3	Horizon Power Order Number					*******		
1.4	Horizon Power Stock Number					*******		
1.5	Rating Plate Voltage					*******		
1.6	Physical Appearance							
1.6.1	Paint Colour/Galvanising					External – Parchment (Y 43) Internal - White		
1.6.2	Paint Chips					*******		
1.6.3	Physical Damage					*******		
1.7	Packaging (if not already assembled)					Fit for transport to site		

2	DOCUMENTATION							
2.1	Material Safety Data Sheets					Clear, Legible and in English		
2.2	Switchboard Documentation & Drawings					Clear, Legible and in English		
2.3	Test and Inspection Reports					Clear, Legible and in English		
2.3.1	Switchgear (including IAC tests)					*******		
2.3.2	Circuit Breakers					*******		
2.3.3	Current Transformer					*******		
2.3.4	Voltage transformer					*******		
2.3.5	Insulation Tests					*******		

SYMBOLS AND ABBREVIATIONS								
H = HOLD POINT	S = SUPERVISOR							
W = WITNESS POINT	T = TECHNICIAN, EL = ELECTRICIAN	REVISION						
V = VERIFICATION POINT	E = ENGINEER	DATE						
S/C = SUBCONTRACTOR	PM = PROJECT MANAGER	APPROVED BY						

APPENDIX C ADDITIONAL REQUIREMENTS

C.1 Current Transformers

Current transformers shall comply with AS 61869.1 [19] and AS 61869.2 [20], they shall be bar primary type having 1 amp secondary. Transformer terminals shall be clearly marked.

The CT terminal box shall have provision for sealing facilities.

The current transformers shall be of the dry type using cast resin or similar insulation and shall be mounted in the stationary part of the switchgear only.

The individual cores of the current transformers in the same enclosure shall be magnetically independent of each other. Current transformer secondary wiring within the MV compartment shall be suitably protected against flashover due to insulation failure of MV equipment.

Current circuits for measurement and protection purposes shall always be galvanically separated, unless specifically indicated on the drawings.

The transformers shall maintain sufficient accuracy under all overload and short circuit conditions, ensuring proper protection relay operation, maintaining the discrimination as required.

Provisions shall be made whereby all current transformers may be removed with ease. Vendors shall give details of the methods to be used to mount current transformers.

Current transformers shall have thermal and mechanical ratings and insulation class not less than those of the associated circuit breakers. Accuracy shall be as specified herein or as determined by the Vendor's design approved by Horizon Power.

The rated output of the current transformer shall be selected to match to the actual burden, taking into account all possible impedances, including the external cabling.

The current transformers shall be selected as specified in Appendix D- Schedule A of the document.

The transformers shall be capable of withstanding the rated and peak momentary current as specified for the switchboard.

C.2 Voltage Transformers

Voltage transformers for protection and measurement purposes shall be:

1) of withdrawable design;
2) situated in a separate dedicated panel;
3) connected directly to the busbar; and
4) accessible from the front.

The voltage transformers shall be moulded dry type, provided with current-limiting high interrupting capacity primary fuses, with accuracy as specified herein and comply with AS/NZS 1243 [5], AS 61869.1 [19] & AS 61869.3 [21].

When the withdrawable voltage transformer is isolated, the secondary circuit wiring shall be broken to prevent energising of the voltage transformer.

All Voltage Transformers shall be either three (3) phase 5 limb or three (3) single phase VT’s, Category B type with secondary windings Class 0.2/50 VA for measurements and Class 3P/100 VA for protection.

Voltage transformers shall be provided with adjacent marshalling boxes to house protective LV MCB's and terminal block for external connections. Secondary MCB's shall only be omitted if specifically indicated in the control diagrams.

The voltage transformers shall be readily disconnectable without taking the busbars out of service. The MV fuses shall only be removable when the voltage transformer is fully isolated. The MCB's shall be accessible with the switchgear fully energised.

Voltage transformers may be provided with devices for disconnecting and automatically earthing the transformers and fuses when they are withdrawn. Earthed metal padlockable shutters shall cover the access to live terminals automatically, as the voltage transformers are drawn out. The VT bus bar shutters shall be signal red, colour R13 to AS 2700 [8].

The secondary wiring between the potential or service transformer and the protecting MCB shall be as short as possible. Each wire of this part of the secondary side shall be double insulated.

C.3 Circuit Breaker

C.3.1 General

Each panel shall contain only one circuit breaker. A tiered arrangement shall not be acceptable for switchgear to this Specification. The circuit breaker bushings shall be contained in the circuit breaker chamber and shall not enter the cable or busbar compartments.

The switchgear shall only use **Vacuum** as the interrupting medium.

All circuit breakers shall be of the 3 pole type, all poles shall operate simultaneously. The breakers shall have at least 6 NO & 6 NC spare auxiliary contacts. All auxiliary contacts shall be wired up to terminal block. They shall also be equipped with self-aligning silver-plated primary and secondary disconnecting devices, earthing contacts, operation counters and position indicators.

Stored energy mechanism: Circuit breakers shall be electrically-operated, trip-free as defined by AS 62271.100 [23], and will be equipped with a stored-energy closing mechanism which shall include a manual charging device.

The circuit breaker stored energy mechanism shall be automatically discharged when the breaker is moved towards the ISOLATED position without movement of the main contacts. A mechanical interlock shall be provided to prevent moving of the circuit breaker when the springs are still loaded.

The stored energy closing mechanism shall include a manual charging device by which the mechanism may be fully charged. Means shall also be provided for slow closing of the circuit breaker for maintenance purposes only.

Earthing contacts: Circuit breakers shall be provided with self-aligning contacts for earthing the removable elements when they are inserted in the housings or in the "TEST" position. The contacts shall be self-aligning, ensuring a sure and good contact and optimum contact pressure. The surface of the contact, both on the fixed and the movable part shall be silver-plated. The contact arms of the circuit breaker shall be fully insulated.

Electrical connections: All electrical control connections between the stationary and withdrawable part have to be made by means of contacts blocks or a socket and plug, such that the circuit breaker can be withdrawn without disconnecting any wiring or using tools. The sockets will be mounted on the moveable portion and the plug contacts on the fixed portion. No spring load fingers will be permitted on the fixed (or busbar) portion.

If a flexible conduit containing the control wiring between the circuit breaker and the connection plug is applied, this flexible conduit shall be protected by the circuit breaker body itself against flashovers.

Anti-pump control: The circuit breaker shall have anti-pump control, preventing undesired operation, when a trip command is present and (repeated) close commands are given. The anti-pump feature shall be maintained despite the loss of the busbar voltage during a fault. The circuit breaker shall not close even when operated mechanically.

Emergency tripping: The circuit breaker mechanisms shall allow for emergency manual mechanical closing and tripping. The closing mechanism shall include the disconnection or the blocking of the electrical closing operations.

Compatibility: All circuit breakers of the same rating shall be fully interchangeable, also with regard to the auxiliary contacts, the sequence of terminal connects, the number of auxiliary contacts and the control circuit diagram and components.

Circuit breakers of differing continuous current and voltage rating, or differing functionality shall be physically keyed so as to not be interchangeable. Also, such circuit breakers shall be clearly marked with their ratings so as to avoid being interchanged by accident.

Circuit Breaker Racking: The circuit breaker assembly or truck is to be supported and to be guided by the switchboard structure until the fully drawn out position, ready for lifting or moving the assembly or truck from the stationary part. The draw-out assembly shall permit handling by one man without excessive effort. Heavy circuit breakers shall not be directly manually moved, but they shall be driven via a hand operated gear. Motor driven truck operation shall only be provided if specified in the requisition. See Section C.3.6 for racking mechanism.

C.3.2 Classification of Circuit Breakers

The classification of circuit-breakers as a function of its capabilities shall be in accordance with Table 3 and as per definitions in AS 62271.100 [23].

Table 3: Operating Tolerances for Circuit Breaker Operation

Circuit Breaker Application	Circuit Breaker Class **	Electrical Endurance	Capacitive switching (restrike performance)	Mechanical Endurance	X/R ratio***
Transformer/ Bus Tie	S2**	E2	C1	M2	14***
Capacitor bank*	S2**	E2	C2	M2	14***
Feeder	S2**	E2****	C2	M2	14***

* - See Section C.3.3 on particular capacitor bank circuit breaker requirements.

** - Class S2 circuit-breakers are restricted to systems of rated voltages equal to or higher than 15 kV and less than 100 kV – in accordance with AS 62271.100 [23]. All circuit-breakers for use at 11 kV are therefore classified as class S1 circuit-breakers.

*** - X/R ratio of 25 shall be used in the North West Interconnected System wherein the switchboard is located in close proximity to the generation source (to be specified in Schedule A of the document).

****- Breakers with electrical endurance E1 shall be selected if auto reclosing capability is to be included.

C.3.3 Capacitive Switching currents and Requirements for Capacitor Bank Breakers

All circuit-breakers classified shall be capable of switching capacitor banks with either low probability (class C1) or very low probability (class C2) of restrike during capacitive current as per Table 3. The circuit-breaker shall be capable of switching single capacitor banks as well as back-to-back capacitor banks and rated as per Appendix D Schedule A of this document. Capacitor switching shall be possible without the need for controlled opening and/or closing.

Shunt capacitor banks in general will be connected to the substation busbar. Current-limiting reactors are normally installed between the circuit-breaker and the shunt capacitor bank being switched in order to obtain transient currents of manageable proportions. However the circuit breakers will have to satisfactorily switch the capacitive currents associated with the shunt capacitor banks. Shunt capacitor bank circuit-breaker will be required to switch more than once a day – in a single and/or back to-back situation of the rating specified.

Preference will be given by Horizon Power towards circuit breakers that are general purpose and can be used for feeder and capacitor bank applications. However vendor shall supply special purpose circuit breakers that will specifically meet the requirement for the capacitor banks.

C.3.4 Reactive Switching currents and Requirements for Reactor Bank Breakers

Circuit-breakers required for reactive switching shall meet the requirements of AS 62271.110 [24] besides the general circuit breaker requirements. The circuit-breaker shall be capable of switching single reactor banks as well as back-to-back reactor banks and rated as per Appendix D Schedule A of this document. Reactive switching shall be possible without the need for controlled opening and/or closing.

