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| Assets Planning and Delivery GroupEngineering |

Design Standard DS 26-39

Type Specifications – Electrical

**Type Specification for Conventional Low Voltage Power Factor Correction Assembly**

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| version 1revision 2 |
| NOVEMBER 2022 |

**FOREWORD**

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

[Overview of Western Australia’s Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)](https://www.dmirs.wa.gov.au/sites/default/files/atoms/files/overview_general_regulations.pdf)

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**Head of Engineering**

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REVISION STATUS

The revision status of this standard is shown section by section below.

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Design Standard DS 26-39

Type Specifications – Electrical

Type Specification for Conventional Low Voltage Power Factor Correction Assembly

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# General

## Scope

This Specification details the requirements for the design, manufacture, assembly, factory testing, delivery and onsite commissioning of a Low Voltage power factor correction (PFC) assembly of the switched capacitor type. The PFC assembly is to provide centralised control of power factor of the electrical power demand in a large pump station or water treatment plant.

This Specification covers PFC assemblies with a kVAr rating in the range 100 kVAr up to 1000 kVAr and covers applications where the PFC assembly is connected directly a dedicated Low Voltage switchboard, all as detailed in this Specification and the Annexure.

The PFC assembly shall consist of a number of three phase kVAr modules together with a controller and ancillary equipment arranged to switch modules in and out of circuit so as to control the power factor of the overall installation within the limits specified.

The PFC assembly shall be supplied complete in a separate enclosure, on a common base frame and shall be supplied to site with all accessories and miscellaneous materials, minor parts and other such items necessary to complete assembly, testing and commissioning of the PFC assembly.

Electrical connection of the PFC assembly will be carried out by the Principal after any on-site assembly and positioning has been completed by the Contractor. The Contractor shall return to site to commission the PFC assembly once the connection of the PFC assembly has been completed.

## Site

The location of and access to the site for installation of the PFC assembly is shown in the Annexure.

## Work by the Principal

1. The Principal will supply and install Current transformers and, where applicable, a potential transformer on the incoming mains supply for the control of the PFC Assembly.
2. The Principal will supply and install an upstream circuit breaker to provide overload and short circuit protection for the PFC and the associated Low Voltage supply.
3. The Principal will supply and install upstream surge diverters for the protection of the PFC Assembly. The surge diverters will be Class I+II supplied in accordance with Clause 5 of DS26-32 Type Specification for Class II Low Voltage Single Phase Surge Diverters and will be installed within 10 meters of the PFC Assembly.
4. The Principal will design, supply and install ducting to remove the discharge cooling air from the room housing the PFC Assembly, if required.

Other work to be carried out by the Principal is specified in the Annexure.

## Principal’s Drawings

The Principal’s Drawings are attached to the Annexure.

The Principal’s Drawings include the fault levels and other information to be used in the design of the PFC Assembly.

Where there is any conflict between the requirements of this Specification and the Principal’s Drawings, the Principal’s Drawings shall take precedence.

## Information to be Provided by the Contractor

The Contractor shall submit the following information to the Principal for approval within the listed number of days after the receipt of the Principal’s order.

1. Manufacturing and Delivery Schedule 7 days
2. Discharge Cooling Air Ducting Requirements (where applicable) 7 days
3. Design Verification and Type Test Certificates 14 days
4. Contractor’s Drawings 28 days
5. Inspection and Test Plan 35 days
6. Routine Verification and Routine Test Certificates On Delivery
7. Operating and Maintenance Manual On Delivery

## Contractor’s Drawings

1. All drawings provided by the Contractor shall be in accordance with the latest issue of the Water Corporation Design Standard DS24 – Electrical Drafting
2. All drawings shall be prepared in AutoCAD format, Release 2018 or later software
3. Drawings shall be prepared on the “Electrical” A1 metric drawing sheet and title block provided in the Water Corporation external (WCX) package (available for download) in accordance with the Water Corporations Design Standard DS80
4. The drawings shall provide within the title block, the details to identify the drawing, including but not limited to its title, plan number, revision status, date of issue, Corporate project number, contractor’s name and reference number (if applicable)
5. Drawings detail shall include, but not limited to, the general arrangement, panel layout, power and control circuit diagrams and equipment specifications, as required
6. The contractor shall submit drawings in both AutoCAD and PDF formats in accordance with the Drawing Submission Process. Adequate contrast within the PDF image shall be maintained between drawing content and background to ensure the clarity and quality of the drawings

## General Requirements

In addition to the requirements of this Specification, the PFC assembly shall be constructed in accordance with the requirements of DS 26-09 Type Specification for Low Voltage Switchboards - General Requirements.

