Specification

Technical Specification - HV Power Factor Correction

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Revision details

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

Introduction

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

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification shall be sufficient to ensure safe systems or work or operation.

It is the user’s sole responsibility to ensure that the copy of the Specification is the current version as in use by Sydney Water.

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Acronyms

Acronym	Definition
AC (ac)	Alternating Current
AI	Analogue Input
AO	Analogue Output
AS	Australian Standard
CB	Circuit Breaker
CT	Current Transformer
DC (dc)	Direct Current
DI	Digital Input
DO	Digital Output
ELV	Extra Low Voltage (i.e. ≤ 50 V AC or ≤ 120 V DC)
FVC	Fused Vacuum Contactor
HMI	Human Machine Interface

Acronym	Definition
HV	High Voltage (i.e. > 1000 V AC or > 1500 V DC)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronic Engineers
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
PF	Power Factor
PFC	Power Factor Correction
SAA	Standards Association of Australia
SLD	Single Line Diagram
TCS	Trip Circuit Supervision
VC	Vacuum Contactor
VCB	Vacuum Circuit Breaker

General Terms & Definitions

Term	Definition
Design life	The period adopted in design for which a product, equipment or component is required to perform its function within the specified parameters with periodic maintenance but without replacement or major overhaul.
Service life	The forecast life expectancy of a product based on operational experience and actual installed conditions during which it remains in use, which may include replacement of critical parts and major overhauls.

1. General

1.1 Scope

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

1.2 Proprietary items

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

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

2. Technical Requirements

2.1 Environmental Requirements

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

Table 1. Environmental Requirements

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

The PFC panels 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 systems must be as follows:

Table 2. Key ratings and features

Ref	Rating or feature	Requirement
1	Construction	Fully type tested metal enclosed
2	Class	Indoor
3	Access	Front access
4	Material of enclosure	Steel / 316 Stainless Steel
5	Conductor and earth material	Tinned copper for Air insulated conductors
6	Mounting arrangement	Free standing floor mounted on a 100mm hot dipped galvanised plinth
7	Accessibility of compartments	Interlocked / tool-based
8	HV Cable connection	Front (preferred)
9	HV Cable entry	Bottom
10	LV and ELV cable entry	Bottom / Top
11	Gland Plate	HV: 6 mm aluminium (undrilled) LV and ELV: 3 mm aluminium (undrilled)
12	Minimum degree of protection	Enclosure (Indoor) - IP4X Inside compartments - IP2X
13	Height to centreline of highest equipment on compartment doors	As per AS4024
14	Control supply voltage	48 V DC
15	Anti-condensation heater circuit	230 V AC ± 10 %
16	LED Lighting circuit	48 V DC

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

2.3 Standardisation

Equipment must be designed with standard parts and components having a minimum of 10 years remaining of their product manufacturing lifecycle. Parts and components must be standardised as much as possible. All replaceable and consumable equipment must be standard supply equipment. The use of “one off” special designs is not permitted.

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.

Separate compartments must be provided in the PFC panel for:

a) HV capacitors, HV reactors, HV fuses and switching devices

b) Damping and harmonic filter reactors

c) Incoming circuit breaker, isolator or HV cables

d) LV/ELV 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 a 100 mm height plinth, if when the plinth is not part of the standard design. The plinth must be hot dipped galvanised construction.

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.

The power factory correction system must be assessed and protected from arc flash hazard in accordance with SW Technical Specification – Arc Flash.

3.2 Sheet Metal Work

The PFC panel 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 panel 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 steels.

Adequate lifting facilities must be provided on the PFC panel.

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 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

All exposed stationary metal surfaces must be prepared and painted to provide adequate protection against the adverse effects of the site conditions specified in Section 2.1. Surface preparation and paint systems must be selected to give a life of not less than the design life of the PFC panel.

All Metal finishing, the preparation, pre-treatment of surfaces and painting must be carried out strictly in accordance with Sydney Water Standard specification WSA201 - Manual for selection and Application of Protective Coatings and WSA201 - Sydney Water Supplement and PCS100 - Protective coating standard. External and internal surfaces of the PFC panel must be RAL7035 (Light Gray).

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 panel must be designed for high voltage cable termination using bolted air insulated connections.

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

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

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 Earthing

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.

3.9 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 panel 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.

3.10 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:

b) 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 DOC0012 - HV switchgear technical specification, circuit breaker section.

4.4 Vacuum Contractors (VCs)

High Voltage Vacuum Contactors shall be designed in accordance with AS 60470 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 DOC0012 - HV switchgear technical specification, disconnector switches section.

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. Earth switches shall be designed in accordance with DOC0012 - HV switchgear technical specification, Earth switches section.

4.7 Voltage Transformers (VTs)

Voltage transformers must be designed in accordance with DOC0012 - HV switchgear technical specification, Voltage transformers section.