Reactor bank circuit-breaker will be required to switch more than once a day – in a single and/or back to-back situation of the rating specified. The 22 kV Reactor Circuit Design Review report HPC-10-DE-23-0001-2020 [3] highlights the consequences and remedial action required for circuit breakers that do not comply.

Preference will be given by Horizon Power towards circuit breakers that are general purpose and can be used for feeder, capacitor bank and reactor bank applications. However vendor shall supply special purpose circuit breakers that will specifically meet the requirement for the reactor banks.

C.3.5 Operating Requirements

Design of the circuit breakers shall be such that they shall provide successful interruption of low magnetising currents, as well as high load currents and short-circuit currents. The short circuit capacity and momentary peak value of the short circuit current shall be given on Appendix D Schedule A of the document.

The circuit breakers shall be capable of 10,000 operating cycles (close and trip) without replacement of parts and 5,000 operating cycles without maintenance. Switching operation counters shall be provided on each circuit breaker.

The circuit breaker must operate according to the following operating sequence as per Section 4.104 of AS 62271.100 [23].

O – t – CO – t'– CO

t – 0.3 seconds at all times

t' – 1 min. Preference will be given to circuit breakers which have a lower time interval for t'.

The circuit breaker must be guaranteed to operate within the following tolerance limits of the control voltage:

Table 4: Operating Tolerances for Circuit Breaker Operation

Battery Voltage	Trip operation	Closing operation
110 V	70-120%	85-120%

Indicators: Circuit breaker removable elements shall have three (3) distinct positions in their housings colour coding and indications as per AS 62271.100 [23] shall be provided.

1) "SERVICE", ready for operation;
2) "TEST", primary contacts separated a safe distance, shutters closed and capable of being locked closed, and secondary contacts connected, breaker available for tripping and closing as required;
3) "ISOLATED", primary contacts separated a safe distance and secondary contacts disconnected.

Also a separate indicating device needs to be provided for the state of the stored energy mechanism, "CHARGED" -when the mechanism is in the condition to close the circuit breaker and 'DISCHARGED" -when it is in any other condition.

The mechanical indicating devices or methods described above shall be visible, by means of transparent fittings, from the front of the switchgear even when all compartment doors are closed, and shall not be subject to parallax error.

C.3.6 Racking Mechanism

The mechanism shall include sufficient limit switches for protection and remote indication purposes included in other parts of this Specification.

Provision shall be made so that all circuit breakers can be easily disconnected and removed from a busbar by mechanical means such as racking out or lowering. A suitably designed handle shall be provided for the switchboard which will enable the racking in and out of circuit breakers of all ratings by a single operator with a force not exceeding 200 newtons.

Circuit breaker trucks used to achieve this shall be of either the four or three wheel type with wheels suitable for making sharp turns. It shall be possible for a single operator to line up and insert the circuit breaker truck into the fixed portion of the switchgear without the need for excessive force or manipulation or the need for levelling rails.

It shall not be necessary to use portable ramps when removing circuit breakers from the compartments. The floor of each compartment shall be designed such that the transition to the switchroom floor is smooth and does not jar the circuit breaker trolley.

The insertion and withdrawal of the movable portion of the circuit breaker will automatically and positively operate the shutters which will close as soon as the withdrawn contacts are clear and well before the movable portion reaches the “test” position. Each set shall be capable of being independently manually operated to expose the fixed contacts, close automatically on release and be lockable in the closed position. When padlocked closed they will be capable of withstanding the racking of the moveable portion towards the “service” position without damage to any item of plant.

The wheels or rollers of the circuit breaker carriage shall not be subject to binding or clogging due to sand or dust present on the floor. The wheels or rollers of the circuit breaker carriage, together with the self aligning feature of the racking mechanism shall ensure that the circuit breaker can be moved into position for insertion or removal without the need for an operator to apply more than 55 Nm in any direction.

If circuit breaker carriages cannot be easily “steered”, without lifting the wheels from the floor, whilst being moved around in the vicinity of the switchboard suitable “tilt and steer” accessories shall be provided.

The racking mechanism of the circuit breaker shall be designed to eliminate misalignment problems and be operable with the compartment door closed. Removable breakers of the vertical-lift type shall have individual motorised elevating mechanisms, in addition to manual means for raising and lowering them.

No stage of the racking process shall involve the use of leverage to achieve movement or displacement of the circuit breaker carriage. Rather, the racking movement shall be achieved by gentle guiding forces applied by the operator and/or screwing of worm gears, shafts or drives.

Provision shall be made to enable padlocking of the circuit breaker carriage in the “ISOLATE” and “TEST” positions. This provision is in addition to the shutter padlocking facilities described elsewhere in this Specification.

NOTE: The requirement to avoid “portable ramps” does not preclude the use of racking trolleys. If racking trolleys are required they shall be provided by the Vendor.

C.3.7 Requirement for Circuit Breakers

C.3.7.1 Vacuum Circuit Breakers

The contacts for the interrupter shall be positively driven in both the open and closed directions and in no way be dependent on the interrupter vacuum.

The vacuum bottles shall be sealed for life. They shall be fitted with an appropriate means of checking contact wear in-situ. The contactor shall be designed so that the effect of current chopping is not eliminated, nor there be a restrike when the contactor is being opened. The value at which current chopping occurs shall be minimal. It shall not be necessary to fit surge arresters to limit switching over voltages generated by the vacuum interrupters.

Vendors shall state the method by which Horizon Power may carry out in-situ tests on the integrity of vacuum in the bottles. The level of x-rays emitted shall meet requirements of AS 62271.1 [22].

If the switching action of the contactor cannot be completed when activated by a pulse contact of 200 ms, Vendor shall provide a time delayed action to ensure that the started action is completed.

Vendors shall outline the precautions and tests carried out during manufacture to ensure the long term maintenance of the vacuum and long term integrity of the vacuum bottles. They shall guarantee the shelf life of the vacuum bottles. Vendors shall guarantee the number of circuit breaker operations at rated short circuit current before replacement of the vacuum bottle is necessary.

Vendors shall state whether the vacuum switchgear offered is subject to any random flashovers across the contact gap of an open bottle under voltage conditions less than or equal to the switchgear test and service voltages specified in this Specification.

The detailed procedure for replacing a vacuum bottle shall be stated in the instruction manual.

The Vendor shall maintain the same make and type of vacuum bottle for all circuit breakers of the same rating throughout the Standing Offer period. The make and type of vacuum bottles shall not be changed without the prior approval of Horizon Power.

C.3.7.2 Loss of Insulating/Switching Medium

Vendors shall state the consequences of loss of vacuum on:

1) The voltage withstand capability (across contact and to earth) of an open circuit breaker,
2) The ability of the *Equipment* to switch load current; and
3) The ability of the *Equipment* to switch fault current.

The statement shall include the effects on the switchboard panel, on adjacent switchboard panels, and on operating personnel standing adjacent to the failed switchboard panel, of such operations.

C.4 General Requirements for Control Circuit Elements

C.4.1 Fuses

All control circuit fuses shall be HRC type conforming with the requirements of Clause 5.8 of IEC 60269.1 [29]. All fuse carriers shall be fitted with the appropriate HRC fuse.

Fuse bases and carriers shall be black. Bases and carriers of a different colour painted black will not be accepted. The SAFECLIP type, or any types similar to SAFECLIP, is not acceptable.

DC supply fuses shall be wired such that the top end of the fuse holder is “live”, and the bottom end is wired to the load. Fuses shall be located such that fuse replacement may be carried out in safety while all Equipment is live.

Fuses for AC supplies shall be spaced from those for DC supplies by at least the width of two carrier bases.

All control circuit fuses shall be located in the auxiliary equipment compartment.

All fuses shall be provided with identification labels which advise of the fuse rating. Two labels, for front and rear mounting, shall be provided for each back connected device and only one front mounted label is required for front connected devices.

C.4.2 Isolation Links

Isolation links (sliding Links) shall be provided on the trip circuits, alarm and on the VT circuits to allow easy isolation of these circuits without disconnecting the wires from the terminal block.

All isolation link assemblies of the SAFECLIP type, or any types similar to SAFECLIP, is not acceptable.

Link bases and carriers shall be white. Bases and carriers of a different colour painted white will not be accepted.

The link carriers shall be fitted with tinned copper links having minimum continuous and short time current ratings equivalent to the fuse carrier rating and equal to or in excess of 20 amps continuous.

Isolation links shall be wired such that the wire to the top end of the link holder originates from the positive DC supply rail, and the wire from the bottom end of the link holder goes to the isolated item.

DC supply fuses and protection isolation links shall be mounted in rows on the inside rear surfaces of the auxiliary equipment compartment with the bottom of such not lower than 900 mm above floor level and top of such not higher than 1600 mm above floor level, unless otherwise approved by Horizon Power. The intent of this requirement is to enable ease of removal and replacement of the fuses and links, from the front of the switchgear.

Fuses shall be grouped and separated from similarly grouped isolation links by at least the width of two carrier bases. Likewise, at the end of a row of fuses or links, there shall be a space of at least the width of two carrier bases to other items or compartment surfaces.

In addition to these spacing requirements, provision shall be made for future expansion of the fuse and link requirements by at least 10%, or two additional carriers to each group, whichever is the greater, and still meet the spacing requirements specified above.

Isolation links, which are associated with bus zone protection functions or circuit breaker failure functions, shall be grouped separately by at least the width of two carrier bases from any other isolation links. Furthermore, the location of such links shall be consistent throughout all compartments of the switchgear.

All links shall be provided with identification labels. Two labels, for front and rear mounting, shall be provided for each back connected device and only one front mounted label is required for front connected devices.

C.4.3 Miniature Circuit Breakers

MCB's as per AS 60947.2 [16], shall be used to protect all VT secondary wiring.

MCB's shall be wired such that the wire to the top end of the MCB originates from the VT, and the wire from the bottom end of the MCB goes to the isolated item or voltage rail.

MCB auxiliary contacts shall be wired to the bus bar VT supervision scheme, or bus bar protection peripheral card, as appropriate, in order to provide the required alarms.

Miniature circuit breakers for the protection of VT secondary wiring shall be housed in VT marshalling boxes. The boxes shall be located as closely as possible to the VT whose secondary is protected by them. The MCB's shall be mounted in rows on the inside rear surfaces of the VT marshalling boxes.

