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| Assets Planning and Delivery Group  Engineering |

Design Standard DS 26-02

Type Specifications – Electrical

Type Specification for 22 kV to 0.433 kV Prefabricated Substation

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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.

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[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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Design Standard DS 26-02

Type Specifications – Electrical

**Type Specification for 22 kV to 0.433 kV Prefabricated Substation**

**CONTENTS**

*Section Page*

1 GENERAL 7

2 SITE 7

3 OPERATING MODE 7

4 Work by the Principal 7

5 Information from the Contractor 7

6 Contractor’s Drawings 7

7 Standards 8

8 Quality Assurance 9

9 Power Supply 9

10 Ambient Conditions 9

11 High Voltage Switchgear 9

11.1 General 9

11.1.1 Standards 9

11.1.2 Equipment 9

11.1.3 Voltage and Frequency Ratings 10

11.1.4 Current Ratings 10

11.1.5 Switchgear Categories 11

11.1.6 Cable Connections 11

11.1.7 Interlocking 11

11.1.8 Protection Equipment 11

11.1.9 Labelling 11

11.2 Arcing Fault Protection 11

12 High Voltage Cabling 12

12.1 Incoming HV Line Cables 12

12.2 Incoming Line HV Cable Terminations 12

12.3 Transformer HV Cables 12

12.4 Transformer HV Cable Terminations 13

12.5 Transformer HV Surge Diverters 13

13 Transformer Technical Requirements 13

13.1 Performance Requirements 13

13.2 Miscellaneous Fittings 14

13.3 Construction Requirements 15

13.3.1 General 15

13.3.2 Cores 15

13.3.3 Windings 15

13.3.4 Tanks 15

13.3.5 Drying Out and Oil Filling 15

13.4 Protective Coatings on Exposed Surfaces 16

13.4.1 General 16

13.4.2 Paint Colour 16

13.4.3 Surface Preparation 16

13.5 Protective Coatings on Internal Surfaces 16

13.5.1 Surface Preparation 16

13.5.2 Paint Coating 16

14 Low Voltage Cables 16

15 Enclosure Requirements 16

16 Low Voltage Star Point Current Transformer 16

17 Testing 17

17.1 Testing of Substation 17

17.2 Testing of Transformers 17

17.3 Testing of Switchgear 17

17.4 Test Certificates 18

18 Liquidated Damages for Excess Losses 18

19 Installation at Site 18

20 Post Installation Requirements 18

20.1 Final Inspection 18

20.2 Final Testing and Commissioning 18

20.3 As-Constructed Drawing 18

20.4 Manuals 19

21 SPECIAL REQUIREMENTS 19

# GENERAL

This Specification covers the requirements for the design, manufacture, assembly, inspection, factory testing, packaging, transport to site, on site assembly, on site testing and commissioning of a HV/LV prefabricated substation rated not greater than 1500 kVA and as detailed further herein.

The prefabricated substation shall consist of High Voltage switchgear and a two winding transformer which will be connected to an external switchboard supplied by others. The High Voltage switchgear and the transformer shall be housed in a suitable weatherproof enclosure.

The specification for the 22 kV to 0.433 kV prefabricated substation kiosk enclosure is covered by DS 26-42 ‘Type Specification for Kiosk Enclosure for HV Switchgear and/or Transformer’ and forms part of this Specification.

Equipment shall be supplied to site complete and shall include all necessary accessories and miscellaneous material, minor parts and other such items necessary to complete assembly, testing and commissioning of the equipment.

The connection of the substation will be carried out by others after on site assembly and positioning of the substation has been completed by the Contractor. The Contractor shall return to the site to commission the substation once connection of the substation is complete under the overall direction of the Principal.

# SITE

The location of and access to the site for the installation of the substation shall be as described in the Annexure.

# OPERATING MODE

The mode under which the substation will be operated shall be as described in the Annexure.

# Work by the Principal

The work to be performed by the Principal shall be as detailed in the Annexure.

# Information from the Contractor

The Contractor shall provide the following documentation in respect of the substation within the listed number of calendar days after receipt of the Principal’s order.

(a) General Arrangement Drawings 28 days

(b) Electrical Wiring and Schematic Drawings 28 days

(c) Manufacturing and Delivery Schedule 14 days

(d) Specification Data Sheets 35 days

(e) Inspection and Test Plan 35 days

(f) Test Certificates On delivery

(g) Operating and Maintenance Manual On delivery

# Contractor’s Drawings

The Contractor shall submit two A3 copies of the Contractor’s Drawings for approval. The Contractor’s Drawings shall show the general arrangement, circuit diagrams and equipment specifications.

All drawings submitted by the Contractor shall be in accordance with the latest issue of the relevant Australian Standards.

Adequate contrast shall be maintained between drawing detail and background, and the clarity and quality of the drawings shall enable the Principal to microfilm the prints and to reproduce by photographic processes clear and legible A3 copies for record purposes.

The drawings shall provide, in the title block, the number and title of the Contract, as well as details to identify the drawing, its contents, revision status and date of issue.

All drawings shall be prepared using Autocad Release 2000 or later software. Drawings shall be prepared on A1 metric size drawing sheets, incorporating the Principal’s border and title block.

