Technical Specification - HV Power Factor Correction

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Revision details

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

Introduction

This Specification is for the design, supply and installation of HV Power Factor Correction works for Sydney Water assets.

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Acronyms

Term	Definition
AC (ac)	Alternating Current
AI	Analogue Input
AIS	Air Insulated Switchgear
ANSI	American National Standards Institute
AO	Analogue Output
AS	Australian Standard
AUD	Australian Dollars
CB	Circuit Breaker
CT	Current Transformer
c/w	complete with
DC (dc)	Direct Current
DI	Digital Input
DO	Digital Output
ELV	Extra Low Voltage (i.e. ≤ 50 V AC or ≤ 120 V DC)

Term	Definition
EN	European Normalised Standard
ESW	Earth Switch
FVC	Fused Vacuum Contactor
GA	General Arrangement (drawing)
GIS	Gas Insulated Switchgear
HMI	Human Machine Interface
HV	High Voltage (i.e. > 1000 V AC or > 1500 V DC)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronic Engineers
I/O	Inputs/Outputs
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LV	Low Voltage (i.e. greater than ELV but ≤ 1000 V AC or ≤ 1500 V DC)
MCB	Miniature Circuit Breaker
MSDS	Material Safety Data Sheet
MV	Medium Voltage (note this term is not used in this Specification)
PF	Power Factor
PFC	Power Factor Correction
pu	per unit
SAA	Standards Association of Australia
SF_6	Sulphur Hexafluoride
Sec.	second
SLD	Single Line Diagram
TBA	To Be Advised
TBC	To Be Confirmed
TCS	Trip Circuit Supervision
VC	Vacuum Contactor
VCB	Vacuum Circuit Breaker

1. General

1.1 Introduction

This Specification defines the minimum technical requirements for the design, manufacture, supply and delivery of High Voltage (HV) Power Factor Correction (PFC) and Harmonic Filters.

1.2 Scope

This Specification ensures that Sydney Water will be delivered with installation to the minimum acceptable requirements.

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

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

1.3 Proprietary items

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

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

2. Technical requirements

2.1 Environmental requirements

The HV Power Factor Correction systems must be designed to suit the following environmental conditions.

Environmental conditions		
Maximum ambient temperature		+45 ºC
Maximum 24h average temperature		+35 ºC
Minimum ambient temperature (corresponds to “minus 5 ºC indoor class”)		-5 ºC
Maximum relative humidity	For one month	90%
	For 24 hours	95%

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

2.2 Key ratings and features

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

Ref	Rating or feature	Requirement
1	Construction	Fully type tested metal enclosed
2	Operation	Fixed / Switched (application specific)
3	Class	Indoor
4	Access	Front access
5	Material of enclosure	Steel / 316 Stainless Steel
6	Insulation medium	Air
7	Conductor and earth material	Tinned copper for Air insulated conductors
8	Mounting arrangement	Free standing floor mounted on a 100mm hot dipped galvanised plinth
9	Minimum short time withstand	25 kA 3 s
10	Minimum Internal Fault Protection Classification	IAC A FLR 25 kA 1 s
11	Accessibility of compartments	Interlocked / tool-based
12	HV Cable connection	Front (preferred)
13	HV Cable entry	Bottom
14	LV and ELV cable entry	Bottom / Top
15	Gland Plate	6 mm aluminium (undrilled)
16	Minimum degree of protection	Enclosure (Indoor) - IP4X Inside compartments - IP2X
17	Circuit Breaker	Vacuum / SF_6
18	HV Contactor	Vacuum / SF_6

Ref	Rating or feature	Requirement
19	Height to centreline of highest equipment on compartment doors	Preferred: 1800 mm Maximum: 200 0mm
21	Control supply voltage	48 V DC
22	Trip/close coil voltages	48 V DC
23	Spring charge motor voltage	48 V DC
24	Racking motor voltage	48 V DC
25	Anti-condensation heater circuit	240 V AC ± 10 %
26	LED Lighting circuit	240 V AC ± 10 %

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

2.3 Standardisation

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

3. Technical requirements - construction

3.1 General

The power factor correction system must comply with AS 62271 series and IEC 62477 series.

The PFC system must have front access and be of the same height to provide a uniform profile along the assembly.

