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| Assets Planning and Delivery Group  Engineering |

DESIGN STANDARD DS 26-14

Type Specifications – Electrical

**Type Specification for HV Variable Speed Controllers**

**with Unit Input Isolating Transformers**

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| version 3  revision 2 |
| february 2023 |

**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.

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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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REVISION STATUS

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

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DESIGN STANDARD DS 26-14

Type Specifications – Electrical

Type Specification for HV Variable Speed Controllers

with Unit Input Isolating Transformers

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# General

## Scope

1. This Specification covers the requirements for the design, manufacture, assembly, factory testing, delivery, installation, on site testing and commissioning of one or more variable speed controllers each with an input isolating transformer.
2. This Specification shall be read in conjunction with the accompanying Specification DS26.16 and its associated Annexure covering the input isolating transformer(s) if the latter are required in the arrangement specified in the Annexure.
3. The number of variable speed controllers required shall be as specified in the Annexure.
4. The scope of this Specification covers High Voltage variable speed controller(s) rated > 300 kW and with the input voltage to the input isolating transformer being < 24 kV.
5. The variable speed controllers shall be supplied to site complete and shall include all accessories and miscellaneous material, minor parts and other such items necessary to complete assembly, testing and commissioning of the variable speed controllers.
6. The supply and installation of any on site cabling between the input isolating transformer and the variable speed controller proper shall be carried out by the Contractor.
7. The connection of the variable speed controller(s) to the incoming electrical supply and the associated motor(s) will be carried out by others after any on site assembly by the Contractor. The Contractor shall return to the site to commission the variable speed controller(s) once connection of same is complete.

## Arrangements

### General

The form of arrangement of the variable speed controllers shall be one of the types listed hereunder as specified in the Annexure.

### Type A Arrangements

A Type A variable speed controller arrangement shall be defined as one where each unit input isolating transformer is mounted integral with the associated variable speed controller proper.

In this respect, an input isolating transformer mounted immediately adjacent to its associated variable speed controller proper shall be considered to be integral with the latter.

### Type B Arrangements

A Type B variable speed controller arrangement shall be defined as one where each unit input isolating transformer is mounted separately from its associated variable speed controller proper.

## Variable Speed Controller Components

Each variable speed controller proper shall consist of the following:

1. input surge diverters
2. input RF filter
3. input power converter
4. output power inverter
5. common mode voltage filter or common mode voltage inductor (if required)
6. sinusoidal phase to phase filter (if required)
7. all other necessary filters
8. cooling equipment, and
9. all necessary control and protective circuitry.

All of the above components shall be enclosed and mounted on a common base frame, as further specified hereunder

# Site

The location of and access to the site for the installation of the variable speed controllers shall be as shown in the Annexure.

# Operating Mode

1. The variable speed controller(s) shall be suitable for controlling cage induction motor(s) having the characteristics specified in the Annexure.
2. The variable speed controller(s) shall be capable of operating in the mode specified in the Annexure.

# Ambient Conditions

1. The variable speed controller(s) proper and associated integral input isolating transformers shall be suitable for operation at maximum load, in the specified operating mode and under the indoors ambient conditions specified in the Annexure.
2. Separately mounted input isolated transformer(s) shall be suitable for operation at maximum load, in the specified operating mode and under the outdoors ambient conditions specified in the Annexure to the accompanying Specification DS26.16.

# Work by the Principal

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

# Information to be provided by the Contractor

The Contractor shall provide the following information in respect to the variable speed controllers within the listed number of days after the receipt of the Principal’s order.

1. General Arrangement Drawings 28 days
2. Electrical Wiring and Schematic Drawings 28 days
3. Manufacture and Delivery Schedule 14 days
4. Inspection and Test Plan 35 days
5. Test Certificates On Delivery
6. Operating and Maintenance Manual On delivery

# Contractor’s Drawings

The Contractor shall submit two A3 copies of the Drawings for acceptance. The drawings shall detail the general arrangement, circuit diagrams (power and control) and equipment specifications.