MCB's shall be located such that operation and inspection of them may be carried out in safety while all Equipment is live.

C.4.4 Test Blocks

Test blocks, and any other test links, shall be flush mounted on the front surface of the auxiliary equipment compartment with the bottom of such not lower than 900 mm above floor level and top of such not higher than 1600 mm above floor level, unless otherwise approved by Horizon Power.

C.4.5 Control Switches

Control switches shall be provided on the door of the auxiliary equipment compartment for each circuit only in the **on-board protection configuration**. Four switches shall be provided per circuit. One for remote control selection, one for trip/close operation of the circuit breaker, one for auto-reclose selection and one for Sensitive Earth Fault (SEF) selection.

The switches shall comply with AS 62271.200 [25] and AS 60947.3 [17].

The trip/close switch shall be of the three position spring return-to-neutral type. The neutral position will be located at 12 O'clock and turn anticlockwise to trip and clockwise to close.

The local/remote control selector switch shall have local and remote positions engraved on the switch panel.

The selection switch shall be snap-action and have functions in clockwise order Local, Remote.

C.4.6 Indicating Lights

Indication lamps shall be provided on the front of the auxiliary equipment compartment to indicate status of the circuit breaker. They shall indicate circuit breaker closed and open position.

Lamps shall:

1) have LED globes with coloured lenses or coloured LED lights.
2) have a bayonet cap mounting;
3) comply with AS 60947.5.3 [18] and the colours to be used shall be: RED for circuit ON, GREEN for circuit OFF;
4) be fused separately from other control circuits; and
5) have a lamp test facility incorporated into the system.

C.4.7 Terminal Blocks

Approved terminals and termination arrangements are detailed in the Panel Wiring and Terminals standard HPC-9DJ-23-0001-2016 [2]. Bridging shall be achieved with screw fittings. Press fit bridges shall not be acceptable.

Terminal blocks shall be of a material which will neither support combustion nor propagate flame. Such terminals shall be numbered and labelled.

The terminals shall be grouped according to the circuit voltages with dividers or spaces between each group. A 20% excess of spare terminals of each voltage level shall be left in each compartment, with an extra 30% terminal strip space for future compartment wiring.

Terminals in each compartment shall be numbered consecutively from top to bottom, left to right, including spares.

Terminals shall be grouped into:

- Circuits.
- Voltages.
- Function.

so that safe access to particular terminals can be obtained while the remaining terminals remain alive.

Terminals containing control wiring shall not be mounted in compartments containing primary circuit components.

C.4.8 Anti-Condensation Heaters

Vendors shall submit proposals for the use of anti-condensation heaters suitable for use with 240 V AC supply.

1) Heaters shall be of the low temperature type, each with an individual single-pole circuit breaker. The heaters shall be sized to keep the air inside the compartment above its dew point.
2) Heaters shall be arranged in at least two groups, for example, one group for each section of the switchgear. The heaters shall be controlled by external thermostats, each controlling the heaters in their respective group of the switchgear assembly. Anti condensation heaters shall not be installed in circuit breaker compartments.
3) Heaters shall be mechanically protected, live parts shall be shrouded, and suitably inscribed warning labels shall be provided. All exposed metal shall be earthed. The heaters shall be situated so that no deterioration to the *Equipment* or wiring can occur. The surface temperature of any heater(s) shall not exceed 65°C.

C.5. Secondary Wiring

- All secondary wiring shall be in accordance with the Panel Wiring and Terminals standard HPC-9DJ-23-0001-2016 [2] and AS/NZS 3000 [9].
- All secondary wiring shall be segregated firstly by circuit and then by function. Figure 1 depicts an example of secondary wiring being segregated by function.

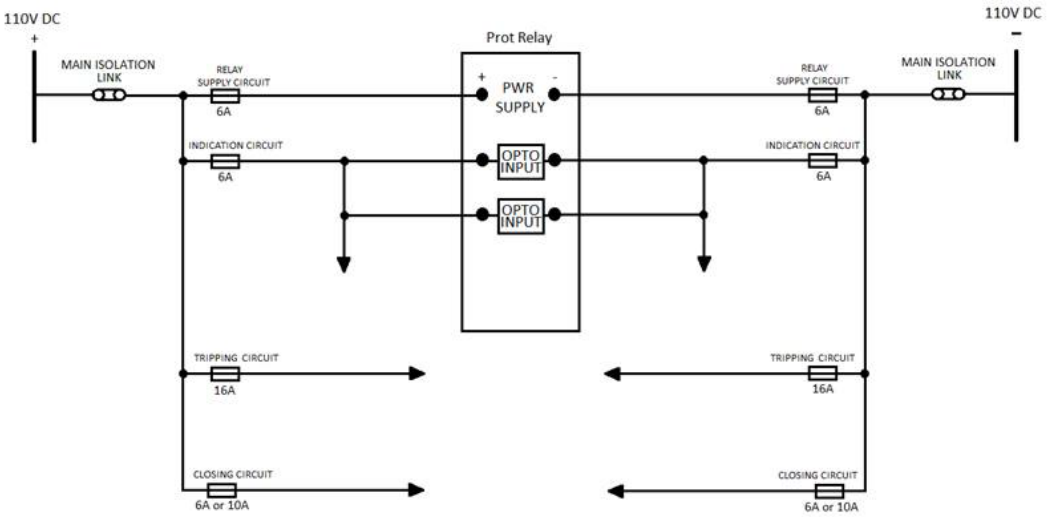

Figure 1: Segregation of secondary wiring functionally

- The minimum size, stranding and colour coding of single core cubicle and panel wiring shall be as defined in the Panel Wiring and Terminals standard HPC-9DJ-23-0001-2016 [2]. Protection and control wiring shall not be less than seven stranded copper wire with 75°C at 0.6/1 kV insulation. The insulation shall be flame retardant, self-extinguishing, and shall not support combustion.
- Splices or tee-connection will not be acceptable. Wire runs from the duct to the device shall be neatly trucked or clamped.
- Wiring passing through compartments containing primary equipment shall be segregated as per AS 62271.1 [22].
- The wiring in auxiliary compartments shall be run in ducts with removable covers. The ducts shall be sized such that a maximum of 60% duct volume is occupied.
- The Vendor shall state clearly in the offer the method of installing small wiring. Separate cable ducts or conduits shall be provided for incoming cables, outgoing cables and inter-compartmental wiring.
- Current transformer secondary wiring shall be continuous with no intermediate connections between the primary equipment and the compartment for the connected relays and transducers.
- Metering and protection functions are to be completely independent of each other. The sharing of cable wiring, test blocks, terminal strips, relays, switches etc. will not be permitted.
- All wiring shall be identified alphanumerically at each end. “C-Type” clip on wire numbers are not acceptable.
- The wire identification shall be with white wire marking ferrules with engraved letters and numerals filled with non-deteriorating black paint, and shall correspond with the coding on approved drawings. Ferrules shall be mounted as close as practicable to the termination point and assembled so that they may be read right-way-up from the normal viewing position.
- If applicable; all control devices, isolation links, test blocks and interlocking contacts shall be on the positive side of the operating coil of each relay and circuit breaker for DC operation, and on the active side for AC operation.
- All switchgear control wiring shall be brought to terminal blocks.

- Protection in the form of cable softeners, or grommets, shall be provided for cables that rest on or cross finished edges.
- Wiring must be installed such that it cannot suffer damage from stretching, pinching, fatigue or accidental interference during normal operation or maintenance.

C.5.1 CT Wiring on Terminal Blocks

All secondary terminals, including the intermediate ratio taps, used or unused, of each current transformer shall be wired directly to grouped terminal blocks. These blocks shall be located in the associated auxiliary equipment compartment, in accordance with other relevant clauses.

The terminal blocks should be grouped such that the CT wiring from a set of related CT cores can be grouped. For example, where a set of CT's contains protection cores and metering cores, the wiring associated with the protection function would be terminated on terminal blocks grouped (and separated, and separately labelled) from the wiring and terminal blocks of the metering wiring. To achieve grouping, a barrier shall be installed between groups.

The star point, or neutral, of each set of current transformers shall be formed on these terminal blocks by means of screwed shorting (bridging) bars.

The three phases (of the tap ratio selected) and the resulting neutral shall then be wired from the terminal blocks to a test block, and from there, be wired to the associated relays or transducers within their auxiliary equipment compartment.

Terminals shall be provided with short-circuiting links for each CT core, to enable shorting out and connecting to earth. At the terminal blocks where the star point, or neutral is formed, the neutral shall be wired to earth, via a sliding earth link. The purpose of this link is to:

- Provide a single point at which the CT secondary's are earthed
- Provide a means of separating the CT secondary's from earth during megger testing without disturbing wiring.

If the secondary windings are delta connected then they shall be earthed only when they are short circuited at the test block. The earth shall be via an approved link. Unit protection schemes shall have only one earth point, the location to be approved by Horizon Power.

C.5.2 VT Wiring on Terminal Blocks

All VT secondary terminals shall be wired directly to grouped terminal blocks in the associated VT marshalling boxes.

The star points, or neutral, of each set of VT's shall be formed on these terminal blocks by means of screwed shorting (bridging) bars.

The three phases and the resulting neutral shall then be wired from the terminal blocks to single phase MCB's and from there be wired back to the terminal blocks to meet outgoing cabling, as required by the function.

At the terminal blocks where the star point, or neutral is formed, the neutral shall be wired to earth, via a sliding earth link. The purpose of this link is to:

- Provide a single point at which the VT secondary's are earthed
- Provide a means of separating the VT secondary's from earth during megger testing without disturbing wiring.

The earth link shall be mounted immediately next to the terminal blocks on which the neutral is formed, and labelled so as to be clearly associated with the particular VT cores.

It should be noted that the earth link is electrically connected before the VT wiring reaches the MCB's. Hence, operation of the MCB's will not remove the earth reference of the VT wiring.

Voltage circuits for measurement and protection purposes may be derived from the same voltage transformer, provided that the indicating circuits are protected with their own MCB, such that protection circuits remain live in case of an indicating circuit failure.