The design of the PFC system must be such to be fully assembled in the manufacturers factory, with all equipment pre-wired and tested before delivery to site for installation. The PFC system must be designed to allow future extension on the left or right of the PFC system.

Separate compartments must be provided in the PFC system for:

a) HV capacitors, HV fuses and switching devices

b) Damping and harmonic filter reactors

c) Incoming circuit breaker or isolator

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

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

The PFC system enclosure must be supplied and mounted on an adequate 100 mm height plinth, if when the plinth is not part of the standard design. The plinth must be typically of hot dipped galvanised construction.

The PFC system must have internal arc withstand to Class A-FLR with minimum time duration of 1 second. The PFC system must have an integrated, type tested pressure relief ducts to ensure operator safety. The PFC system internal arc withstand must be verified according to the criteria of the standard, class A accessibility. The tests must be carried out, for each PFC system with the LV compartment door open.

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

A separate LV compartment for LV/ELV control, monitoring, protection and indication is to form part of the PFC system with access for ELV/LV wiring.

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

Type test certificates for the PFC system, incorporating all accessories must be supplied by the Contractor.

3.2 Sheet metal work

The PFC system must be fabricated such that the framework is sufficiently rigid and stable to withstand all normal operating handling and shipping forces without deformation, misalignment or damage. Removable sections of the enclosure must not be used to obtain such rigidity. Rivets must not be used in the assembly of steel sections.

All steel panelling must be of folded construction, zinc annealed sheet steel or 316 stainless steel.

Adequate lifting facilities must be provided on the PFC system.

The enclosure design must incorporate the following features:

3.3 Compartment doors

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

All compartment doors must be fitted with hinges that swing through 120 degrees and be fitted with a latching mechanism to prevent the door from self-closing.

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

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

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

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

3.4 Surface preparation and painting

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

All Metal finishing, the preparation, pre-treatment of surfaces and painting must be carried out strictly in accordance with Sydney Water Standard specification WSA201 - Manual for selection and Application of Protective Coatings and WSA201 - Sydney Water Supplement and PCS100 - Protective coating standard to provide adequate protection against the adverse effects of the site conditions specified in the design specification.

Preferred Paint Colours	
Electrical Cabinets (Indoor)	RAL7035 (Light Grey) for external surfaces N14 (White) for internal surfaces
Electrical Cabinets (Outdoor)	G66 (Environmental Green) for external surfaces N14 (White) to AS2700 for internal surfaces

3.5 Fixings

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

Externally fitted fixings must be hot dipped galvanised

Cadmium plated fixings must not be used.

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

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

3.6 HV cable termination

The PFC system must be designed for high voltage cable termination using bolted air insulated connections.

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

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

The PFC system design must make provision for the installation of fire stopping material to provide a two hour fire rating between the PFC system and the cable basement or subfloor of the switchroom.

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

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

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

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

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

3.7 Low voltage (LV) cable termination

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

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

3.8 Busbars

Busbars must be sized in accordance with the relevant type test certificate.

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

a) Causing mechanical damage to any part

b) Causing flashover between phases or phase to earth

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

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

All air insulated busbar must be electro-tinned plated.

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

Busbar connection colour coding		
Supply	L1 L2 L3	Red White Blue
Apparatus	Phase 1 Phase 2	Red White

Busbar connection colour coding		
	Phase 3	Blue
Neutral	N	Black
Earth	E	Green / Yellow

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

3.9 Earthing and earth bars

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

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

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

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

Earthing switches must be provided as detailed in Section **Error! Reference source not found.** - Earthing Switches

3.10 Operation

It must be possible for one operator to perform all PFC system operations including earth switch, and main disconnect switch open and close with all compartment doors closed and secured.

The PFC system main switch must be designed for local operation. All local operating functions must be capable of being carried out by an operator whilst standing in front of the PFC system at floor level.

The PFC system must be designed for the switching in and out of capacitance automatically based on the information collected by the power factor controller unit.

All operating mechanisms, including disconnect switch closure control, must be pad-lockable.

In accordance with AS3000, the PFC system design must provide effective arc barriers on enclosed switches, where the operating handle can be operated through a slot in the enclosing case. Design must provide protection for personnel, particularly when located at the front of the PFC system, and must maintain compartment segregation under fault conditions.

The contractor must address the issues outlined in Annex A1, 2, 3, 4, 5, 6, 7 and 8 of AS 62271.200 in demonstrating the arc containment capabilities of the PFC system offered.