## Standards

In addition to the Standard requirements specified in the Water Corporation’s DS 26-09 Type Specification for Low Voltage Switchboards - General Requirements, the following Australian and International Standards are referred to in this Specification.

AS/NZS ISO 9001 Quality Management Systems

AS/NSZ 60076.6 Power Transformers – Part 6: Reactors

IEC 60831-1 Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V Part 1: General Performance, testing and rating - Safety requirements - Guide for installation and operation

AS/NZS IEC 60947.4.1 Low-voltage switchgear and controlgear - Contactors and motor-starters - Electromechanical contactors and motor-starters

SA/SNZ TR 61439.0 Low voltage switchgear and controlgear assemblies - Part 0: Guidance to Specifying Assemblies

AS/NZS 61439.1 Low voltage switchgear and controlgear assemblies - Part 1: General Rules

AS/NZS 61439.2 Low voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies

## Quality Assurance

The PFC assembly shall be manufactured under a Quality System certified by an Accredited Authority to be in accordance with AS/NZS ISO 9001 or an approved equivalent.

## Electrical Work

All electrical work shall be performed by appropriately qualified and experienced personnel who shall hold a current electrical worker’s license to perform such work.

# Service Conditions

## Location

The PFC assembly will be located indoors and will be protected from water spray and water leakage.

## Accessibility

Access to the will be restricted to authorised personnel only.

## Pollution Degree

The PFC assembly will be operated in a micro-environment with the pollution degree specified in the Annexure.

## Special Service Conditions

The PFC assembly shall be rated for operation under the normal service conditions specified in AS/NZS 61439.1, unless more arduous, special service conditions apply as specified in the Annexure.

# PFC Assembly Principal Components

The PFC assembly shall consist of the following principal components:

1. An overall enclosure
2. An incoming supply main switch
3. kVAr modules
4. A power factor controller (arranged to switch the kVAr modules in and out)
5. Cooling fans and cooling air filters (if required for the service conditions specified in Clause 2)
6. Temperature-controlled panel heaters (if required for the service conditions specified in Clause 2)
7. An arc flash detection system (where applicable)
8. A communications interface for remote monitoring of the PFC assembly status

# DESIGN VERIFICATION AND TYPE TESTING

The Contractor shall supply design verification certificates and supporting documentation for the PFC assembly in accordance with the requirements of AS/NZS 61439.1 and AS/NZS 61439.2. The design verifications conducted shall include all those listed in AS/NZS 61439.1 Table D.1.

The Contractor shall supply type test certificates confirming that the capacitors have been successfully type tested in accordance with IEC 60831-1.

# Construction

## General

The PFC assembly shall be designed and constructed in accordance with AS/NZS 61439.0, AS/NZS 61439.1 and AS/NZS 61439.2.

## Type of Enclosure

The PFC assembly shall be a metal enclosed assembly in accordance with AS/NZS 61439.0 having a form of internal separation of at least Form 1.

## Cable Entry

The cable entry into the PFC assembly shall be either top or bottom entry as specified in the Annexure.

## Degree of Protection

The PFC Assembly shall have a degree of protection (IP Rating) as specified in the Annexure.

## Cooling

The PFC Assembly shall be either fan cooled, or natural air cooled, as required for the service conditions specified in Clause 2.

If fan cooling is required, the discharge cooling air shall exit from the top of the enclosure from where it will be ducted outside the room housing the PFC Assembly. In this case, the Contractor shall supply all dimensions and other details necessary to enable the Principal to design efficient and effective discharge cooling air ducting.