C.5.3 Wiring Access

Multi-core control, indication and protection cables shall be terminated in a readily accessible position. Cables shall be supported at a point approximately 300 mm above the bottom of the enclosure. Provision of horizontally mounted Uni-strut will satisfy this requirement.

The compartment shall be provided with undrilled gland plates at the top and bottom to permit multi-core cable entry from the top or bottom as required. Gland plates must be minimum of 3 mm thickness brass or aluminium.

It shall be possible to access secondary cable terminations, within the bounds of Horizon Power Corporation Safety Instructions with the circuit ON and live. Means shall also be provided for lifting the cable ends for cable testing.

APPENDIX D TECHNICAL SCHEDULES A & B FOR EQUIPMENT

D.1 Standard panel configuration for switchboards

(To be completed along with the technical schedule)

PANEL SEQUENCE	PANEL Nx	BUSBAR Nx	PANEL TYPE	CIRCUIT NAME
1				INTERCONNECTOR (BUS TIE) WITH BREAKER
2				CAP BANK WITH BREAKER
3				FEEDER WITH BREAKER
4				FEEDER WITH BREAKER
5				TRANSFORMER INCOMER WITH BREAKER
6				VT/BUS ZONE PANEL
7				FEEDER WITH BREAKER
8				FEEDER WITH BREAKER
9				AUX/STATION TRANSFORMER
10				ADDITIONAL CAP BANK/FEEDER WITH BREAKER
11				FUTURE EXPANS ION
12				FUTURE EXPANSION
13				FUTURE EXPANSION

1

Schedule A: Purchaser's specific requirements

Schedule B: Guarantee and Technical particulars of *Equipment* offered

D.2 Technical Schedule for 22 kV switchboard operating at 11/ 6.6 kV

Switchboard Assembly (Common Requirements of all Components)

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated voltage/highest *Equipment* voltage	kV	22	
Rated insulation level			
Lightning impulse withstand voltage			
- To earth and between phases	kV	125	
- Across the isolating distance	kV	145	
One minute power frequency withstand voltage			
- To earth and between poles	kV	50	
- Across the isolating distance	kV	60	
Rated frequency	Hz	50	
Number of phases		3	
Rated 3 second short circuit withstand current	kA	25[1]	
Rated peak withstand current	kA	62.5[1]	
Rated 1 sec Internal Arc withstand current	kA	25	
Nominal Current			
- Busbar	A	2000[2]	
- Transformer circuit	A	2000[2]	
- Feeder circuit	A	630[2]	
- Bus tie feeder circuit	A	2000[2]	
Earth bar cross section	mm x mm	40 mm * 5 mm	
Partial discharge level			
- Each panel assembled with CB at 23 kV rms	pC	20	
- Fully assembled switchgear at 23 kV rms	pC	20	
Degree of protection			
- Relay panels	IP	54	
- Circuit breaker in service position	IP	54	
- Circuit breaker in test position	IP	54	
- Circuit breaker in withdrawn position	IP	54	
Cable box insulation		XXXXXXXXXX	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Control Voltages - Trip and Close Circuit - Spring Charging circuit - Indication circuit - Cubicle heating circuit	 V (DC) V (AC) V (DC) V (AC)	 110 240 110 240	
Have all components been fully type tested with respect to design/materials and manufacturing process	YES/NO	XXXXXXXXXX	
Are the sizes of protection/control wiring as per Specification?	YES/NO	XXXXXXXXXX	
Make and type of current transformer circuit links to be provided		XXXXXXXXXX	
Are the current transformer circuit links push-pull disconnecting type?	YES/NO	XXXXXXXXXX	
Location of test plugs / links	Provide details	XXXXXXXXXX	
Are flaps provided in each chamber for arc fault pressure relief?	YES/NO	XXXXXXXXXX	

Circuit Breaker (note AS 62271.110 to be considered for inductive switching)

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated short circuit breaking current (3 sec) - AC component - DC component 60 ms from initiation of short circuit	 kA rms %	 25[1] Figure 9 of AS 62271.100 for a time constant of 45 ms	
X/R ratio		14	
Rated short circuit making current (3 sec)	kA	62.5[1]	
First pole to clear factor		1.5	
Rated operating sequence	O-t-CO-t'-CO	O–0.3 s–CO–1 min–CO	
Maximum break time	ms	100	
Rated small inductive breaking current:	A (rms)	20	
Rated back-to-back capacitor bank breaking current	A	400	
Rated cable charging breaking current	A	31.5	
Rated out of phase breaking current	kA (rms)	As per Section 4.106 of AS 62271.100	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated out of phase recovery voltage	V	As per Section 4.106 of AS 62271.100	
Rated transient recovery voltage	V	As per Table 24 of AS 62271.100	
Rated capacitor bank inrush making current (for back to back switching)	kAp	As per Table 5 of AS 62271.100	
Rated reactor bank transient recovery voltages (for back to back switching)	kV	As per Table 3 of AS 62271.110	
Minimum Breaker Opening time at:			
- 100% auxiliary supply voltage	ms	XXXXXXXXXX	
- 70% auxiliary supply voltage	ms	XXXXXXXXXX	
Is the circuit breaker fixed trip or trip free?		XXXXXXXXXX	
Duration of fault current let through on a C-O operation	ms	XXXXXXXXXX	
Resistance of trip coil at 20°C	ohms	XXXXXXXXXX	
Tripping current at rated DC voltage	A	XXXXXXXXXX	
Trip coil voltage operating range			
- Upper limit	%	120	
- Lower limit	%	70	
Minimum current to hold trip coil in after energisation	mA	XXXXXXXXXX	
Resistance of closing coil at 20°C	ohms	XXXXXXXXXX	
Closing current at rated DC voltage	A	XXXXXXXXXX	
Closing coil voltage operating range			
- Upper limit	%	120	
- Lower limit	%	85	
Do the circuit breakers meet the requirements for single phase short circuit testing to AS 62271.100? If not, what is the maximum short circuit breaking current for this case?		XXXXXXXXXX	
Rating of auxiliary switches			
- Make and carry continuously	A	10	
- Break inductive current (time constant 40 ms) at 110 V DC	A	2	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Number of operations permitted without inspection/maintenance (1 close + 1 open = 1 operation) - At rated normal current - At rated short circuit breaking current - At 50% rated short circuit breaking current - At rated capacitor breaking current		 5,000 _____ _____ _____	
Operating mechanisms - Inspection free interval - Maintenance free interval	 months months	 XXXXXXXXXX XXXXXXXXXX	
Number of spare auxiliary contacts available to Purchaser - Normally open - Normally closed		 6 6	
Guaranteed number of close-open operations prior to interrupter replacement. - At rated normal current - At rated short circuit current		 10,000 _____	
Have the circuit breakers of each rating been fully type tested as per AS 62271.100	YES/NO	XXXXXXXXXX	
For vacuum circuit breakers: - Make of vacuum bottle - What is the shelf life of the bottle? - What method is used to check integrity of the vacuum? - What method is used to check contact wear? - X-radiation with kV rms applied across interrupter - Voltage withstand capacity across the contacts on loss of vacuum - Percentage of rated normal current which can be switched on loss of vacuum		 XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	
Type of arc quenching method		XXXXXXXXXX	
Do the circuit breakers rack out horizontally or vertically?		XXXXXXXXXX	
Number of main contacts in parallel per phase for circuit breaker.		XXXXXXXXXX	
Material of insulating phase barriers.		XXXXXXXXXX	
Restrike performance of Capacitor bank breakers conforms to requirements in Section C.3.2 and C.3.3 of this specification.	YES/NO	XXXXXXXXXX	

Fault-Make Earth Switch

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated fault making current	kAp	62.5[1]	
Rated 3 second withstand current	kA rms	25[1]	
Number of fault-make operations prior to: - Maintenance - Replacement		 2	

Current Transformers

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A			SCHEDULE B		
		TRANSFORMER	FEEDER/ CAPACITOR	INTERCONNECTOR/ BUS TIE SECTION	TX	FDR/ CAP	BUS TIE SECTION
Advise CT parameters and classifications:							
Core A ratios	Main Protection	**2000/1** [3]		**2000/1** [3]			
Core A class		0.05PX400R5		0.05PX400R5			
Core B ratios	Bus Zone	**2000/1** [3]	**2000/1** [3]	**2000/1** [3]			
Core B class		0.05PX400R5	0.05PX400R5	0.05PX400R5			
Core C ratios	Metering/ Backup Protection	**2000/1 MR** [3]	**600/1 MR** [3]	**2000/1 MR** [3]			
Core C class		0.5M/2.5P300F30	0.5M/2.5P300 F30	0.5M/2.5P300F30			
Core D ratios	Metering	**2000/1 MR** [3]	**600/1 MR** [3]	**200/1 MR** [3]			
Core D class		0.2M, 15VA	0.2M, 15VA	0.2M, 15VA			
Secondary withstand voltage		2 kV for one minute	2 kV for one minute	2 kV for one minute			
Thermal limit secondary current		2 A	2 A	2 A			
Number of cores per phase		_____	_____ _	_____			
Physical configuration of cores		_____	_____ _	_____			
Is core balance transformer required for cables?	YES/NO	XXXXXXXXXX	XXXXXXXXX X	XXXXXXXXXX			
Partial discharge level 1.1 x rated line to neutral rated voltage	pC	XXXXXXXXXX	XXXXXXXXX X	XXXXXXXXXX			

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A			SCHEDULE B		
		TRANSFORMER	FEEDER/ CAPACITOR	INTERCONNECTOR/ BUS TIE SECTION	TX	FDR/ CAP	BUS TIE SECTION
Can each core be operated continuously with open circuited secondary?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			
Is the current transformer within HV compartment shielded from flashover due to primary faults?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			

Voltage Transformers

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Advise VT parameters and classifications:			
- Rated phase to primary voltage	kV	11/6.6	
- Rated phase to phase secondary voltage	V	110/√3	
- Connections		YN/yn/yn	
- Category of performance		B	
- Accuracy class measurement		0.2M	
- Rated burden/output measurement	VA	50	
- Accuracy class protection		3P	
- Rated burden/output protection	VA	100	
- Rated voltage factor and duration		1.9	
Partial discharge level at 1.1 x rated line to neutral voltage (alternatively 1.1 x rated line to line voltage for “V” connected voltage transformer)	pC	XXXXXXXXXX	XXXXXXXXXX
Lightning impulse withstand voltage of primary neutral	kVp	60/75	
One minute power frequency withstand voltage of primary neutral	kV rms	20/28	
Can the HV neutral be operated unearthed?	YES/NO	XXXXXXXXXX	XXXXXXXXXX
Are the voltage transformers fused on the HV side?	YES/NO	XXXXXXXXXX	XXXXXXXXXX

Cable box

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Dedicated feeders			
Power cable size			
Power cable type			
Power cable quantity			
Normal feeders			
Power cable size			
Power cable type			
Power cable quantity			
Transformer circuits			
Power cable size			
Power cable type			
Power cable quantity			

Protection Requirements

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
PROTECTION REQUIREMENTS			
Configuration for protection	On board ☐		
	Off board ☐		
Bus Zone Protection			
- Type of Relay and Functions			
Local Control			
- Type of Relay and Functions			

Note 1- Refer Section 3.1.1 for short time withstand current of non interconnected systems.