3.11 Interlocking

Mechanical key interlocking must be provided between the upstream supply circuit breaker and PFC System so that only when the upstream supply circuit breaker is opened and earthed can the PFC system be earthed and access to the PFC cabinet be allowed.

4. Technical requirements - HV equipment

4.1 General

Circuit breakers or disconnect switches must be utilised for:

a) Incoming circuits

Vacuum contactors must be used for:

a) Capacitance switching

PFC systems connected directly to motors must typically be of fixed capacitance design having as a minimum the following devices:

a) Fixed value of capacitance

b) Fuse protection for capacitors

c) Isolating device for PFC system

PFC systems connected to a HV network of switchgear must have must typically be of switched type capacitance design having as a minimum the following devices:

a) A number of capacitor banks depending on application

b) Fuse protection for each capacitor bank

c) Switching device for each capacitor bank to allow switching in and out of banks.

d) Power Measuring apparatus (CTs and VTs)

e) PFC Controller

f) Isolating device for PFC system

g) PFC system protective devices (where required)

h) Damping and harmonic filter reactors (where required).

The PFC system must also be capable of carrying for the specified time full prospective fault currents corresponding to the nominated symmetrical fault level of the system.

Capacitors must have short circuit protection utilising either externally mounted or internally mounted HV current limiting fuses.

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

4.2 PFC system dielectric medium

Air must be used for the dielectric medium for PFC systems.

4.3 Circuit breakers (CBs)

Circuit breakers must be designed in accordance with AS 62271.100.

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

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

Circuit breakers must have minimum mechanical endurance M2, electrical endurance of E2 and restrictive capacitive breaking current of C2.

Closing

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

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

The following must apply:

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

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

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

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

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

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

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

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

Tripping

Tripping must be possible by both:

Local mechanical trip method (for maintenance purposes).

Local and remote electric trip methods.

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

Trip coils must be continuously rated.

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

Operating voltages

All switching devices must be able to meet their rated making duty for closing circuit voltages from eighty (80%) to one hundred and twenty percent (120%) of nominal and their rated breaking capacity for the trip circuit voltages from fifty (50%) to one hundred and twenty percent (120%) of nominal.

Switchgear Auxiliary Switches and Indications.

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

Contacts must be individually adjustable for early or late operation.

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

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

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

Fixed CBs

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

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

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

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

Withdrawable CBs

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

Withdrawable circuit breakers and its operating mechanism must have a minimum five thousand (5000) operations prior to needing major maintenance.

Padlocking facilities must be provided for each position.

SERVICE in which the main and secondary circuits are connected.

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

ISOLATED in which both the main and secondary circuits are isolated.

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

Sulphur Hexafluoride (SF_6) CBs

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

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

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

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

Vacuum CBs

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

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

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

4.4 Vacuum contractors (VCs)

High Voltage Vacuum Contactors shall be designed in accordance with AS 60470-2001 and be suitably rated for heavy duty capacitor switching.

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

Control supply for Vacuum contactor units shall be 48 V DC.

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

Closing

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

Opening

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

4.5 Disconnector switches

Disconnectors shall be designed in accordance with AS 62271.102.

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

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

The switches shall be of the “increased operating frequency” in accordance with the standards. They shall have 3 positions as follows and be constructed in such a way that natural interlocks prevent incorrect operation. Padlocking facilities shall be provided for each position.

CLOSED	Connected
OPENED	Disconnected

Earthed

Closing and Opening

Closing and opening must be possible by both:

a) Local mechanical opening and close method (for maintenance purposes)

b) Local and remote electric opening and closing methods

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

Operating voltages

All switching devices must be able to meet their rated making duty for closing circuit voltages from eighty (80%) to one hundred and twenty percent (120%) of nominal and their rated breaking capacity for the open circuit voltages from fifty (50%) to one hundred and twenty percent (120%) of nominal.

Switchgear Auxiliary Switches and Indications

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

Contacts must be individually adjustable for early or late operation.

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

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

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

4.6 Earthing switches

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

Earthing of the bus must be done by a fixed switch. Mechanical keyed interlocking must be provided between the bus earthing switch and incomer circuit breaker so that the bus earth switch can only be closed when the incomer is opened and racked out in isolated position.

Earthing switches must be preferably electrically operable to allow for remote control.