# Standards

In particular the prefabricated substation shall comply with the requirements of AS 62271.202 as further detailed in this Specification. Specific reference is made in this Specification to the following Australian and International Standards. In their absence, relevant International Standards together with the requirements of competent Authorities having jurisdiction over all or part of the manufacture, installation and operation of the equipment shall be adhered to. Compliance with Standards and Regulations shall include all amendments after the date of tender.

Specific reference is made within the Specification to the following Australian and International Standards:

AS 1627.4 Metal-Finishing - Preparation and Pre-treatment of Surfaces - Abrasive Blast Cleaning.

AS 1767 Insulating Oil for Transformers and Switchgear (incorporating Amendment 1)

AS 2067 Substations and High Voltage installations exceeding 1 kV AC

AS 2374.1.2 Power Transformers – Minimum Energy Performance Standard (MEPS)

AS 2700 Colour Standard for General Purposes

AS/NZS 61439 Low Voltage Switchgear and Control Gear Assemblies

AS/NZS 60076 Power Transformers

AS 60529 Degree of Protection Provided by Enclosures (IP Code)

AS 62271.100 High voltage switchgear and controlgear - Alternating current circuit-breakers

AS 62271.102 High voltage switchgear and controlgear – alternating current disconnectors and earthing switch

AS 62271.200 High voltage switchgear and controlgear – AC metal-enclosed switchgear and control gear for rates voltages above 1 kV and up to and including 52 kV

AS 62271.202 High voltage switchgear and controlgear – High voltage/low voltage prefabricated substations

AS/NZS 2312 Guide to the Protection of Iron and Steel Against Exterior Atmosphere Corrosion

AS/NZS 3000 Electrical Installations - Buildings, Structures and Premises (Wiring Rules)

AS/NZS 3008.1 Cables for Alternating Voltages up to and including 0.6/1 kV.

AS/NZS 3750 Paints for Steel StructuresAS/NZS 60076.1 Power transformers – General

AS/NZS 60076.3 Power transformers - Insulation levels, dielectric tests and external clearances in air

AS/NZS 60076-10 Power Transformers – Determination of sound level

IEC 60815 Guide for the selection of insulators in respect of polluted conditions

AS/NZS 62271.1 High voltage switchgear and controlgear – common specifications for high voltage switchgear and controlgear standards

AS/NZS 60265.1 High voltage switches – Switches for voltages above 1 kV and less than 52 kV

IEEE C57-110 Establishing liquid filled and dry-type power and distribution transformer capability when supplying non-sinusodal load currents

AS 60044.1 Instrument transformers - Current transformers

AS/NZS ISO 9001 Quality Management Systems – Requirements

ISO 9223 Corrosion of metals and alloys - corrosivity of atmospheres – Classification determination and estimation

# Quality Assurance

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

# Power Supply

The electrical supply to the substation shall be 22,000 Volts +/- 10%, 50 Hz, 3 phase, 3 wire.

# Ambient Conditions

The substation shall be suitable for both continuous and cyclic full load operation under the following site ambient conditions:

1. Ambient temperature range of -5oC to 50oC,
2. Maximum relative humidity of 90% with periods of heavy condensation.
3. Pollution level in accordance with IEC 60815 as specified in the Annexure

# High Voltage Switchgear

## General

The High Voltage Switchgear shall consist of a fully enclosed High Voltage Ring Main Unit (RMU), plinth mounted within the kiosk and switching the supply to the transformer.

### Standards

The RMU shall be in accordance with the requirements of the following standards:

1. AS 62271.100
2. AS 62271.102
3. AS 62271.200
4. AS 62271.1
5. AS/NZS 60265.1

### Equipment

The RMU shall consist of:

1. one or two incoming line load break switch(es), as specified in the Annexure, which shall be complete with line side earthing switch(es), the latter being padlockable in both the on and off positions,
2. if so specified in the Annexure, either SF6 gas or vacuum circuit breakers switching the supply to the transformer,
3. a load side isolator on the vacuum circuit breaker (if this is provided as per (b) above,
4. a load side earthing switch on the SF6 circuit breaker, (if the latter is provided as per (b) above), with the earthing switch being interlocked with the circuit breaker and being padlockable in both the on and off positions,
5. an earthing switch on the load side of each vacuum circuit breaker isolator (if the latter is provided as per (b) above), with the earthing switch being interlocked with the isolator and being padlockable in both the on and off positions,
6. if so specified in the Annexure, a switchfuse switching the supply to transformer complete with an earthing switch interlocked with the isolating switch and earthing both sides of the fuse, and with the earthing switch being padlockable in both the on and off position,
7. a single SF6 gas filled chamber, complete with a gas pressure indicator, housing the and earthing Switch contacts, the circuit breaker(s) and the associated interconnecting bus bar system,
8. separate compartments for each incoming and outgoing cable connection compartment.

### Voltage and Frequency Ratings

The RMU voltage and frequency ratings shall be as follows:

1. Rated voltage: 24 kV,
2. Rated frequency: 50 Hz
3. Power frequency withstand voltage: not less than 50 kV,
4. Impulse withstand voltage: not less than 125 kVp.

### Current Ratings

The RMU current ratings shall have current ratings as detailed hereunder.

1. Incoming line isolating switches shall have:

(i) a nominal full load rating of not less than 400 Amps,

(ii) a one second short time current rating of not less than 16 kA,

(iii) a making capacity of not less than 40 kA.