## Protection Against Internal Faults

The design and construction of the PFC assembly shall incorporate features to minimise the likelihood of internal faults, particularly in the following locations:

1. Cable terminations
2. Circuit breakers, disconnectors and switches
3. Bolted connections and contacts

## Control and Auxiliary Circuits

The PFC Assembly shall be self-powered; no external power supply will be provided by the Principal for the purposes of the control and auxiliary circuits.

All control and auxiliary circuits shall be protected by appropriately rated fault Current limiting fuses.

## Creepage Distances

Creepage distances across insulator surfaces between bare air-insulated conductors in the PFC assembly shall be not less than the values shown in Table 2 of AS/NSZ 61439.1.

# INPUT POWER SUPPLY

The PFC assembly shall be rated for operation from a 3 phase, 415 Volt + 10 %, 50 Hz, power supply having a solidly grounded neutral.

# MAXIMUM PERMISSIBLE VOLTAGE

The PFC Assembly shall be suitable for operation at Voltage levels as specified in Table 3 of IEC 60831-1.

# KVAR MODULES

## General

Each kVAr module shall consist of the following items of equipment:

1. Overcurrent protection
2. Capacitor switching contactor
3. Detuning reactors
4. Capacitors
5. Capacitor discharge devices

The number and size of kVAr steps shall be specified in the Annexure.

## Capacitor Switching Contactors

Capacitor switching contactors shall incorporate low bounce main contacts with leading contacts and inrush Current limiting resistors. Capacitor switching contactors shall be rated for a utilisation category of AC6b as specified in AS/NZS IEC 60947.4.1.

## Detuning Reactors

1. Detuning reactors shall be three phase series reactors complying with the requirements of Clause 9 of AS/NZS 60076.6
2. Detuning reactors shall be of a dry type air core design and shall be provided with overtemperature protection incorporating a Voltage-free, normally open contact to trip an external circuit breaker in the event of reactor overtemperature
3. The resonant frequency of the inductance of the detuning reactors in conjunction with the capacitance of the kVAr module shall be selected by the Contractor

## Capacitors

1. Capacitors in kVAr modules shall be shunt power self-healing capacitors in accordance with IEC 60831-1
2. Each capacitor shall incorporate an over-pressure disconnector
3. The capacitor ambient air temperature category shall be -5/D in accordance with IEC 60831-1, Table 1
4. Capacitors shall be fitted with touch proof terminals (i.e. terminals with IP20 protection)
5. Capacitor total losses shall be not more than 0.5 W/kVAr
6. Capacitors shall have a rated life expectancy of not less than 100,000 hours
7. Capacitors shall be rated for up to 5,000 switching operations per year
8. Capacitors shall be protected against Overcurrent by means of suitable Overcurrent relays
9. Cables connecting capacitors shall have a Current rating not less than 150 % of the capacitor rated Current

## Capacitor Discharge Devices

The capacitor discharge devices shall discharge the capacitors to 75 V or less in less than 6 seconds.

# Power Factor Controller

## General

The PFC assembly shall be fitted with an automatic controller to maintain the power factor of the whole electrical installation within the range 0.9 to 1.0 or 0.95 to 1.0 as specified in the Annexure. The controller shall operate by switching kVAr modules in and out in response to Voltage and Current signals from the electrical installation main incoming busbars.

## Control Mode

The controller switching program shall be optimised so that the number of capacitor switching operations is minimised consistent with maintaining the whole electrical installation power factor within the specified range.

## Measurement Voltage

Where the supply to the site is 415VAC, as shown in the Single Line diagram attached to the Annexure, the measurement Voltage shall be 415VAC, 3 phase, 4 wire. In all other cases, the measurement Voltage shall be 3 phase 3 wire 110VAC derived from a potential transformer connected to the High Voltage supply.

## Measurement Current

The measurement Current shall be derived from three Class 1M Current transformers supplied by the Principal in accordance with Clause 1.3. The Current transformers will have a 1A secondary rating and a primary rating as specified in the Annexure.