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

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

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

Earthing switches must comply with AS 1306-1985, AS/NZS 60265.1-2001 and IEC 62271-102.

4.7 Voltage transformers (VTs)

Voltage transformers must be designed in accordance with AS 60044.2-2003 and must have phase-to-phase secondary terminals of 110 V.

VT’s must be typically of the fixed type with HV fuse and LV miniature circuit breaker protection. Auxiliary contacts from the LV MCB must be wired to the LV compartment.

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

VT isolating test links must be provided for all metering VTs.

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

4.8 Current transformers (CTs)

CTs must comply with AS 600044.1-2003 and be designed with insulation and fault level ratings compatible with the switchgear.

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

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

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

Toroidal CT secondary wiring must be S1-Orange and S2-Black.

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

All CT tappings must be wired to slide test link terminals in the LV compartment of the PFC system.

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

a) Detect damage in transit or installation

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

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

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

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

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

Records of all such tests by the CT manufacturer(s) must be collated by the Contractor for review during the auxiliary transformer factory tests (refer Section 7.2 - Routine (Factory) Testing).

4.9 HV capacitors

HV capacitors must be designed in accordance with IEC 60871.

The capacitors must be heavy duty rated for industrial power system applications designed with very low dielectric losses and low partial discharge.

The capacitor tanks must be of fully welded stainless steel construction. Each capacitor unit must have a dielectric medium of environmentally friendly biodegradable, non PCB, non-chlorine fluid.

Each capacitor unit must be provided with an internal discharge resistor.

Capacitor unit must be fitted with porcelain bushings protruding from the top of the tank and be suitable for bolted connection to PFC system busbar.

Where capacitors unit are provided with internal fuses, they must isolate a faulty capacitor element in order to enable operation of the remaining parts of the capacitor unit without cause further failure of the unit and potential rupturing of the tank.

4.10 HV reactors

Reactors must be designed in accordance with AS 60076.6.

Damping Reactors

Typically damping reactors must typically be of aluminium wound resin encapsulated construction.

Damping reactors must be installed in PFC systems to limit the current transients to suitable levels for the capacitor units and also to reduce the surge current to acceptable levels for the switching devices.

4.11 HV iron-core harmonic filter reactors

Harmonic filter reactors must typically be of low loss iron-core, copper or aluminium winding dry type construction.

Harmonic filter reactors must be installed and specifically tuned to each PFC system to decrease the level of harmonic distortion of the system.

4.12 HV fuses

HV fuses must be designed in accordance with AS 1033 or IEC equivalent.
All have HV fuses must be fitted with fuse failure indication with auxiliary contacts wired to terminals for either local or remote indication.

4.13 Bushings and insulators

Bushing insulators must be porcelain type mounted, fixed, sealed and leak-proof, into the tank wall in accordance with the manufacturer's instructions.

They must be of a high quality, high strength, non-hygroscopic and non-tracking material, capable of withstanding handling conditions during transport, erection and maintenance and be in accordance with AS/NZS 60137.

Terminal stems through the bushing insulator must be effectively sealed and locked in such a way that rotating/turning of the stem inside the bushing is completely impossible under any circumstances. The internal winding ends connected to the bushings must always remain submerged under the oil level.

All bushings must be clearly marked to identify the phase connections in accordance with the connection diagram on the rating plate.

If required, insulators must be air insulated indoor or outdoor porcelain type, and must comply with AS 4398-1996.

Air clearances for all live parts must comply with the relevant Australian Standards.

All types of bushings and insulators must satisfactorily withstand the service conditions. Porcelain and metal fittings must remain unaffected by atmospheric conditions producing weathering, acids, alkalis, dust or rapid changes in temperature.

The strength of bushings and insulators as given by the electro-mechanical test load must be such that the factor of safety when supporting their maximum working loads must be not less than 2.5.

Designs must be such that stresses due to expansion or contraction in any part of the bushings, insulators or associated fittings do not lead to the development of defects.

All porcelains must be manufactured in one piece. Jointing of solid or hollow porcelains is not permitted except by use of metal fittings. Porcelain must be sound, free from defects and thoroughly vitrified and the glaze must not be depended upon for insulation. Glaze must be smooth, hard, of a uniform shade of grey and must completely cover all exposed parts of the insulators.