1. Earthing switches shall have:
2. a one second short time current rating of not less than 16 kA,
3. a making capacity of not less than 40 kA.
4. The transformer vacuum circuit breaker (if required) shall have:

(i) a nominal full load rating of not less than 200 Amps,  
(ii) a one second short time current rating of not less than 16 kA,  
(iii) a short circuit breaking capacity of 16 kA,  
(iv) a making capacity of not less than 40 kA.

1. The transformer circuit breaker disconnector shall have:

(i) a second short time current rating of not less than 16 kA,  
(ii) a making capacity of not less than 40 kA.

1. The bus bar system shall have:

(i) a nominal full load rating of not less than 400 Amps,  
(ii) a one second short time current rating of not less than 16 kA.

1. Incoming and outgoing line cable bushings shall have a one second short time current rating of not less than 16 kA.
2. The transformer circuit breaker load side cable bushings shall have a short time one second current rating of not less than 5 kA.

### Switchgear Categories

The RMU shall:

1. be metal enclosed switchgear category LSC1 incorporating class PM partitioning, such that separate compartments are provided for incoming cable connections, switchgear and outgoing cable connections, and
2. incorporate a degree of protection of not less than IP3X in accordance with AS 60529 externally and between compartments.

### Cable Connections

The RMU cable connections to the RMU shall be suitable for use with dead break elbows and shall be EN50181 standard profile bushings of the following types:

1. Incoming HV line cable connections bushings shall be Type C profile,
2. Outgoing transformer cable connections shall be either Type A profile or Type C profile, preferably Type C profile.

### Interlocking

The RMU shall be provided with interlocking so as to prevent:

1. earthing switches being closed unless the associated isolating switch or circuit breaker is open, and
2. access to the cable connection compartments unless the associated earthing switch is closed.

### Protection Equipment

All transformers rated >315 kVA shall be provided with Low Voltage neutral over current and earth fault protection. In such cases, a definite minimum time over current protection relay shall be provided for this purpose. This relay shall be suitable for operation from a current transformer having a rated one amp secondary current (Clause 16 refers)

Each RMU circuit breaker shall be provided with fault over current protection by way of an inverse time over current relay and a circuit breaker release both powered by the associated current transformers and not requiring an external power source.

Also, it shall be possible to trip each circuit breaker by the closure of an external pair of contacts, either via a connection to the associated over current relay or via a separate shunt trip release on the circuit breaker, (preferably the former). If a separate shunt trip release is required it shall be suitable for operation from a 240 Volt AC supply.

Transformer overload protection will be provided at the associated Low Voltage switchboard by others.

### Labelling

The RMU shall be labeled appropriately and shall be provided with appropriate operating and maintenance handbooks. All labelling and handbooks shall be in the English language.

## Arcing Fault Protection

1. The RMU cable connection compartments shall be of a design which has been arcing fault type tested at not less than 16 kA for one second in accordance with AS 62271.200 classification IAC AFL, unless specified otherwise in the Annexure. Such type testing shall have been carried out in accordance with AS 62271.200 Annex A.
2. Additional arcing fault protection shall be provided either by successful arcing fault type testing of the prefabricated substation, or an arc suppression system installed within the SF6 gas filled switchgear chamber, all as described further hereunder.
3. If the prefabricated substation is being provided as an arcing fault type tested design, an internal arc classification of IAC-A shall be sufficient. The arcing fault type test current shall have been not less than 16 kA for one second.
4. If fitted, the arcing suppression system shall consist of a mechanical pressure detector arranged to detect the over pressure caused by an arcing fault and to trip a very quick make short circuit device connected on the line side of the incoming supply isolator, thus providing a solid short circuit, extinguishing the arc and leaving the fault to be cleared quickly by the incoming supply upstream circuit breaker.

The arcing suppressor system shall be insensitive to variations due to changes in atmospheric pressure, changes in ambient temperature, vibrations or external shocks.

The arcing suppressor shall operate in the arcing fault current range 1 kA to 20 kA and shall reduce the generated arcing fault energy by a factor of more than 20 compared to the energy released during an arcing time of one second.

The arcing suppressor system shall be fitted with a normally open auxiliary contact to signal it operation.

# High Voltage Cabling

## Incoming HV Line Cables

The incoming line High Voltage cables will be three single core, 95mm2 copper conductor XLPE insulated, heavy duty copper screened, PVC sheathed cables rated as follows:

(a) Operating Voltage: 22/12.7 kV

(b) Power Frequency Withstand Voltage: 30 kV for 15 minutes

(c) Impulse Withstand Voltage: 150 kVp

(d) Earth Fault Current Rating:  **>** 13 kA for one second

## Incoming Line HV Cable Terminations

The prefabricated substation shall be supplied with fully screened cold applied dead break elbows suitable for terminating the incoming line High Voltage cables onto the RMU bushings specified in clause 11.1.6 above. These dead break elbows shall be rated as follows:

(a) Operating Voltage: 22/12.7 kV +10%

(b) Power Frequency Withstand Voltage: 42 kV for 15 minutes

(c) Impulse Withstand Voltage: 125 kVp

(d) Continuous Current Rating: > 400 Amps

(e) Earth Fault Current Rating:  **>** 13 kA for one second

## Transformer HV Cables

The High Voltage cables supplying the transformer shall be three single core,   
95mm2 copper conductor XLPE insulated, heavy duty copper screened, PVC sheathed cables rated as follows:

(a) Operating Voltage: 22/12.7 kV

(b) Power Frequency Withstand Voltage: 30 kV for 15 minutes

(c) Impulse Withstand Voltage: 150 kVp

(d) Earth Fault Current Rating:  **>** 13 kA for one second

## Transformer HV Cable Terminations

The prefabricated substation shall be supplied with fully screened cold applied dead break elbows suitable for terminating the transformer High Voltage cables onto the RMU bushings and onto the transformer High Voltage bushings specified in clause 11.1.6 above and clause 12.2 (a) hereunder, respectively. These dead break elbows shall be rated as follows:

(a) Operating Voltage: 22/12.7 kV +10%

(b) Power Frequency Withstand Voltage: 42 kV for 15 minutes

(c) Impulse Withstand Voltage: 125 kVp

(d) Continuous Current Rating: > 200 Amps

(e) Earth Fault Current Rating:  **>** 13 kA for one second

## Transformer HV Surge Diverters

Fully screened surge diverters shall be incorporated with the transformer cable terminations either at the switchgear end or at the transformer. The characteristics of such surge diverters shall be as detailed in the Annexure.

# Transformer Technical Requirements

## Performance Requirements

The transformer shall be supplied in accordance with the following performance requirements:

1. Service Requirements: To be determined as per AS 62271.202 clause 2.1.3
2. Frequency: 50 Hz
3. No. of Windings: 2
4. Voltage

i) primary: 22,000 Volts nominal phase to phase

ii) secondary: 433 Volts nominal phase to phase (no load)

1. Connection

i) primary: delta

ii) secondary: star with neutral brought out

1. Vector group: group 3 (Dyn1)
2. HV Supply Earth Fault Factor– as specified in the Annexure.
3. System LV Neutral: Solidly grounded
4. kVA rating: The continuous kVA rating of the substation shall be not less than the maximum load kVA ratings specified in the Annexure.

The nominal 50 Hz kVA rating of the transformer installed in the substation shall be determined taking into account the enclosure and, for non-linear loads, the derating necessary for harmonic currents as determined by IEEE Std. C57-110.

1. Type of Load: as detailed in the Annexure
2. Type of Construction: core type
3. Cooling: ONAN
4. Ambient Temperature: 50 oC
5. Maximum Oil/Winding temperature: 100 oC /105oC
6. High Voltage Insulation Level

i) Lightning Impulse Withstand Voltage: 150 kVp

ii) Short Duration 50 Hz Withstand Voltage: 50 kV for one min.

1. Voltage Tappings

i) Range: +/- 5%

ii) Step Size: 2.5%

iii) Tapped Winding: primary

1. Impedance: as detailed in the Annexure
2. Losses
   * 1. Transformer efficiency at 50% full load shall be in accordance with the values shown at AS 2374.1.2 Table 1.
     2. Transformer shall be of a low loss design with minimum eddy current losses.

(Transformer capability when supplying non sinusoidal loads shall be determined in accordance with IEEE Std. C57-110).

1. Maximum Audible Sound Power Level: Reduced limit to AS 60076.10 Fig. ZA1
2. Electromagnetic Interference: When operated at voltages up to 10% in excess of the normal system rating, the transformer shall be substantially free of partial discharges which are likely to cause interference with radio, television, or telephone communications.

## Miscellaneous Fittings

The transformer shall be fitted with the following:

1. EN50181 Type C standard profile High Voltage bushings for use with fully screened dead break elbow cable terminations as specified para. 12.4 above.
2. Low Voltage air insulated bushings suitable for the connection of Low Voltage cables.
3. A fully enclosed Low Voltage cable box suitable for terminating the Low Voltage cables specified in the Annexure.
4. Manual off circuit tapping switch brought out via an oil tight gland and complete with a warning label located next to the handle indicating that the transformer must be de-energised before operating the switch.
5. An earthed screen between the High Voltage and Low Voltage windings (only if the type of load has been specified in the Annexure as non-linear)
6. Earthing connection for the tank.
7. 100mm dial type thermometer with top oil temperature indicator, with or without alarm and trip change over contacts, as specified in the Annexure.
8. Resealing pressure relief valve with operation indicator
9. Oil filling hole and cap
10. Oil level indicator
11. Oil drain valve with a sampler
12. Oil catchment tray capable of retaining all of the oil in the event of an oil leak from the tank or the radiators.
13. Lifting lugs.
14. Skid type base suitable for direct bolting onto the base of the kiosk.
15. Stainless steel rating plate
16. Terminal marking plate
17. The surge arresters specified in the Annexure are to be installed in the immediate vicinity of the transformer HV terminals. The surge arresters shall be connected directly to the transformer earth.

## Construction Requirements

### General

The cores, windings, tank, framework, clamping arrangements and general structure of the transformers, when assembled, shall form a rigid construction which shall minimise vibration and shall be unaffected by normal use, short circuit conditions or handling during transport, insulation, inspection or repair.