All drawings provided by the Contractor shall be in accordance with the latest edition of the relevant Australian Standards and shall be available in electronic format.

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 the 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

Unless specified otherwise, the workmanship, equipment and materials provided in accordance with this Specification shall comply in design, construction, rating and performance with the current relevant Australian or International Standards and Codes. In particular, the equipment shall comply with the requirements of AS 60146.1.

The equipment shall comply with the requirements of competent Australian Authorities having jurisdiction over all or part of the manufacture, installation and operation of the equipment.

The equipment shall be in accordance with the requirements of AS 3000 and with the further requirements of this Specification.

The equipment shall comply with electromagnetic interference (EMI) standards AS/NZS 61000.6.4 and AS/NZS 61000.6.2 and shall carry the CE-Mark certifying compliance with these standards. The equipment shall be entitled to carry the Australian C-tick mark. In addition the equipment shall comply with the further requirements of AS 61800.3.

Each variable speed controller shall comply with the above standard when operating connected to its associated motor via motor cable of the type and length specified in the Annexure.

Specific reference is made in this Specification to the following national and international standards.

AS 60034.1 Rotating Electrical Machines – General Requirements – Rating and Performance

AS/NZS 60076.1 Power Transformers – General

AS 60076.11 Power Transformers – Dry Type Transformers

AS 60146.1.1 Semiconductor converters – general requirements and line commutated converted – Specifications of basic requirements

AS 60146.1.3 Semiconductor converters – general requirements and line commutated converters – Transformers and reactors

AS 60529 Degrees of protection provided by enclosure (IP Code)

AS 61800.3 Adjustable speed electrical power drive systems – EMC requirement and specific test methods

AS/NZS 61000.2.4 Compatibility levels in industrial plants for low frequency conducted disturbances

AS/NZS 61000.3.6 Assessment of emission limits for distorting loads in MV and HV power systems

AS/NZS 61000-6-2 Electromagnetic Compatibility – General Immunity Standard – Industrial Environment

AS/NZS 61000-6-4 Electromagnetic Compatibility – General Emission Standard Industrial Environment

AS/NZS 3000 Electrical Installations ‘Wiring Rules’

AS/NZS ISO 9001 Quality Management Systems – Requirements

AS 60034.17 Rotating electrical machines – cage induction motors when fed from converters – Application guide

IEC 60721-3-3 Classification of environmental conditions - Classification of groups of environmental parameters and their severities - Stationary use at weather protected locations

IEC 60269.4 Low Voltage fuses - Supplementary requirements for fuse links for the protection of semiconductor devices

AS IEC 61800.5.1 Adjustable speed electrical power drive systems – safety requirements – electrical, thermal and energy

IEEE 519 Recommended practices and requirements for harmonic control in electrical power systems

ISO 9223 Corrosion of Metals and Alloys – Classification of Corrosivity of Atmospheres

# Quality Assurance

The variable speed controllers 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 licence to perform such work. All electrical equipment shall be in accordance with any relevant clauses of AS/NZS 3000.

# Input Power Supply

1. The variable speed controller(s) shall be rated for operation from a 3 phase, 50 Hz (+1.5 %) power supply, having a solidly grounded neutral, a RWB phase sequence and a voltage imbalance of < 2 %.
2. The variable speed controller(s) shall be rated for an input voltage range including both the incoming supply voltage range as specified in the Annexure to the accompanying DS26.16 specification plus the voltage drop through the input transformer.
3. For Type A arrangements, the supply voltage and the onsite fault current level at the input terminals of the variable speed controller integral input isolating transformer shall be as specified in the Annexure to the accompanying DS26.16 Specification.
4. For Type B arrangements the supply voltage and the onsite fault current level at the input terminals of the variable speed controller separate input isolating transformer shall be as specified in the Annexure to the accompanying DS26.16 Specification.