Each bushing and insulator must be clearly marked with the manufacturer's name or trademark, the year of manufacture and the insulator type. Marks must be visible after assembly of fittings and must be imprinted before firing.

4.14 Live line indication

Live line capacitive voltage divider neon indicators must be fitted:

a) On the cable-side of all incoming main switches.

b) Testing points (100 V minimum rating)

4.15 Operating tools

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

a) Main switch operating handle

b) Earth switch operating handle.

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

5.1 General

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

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

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

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

5.2 Equipment layout

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

a) All controls, indications or devices with a test or numerical display must be installed preferably no higher than 1800 mm from the floor level, with a maximum of 2000 mm

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

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

d) Duct work must be at least 50 mm from any other component not mentioned in 2) or 3) above.

5.3 Control and Protection Equipment on LV Compartment Door

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

a) Digital PFC controller incorporating HMIs

b) Pilot lights indicating switch status (OPENED and CLOSED)

c) LOCAL-REMOTE control selector switch

d) OPEN-N-CLOSE control switch with spring return to the centre position.

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

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

b) Via an external PLC.

The maximum height above floor level for all door-mounted control and protection equipment (measured to the centreline of the equipment) must preferably be not more than 1800 mm and must not exceed 2000 mm.

5.4 Control switches and control selector switches

Each PFC system low voltage control compartment must be provided with:

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

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

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

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

Selector switches and pushbuttons must comply with the following minimum requirements:

a) Oil tight design

b) IP54

c) Engraved escutcheon plate mounted above the switch

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

5.5 Pushbuttons

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

Pushbuttons must not have exposed live terminals.

Emergency stop pushbuttons must be shrouded to avoid accidental trip and must comply with “Sydney Water Corporation Emergency Stops Policy”.

Pushbuttons must comply with the following minimum requirements:

a) Oil tight design

b) IP54

c) 22 mm diameter body

d) Engraved escutcheon plate mounted above the pushbutton

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

5.6 Indicating lights

Indication lights must operate on the switchboard at the auxiliary supply as specified in section **Error! Reference source not found.** of this specification. The colours of indication lights must typically comply with IEC60073.

Indication lights must comply with the following minimum requirements:

a) Oil tight design

b) IP54

c) 22 mm diameter body

d) LED cluster type

e) Lamp replacement from the front only

f) Press-to-test mechanism

g) RED lens for CLOSED

h) GREEN lens for OPENED

i) AMBER lens for ABNORMAL CONDITIONS

j) WHITE lens for NORMAL CONDITIONS

k) Engraved escutcheon plate mounted above the lens.

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

Indication lights must not have exposed live terminals.

- Push to test indicating lights must be used throughout.

5.7 Fuses and links

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

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

5.8 Miniature CBs

MCBs must be provided for isolating all auxiliary power supplies in the LV compartment of each PCF system.
MCBs must comply with the following requirements:

a) Compliant with AS/NZS 60898.1:2004 and AS 3111-1994

b) DIN-style

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

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

5.9 Miniature relays

Miniature relays must comply with the following requirements:

a) Compliant with AS 3947.5:2000

b) Plug-in flat-pin style

c) DIN rail mounted base

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

e) Integral LED indication

f) Contacts rated 240 V AC 5 A.

5.10 Digital PFC Controller

All switched metal enclosed PFC systems must be equipped with an automatic controller that switches each capacitor stage based upon the programmed power factor. The unit must have a LED display for programming interface and display of power measurements and alarms. The unit must also have compatible communication capabilities so parameters can be monitored from a PLC/SCADA system using Ethernet TCP/IP and MODBUS.

The following power measurements must be provided:

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

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

c) Current (per phase, three phase)

d) Active power kW/MW (per phase, three phase)

e) Reactive power kVAr/MVAr (per phase, three phase)

f) Reactive power kVAr/MVAr to reach programmed target power factor (per phase, three phase)
g) Apparent power kVA/MVA (per phase, three phase)
h) Power Factor cosφ (per phase, three phase)
i) Target Power Factor cosφ (per phase, three phase)
j) Voltage THD (per phase)
k) Current THD (per phase)
l) Voltage harmonics H2-H49
m) Current harmonics H2-H49.

The following protection alarms must be provided:

n) Under/Over voltage
o) Step warning
p) Step fault
q) Under/Over compensation.