## Operator Interface

The controller shall have a user-friendly operator interface with a clear display and intuitive menu system, enabling easy configuration.

The controller operator interface shall permit the display of a broad range of parameters including target and real-time power factors, Voltage, Current, temperature, Voltage and Current harmonic distortion, Current system status, events, warnings and alarms.

## Alarm Output

The controller shall provide a Voltage-free alarm output to interface with the site control system. The conditions activating the alarm output shall include:

1. A PFC assembly fault, including overtemperature
2. Site low power factor

The alarm output shall be rated at not less than 240 VAC, 2 A inductive.

## Communication Interface

The PFC assembly shall communicate with the Principal’s control system via the communication protocol and physical connection specified in the Annexure.

# RIPPLE CONTROL SIGNALS

If the Annexure indicates that the Network Operator uses ripple control signals in the vicinity of the site, the Contractor shall install any additional equipment necessary to ensure the operation of the capacitor banks is unaffected and the strength of the ripple control system is not reduced.

# Arc Flash Detection System

## General

The PFC assembly shall be fitted with an arc flash detection system, if required in the Annexure.

## Method of Detection

The arc flash detection system shall detect an arcing fault using a combination of light and Current monitoring.

Arc flashlight sensors shall be included in all PFC assembly compartments and activation of a sensor/s in conjunction with the detection of abnormal Currents shall cause an output trip contact to close in less than 10 milliseconds. The output trip contact shall be rated at not less than 240 VAC, 2 A inductive and will operate to trip the upstream circuit breaker supplied by the Principal in accordance with Clause 1.3.

The trip Current setting for the arc flash detection system shall be as specified in the Annexure.

## Battery Backup

The arc flash detection system shall be provided with a battery-operated backup supply. In the event of failure of the mains power supply, the backup supply shall power the arc flash detection system for a minimum of 8 hours with the battery residual charge maintained above 20 %.

The backup supply shall include a battery charger capable of recharging the batteries to 90 % charge within 15 hours.

## Alarm Outputs

In addition to the output trip contact, the arc flash detection system shall provide the following hard-wired alarm outputs to interface with the site control system:

1. A Voltage free, normally open contact which closes to indicate an arc flash has been detected
2. A Voltage free, normally open contact which closes to indicate a fault in the arc flash detection system

Hard-wired outputs shall be rated at not less than 240 VAC, 2 A inductive.

# ROUTINE CERTIFICATION

## PFC Assembly Routine Verification

The Contractor shall submit the PFC assembly to routine verification at the Contractor’s workplace in accordance with the approved Inspection and Test Plan and the requirements of AS/NZS 61439.1 and AS/NZS 61439.2.

Unless otherwise agreed by the Principal, the routine verification shall be carried out in the presence of and to the satisfaction of the Principal.

The Contractor shall give the Principal 10 working days’ written notice of the intention to carry out the routine verification.

## Capacitor Routine Tests

The capacitors shall have successfully undergone routine testing in accordance with IEC 60831-1 clause 9.1.

# DELIVERY AND INSTALLATION

The Contractor shall give the Principal seven working days’ notice of when the PFC assembly will be delivered and when it will be ready for connection by the Principal.

The Contractor shall deliver, unload, unpack and assemble as necessary the complete PFC assembly at the site. Following the unpacking the Contractor shall inspect the PFC assembly and shall ensure that the PFC assembly is undamaged.

The Contractor shall mount the PFC assembly in its permanent position in the switch room ready for connection by the Principal.

# ON SITE TESTING AND COMMISSIONING

Before the Contractor makes the PFC assembly available to the Principal for connection to the electrical system, the Contractor shall carry out an insulation resistance test.

Once the PFC has been connected, the Contractor shall commission the PFC assembly in the presence of and to the approval of the Principal. The PFC assembly shall be tested over a representative range of loads over a period of not less than three hours during which time the Contractor shall monitor the performance of the overall power factor correction system and adjust the control configuration to optimise performance.