### Cores

The cores shall be constructed of high grade, cold rolled grain orientated silicon steel coated with temperature resistant inorganic insulation. The structure shall be formed into legs which are interconnected to the yokes with mitred joints. The active parts of the core shall be insulated from the structural support except for the earthing straps and any bolts passing through the core shall be fully insulated from it.

The cores shall be so designed and constructed as to ensure that excessive temperatures do not occur at the centres of the cores.

Facilities shall be provided for lifting the cores, with windings, from the tanks for inspection and repair.

### Windings

Windings shall be wound in the same directions. Winding assemblies shall be dried and shrunk during construction so that shrinking during the life of transformer will be minimal. Convenient means shall be provided to take up any slackness that does occur due to shrinkage of the windings.

### Tanks

The tank, which shall be of the sealed type, shall be constructed of steel plate, without conservators or breathers. The tank and radiators shall be constructed in such a manner that the transformer internal pressure may vary between 50 kPa vacuum and 115 kP positive pressure without damage or oil leakage for a fin-wall style of design or, 0 kPa vacuum and 150 kPa positive pressure in case of panel style of cooling radiators. Joints and stiffeners shall be continuously welded along the upper line of contact with the tank to prevent lodging of water behind the bracing. The undersides may be tack welded. Joints between the tank and tank covers and the flanges of bushings shall be rendered oil-tight by the insertion of gaskets of neoprene or similar material that is impervious to and unaffected by transformer oil. The gaskets shall be under controlled pressure. All parts of the tank shall be so designed and constructed as to eliminate the formation of air pockets inside the tank. The tank covers shall be removable independently of the cores and windings.

### Drying Out and Oil Filling

Transformers shall be dried out thoroughly at the Contractor’s works before filling with oil. The transformer shall be filled with oil in such a manner as to prevent air inclusion in the coil/core assembly.

## Protective Coatings on Exposed Surfaces

### General

The exposed metal surfaces shall be protected by the application of a painting system either Type LP1-A or LP2-A in accordance with AS2312. All paints comprising the paint system shall be from the same manufacturer.

The paint coating shall be rated as providing medium term, protection in tropical, industrial, marine and severe marine environments in accordance with AS 2312 (and ISO 9223).

### Paint Colour

The colour of the top coat paint applied to external surfaces shall be a standard colour in accordance with AS2700 as specified in the Annexure.

### Surface Preparation

All exposed metal surfaces shall be abrasive blast cleaned in accordance with AS 1627.4 Class 2.5.

## Protective Coatings on Internal Surfaces

### Surface Preparation

All tank internal surfaces above oil level shall be abrasive blast cleaned in accordance with AS 1627.4 Class 2.5.

### Paint Coating

A protective paint coating consisting of a zinc phosphate/micaceous iron oxide epoxy primer conforming to AS 3750.13 Type 2 shall be applied to minimum dry film thickness of 20 microns to all tank internal surfaces above oil level surfaces.

# Low Voltage Cables

The outgoing Low Voltage cables will be single core, copper conductor, XLPE insulated, PVC sheathed cables of the size and number per phase specified in the Annexure.

# Enclosure Requirements

The kiosk enclosure shall be provided by the Contractor as part of the Contract.

The kiosk enclosure shall comply with requirements of Type Specification DS26.42

The Contractor shall ensurethat the transformer is designed and built so as to meet the requirements of this Specification when operating in the kiosk enclosure.

The Contractor shall ensurethat the HV switchgear operation is not compromised and meets the requirements of this Specification when operating in the kiosk enclosure.

# Low Voltage Star Point Current Transformer

If Low Voltage neutral over current and earth fault protection is required as per clause 11.1.8, a current transformer shall be provided to measure the transformer Low Voltage winding star point current. This current transformer shall be mounted in either the transformer Low Voltage cable terminal box or in an adjacent suitable protected location.

The primary winding current rating of the current transformer shall be the preferred current rating closest to 30% of the transformer Low Voltage current rating.

The secondary winding current rating of the current transformer shall be one Amp.

# Testing

## Testing of Substation

(a) Type Tests

Evidence shall be submitted on delivery indicating that all type tests required by AS 62271.202 have been carried out on the substation or on a substation of an identical design.

1. Sound Level Tests

Evidence shall be submitted on delivery indicating that sound level type tests required by AS 62271.202 have been carried out on the substation or on a substation of an identical design in accordance with AS/NZS 60076-10.

(c) Routine Tests

Prior to delivery, the substation shall undergo routine tests in accordance with AS 62271.202. The Contractor shall supply one copy of the routine test certificate for the substation on delivery.

## Testing of Transformers

(a) Type Tests

Evidence shall be submitted on delivery indicating that all type tests required by the relevant parts of AS 60076 have been carried out satisfactorily on the transformer in a kiosk enclosure or on a transformer in a kiosk of an identical design

(b) Routine Tests

The transformer shall undergo routine testing in accordance with the relevant parts of AS 60076.

The Contractor shall supply one copy of the routine test certificate for the transformer on delivery of the substation.

1. Short Circuit Test

The AS/NZS 60076.5, Ability to Withstand Short Circuit, identifies the requirements for transformers to sustain without damage the effects of overcurrents originated by external short circuit.