5.11 Anti-condensation heaters

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

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

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

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

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

5.12 LV and ELV wiring

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

All LV and ELV wiring must fully comply with the requirements of AS 3000:2007 Wiring Rules.

All conductors must be FLEXIBLE stranded tinned copper wire.

Minimum conductor sizes must be:

Item	Wire type	Wiring and/or Conductors	Colours
Extra Low Voltage (AC or DC)	1.5 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147	Active/Positive Neutral/Negative	Light Grey (LtG)
240 V AC control when supplied from same compartment or SCA In all other cases	2.5 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147	Active Neutral	Brown (BN) Black (BK)

Item	Wire type	Wiring and/or Conductors	Colours
		Active Neutral	Orange (O) Black (BK)
CT and VT secondaries	4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V105 to AS 3147	Red Phase White Phase Blue Phase Neutral	Red (R) White (W) Blue (B) Black (BK)
Core Balance toroids	4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V105 to AS 3147	S1 S2	Black (BK) Black (BK)
Earth conductors	Minimum 4 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147		Green-Yellow (G-Y)
Instrumentation twisted pair conductors		Positive Negative	White (w) Black (BK)
Ethernet	CAT 6		Blue
Conductors connecting voltage free relay contacts where the voltage is undefined	1.5 mm^2 Cu, 0.6 / 1 kV PVC insulated type V75 to AS 3147	Active/Positive Neutral/Negative	Violet (V)

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

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

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

Adhesive wiring supports are unacceptable.

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

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

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

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

Solder connections are not acceptable

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

All field wiring must be marshalled at terminal strips.

Terminals must comply with the following requirements:

a) Tunnel type connectors

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

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

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

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

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

g) Provide a separate earth terminal for each field cable

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

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

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

5.13 Interfaces with external systems and equipment

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

Such interfaces must include:

a) DIs, AIs and DO's to/from the plant PLC via the comms interfaces

b) Hardwired intertrip signals to/from substation and HV PFC system

c) Hardwired CT and VT signals to the Metering Systems

d) All hardwired digital outputs must be volt-free contacts

e) All hardwired digital inputs must be from volt-free contacts.

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

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

6. Identification and labelling

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

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

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

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

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

Generally, labels must be manufactured to the following specification:

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
PFC system main label - Mounted in centre of fully assembled PFC system.	400L x 100H	Black / White	PFC system Number PFC system Name	40 20
PFC rating plate - Mounted on LV compartment door of fully assembled PFC system	120L x 100H	Black / White	Sellers/manufactures name Purchase order number Year of Manufacture Type and serial number PFC voltage, current, kVAR and fault rating	10 10 10 10 10
PFC main switch number label (Sydney Water numberplate style) - Mounted on compartment for main switch device	100L x 100H	Black/Yellow	Switch Number	80
HV fuse rating label - Mounted on front panel of fuse compartment	50L x 30H	Black / White	Fuse Fuse rating / Holder rating	10 10
Warning label - Mounted on compartment door to access capacitors	200L x 200H	Red / White	“ENSURE POWER FACTOR UNIT IS FULLY DISCHARGED PRIOR TO GAINING ACCESS”	30
High Voltage compartment label - Mounted on all compartment doors that provide access to HV		White / Red / Black	DANGER HIGH VOLTAGE (to AS 1319)	
All other removable cover labels that provide access to high voltage equipment		White / Red / Black	DANGER HIGH VOLTAGE (to AS 1319)	

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
- Mounted on all covers that provide access to HV				
Current transformer - Mounted on side wall in the LV compartment of specific circuit	50L x 30H	Black / White	Circuit Number Function e.g. metering Cores ratio Class	5 5 5 5
Voltage transformer and reactor labels - Mounted on side wall in the LV compartment of specific circuit	50L x 30H	Black / White	Circuit Number Function e.g. metering Cores ratio Class / VA	5 5 5 5
All compartment door mounted equipment labels (e.g. Controllers, indication lights, selector switches, pushbuttons etc) - Mounted on front and rear of LV compartment door below equipment		Black / White		3
All compartment internally mounted equipment labels (e.g. control relays, control MCB's, Terminals etc) - Mounted below equipment		Black / White		3

6.1 Label schedule

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

7. Testing requirements

7.1 Type testing

Type test reports must be provided by the Contractor for the PFC System enclosures, Capacitors, reactors, VCs, switches and earth switches for all type tests listed within:

AS 62271.100-2005 HV switchgear and control gear - HV AC circuit-breakers.