Note 2- Nominal current values are based on traditional requirements for Horizon Power. The designer must confirm if the values meet the project requirements prior to submission.

Note 3 - CT ratios are indicative only and are for the nominal current values specified in the Schedule. MR indicates Multi ratio and the designer shall select appropriate ratios as per the design requirements.

SIGNATURE OF TENDERER: _____

DATE: _____

D.3 Technical Schedule for 22 kV switchboard operated at 22 kV

Switchboard Assembly (Common Requirements of all Components)

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated voltage/highest *Equipment* voltage	kV	22	
Rated insulation level			
Lightning impulse withstand voltage			
- To earth and between phases	kV	125	
- Across the isolating distance	kV	145	
One minute power frequency withstand voltage			
- To earth and between poles	kV	50	
- Across the isolating distance	kV	60	
Rated frequency	Hz	50	
Number of phases		3	
Rated 3 second short circuit withstand current	kA	25[1]	
Rated peak withstand current	kA	62.5[1]	
Rated 1 sec Internal Arc withstand current	kA	25	
Nominal Current			
- Busbar	A	2000[2]	
- Transformer circuit	A	1600[2]	
- Feeder circuit	A	630[2]	
- Bus tie feeder circuit	A	1600[2]	
Earth bar cross section	mm x mm	40 mm * 5 mm	
Partial discharge level			
- Each panel assembled with CB at 23 kV rms	pC	20	
- Fully assembled switchgear at 23 kV rms	pC	20	
Degree of protection			
- Relay panels	IP	54	
- Circuit breaker in service position	IP	54	
- Circuit breaker in test position	IP	54	
- Circuit breaker in withdrawn position	IP	54	
Cable box insulation		XXXXXXXXXX	
Control Voltages			
- Trip and Close Circuit	V (DC)	110	
- Spring Charging circuit	V (AC)	240	
- Indication circuit	V (DC)	110	
- Cubicle heating circuit	V (AC)	240	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Have all components been fully type tested with respect to design/materials and manufacturing process	YES/NO	XXXXXXXXXX	
Are the sizes of protection/control wiring as per Specification?	YES/NO	XXXXXXXXXX	
Make and type of current transformer circuit links to be provided		XXXXXXXXXX	
Are the current transformer circuit links push-pull disconnecting type?	YES/NO	XXXXXXXXXX	
Location of test plugs / links	Provide details	XXXXXXXXXX	
Are flaps provided in each chamber for arc fault pressure relief?	YES/NO	XXXXXXXXXX	

Circuit Breaker (note AS 62271.110 to be considered for inductive switching)

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated short circuit breaking current (3 sec) - AC component - DC component 60 ms from initiation of short circuit	 kA rms %	 25[1] Figure 9 of AS 62271.100 for a time constant of 45 ms	
X/R ratio		14	
Rated short circuit making current (3 sec)	kA	62.5[1]	
First pole to clear factor		1.5	
Rated operating sequence	O t CO t' CO	O – 0.3 s – CO – 1 min – CO	
Maximum break time	ms	100	
Rated small inductive breaking current:	A (rms)	20	
Rated back-to-back capacitor bank breaking current	A	400	
Rated cable charging breaking current	A	31.5	
Rated out of phase breaking current	kA (rms)	As per Section 4.106 of AS 62271.100	
Rated out of phase recovery voltage	V	As per Section 4.106 of AS 62271.100	
Rated transient recovery voltage	V	As per Table 24 of AS 62271.100	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated capacitor bank inrush making current (for back to back switching)	kAp	As per Table 5 of AS 62271.100	
Rated reactor bank transient recovery voltages (for back to back switching)	kV	As per Table 3 of AS 62271.110	
Minimum Breaker Opening time at:			
- 100% auxiliary supply voltage	ms	XXXXXXXXXX	
- 70% auxiliary supply voltage	ms	XXXXXXXXXX	
Is the circuit breaker fixed trip or trip free?		XXXXXXXXXX	
Duration of fault current let through on a C-O operation	ms	XXXXXXXXXX	
Resistance of trip coil at 20°C	ohms	XXXXXXXXXX	
Tripping current at rated DC voltage	A	XXXXXXXXXX	
Trip coil voltage operating range			
- Upper limit	%	120	
- Lower limit	%	70	
Minimum current to hold trip coil in after energisation	mA	XXXXXXXXXX	
Resistance of closing coil at 20°C	ohms	XXXXXXXXXX	
Closing current at rated DC voltage	A	XXXXXXXXXX	
Closing coil voltage operating range			
- Upper limit	%	120	
- Lower limit	%	85	
Do the circuit breakers meet the requirements for single phase short circuit testing to AS 62271.100? If not, what is the maximum short circuit breaking current for this case?		XXXXXXXXXX	
Rating of auxiliary switches			
- Make and carry continuously	A	10	
- Break inductive current (time constant 40 ms) at 110 V DC	A	2	
Number of operations permitted without inspection/maintenance (1 close + 1 open = 1 operation)			
- At rated normal current		5,000	
- At rated short circuit breaking current		_____	
- At 50% rated short circuit breaking current		_____	
- At rated capacitor breaking current		_____	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Operating mechanisms - Inspection free interval - Maintenance free interval	 months months	 XXXXXXXXXX XXXXXXXXXX	
Number of spare auxiliary contacts available to Purchaser - Normally open - Normally closed		 6 6	
Guaranteed number of close-open operations prior to interrupter replacement. - At rated normal current - At rated short circuit current		 10,000 _____	
Have the circuit breakers of each rating been fully type tested as per AS 62271.100	YES/NO	XXXXXXXXXX	
For vacuum circuit breakers: - Make of vacuum bottle - What is the shelf life of the bottle? - What method is used to check integrity of the vacuum? - What method is used to check contact wear? - X-radiation with kV rms applied across interrupter - Voltage withstand capacity across the contacts on loss of vacuum - Percentage of rated normal current which can be switched on loss of vacuum		 XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	
Type of arc quenching method		XXXXXXXXXX	
Do the circuit breakers rack out horizontally or vertically?		XXXXXXXXXX	
Number of main contacts in parallel per phase for circuit breaker.		XXXXXXXXXX	
Material of insulating phase barriers.		XXXXXXXXXX	
Restrike performance of Capacitor bank breakers conforms to requirements in Section C.3.2 and C.3.3 of this specification.	YES/NO	XXXXXXXXXX	

Fault-Make Earth Switch

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated fault making current	kAp	62.5[1]	
Rated 3 second withstand current	kA rms	25[1]	
Number of fault-make operations prior to: - Maintenance - Replacement		 2	

Current Transformers

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A			SCHEDULE B		
		TRANSFORMER	FEEDER/ CAPACITOR	INTERCONNECTOR / BUS TIE	TX	FDR CAP	BUS TIE SEC
Advise CT parameters and classifications:							
Core A ratios	Main Protection	**1600/1** [3]		**1600/1** [3]			
Core A class		0.05PX400R5		0.05PX400R5			
Core B ratios	Bus Zone	**1600/1** [3]	**1600/1** [3]	**1600/1** [3]			
Core B class		0.05PX400R5	0.05PX400R5	0.05PX400R5			
Core C ratios	Metering/ Backup Protection	**1600/1 MR** [3]	**600/1 MR** [3]	**1200/1 MR** [3]			
Core C class		0.5M/2.5P300F30	0.5M/2.5P300 F30	0.5M/2.5P300F30			
Core D ratios	Metering	**1600/1 MR** [3]	**600/1 MR** [3]	**1200/1 MR** [3]			
Core D class		0.2M, 15VA	0.2M, 15VA	0.2M, 15VA			
Secondary withstand voltage		2 kV for one minute	2 kV for one minute	2 kV for one minute			
Thermal limit secondary current		2 A	2 A	2 A			
Number of cores per phase		_____	_____	_____			
Physical configuration of cores		_____	_____	_____			
Is core balance transformer required for cables?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			
Partial discharge level 1.1 x rated line to neutral rated voltage	pC	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			

Can each core be operated continuously with open circuited secondary?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			
Is the current transformer within HV compartment shielded from flashover due to primary faults?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			

Voltage Transformers

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Advise VT parameters and classifications:			
- Rated phase to primary voltage	kV	22	
- Rated phase to phase secondary voltage	V	110/√3	
- Connections		YN/yn/yn	
- Category of performance		B	
- Accuracy class measurement		0.2M	
- Rated burden/output measurement	VA	50	
- Accuracy class protection		3P	
- Rated burden/output protection	VA	100	
- Rated voltage factor and duration		1.9	
Partial discharge level at 1.1 x rated line to neutral voltage (alternatively 1.1 x rated line to line voltage for “V” connected voltage transformer)	pC	XXXXXXXXXX	
Lightning impulse withstand voltage of primary neutral	kVp	125	
One minute power frequency withstand voltage of primary neutral	kV rms	50	
Can the HV neutral be operated unearthed?	YES/NO	XXXXXXXXXX	
Are the voltage transformers fused on the HV side?	YES/NO	XXXXXXXXXX	

Cable box

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Dedicated feeders			
Power cable size			
Power cable type			
Power cable quantity			
Normal feeders			
Power cable size			
Power cable type			
Power cable quantity			
Transformer circuits			
Power cable size	Vendor specified		
Power cable type	Vendor specified		
Power cable quantity	Vendor specified		

Protection Requirements

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
PROTECTION REQUIREMENTS			
Configuration for protection	On board		
	Off board		
Bus Zone Protection			
- Type of Relay and Functions			
Local Control			
- Type of Relay and Functions			

Note 1- Refer Section 3.1.1 for short time withstand current of non interconnected systems.