The transformer manufacturer shall submit:

* a short circuit withstand capability test certificate of the proposed transformer design, or
* the theoretical evaluation of the ability of a power transformer to withstand the dynamic effects of short circuit and the thermal ability of a transformer. The documentation needed for the purpose includes all necessary technical data, such as electromagnetic design data sheets, calculations od short circuit currents, electromagnetic forces and mechanical stresses, supplemented by drawings, material specifications, manufacturing practices and process instructions, etc., either produced for the specific purpose of the electromagnetic and mechanical design of the transformer or as part of the manufacturer’s technology documentation.

## Testing of Switchgear

(a) Type Tests

Evidence shall be submitted on delivery indicating that all type tests required by AS 62271.200 have been carried out on the switchgear or on a switchgear of an identical design.

(b) Routine Tests

Prior to installation into the substation enclosure, the switchgear shall undergo routine tests in accordance with AS 62271.200. The Contractor shall supply one copy of the routine test certificate for the switchgear on delivery of the substation.

(c) Special Routine Tests at Manufacturer’s Works

In addition to the standard routine tests specified clause 7.3 of this Specification, the Contractor shall carry out routine tests to verify:

(i) the accuracy of all instrumentation and instrument transformers , and

(ii) the correct operation of the current operated protection devices at the proposed operational settings specified on the Principal’s drawings.

Tests on current operated protection devices shall be carried out by secondary injection and shall test each protective device at not less than six points spread evenly over the complete operating range of the device at the specified device setting. In addition, each protective device shall be tested at one point by primary injection

## Test Certificates

All test certificates shall describe the tests carried out and the test results obtained.

# Liquidated Damages for Excess Losses

In addition to any liquidated damages specified in the General Conditions of Contract, the Contractor shall be liable to the Principal for liquidated damages in respect to cost of the amount of transformer total losses in excess of the value quoted previously by the Contractor in the Tender Technical Response Schedule.

Such liquidated damages shall be calculated on the basis of the capitalised cost of losses quoted in the Annexure.

# Installation at Site

The Contractor shall deliver the prefabricated substation to the site.

The Contractor shall uncrate and position the equipment if necessary.

# Post Installation Requirements

## Final Inspection

Before final testing and commissioning of the prefabricated substation takes place, the Contractor shall undertake an inspection to verify that the prefabricated substation has been installed correctly and is undamaged.

## Final Testing and Commissioning

The Contractor shall carry out the following tests after Final Inspection has been completed:

(a) Insulation Resistance Check

(b) Voltage Ratio Check

(c) Protection Settings

Once Final Inspection and Final Testing has been completed, the Contractor shall commission the prefabricated substation in conjunction with the Principal’s electrical staff.

## As-Constructed Drawing

The Contractor shall provide As-Constructed information on all drawings.

As-Constructed drawings shall be supplied on a 3.5 inch diskette with A3 size hard copies.

## Manuals

The Contractor shall supply three copies of comprehensive instruction manuals, written in English and covering the complete operation and maintenance requirements of all equipment supplied under the Contract. The manuals shall be printed on high grade A4 size paper and shall be bound in a high grade A4 size loose leaf binder.

Information included in the manuals shall include:

1. operating instructions;
2. safety instructions and warnings;
3. maintenance instructions and schedules;
4. recommended spare parts and special tool list;
5. as-constructed drawings;
6. detailed equipment performance specifications and;
7. test reports and test certificates.

# SPECIAL REQUIREMENTS

In addition to the above the transformer shall be supplied in accordance with any special requirements detailed in the Supplementary Annexure.