4.8 Current Transformers (CTs)

CTs must comply with DOC0012 - HV switchgear technical specification, current transformers section.

4.9 HV capacitors

HV capacitors must be designed in accordance with IEC 60871, the capacitors must have a minimum of 15 years' service without needing for replacement under the environmental condition nominated in Section 2.

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 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 or epoxy 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.

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 must comply with DOC0012 - HV switchgear technical specification, live line indication section.

4.15 Operating Tools

Two complete set of operating tools as per manufacturer recommendation must be supplied for the HV PFC system.

5. Technical Requirements - LV and ELV Control and Protection Equipment

5.1 General

The design and integration of LV and ELV control and protection equipment of PFC systems must conform to the relevant Sydney water specifications and Australian Standards. Approval from SW is required in advance for the proposed control, monitoring, protection, indication, communication protocols, and interfaces to SCADA/IICATS.

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:

Table 3. Labels

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 - Mounted on all covers that provide access to HV		White / Red / Black	DANGER HIGH VOLTAGE (to AS 1319)	
Current transformer - Mounted on side wall in the LV compartment of specific circuit	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

Label function and location	Typical label size (mm)	Text colour / Background colour	Label description	Text height (mm)
All compartment internally mounted equipment labels (e.g. control relays, control MCB's, Terminals etc) - Mounted below equipment		Black / White		3
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 - Mounted on all covers that provide access to HV		White / Red / Black	DANGER HIGH VOLTAGE (to AS 1319)	
Current transformer - Mounted on side wall in the LV compartment of specific circuit	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

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 (including enclosures, Capacitors, reactors, VCs, switches and earth switches) as per applicable part of Australian standards, IEC standards and nominated standard by SW. 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.

Certificates 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. Routine (factory) tests must be complied with applicable part of Australian standards, IEC standards and nominated standard by SW including but not limited to:

AS 60076.6 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) Insulation resistance tests (before dielectric withstand tests)

l) Dielectrics withstand tests (power frequency tests)

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

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

o) Inspection of all loose-supplied equipment

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

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

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

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

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

u) Review of manufacturing inspection and test documentation and records

v) 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 all equipment in PFC system

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 PFC system is fully complete and ready for energising.

Such site tests must comply with the applicable requirements of following but not limited to:

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

AS 60076.6 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) Dielectrics 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 / punch lists.

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 / punch lists
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/punch list, 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/punch list, 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.

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 as part of the project.

10. Deliverables

10.1 Deliverables during design stages

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

a) Layout drawings

b) Datasheets

c) CT calculations

d) Assembly drawings

e) Assembly manuals

f) PFC schematics

10.2 Post design deliverables

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	- The latest edition of the Work Health and Safety Act 2011 - The latest edition of the Service and Installation Rules of New South Wales
Policies and procedures	- WSA201 - Manual for Selection and application of protective coatings - Supplement to WSA201 - Manual for Selection and application of protective coatings. - PCS100 - Protective Coatings - Sydney Water Corporation Emergency Stop Policy
Other documents	- D0002010 - Engineering Standard governance
Standards	- 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 1627: Metal finishing - Preparation and pre-treatment of surfaces - 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 4243: Additional requirements for enclosed switchgear and control gear from 1 kV to 72.5 kV to be used in severe climatic conditions - AS 60038: Standard voltages - AS 60076.6 (IEC 60076-6): Power transformers - Part 6: Reactors - AS 60099 (IEC 60099): Surge arresters (diverters) - AS 60137 (IEC 60137): Bushings for alternating voltages above 1000 V - AS/NZS 60265.1 (IEC 60265-1): High-voltage switches - Switches for rated voltages above 1 kV and less than 52 kV - 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

Document type	Title
	- AS 60947 (IEC 60947): Low-voltage switchgear and controlgear. Please note: Some parts still exist as AS/NZS 3947. - AS 61869.2 Instrument transformer- Additional requirements for current transformers (IEC 61869-2) - AS61869.3 Instrument transformers - Additional requirements for inductive voltage transformers (IEC 61869-3) - AS 62053.21 (IEC 61036): Electricity metering equipment (AC) - Particular requirements - Static meters for active energy (classes 1 and 2) (IEC 62053-21) - AS 62053.22 (IEC 62053-22): Electricity metering equipment (AC) - Particular requirements - Static meters for active energy (classes 0.2 S and 0.5 S) - AS 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. - IEC 60073: Basic and Safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators. - IEC 60255 series: Measuring relays and protective equipment - IEC 60269: Low-voltage fuses - 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	Water and Environment Services
Owner	Manager of Engineering Modernisation
Author	Technical Director - 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
3	Paul Zhou/ Hedi Mahdavi Aghdam	14/03/202	Norbert Schaeper	21/03/2025