AS 62271.102-2005 HV switchgear and control gear - AC disconnectors and earthing switches.

AS 62271.200-2005 HV switchgear and control gear - AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.

AS 60470-2001 HV AC contactors and contactor-based motor-starters.

AS60076.6 - 2013 Power Transformers – reactors

IEC 60871 Shunt capacitors for AC power systems having a rated voltage above 1000 V (Parts 1, 2, 3, 4)

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

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

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

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

If new type tests are performed, representatives from the Principal must be given the opportunity to witness the tests. 14 calendar days' notice must be given for tests in Australia and 21 calendar days' notice must be given for tests outside Australia.

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

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

7.2 Routine (Factory) Testing

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

AS 62271.100-2005 HV switchgear and control gear - HV AC circuit-breakers.

AS 62271.102-2005 HV switchgear and control gear - AC disconnectors and earthing switches.

AS 62271.200-2005 HV switchgear and control gear - AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV.

AS 60076.6-2013 Power Transformers - Reactors.

IEC 60871 Shunt capacitors for AC power systems having a rated voltage above 1000 V (Parts 1, 2, 3, 4)

Routine (factory) tests must include:

a) Detailed mechanical inspection

b) Detailed electrical inspection

c) Verification of correct labelling

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

e) Mechanical tests on all CBs earth switches

f) Electrical tests on all electrical interlocking

g) Review of setup parameters for all digital relays and controllers

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

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

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

k) Functional testing of all metering circuits

l) Insulation resistance tests (before dielectric withstand tests)

m) Dielectric withstand tests (power frequency tests)

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

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

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

q) Inspection of all loose-supplied equipment

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

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

t) Magnetisation tests on all CTs (if not already performed at the place of manufacture)

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

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

w) Review of manufacturing inspection and test documentation and records

x) Review of manufacturing defect lists / punchlists.

Representatives from Sydney Water must be given the opportunity to witness the factory tests. 14 calendar days’ notice must be given for tests in Australia and 21 calendar days’ notice must be given for tests outside Australia.

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

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

a) Results of all tests

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

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

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

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

f) Copies of factory defect lists / punchlists

g) Copy of the completed Factory ITP.

Statement confirming compliance with the specified requirements.

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

7.3 Site testing

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

Such site tests must comply with the applicable requirements of:

AS 62271.100-2005 HV switchgear and control gear - HV AC circuit-breakers.

AS 62271.102-2005 HV switchgear and control gear - AC disconnectors and earthing switches.

AS 62271.200-2005 HV switchgear and control gear - AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.

AS 60470-2001 HV AC contactors and contactor-based motor-starters.

AS 60076.6-2001 Power Transformers - Reactors.

IEC 60871 Shunt capacitors for AC power systems having a rated voltage above 1000 V (Parts 1, 2, 3, 4)

As a minimum, the following tests must be performed:

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

s) Review of assembly inspection and test documentation and records

t) Review of assembly defect lists / punchlists.

Representatives from the Principal must be given the opportunity to witness the site tests.

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

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

a) Results of all tests

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

c) Copies of site defect lists / punchlists

d) Copy of the completed Site ITP

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

8. Quality assurance and inspection and test plans

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

The Contractor must submit for approval two project-specific Inspection and Test Plans (ITPs) for the PFC system:

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

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

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

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

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

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

Sydney Water must be given the option of witnessing all inspections and tests including type tests, (routine) factory tests and site tests. Sufficient notice (seven calendar days for tests onsite, 14 calendar days for test elsewhere in Australia, 21 calendar days for tests outside Australia) must be given to enable the necessary travel arrangements to be made.

Sydney Water may elect to appoint third-party inspector(s) to witness inspections and tests.

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

9. Spare parts

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

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

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

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

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

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

10. Manuals and drawings

Two paper copies of erection, maintenance and operating manuals must be supplied. One electronic copy of all manuals, drawings and test results must be provided on suitable electronic media in PDF file format as a minimum.