# AS CONSTRUCTED INFORMATION

The Contractor shall provide as-constructed information on all drawings detailing all changes and modifications made during the construction and installation phases of the project.

The contractor shall submit drawings in both AutoCAD and PDF formats in accordance with the Drawing Submission Process. Adequate contrast within the PDF image shall be maintained between drawing content and background to ensure the clarity and quality of the drawings.

# Manuals

The Contractor shall supply three paper copies and an electronic copy of comprehensive instruction manuals, written in English and covering the complete operation and maintenance requirements of all equipment supplied under the Contract.

The paper copies of the manual shall be printed on high grade A4 size paper and shall be bound in a high grade A4 size loose leaf binder. The electronic copy shall be supplied in Adobe Acrobat or Word format.

The manual shall include:

1. Operating instructions
2. Safety instructions and warnings
3. Maintenance instructions and schedules
4. Recommended spare parts and special tools
5. As-constructed drawings
6. Detailed equipment performance specifications
7. Verification and test certificates

# SPARE PARTS

The Contractor shall guarantee that a complete set of spare parts will be held within Australia.

**Annexure to Specification**

**for**

**Conventional Low Voltage Power Factor Correction Assembly**

**Project:**

**Site Location:**

**Access to Site:**

**Additional Work by the Principal:**

**Principal’s Drawings:**

Single Line Power Diagram (attached), Drawing No.

Earthing Diagram (attached), Drawing No.

Electrical Protection Diagram (attached), Drawing No.

Preliminary Site Layout (attached), Drawing No.

Preliminary Building Layout (attached), Drawing No.

**Pollution Degree of Micro-Environment:**

**Special Service Conditions:**

**Cable Entry** *(i.e. top or bottom entry)*:

**Degree of Protection (IP Rating):**

**kVAr Steps required**:

**Required Power Factor Control Range***(e.g. 0.9 to 1.0 or 0.95 to 1.0)*

**Measurement Current:**

 Current Transformer Primary Current A

**Communication Interface** *(i.e. protocol and physical connection):*

**Ripple Control Signals Used by Network Operator:** Yes/ No

**Arc Flash Detection System required:** Yes/ No

 If Yes, Trip Current Setting A

|  |
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| **Tender Technical Response Schedule** **for Conventional Low Voltage Power Factor Correction Assembly** |
| **Clause No.** | **Subject** | **Noted** | **Compliance** | **Comments** |
|  |  |  | **Yes** | **No** |  |
| **1.** | **General** |  |  |  |  |
| 1.1 | Scope  |  |  |  |  |
| 1.2 | Site |  |  |  |  |
| 1.3 | Work by the Principal |  |  |  |  |
| 1.4 | Principal’s Drawings |  |  |  |  |
| 1.5 | Information to be provided by the Contractor |  |  |  |  |
| 1.6 | Contractor’s Drawings |  |  |  |  |
| 1.7 | General Requirements |  |  |  |  |
| 1.8 | Standards |  |  |  |  |
| 1.9 | Quality Assurance |  |  |  |  |
| 1.10 | Electrical Work |  |  |  |  |
| **2.** | **Service Conditions** |  |  |  |  |
| 2.1 | Location |  |  |  |  |
| 2.2 | Accessibility |  |  |  |  |
| 2.3 | Pollution Degree |  |  |  |  |
| 2.4 | Special Service Conditions |  |  |  |  |
| **3.** | **PFC Assembly Principal Components** |  |  |  | Panel Heaters Supplied?........................Yes/No |
| **4.** | **Design Verification and Type Testing** |  |  |  |  |
| **5.** | **Construction** |  |  |  |  |
| 5.1 | General |  |  |  |  |
| 5.2 | Type of Enclosure |  |  |  |  |
| 5.3 | Cable Entry |  |  |  |  |
| 5.4 | Degree of Protection |  |  |  |  |
| 5.5 | Cooling |  |  |  | Fan cooled? Yes/No orNatural Air Cooled? Yes/No |
| 5.6 | Protection Against Internal Faults |  |  |  |  |
| 5.7 | Control and Auxiliary Circuits |  |  |  |  |
| 5.8 | Creepage Distances |  |  |  | Min. creepage mm = |
| **6.** | **Input Power Supply** |  |  |  |  |
| **7.** | **Maximum Permissible Voltage**  |  |  |  | Voltage factor x UN rms for 8 hrs. daily = |
|  |  |  |  |  | Voltage factor x UN rms for 30 min. daily = |
|  |  |  |  |  | Voltage factor x UN rms for 5 min. daily -= |
|  |  |  |  |  | Voltage factor x UN rms for 1 min. daily = |
| **8.** | **kVAr Modules** |  |  |  |  |
| 8.1 | General |  |  |  |  |