**Annexure to Specification**

**for**

**22/0.433 kV Prefabricated Substation**

**Project:**

**Site Location**:

**Work to be done by the Principal:**

**Capitalised Cost of Losses:** $/kW

**Special Service Conditions:**

Pollution level in accordance with IEC 60815

Ambient temperature oC

**HV Electrical Supply Conditions**

Highest Voltage for Equipment Um kV

System Fault Level MVA

Earth Fault Factor

**Substation Load**

Type of Load *(i.e. linear or non-linear)*

Maximum Load/Transformer kVA rating kVA

**HV Switchgear**

Main Circuit Breaker *(required or not)*

If MCB required – MCB protection long time trip current Amps

RMU Line Output Switch *(required or not)*

**Transformer**

Transformer impedance %

22 kV Surge Diverter 5 kA Residual Voltage kV

22 kV Surge Diverter Continuous Power Frequency Voltage k V

Low Voltage Winding Star Point C.T. Primary Current Rating Amps

Low Voltage Winding Star Point C.T. Primary VA Rating VA

**Over Temperature Contacts**

Oil over temperature warning contacts *(required or not)*

Oil over temperature trip contacts *(required or not)*

**Outgoing Low Voltage Cables**

Cable type and rated voltage

Outgoing Low Voltage Cables Conductor Size mm2

Outgoing Low Voltage Cables No. per Phase *(not more than 4)*

Outgoing Low Voltage Cables No. for Neutral

| **Type Specification for 22kV/0.433 kV Prefabricated Substation**  **Tender Technical Response Schedule** | | | | | |
| --- | --- | --- | --- | --- | --- |
| Clause | Subject | Noted | Compliance | | Comments |
| No. |  |  | Yes | No |  |
| 1 | **General** |  |  |  |  |
| 2 | **Site** |  |  |  |  |
| 3 | **Operating Mode** |  |  |  |  |
| 4 | **Work by Principal** |  |  |  |  |
| 5 | **Information from Contractor** |  |  |  |  |
| 6 | **Contractor’s Drawings** |  |  |  |  |
| 7 | **Standards** |  |  |  |  |
| 8 | **Quality Assurance** |  |  |  |  |
| 9 | **Power Supply** |  |  |  |  |
| 10 | **Ambient Conditions** |  |  |  |  |
| 11 | **High Voltage Switchgear** |  |  |  |  |
| 11.1 | ***General*** |  |  |  |  |
| 11.1.1 | Standards |  |  |  |  |
| 11.1.2 | Equipment |  |  |  | Vacuum or SF6 circuit breakers? |
| 11.1.3 | Voltage & Frequency Ratings |  |  |  |  |
| 11.1.4 | Current Ratings |  |  |  |  |
| (a) | Incoming line switches |  |  |  |  |
| (b) | Earthing switches |  |  |  |  |
| (c) | Transformer circuit breaker |  |  |  |  |
| (d) | Transformer disconnector |  |  |  |  |
| (e) | Busbar system |  |  |  |  |
| (f) | Line cable bushings |  |  |  |  |
| (g) | Transformer feed cable bushings |  |  |  |  |
| 11.1.5 | Switchgear Categories |  |  |  |  |
| (a) | Loss of service category partitioning class |  |  |  |  |
| (b) | Degree of protection |  |  |  |  |
| 11.1.6 | Cable Connections |  |  |  |  |
| (a) | Line connectors |  |  |  |  |
| (b) | Transformer. feed connections |  |  |  |  |
| 11.1.7 | Interlocking |  |  |  |  |
| (a) | Earthing switches |  |  |  |  |
| (b) | Cable connections |  |  |  |  |
| 11.1.8 | Protection Equipment |  |  |  | Separate shunt trip release required for trip by external contacts? |
| 11.1.9 | Labelling |  |  |  |  |
| ***11.2*** | ***Arcing Fault Protection*** |  |  |  |  |
| (a) | RMU connections IAC |  |  |  |  |
| (b) | Additional protection |  |  |  |  |
| (i) | by substation IAC, or |  |  |  | Substation IAC classification = |
| (ii) | by RMU arc suppression |  |  |  |  |
| 12 | High Voltage Cabling |  |  |  |  |
| ***12.1*** | ***In & Out Line Cabling*** |  |  |  |  |
| (a) | operating voltage |  |  |  |  |
| (b) | 50 Hz withstand voltage |  |  |  |  |
| (c) | impulse withstand voltage |  |  |  |  |
| (d) | earth fault current |  |  |  |  |
| ***12.2*** | ***Line Cable Terminations*** |  |  |  |  |
| (a) | Operating voltage |  |  |  |  |
| (b) | 50 Hz withstand voltage |  |  |  |  |
| (c) | Impulse withstand voltage |  |  |  |  |
| (d) | Continuous current |  |  |  |  |
| (e) | Earth fault current |  |  |  |  |
| ***12.3*** | ***Transformer Cable*** |  |  |  |  |
| (a) | Operating voltage |  |  |  |  |
| (b) | 50 Hz withstand voltage |  |  |  |  |
| (c) | Impulse withstand voltage |  |  |  |  |
| (d) | Earth fault current |  |  |  |  |
| ***12.4*** | ***Tansformer Cable Terminations*** |  |  |  |  |
| (a) | Operating voltage |  |  |  |  |
| (b) | 50 Hz withstand voltage |  |  |  |  |
| (c) | Impulse withstand voltage |  |  |  |  |
| (d) | Continuous current |  |  |  |  |
| (e) | Earth fault current |  |  |  |  |
| ***12.5*** | ***Tfr. Surge Diverters*** |  |  |  |  |
| (a) | Location |  |  |  | Mounted in switchgear or on transformer cable terminations? |
| (b) | 5 kA residual voltage |  |  |  | 5 kA residual kV = |
| (c) | 50 Hz continuous voltage |  |  |  | 50 Hz continuous kV = |
| 13 | **Transformer Requirements** | |  |  |  |
| ***13.1*** | ***Performance Requirements*** |  |  |  |  |
| (a) | Service Conditions |  |  |  |  |
| (b) | 3 phases |  |  |  |  |