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

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

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

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

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

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

11. Related documents

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

Document type	Title
Legislation	- Work Health and Safety Act 2011 - Service and Installation Rules of New South Wales 2006
Policies and procedures	- WSA201 - Manual for Selection and application of protective coatings - Supplement to WSA201 - Manual for Selection and application of protective coatings. - PCS100 - Protective Coatings - Sydney Water Corporation Emergency Stop Policy
Other documents	Click to add details of HIDRA and other relevant documents
Standards	- AS ISO 1000: The International System of Units (SI) and its application (ISO 1000) - AS 1033 (IEC 60282.2): High voltage fuses (for rated voltages exceeding 1000V) (Parts 1 and 2) - AS 1170: Minimum design loads on structures (known as the SAA Loading Code). (Parts 2 and 4) - AS 1307 (IEC 60099): Surge arresters (diverters) - AS 1627: Metal finishing - Preparation and pre-treatment of surfaces - AS 1824 (IEC 60071): Insulation coordination (phase-to-earth and phase-to-phase, above 1kV) (Parts 1 and 2) - AS 1852.441: International electrotechnical vocabulary - Switchgear, controlgear and fuses - AS 1931 (IEC 60060): High voltage testing techniques (Parts 1 and 2). - AS 2024 (IEC 62271-105): High voltage AC switchgear and control gear - Switch-fuse combinations - AS 2067: Switchgear assemblies and ancillary equipment for alternating voltages above 1 kV - AS 2467: Maintenance of electrical switchgear - AS 2700: Colour standards for general purposes - AS/NZS 3000: Electrical installations (known as the Australian/New Zealand Wiring Rules) - AS/NZS 3008.1.1: Electrical installations - Selection of cables - Cables for alternating voltages up to and including 0.6/1 kV - Typical Australian installation conditions - AS 3111: Approval and test specification - Miniature overcurrent circuit-breakers - AS 3947 series: LV switchgear and control gear - AS 4243: Additional requirements for enclosed switchgear and control gear from 1 kV to 72.5 kV to be used in severe climatic conditions - AS 60038: Standard voltages

Document type	Title
	- AS 60044.1 (IEC 60044-1): Instrument transformer - Current transformers - AS 60044.2: Instrument transformers - Inductive voltage transformers - AS 60076.6 (IEC 60076-6): Power transformers - Part 6: Reactors - AS 60137 (IEC 60137): Bushings for alternating voltages above 1000 V - AS/NZS 60265.1:2001 (IEC 60265-1): High-voltage switches - Switches for rated voltages above 1 kV and less than 52 kV - AS 60269 (IEC 60269): Low-voltage fuses - AS 60470 (IEC 60470): High-voltage alternating current contactors and contactor -based motor-starters - AS 60529 (IEC 60529): Degrees of protection provided by enclosures (IP Code) - AS/NZS 60898.1 (IEC 60898): Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Circuit-breakers for AC operation - AS 60947 (IEC 60947): Low-voltage switchgear and controlgear. Please note: Some parts still exist as AS/NZS 3947. - AS 62271.1 (IEC 62271-1): High-voltage switchgear and controlgear – Common specifications. - AS 62271.100 (IEC 62271-100): High-voltage switchgear and controlgear - High-voltage alternating-current circuit-breakers. - AS 62271.102 (IEC 62271-102): High voltage switchgear and controlgear - Alternating current disconnectors and earthing switches. - AS 62271.103 (IEC 62271-103): High-voltage switchgear and controlgear - Switches for rated voltages above 1 kV and less than 52 kV. - AS 62271.200 (IEC 62271-200): High-voltage switchgear and controlgear - A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV. - AS 62271-201 (IEC 62271-201): High-voltage switchgear and controlgear - AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV. - AS 62271-303 (IEC 62271-303): High-voltage switchgear and controlgear - Use and handling of sulphur hexafluoride (SF_6) in high-voltage switchgear and controlgear. - IEC 376: Sulfur Hexafluoride - IEC 60073: Basic and Safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators. - IEC 60255 series: Measuring relays and protective equipment - IEC 60549: High-voltage fuses for the external protection of shunt capacitors - IEC 60871: Shunt capacitors for AC power systems having a rated voltage above 1000 V (Parts 1, 2, 3, 4).

11.1 Conflicts between Specification, Standards and/or Codes

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

Ownership

Ownership

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

Change history

Version No.	Prepared by	Date	Approved by	Issue date
1	Robert Lau / Andrew Manganas / Paul Zhou	21/09/2016	Norbert Schaeper	21/09/2016
2	Paul Zhou	20/02/2020	Steve Keevil-Jones	20/02/2020