# Input Isolating Transformers

1. Input isolating transformers shall be dry type and shall be air cooled.
2. For both Types A and B arrangements, input isolating transformers shall comply with the requirements of Type Specification DS26.16, all as detailed in the accompanying DS26.16 Specification

# Overcurrent and Earth Fault Protection

1. The electrical supply to each variable speed controller input isolating transformer will be via an individual circuit breaker and an individual contactor in the Principal’s High Voltage switchboard.
2. Each of the above circuit breakers will be fitted with current transformer operated extremely inverse overcurrent and earth fault protection.
3. The overcurrent relay minimum tripping current will be 1.2 times the setting current and the circuit breaker tripping time will be not more than 80 milliseconds after the fault relay trip.
4. Unless the variable speed controller(s) are of a fuseless design, each variable speed controller shall be provided with suitable internal semiconductor protection fuses providing protection against output short circuits.
5. If the variable speed controller(s) are of fuseless design, semiconductor protection against output short circuits shall be provided by a means approved by the Principal and as detailed in the Contractor’s Tender Response Schedule.

# Variable Speed Controller Enclosure

1. The variable speed controller enclosures shall be floor mounted.
2. Variable speed controller enclosures shall be provided with a degree of protection in accordance with AS 60529 as specified in the Annexure.
3. If so specified in the Annexure the variable speed controller enclosure shall be arranged for front access only.
4. The variable speed controller enclosure shall be arranged for top or bottom cable access as specified in the Annexure.

# Variable Speed Controller Cooling

1. Each variable speed controller proper in a Type A arrangement shall be force fan cooled by an integral cooling fan. If the associated input isolating transformer is in the same enclosure as the variable speed controller proper, it shall be force fan cooled either by the same fan or by a separate cooling air fan.
2. In type A arrangements the cooling air discharge shall exit from the top of each enclosure and facilities shall be provided to allow the discharge cooling air to be ducted directly outside the switchroom building.
3. The primary coolant for variable speed controller(s) proper in Type B arrangements shall be air and the secondary coolant shall be either air or water as specified in the Annexure.
4. In Type B arrangements with air as the secondary coolant, the cooling air discharge shall exit from the top of each enclosure and facilities shall be provided to allow the discharge cooling air to be ducted directly outside the switchroom building.
5. In Type B arrangements with water as the secondary coolant, an air to water heat exchanger shall be provided within the variable speed controller proper enclosure.

# Locking

1. Access to all High Voltage conductors shall be controlled by Water Corporation standard key Lockwood type EL1
2. Access to all Low Voltage shall be controlled by the Water Corporation standard electrical key (EL2 or bilock equivalent) of the type applicable to the particular Water Corporation Region
3. Such access shall be controlled either by the variable speed controller doors being fitted with locks matched to the above Water Corporation key, or by providing a key interchange box between the above Water Corporation key and the variable speed controller door key
4. In the latter case, insertion and turning the Water Corporation standard key shall release the variable speed controller door key from the key interchange box while the former shall remain trapped

# Fault Current Rating

For both Type A and Type B arrangements, the fault current rating of the variable speed controller(s) proper shall be not less than the fault current level at the output terminals of the associated input isolating transformer, calculated on the basis of the specified fault level at the input terminals of the associated input isolating transformer.

# Arcing Fault Protection

1. The design of the variable speed controllers shall be such as to minimise the risk of an internal arcing fault developing and to minimise the risk to the operator should such a fault develop
2. Arcing fault detectors shall be fitted in all variable speed controller proper compartments containing bare conductors on the line side of the semiconductor over current protection
3. Arcing fault detectors shall be fitted in all Type A arrangement transformer enclosures
4. Arcing fault detector relays shall be fitted with normally open contacts of the ratings shown in the Annexure
5. Arc fault detectors shall utilise current and light for detection

# Input Converters

## Input Converter Type

Variable speed controller input converters shall be one of the following types, as specified in the Annexure:

1. 18 pulse uncontrolled rectifier.
2. active front end rectifier
3. 24 pulse uncontrolled rectifier,
4. 36 pulse uncontrolled rectifier.