Note 2- Nominal current values are based on traditional requirements for Horizon Power. The designer must confirm if the values meet the project requirements prior to submission.

Note 3 - CT ratios are indicative only and are for the nominal current values specified in the Schedule. MR indicates Multi ratio and the designer shall select appropriate ratios as per the design requirements.

SIGNATURE OF TENDERER: _____

DATE: _____

D.4 Technical Schedule for 33 kV switchboard operated at 33 kV

Switchboard Assembly (Common Requirements of all Components)

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated voltage/highest *Equipment* voltage	kV	33	
Rated insulation level			
Lightning impulse withstand voltage			
- To earth and between phases	kV	170	
- Across the isolating distance	kV	195	
One minute power frequency withstand voltage			
- To earth and between poles	kV	70	
- Across the isolating distance	kV	80	
Rated frequency	Hz	50	
Number of phases		3	
Rated 3 second short circuit withstand current	kA	16[1]	
Rated peak withstand current	kA	50[1]	
Rated 1 sec Internal Arc withstand current	kA	16[1]	
Nominal Current			
- Busbar	A	1250[2]	
- Transformer circuit	A	1250[2]	
- Feeder circuit	A	630[2]	
- Bus tie feeder circuit	A	1250[2]	
Partial discharge level			
- Each panel assembled with CB at 30 kV rms	pC	20	
- Fully assembled switchgear at 30 kV rms	pC	20	
Earth bar cross section	mm x mm	40 mm * 5 mm	
Degree of protection			
- Relay panels	IP	54	
- Circuit breaker in service position	IP	54	
- Circuit breaker in test position	IP	54	
- Circuit breaker in withdrawn position	IP	54	
Cable box insulation		XXXXXXXXXX	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Control Voltages: - Trip and Close Circuit - Spring Charging circuit - Indication circuit - Cubicle heating circuit	 V (DC) V (AC) V (DC) V (AC)	 110 240 110 240	
Have all components been fully type tested with respect to design/materials and manufacturing process	YES/NO	XXXXXXXXXX	
Are the sizes of protection/control wiring as per Specification?	YES/NO	XXXXXXXXXX	
Make and type of current transformer circuit links to be provided		XXXXXXXXXX	
Are the current transformer circuit links push-pull disconnecting type?	YES/NO	XXXXXXXXXX	
Location of test plugs / links	Provide details	XXXXXXXXXX	
Are flaps provided in each chamber for arc fault pressure relief?	YES/NO	XXXXXXXXXX	

Circuit Breaker (note AS 62271.110 to be considered for inductive switching)

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated short circuit breaking current (3 sec) - AC component - DC component 60 ms from initiation of short circuit	 kA rms %	 16[1] Figure 9 of AS 62271.100 for a time constant of 45 ms	
Rated short circuit making current (3 sec)	kA	50[1]	
X/R ratio		14	
First pole to clear factor		1.5	
Rated operating sequence	O t CO t' CO	O – 0.3s – CO – 1min – CO	
Maximum break time	ms	100	
Rated small inductive breaking current:	A (rms)	20	
Rated back-to-back capacitor bank breaking current	A	400	
Rated cable charging breaking current	A	50	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated out of phase breaking current	kA (rms)	As per Section 4.106 of AS 62271.100	
Rated out of phase recovery voltage	V	As per Section 4.106 of AS 62271.100	
Rated transient recovery voltage	V	As per Table 24 of AS 62271.100	
Rated capacitor bank inrush making current (for back to back switching)	kAp	As per Table 5 of AS 62271.100	
Rated reactor bank transient recovery voltages (for back to back switching)	kV	As per Table 3 of AS 62271.110	
Minimum Breaker Opening time at: - 100% auxiliary supply voltage - 70% auxiliary supply voltage	 ms ms	 XXXXXXXXXX XXXXXXXXXX	
Is the circuit breaker fixed trip or trip free?		XXXXXXXXXXXX	
Duration of fault current let through on a C-O operation	ms	XXXXXXXXXXXX	
Resistance of trip coil at 20°C	ohms	XXXXXXXXXXXX	
Tripping current at rated DC voltage	A	XXXXXXXXXXXX	
Trip coil voltage operating range: - Upper limit - Lower limit	 % %	 120 70	
Minimum current to hold trip coil in after energisation	mA	XXXXXXXXXXXX	
Resistance of closing coil at 20°C	ohms	XXXXXXXXXXXX	
Closing current at rated DC. voltage	A	XXXXXXXXXXXX	
Closing coil voltage operating range: - Upper limit - Lower limit	 % %	 120 85	
Do the circuit breakers meet the requirements for single phase short circuit testing to AS 62271.100? If not, what is the maximum short circuit breaking current for this case?		XXXXXXXXXX	
Rating of auxiliary switches: - Make and carry continuously - Break inductive current (time constant 40 ms) at 110 V DC	 A A	 10 2	

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Number of operations permitted without inspection/maintenance (1 close + 1 open = 1 operation) - At rated normal current - At rated short circuit breaking current - At 50% rated short circuit breaking current - At rated capacitor breaking current		 5,000 _____ _____ _____	
Operating mechanisms - Inspection free interval - Maintenance free interval	 months months	 XXXXXXXXXX XXXXXXXXXX	
Number of spare auxiliary contacts available to Purchaser - Normally open - Normally closed		 6 6	
Guaranteed number of close-open operations prior to interrupter replacement. - At rated normal current - At rated short circuit current		 10,000 _____	
Have the circuit breakers of each rating been fully type tested as per AS 62271.100	YES/NO	XXXXXXXXXX	
For vacuum circuit breakers: - Make of vacuum bottle - What is the shelf life of the bottle? - What method is used to check integrity of the vacuum? - What method is used to check contact wear? - X-radiation with kV rms applied across interrupter - Voltage withstand capacity across the contacts on loss of vacuum - Percentage of rated normal current which can be switched on loss of vacuum		 XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	
Type of arc quenching method		XXXXXXXXXX	
Do the circuit breakers rack out horizontally or vertically?		XXXXXXXXXX	
Number of main contacts in parallel per phase for circuit breaker.		XXXXXXXXXX	
Material of insulating phase barriers.		XXXXXXXXXX	
Restrike performance of Capacitor bank breakers conforms with requirements in Section C.3.2 and C.3.3 of this specification.	YES/NO	XXXXXXXXXX	

Fault-Make Earth Switch

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Rated fault making current	kAp	50[1]	
Rated 3 second withstand current	kA rms	16[1]	
Number of fault-make operations prior to: - Maintenance - Replacement		 2	

Current Transformers

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A			SCHEDULE B		
		TRANSFORMER	FEEDER/ CAPACITOR	BUS SECTION	TX	FDR/ CAP	BUS TIE SECTION
Advise CT parameters and classifications:							
Core A ratios	Main Protection	**1200/1** [3]		**1200/1** [3]			
Core A class		0.05PX400R5		0.05PX400R5			
Core B ratios	Bus Zone	**1200/1** [3]	**1200/1** [3]	**1200/1** [3]			
Core B class		0.05PX400R5	0.05PX400R5	0.05PX400R5			
Core C ratios	Metering/ Backup Protection	**1200/1 MR** [3]	**600/1 MR** [3]	**1200/1 MR** [3]			
Core C class		0.5M/2.5P300F30	0.5M/2.5P300F30	0.5M/2.5P300F30			
Core D ratios	Metering	**1200/1 MR** [3]	**600/1 MR** [3]	**1200/1 MR** [3]			
Core D class		0.2M, 15VA	0.2M, 15VA	0.2M, 15VA			
Secondary withstand voltage		2 kV for one minute	2 kV for one minute	2 kV for one minute			
Thermal limit secondary current		2 A	2 A	2 A			
Number of cores per phase		_____	_____	_____			
Physical configuration of cores		_____	_____	_____			
Is core balance transformer required for cables?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			
Partial discharge level 1.1 x rated line to neutral rated voltage	pC	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A			SCHEDULE B		
		TRANSFORMER	FEEDER/ CAPACITOR	BUS SECTION	TX	FDR/ CAP	BUS TIE SECTION
Can each core be operated continuously with open circuited secondary?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			
Is the current transformer within HV compartment shielded from flashover due to primary faults?	YES/NO	XXXXXXXXXX	XXXXXXXXXX	XXXXXXXXXX			

Voltage Transformers

PARTICULARS	UNIT/ RESPONSE	SCHEDULE B	SCHEDULE B
Advise VT parameters and classifications:			
- Rated phase to primary voltage	kV	33	
- Rated phase to phase secondary voltage	V	110/√3	
- Connections		YN/yn/yn	
- Category of performance		B	
- Accuracy class measurement		0.2M	
- Rated burden/output measurement	VA	50	
- Accuracy class protection		3P	
- Rated burden/output protection	VA	100	
- Rated voltage factor and duration		1.9	
Partial discharge level at 1.1 x rated line to neutral voltage (alternatively 1.1 x rated line to line voltage for “V” connected voltage transformer)	pC	XXXXXXXXXX	
Lightning impulse withstand voltage of primary neutral	kVp	170	
One minute power frequency withstand voltage of primary neutral	kV rms	70	
Can the HV neutral be operated unearthed?	YES/NO	XXXXXXXXXX	
Are the voltage transformers fused on the HV side?	YES/NO	XXXXXXXXXX	

Cable box

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
Dedicated feeders			
Power cable size			
Power cable type			
Power cable quantity			
Normal feeders			
Power cable size			
Power cable type			
Power cable quantity			
Transformer circuits			
Power cable size	Vendor specified		
Power cable type	Vendor specified		
Power cable quantity	Vendor specified		

Protection Requirements

PARTICULARS	UNIT/ RESPONSE	SCHEDULE A	SCHEDULE B
PROTECTION REQUIREMENTS			
Configuration for protection	On board ☐		
	Off board ☐		
Bus Zone Protection			
- Type of Relay and Functions			
Local Control			
- Type of Relay and Functions			

Note 1- Refer Section 3.1.1 for short time withstand current of non interconnected systems.