| (c) | Operating Hz |  |  |  | Offer rated Hz = |
| (d) | 2 windings |  |  |  |  |
| (e) | Primary kV |  |  |  | Offer rated primary kV = |
|  | Secondary kV |  |  |  | Offer rated secondary kV = |
| (f) | Connection |  |  |  | Offer connection = |
| (g) | Vector Group |  |  |  | Offer vector group = |
| (h) | System L.V. neutral |  |  |  |  |
| (j) | kVA rating |  |  |  | Substation summer rating kVA = |
|  |  |  |  |  | Substation winter kVA rating = |
|  |  |  |  |  | Transformer 40 deg. C rated kVA = |
|  |  |  |  |  | Enclosure load factor = |
|  |  |  |  |  | Derating factor for harmonics = |
| (j) | Type of load |  |  |  |  |
| (k) | Type of construction |  |  |  |  |
| (l) | Type of cooling |  |  |  |  |
| (m) | Ambient temperature |  |  |  |  |
| (n) | Maximum Oil/Winding temperature |  |  |  | Offer O/W deg. C limits = |
| (o) | Lightning Impulse withstand kV |  |  |  | Offer rated impulse withstand kV = |
|  | 1 min. 50 Hz withstand kV |  |  |  | Offer 1 min. 50 Hz withstand kV = |
| (p) | Voltage tappings: |  |  |  |  |
|  | Range |  |  |  | Offer tapping range % = |
|  | Size |  |  |  | Offer tapping step % = |
| (q) | Impedance |  |  |  | Offer impedance % = |
| (r) | Losses |  |  |  |  |
|  |  |  |  |  | Offer no load 50 Hz losses, kW = |
|  |  |  |  |  | Offer full load 50 Hz losses, kW = |
|  |  |  |  |  | Offer full load eddy current losses, kW = |
|  |  |  |  |  | Offer full load stray losses, kW = |
| (s) | Max. audible sound power level |  |  |  | Offer max. sound power dB(A) = |
| (t) | Electromagnetic Interference |  |  |  |  |
| ***13.2.*** | ***Miscellaneous Fittings*** |  |  |  |  |
| (a) | HV bushings |  |  |  |  |
| (b) | LV bushings |  |  |  |  |
| (c) | LV cable box |  |  |  |  |
| (d) | Tapping switch |  |  |  |  |
| (e) | Earthed screen |  |  |  |  |
| (f) | Earthing terminal |  |  |  |  |
| (g) | Thermometer |  |  |  |  |
| (h) | Pressure relief valve |  |  |  |  |
| (i) | Oil filling hole and cap |  |  |  |  |
| (j) | Oil level indicator |  |  |  |  |
| (k) | Oil drain valve with a sampler |  |  |  |  |
| (l) | Oil catchment tray |  |  |  |  |
| (m) | Lifting lugs |  |  |  |  |
| (n) | Skid type base |  |  |  |  |
| (o) | Stainless steel Rating plate |  |  |  |  |
| (p) | Terminal marking plate |  |  |  |  |
| (q) | Surge Arresters |  |  |  | Type = |
| ***13.3*** | ***Construction Requirements*** |  |  |  |  |
| 13.3.1 | General |  |  |  |  |
| 13.3.2 | Cores |  |  |  |  |
| 13.3.3 | Windings |  |  |  |  |
| 13.3.4 | Tanks |  |  |  |  |
| 13.3.5 | Drying out and oil filling |  |  |  |  |
| ***13.4.*** | ***Protective Coatings on Exposed Surfaces*** | |  |  |  |
| 13.4.1 | General |  |  |  |  |
| 13.4.2 | Paint Colour |  |  |  |  |
| 13.4.3 | Surface preparation |  |  |  |  |
| ***13.5*** | ***Protective Coatings on Internal Surfaces*** | |  |  |  |
| 13.5.1 | Surface preparation |  |  |  |  |
| 13.5.2 | Paint coating |  |  |  | Offer DFT microns = |
| 14 | **Low Voltage Cables** |  |  |  |  |
| 15 | **Enclosure Requirements** |  |  |  |  |
| 16. | **LV Star Point Current Transformer** |  |  |  |  |
| 17. | **Testing** |  |  |  |  |
| ***17.1.*** | ***Testing of Substation*** |  |  |  |  |
| (a) | Type tests |  |  |  |  |
| (b) | Noise level tests |  |  |  | Offer sound power level of dBA = |
| (c) | Routine tests |  |  |  |  |
| ***17.2.*** | ***Testing of Transformers*** |  |  |  |  |
| (a) | Type tests |  |  |  |  |
| (b) | Routine tests |  |  |  |  |
| (c) | Short Circuit Test |  |  |  | Test certificate or theoretical evaluation attached = |
| ***17.3*** | ***Testing of Switchgear*** |  |  |  |  |
| (a) | Type tests |  |  |  |  |
| (b) | Routine tests |  |  |  |  |
| ***17.4*** | ***Test Certificates*** |  |  |  |  |
| 18. | **Liquidated Damages** |  |  |  |  |
| 19. | **Installation at Site** |  |  |  |  |
| 20. | **Post Installation Requirements** |  |  |  |  |
| *20.1.* | *Final inspection* |  |  |  |  |
| *20.2.* | *Final Inspection and Testing* |  |  |  |  |
| *20.3.* | *As-constructed drawings* |  |  |  |  |
| *20.4.* | *Manuals* |  |  |  |  |
| 21. | **Special Requirements** |  |  |  |  |
|  | **Other Required Information** |  |  |  |  |
|  | Transformer oil volume |  |  |  | Transformer oil volume litres = |
|  | Transformer height |  |  |  | Transformer height m = |
|  | Transformer width |  |  |  | Transformer width m = |
|  | Transformer depth |  |  |  | Transformer depth m = |
|  | Transformer core and coil weight |  |  |  | Transformer core & coil kg = |
|  | Transformer total weight including oil |  |  |  | Transformer total kg = |
|  | Enclosure height |  |  |  | Enclosure height m = |
|  | Enclosure width |  |  |  | Enclosure width m = |
|  | Enclosure depth |  |  |  | Enclosure depth m = |
|  | Enclosure weight excluding base |  |  |  | Enclosure kg excluding base = |
|  | Substation complete overall weight |  |  |  | Substation overall kg = |

END OF DOCUMENT