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| **Tender Technical Response Schedule** **for Conventional Low Voltage Power Factor Correction Assembly**  |
| **Clause No.**  | **Subject** | **Noted** | **Compliance** | **Comments** |
|  |  |  | **Yes** | **No** |  |
| 8.2 | Capacitor Switching Contactors |  |  |  | Contactor Utilisation Category = |
|  |  |  |  |  | Contactor rated Amps (lr) = |
|  |  |  |  |  | Contactor rated Volts = |
|  |  |  |  |  | Limit of inrush Current, Amps = |
| 8.3 | Detuning Reactors |  |  |  | Inductance, mH = |
|  |  |  |  |  | Losses, Watts = |
|  |  |  |  |  | Natural air ambient temp. rating, deg. C= |
| 8.4 | Capacitors |  |  |  | Each capacitor microFarads = |
|  |  |  |  |  | Min. temp rating deg. C = |
|  |  |  |  |  | Max. temp rating deg. C = |
|  |  |  |  |  | Losses, W/kVAr =- |
|  |  |  |  |  | Connecting cables rated Amps = |
|  |  |  |  |  | L/C resonant Hz = |
| 8.5 | Capacitor Discharge Devices |  |  |  | Capacitor discharge time to 75V, secs = |
|  |  |  |  |  | Steady state losses, Watts = |
|  |  |  |  |  | Steady state milliAmps = |
| **9.** | **Power Factor Controller** |  |  |  | PF control range = to  |
| 9.1 | General |  |  |  |  |
| 9.2 | Control Mode |  |  |  |  |
| 9.3 | Measurement Voltage |  |  |  | Measurement Volts = |
| 9.4 | Measurement Current |  |  |  | Number of CTs required =  |
| 9.5 | Operator Interface |  |  |  | *Attach separate description* |
| 9.6 | Alarm Output |  |  |  |  |
| 9.7 | Communication Interface |  |  |  |  |
| **10.** | **Ripple Control Signals** |  |  |  |  |
| **11.** | **Arc Flash Detection System** |  |  |  |  |
| 11.1 | General |  |  |  | Arc Flash Detection System, Make and Model………………………………………………… |
| 11.2 | Method of Detection |  |  |  | Number of arc detectors =Trip time (ms) =………at Trip Current (A)= ………. |
| 11.3 | Battery Backup |  |  |  | Battery Ah = Battery Charger Make and Model…………………… |
| 11.4 | Alarm Outputs |  |  |  |  |
| **12.** | **Routine Certification** |  |  |  |  |
| 12.1 | PFC Assembly Routine Verification |  |  |  |  |
| 12.2  | Capacitor Routine Tests |  |  |  |  |

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| **Tender Technical Response Schedule** **for Conventional Low Voltage Power Factor Correction Assembly**  |
| **Clause No.**  | **Subject** | **Noted** | **Compliance** | **Comments** |
|  |  |  | **Yes** | **No** |  |
| **13.** | **Delivery and Installation** |  |  |  |  |
| **14.** | **On Site Testing & Commissioning** |  |  |  |  |
| **15.** | **As Constructed Information** |  |  |  |  |
| **16.** | **Manuals** |  |  |  |  |
| **17.** | **Spare Parts** |  |  |  | Location spare parts held…………………… |
|  |  |  |  |  | Attach policy for maintenance of spares for obsolete equipment. |

END OF DOCUMENT