Note 2- Nominal current values are based on traditional requirements for Horizon Power. The designer must confirm if the values meet the project requirements prior to submission.

Note 3 - CT ratios are indicative only and are for the nominal current values specified in the Schedule. MR indicates Multi ratio and the designer shall select appropriate ratios as per the design requirements.

SIGNATURE OF TENDERER: _____

DATE: _____

APPENDIX E COMPLIANCE DOCUMENT

The Vendor shall indicate below whether this offer is fully compliant with the nominated clause in this Specification. A YES shall ONLY be indicated if the offer is 100% compliant with the relevant Clause. If NO is indicated and supporting documents are submitted, then mark the ATT box with the attachment number. Details of departure shall be provided in Appendix F.

CLAUSE NUMBER		YES	NO	ATT.
3	REQUIREMENTS			
3.1	Power System Particulars			
3.1.1	*Design Fault Levels*	☐	☐	☐
3.1.2	*Nominal System Frequency*	☐	☐	☐
3.1.3	*System Insulation Levels*	☐	☐	☐
3.1.4	*Environmental Conditions*	☐	☐	☐
3.1.5	*Clearances & Insulation*	☐	☐	☐
3.1.6	*Dimensions*	☐	☐	☐
4	SWITCHBOARD DESIGN AND CONSTRUCTION			
4.1	General Requirements	☐	☐	☐
4.1.1	*Partition Class*	☐	☐	☐
4.1.2	*Loss of Service Continuity*	☐	☐	☐
4.2	Switchboard Layout			
4.2.1	*Rated Parameters and Performance*	☐	☐	☐
4.2.2	*Enclosure*	☐	☐	☐
4.2.3	*Compartments*			
4.2.3.1	*General requirement*	☐	☐	☐
4.2.3.2	*Doors*	☐	☐	☐
4.2.4	*Shutters*	☐	☐	☐
4.2.5	*Fixing of Equipment on Side Walls*	☐	☐	☐
4.2.6	*Venting*	☐	☐	☐
4.2.6.1	*Internal Arc Classification (IAC)*	☐	☐	☐
4.2.6.2	*Explosion Relief Chamber and Ducting*	☐	☐	☐
4.2.7	*Earthing*	☐	☐	☐
4.2.7.1	*Earthbar*	☐	☐	☐
4.2.7.2	*Accessory Earthing*	☐	☐	☐
4.2.7.3	*Circuit Breaker Earthing*	☐	☐	☐
4.2.7.4	*Cable Earthing*	☐	☐	☐
4.2.7.5	*Bus Duct Earthing*	☐	☐	☐

CLAUSE NUMBER		YES	NO	ATT.
4.2.7.6	*Earthing Switches*	☐	☐	☐
4.2.8	*Interlocks*	☐	☐	☐
4.2.9	*Busbars and Primary Connections*	☐	☐	☐
4.2.10	*Cable Termination*	☐	☐	☐
4.2.10.1	*Cable Glands*	☐	☐	☐
4.2.11	*Current Transformers*			
4.2.12	*Voltage Transformers*			
4.2.13	*Rating and Designation Plates*	☐	☐	☐
4.2.14	Painting	☐	☐	☐
4.3	Circuit Breaker			
4.4	Auxiliary Equipment	☐	☐	☐
4.4.1	*Auxiliary Equipment Compartment*	☐	☐	☐
4.4.2	*General Requirements for Control Circuit Elements*	☐	☐	☐
4.4.3	*Secondary Wiring*			
4.4.3.1	*General*	☐	☐	☐
4.4.3.2	*Secondary Wiring*			
4.4.4	*General Protection Control Requirements*			
4.4.4.1	*General*	☐	☐	☐
4.4.4.2	*Protection Relay*	☐	☐	☐
4.4.4.3	*Trip and Control Relays*	☐	☐	☐
4.4.4.4	*Non Operation for Interruption / Restoration of Measuring or Trip Supplies*	☐	☐	☐
4.4.4.5	*Arc Detection Protection System Equipment*	☐	☐	☐
4.4.4.6	*Masking of Alarm Conditions*	☐	☐	☐
4.4.4.7	*VESDA Systems*	☐	☐	☐
5	PACKAGING REQUIREMENTS	☐	☐	☐
6	STORAGE	☐	☐	☐
7	RELIABILITY	☐	☐	☐
8	SAFETY	☐	☐	☐
9	ENVIRONMENTAL CONSIDERATIONS	☐	☐	☐
10	ELECTRICAL TESTS	☐	☐	☐
10.1	General			
10.1.1	*Manufacturer's Testing Capabilities*	☐	☐	☐
10.1.1.1	*Witnessing of Tests*	☐	☐	☐

	CLAUSE NUMBER	YES	NO	ATT.
10.1.1.2	*Test Instruments and Apparatus*	☐	☐	☐
10.1.1.3	*Test Certificates*	☐	☐	☐
10.2	Type Tests	☐	☐	☐
10.2.1	*Routine Tests*	☐	☐	☐
10.2.1.1	*Switchgear*	☐	☐	☐
10.2.1.2	*Current and Voltage Transformers*	☐	☐	☐
10.2.1.3	*Insulation Tests*	☐	☐	☐
10.2.2	*Tests Prior to Completion of Defects Liability Period*	☐	☐	☐
11	DOCUMENTATION AND SAMPLES			
11.1	Documentation to be provided with Proposal	☐	☐	☐
11.2	Service History	☐	☐	☐
11.3	Training Materials	☐	☐	☐
12	SPARE EQUIPMENT	☐	☐	☐
C.1	CURRENT TRANSFORMERS	☐	☐	☐
C.2	VOLTAGE TRANSFORMERS	☐	☐	☐
C.2	CIRCUIT BREAKERS			
C.3.1	General	☐	☐	☐
C.3.2	Classification of Circuit Breakers	☐	☐	☐
C.3.3	Capacitive Switching currents and Requirements for Capacitor Bank Breakers	☐	☐	☐
C.3.4	Reactive Switching currents and Requirements for Reactor Bank Breakers	☐	☐	☐
C.3.5	Operating Requirements	☐	☐	☐
C.3.6	Racking Mechanism	☐	☐	☐
C.3.7	Requirement for Circuit Breakers			
C.3.7.1	Vacuum Circuit Breakers	☐	☐	☐
C.3.7.2	Loss of Insulating/Switching Medium	☐	☐	☐
C.4	GENERAL REQUIREMENTS FOR CONTROL CIRCUIT			
C.4.1	Fuses	☐	☐	☐
C.4.2	Isolation Links	☐	☐	☐
C.4.3	Miniature Circuit breakers	☐	☐	☐
C.4.4	Test Blocks	☐	☐	☐
C.4.5	Control Switches	☐	☐	☐

CLAUSE NUMBER		YES	NO	ATT.
C.4.6	Indicating Lights	☐	☐	☐
C.4.7	Terminal Blocks	☐	☐	☐
C.4.8	Anti-Condensation Heaters	☐	☐	☐
C.5	SECONDARY WIRING	☐	☐	☐
C.5.1	CT Wiring on Terminal Blocks	☐	☐	☐
C.5.2	VT Wiring on Terminal Blocks	☐	☐	☐
C.5.3	Wiring Access	☐	☐	☐

APPENDIX F DEPARTURES FROM TECHNICAL SPECIFICATION

The Vendor shall nominate the Clause and describe the departure:

CLAUSE NO	DEPARTURE

APPENDIX G MISCELLANEOUS INFORMATION

CORRELATION BETWEEN ALPHANUMERIC NOTATION, SYMBOLS AND COLOURS

DESIGNATION OF CONDUCTORS		ALPHANUMERIC NOTATION	COLOUR
Alternating current system			
Supply	Phase 1	L1	Red
	Phase 2	L2	White
	Phase 3	L3	Blue
Neutral		N	Black
Apparatus	Phase 1	U	Red
	Phase 2	V	White
	Phase 3	W	Blue
Battery Supply			
	Positive	L +	Red
	Negative	L –	Black
	Mid-wire	M	Blue
Earth		E	Green/Yellow

SPECIFIC REQUIREMENTS FOR PROTECTION DRAWINGS

- **Auxiliary compartment equipment arrangement**

  A scaled drawing shall show when viewed from the front the layout of all *Equipment* contained on or within each compartment.

  Each item of *Equipment*, including the compartment itself, terminal strip and labels shall be identified with a number referenced to an *Equipment* list.

  Equipment label inscription details may be shown on a separate schedule.

- **Terminal arrangement in compartment**

  The arrangement of each terminal strip shall be shown on a drawing detailing:

  1. The sequence and grouping of terminals in which they are installed in the *Equipment*.
  2. Detail type of terminal.
  3. Detail wire number and terminal number if not same.

- **Schematic circuit diagrams**

  Schematic diagrams shall be supplied for all *Equipment* unless approval for non-supply is granted.

  Schematic diagrams for protection circuits shall show the Current Transformer and Voltage Transformer AC circuitry and DC circuitry from the 110 V battery all on separate drawings.

  Cross referencing between drawings shall be to the satisfaction of the HP and shall generally be only between three types of drawings listed above.

  Symbols for coils, contacts, devices etc. shall be in accordance with AS/NZS 1102.107 [4].

  The Schematic diagrams shall be arranged to read from left to right or top to bottom with power flow or positive to negative in the case of DC circuits, or order of operating sequence.

  The schematic diagrams shall be similar to the drawings provided and shall detail the following:

  1. Each item of equipment component identified (may be abbreviated to the satisfaction of HP).
  2. All wire numbers and terminal numbers.
  3. Ratings and ratios of windings, fuses, resistors, motors, heaters, etc.
  4. Relationship of coils and associated contacts and multi-contacts switches.
  5. This shall preferably be by dotted line.

  Block representation of equipment shall not be used without approval of the HP generally will only be acceptable for electronic devices. In any case input and output/function terminals must be identified, as well as the current paths relevant to the drawing.

- **Compartment drawings**

  Drawings for compartment equipment other than the Approved relays and devices listed in this Specification shall include drawings of:

  1. Outline showing principle dimensions and all parts affecting electrical clearances, mounting details and terminal details.
  2. Details of module or card locations in the case of solid state equipment.
  3. Interconnection wiring between modules (where applicable).
  4. Schematics of all circuits and modules to component level, with component specifications and terminal details.
  5. Layout of components on cards or modules (where applicable).

SPECIFIC REQUIREMENTS FOR LABEL INSCRIPTIONS

- **Inscriptions**

  General

  In the label inscriptions schedule, the inscription on a particular line, will be separated from those on other lines by commas, which shall NOT be included on the label when engraved.

  Where abbreviations are used, full stops shall NOT be included in the inscription. Abbreviations shall be identical to those used on the schematic diagrams.

  Relays

  The word relay, or any abbreviation thereof, should not be included in the inscription of a label defining the type relay with which it is associated. The main function of the relay should be shown on the first line and ancillary information on subsequent lines. The inscription shall include, in brackets, the relay abbreviation that appears on the associated link label eg. for a local back-up trip relay the label inscription should be “TRIP (LBU1TR), LOAL BACK-UP NO1”

  The rear mounted relay identification label shall be size 8 and be inscribed with line 1 inscription on the front label e.g. “TRIP (LBU1TR)”.

  Fuses

  Main supply fuse labels should show the material list Ref. No., circuit function, the voltage, the polarity or phase, the rating and the fuse number e.g.

  “[4] PROT1, 110 V, +,20 A, FS21” or

  “[6] DIST PROT, 110 V, R, 6 A, FS8” or

  “[30] ISOL 853.3, 440 V, Y, 20 A, FS20”

  For all fuses, the label inscription shall be shown for the size 3 label. A second label for rear identification of back connected fuses, shall be inscribed with just the fuse number, as shown for the size 5 label on the same drawing.

  For front connected fuses, only one label is required.

  Sub-circuit fuse labels should show the sub-circuit function, the voltage, the polarity or phase, the rating and the fuse number e.g.

  “CB CTRL, 110 V, +, 6 A, FS23” or

“NO VOLT, INT’LOCK, 110 V, R, 6 A, FS81”

The words phase, positive, negative or any abbreviations or symbols for these words shall not be used, except that + or – shall be used to indicate polarity in DC schemes.

Isolation Links

The label inscription should provide sufficient information for the link’s purpose to be clearly understood. Because of space limitations, inscriptions must be concise without losing their meaning to staff familiar with the equipment. To attain this, the following information only should be displayed.

Circuit Isolation Links

On the first line of the inscription shown, in abbreviated form, the name of the relay which will be rendered inoperable when the link is opened. If there is more than one such relay, these shall be shown on subsequent lines. The polarity or phase should then be shown, followed by the link number e.g. “BLBU1, +, LK3”.

Relay, MCB etc, Contact Isolating Links

Where a relay is caused to operate by a contact in another device, the first line of the inscription will show in abbreviated form the name of the relay which is caused to operate by the contact, the next line will shown in abbreviated form the name of the relay, MCB, etc., in which the contact will be found. This description shall be enclosed in brackets. The last line will be the link number. Where links are provided on each side of a relay contact, the label inscription shall be same for both, except for the link number. In some cases the opening of a link will prevent a circuit breaker closing or tripping. In these cases the circuit breaker number will be used in the space reserved for the relay name in the label inscription.

Separation Links

These are links used to separate schemes from each other but the opening of which does not render either scheme inoperable, (e.g. HV and LV protection on a transformer), and are usually referred to as inter-tripping links. Such links shall be provided with labels inscribed as follows. The first line will show the name of the plant protected by the schemes, the next line will show the protection involved, the following line will be engraved "INTERTRIP” and the last line will show the link number e.g. in a transformer protection scheme with inter-tripping facilities between the HV and LV protection, the inscription on the label for the inter-tripping links shall be “T1 HV-LV, PROT 2, INTERTRIP, LK26”.

Links which cannot be included in any of the above categories shall be provided with labels having an inscription based as nearly as possible on the principles stated above.

Characters Per Line

When used, opening and closing brackets shall not be counted when determining the number of letters in a line. Where the number of letters in a description exceeds the allowable number for one line, the continuation of the description on the next line shall be indicated by the use of the oblique stroke “/” followed immediately by a comma indicating the end of the inscription on that line.

Test Blocks

The label inscription for test blocks should show the block number, the description of the circuit in which the blocks are located and the function of the blocks e.g., for current test links in a distance protection scheme, the inscription should be “CLK3 DIST PROT”. The label for the associated earth link should read “ELK3 DIST PROT”. In busbar protection schemes, the primary circuit identification 9 e.g. WT81) will also be included in the label inscription. In cases where VT secondaries are also connected to test blocks, similar information shall be displayed on a separate label as that displayed for current transformer secondaries e.g. “CLK3 DIST PROT, VT918”.

Other Items

Other items, such as VT test terminals, interposing VT’s and CT’s and similar items should be provided with a label inscribed to follow the general principles outlined above. Meters, telemeters and transducers should not have the word “meter” etc. included in the description e.g. for a megawatt telemeter, the inscription would be “MEGAWATTS”, for a kilowatt hour meter “kWh EXPORT”. Transducers should be provided with labels inscribed “LINE VOLTS” or “LINE AMPS”.

The labels for VT test terminals should indicate the scheme in which the terminal is located and the voltage source e.g. “DIST PORT, VT807b”. If the terminals are not colour coded, separate labels to indicate phasing should be added.

Modular Protection

Where possible, label inscriptions for modular protection equipment shall conform to the requirements detailed above. However, due to the compactness of modular equipment, it may be necessary to use smaller labels with consequent reductions of the inscriptions. In these cases, the standard abbreviations will have to be to Horizon Power approval.

WIRING IDENTIFICATION SCHEME

General

The small wiring shall have colours in accordance with the above table. Each wire shall have a prefix letter to denote its function, e.g. control of circuit breaker, current transformer for primary protection, voltage for instruments, metering and protection. The function letter shall be followed by a number identifying the individual wire. Every branch of every connection shall bear the same identification mark. Where it is necessary to identify branches which are common (e.g. current transformer leads), different identification marks for the branches shall be employed only if they are commonned through links, or are connected to separate terminals which are then commoned by removable connections.

The circuit function letters and wire numbers are listed above.

Ferrules

Identification ferrules shall preferably be white insulating material, having a glossy finish to prevent adhesion of dirt. Alternative methods of ferruling can be offered and any such proposal will require the approval of HP. Ferrules and markings shall not be affected by damp or oil and characters shall be clearly and permanently marked in black or with a contrasting colour.

Prefix Letters

These circuit function letters shall be used in accordance with the following:

(i) Circuit Common to More Than One Function

Where part of a circuit is common to more than one function, letters in the table shall be used for the common part. Where the circuits split at a separate contact, (e.g. fuse, link, switch or relay contact) the function letter should change if necessary from the splitting point onwards.

(ii) Circuits Having Functions Not Included in the Table

Circuits having functions not included in the function letter table shall not have prefix letters. For example, circuit or device which provide a continuous indication, such as remote winding temperature indicators or resistance thermometers, should not have a prefix letter unless the circuit of the particular indication already has a function letter. Where, however, an indication or alarm is initiated by the opening or closing of an auxiliary contact prefix 'L' or 'X' should be used as appropriate.

(iii) Circuits Having Functions Not Assigned by the Purchaser

Where the manufacturer has been unable to ascertain from the Purchaser the function letters and numbering to be assigned to equipment wiring by the time that wiring is required, the manufacturer should himself provide wire numbers preceded by the letter 'O'. Where the appropriate function letter can only be determined, it shall be preceded by an 'O' and followed by the manufacturer's own number. The same procedure may be applied to equipment or parts of equipment not assigned to specific contracts at the time of manufacture, subject to the purchaser's approval and to the use of ferruling in accordance with approved standard diagrams as far as they are applicable.

(iv) Circuits Employing Relays

Where relays are employed, the coil and the contact circuits do not necessarily bear the same function letter, this could be determined by the function of the individual circuit e.g. the coil circuit of a series flag relay may be 'K' by the contact circuits may bear letters such as 'X', 'L' or 'N' as appropriate.

(v) Current Transformers for Protection

Prefix 'C' should be used for all types of over current protection (whether used as primary or back-up protection), standby earth fault, generator negative phase sequence, transformer winding temperature protection and instruments fed from separate current transformers. Where duplicate primary protection is applied prefix 'A' shall be used for both, with the No. 2 protection being distinguished by adding 300 to the number.

(vi) Current Transformer Connections for Line Drop Compensation or Compounding

Prefix 'D' shall be used for these circuits including the primary current side of the isolating transformer, where applicable. The connections to the voltage circuit from this transformer shall be prefix 'F'.

(vii) Interposing and Auxiliary Transformers

The function letters shall follow through any interposing and auxiliary current and voltage transformers, including such transformers when used for light current circuits, provided that these are not used as isolating transformers to couple circuits which have differing functions.

(viii) Voltage Transformer Connections for Automatic Voltage Control

Prefix ‘F’ shall be used for these circuits.

(ix) Light Current Control Connections

Light current equipment may require numbering schemes differing from the above for complete identification. In such cases, where connections from such equipment are associated with power equipment wire in accordance with this instruction, the numbering of such connections should include the appropriate prefix letter (J, W, X or Y) to distinguish them. The letter ‘W’ is generally used for the light current side of interposing relays for control purposes.

Wire Numbers

The wire numbers may consist of one or more digits as required and as detailed in the following tables.

The 110 V DC battery wiring for the protection needs to be in accordance with the following:

Protection	(+)	J601
Protection	(-)	J602

DC supplies from a positive source shall bear odd numbers and DC supplies from a negative source shall bear even numbers. Where coils or resistors are connected in series, the change from odd to even shall be made at the coil or resistor lead nearest to the negative supply.

Suffix Letters

Where similarly numbered leads from separate primary equipment are taken to a common panel (e.g. bus zone protection) suffixes A, B, C, etc. shall be used to distinguish them. When more than two sets of leads require are to be distinguished, specific wire numbering schemes appropriate to the case shall be issued by means of an overall diagram showing the scheme to be adopted.