## Input Harmonic Currents

1. The design of any 18 pulse rectifiers provided shall be such that with a balanced input voltage and an input fault current level to full load current (ISC/IL) ratio of 35, the input current total harmonic distortion [THD(i)]shall be not greater than 6.5%.
2. The design of any active front end rectifiers provided shall be such that with a balanced input voltage and a ISC/IL ratio of 35, the input THD(i)shall be not greater than 5.0 %.
3. The design of any 24 pulse rectifiers provided shall be such that with a balanced input voltage and a ISC/IL ratio of 35, the input THD(i)shall be not greater than 4.0 %.
4. The design of any 36 pulse rectifiers provided shall be such that with a balanced input voltage and a ISC/IL ratio of 35, the input THD(i)shall be not greater than 1.5%.
5. When operating at the site, input converters shall not draw harmonic currents significantly different from the values specified previously by the Contractor in the Contractor’s Tender Technical Response Schedule.

## Input Total Power Factor

The total power factor of variable speed controllers shall be within the range 0.95 lagging to 0.95 leading for loads in the range 30% to 100% full load current.

## Ripple Filtering

Variable speed controllers having input converters of the sinusoidal rectifier type shall be fitted with input ripple filters which shall be tuned to the modulating frequency and its low order harmonics so as to prevent modulating ripple in the input voltage wave form.

## Radio Frequency Interference

Variable speed controllers, when installed and connected to their associated input isolating transformers and to associated motors by the lengths and types of cables specified in the Annexure, shall not cause radio frequency interference greater than the limits specified in AS/NZS 61800.3 for category C4 equipment.

# Output Converters

## Output Inverter Type

1. Output inverters shall be either a voltage source pulse width (PWM) type or a current source PWM type, as specified in the Contractor’s Tender Response Schedule.
2. Except as specified sub-clauses 20.1 (c) and 20.1(d) hereunder. Output voltage source inverters shall be multilevel type producing an output voltage waveform so close to a sinusoidal voltage waveform that standard motors can be used without the need for dV/dt filters, without restrictions on motor cable length and without the need for increased insulation impulse voltage rating.
3. Output inverters producing a single level voltage waveform output shall be acceptable provided these are fitted with output sinusoidal filters
4. Multilevel inverters not complying with sub-clause 20.1(b) above shall be acceptable provided:
5. the variable speed controller(s) are being supplied from the same manufacturer as part of a single contract for the supply and installation of complete variable speed drive system(s), consisting of the variable speed controller(s), motor(s) and motor cabling
6. the inverter output voltage waveform dV/dt does not exceed 6 kV/µs
7. the dV/dt ratings of the motor winding and of the cable are not less than 6 kV/µs
8. the motor cable length does not exceed 50 metres, and
9. the motor cable is a type specifically designed for variable speed drive applications

## Control Power

* 1. If a variable speed controller’s control power is not provided internally, control power will be provided by the Principal
  2. If the latter is the case, the variable speed controller shall be designed to operate from a 3 phase, 4 wire, 415 Volt +/- 10% control power supply

## Output Power Supply

* 1. Each variable speed controller shall provide a 3 phase power supply output having an RWB phase sequence and a controlled frequency range as specified in the Annexure.
  2. The output power supply shall be suitable for driving the associated motor and its associated load, all as specified in the Annexure.
  3. A high voltage isolating and earthing switch shall be provided to allow the HV cable and HV motor to be earthed during maintenance.

## Output Ratings

* 1. Each variable speed controller shall have a minimum frequency output kVA rating as specified in the Annexure. The output current rating shall be constant over the frequency range specified in the Annexure.
  2. Each variable speed controller shall have a short time (10 second) over current capacity as specified in the Annexure.

## Output Frequency Control

* 1. The static frequency control error over the specified frequency range shall be not greater than 1% nominal frequency.
  2. Variable speed controllers shall include facilities to enable driven load resonant frequencies to be bypassed.

## Output Voltage Control

1. Variable speed controller output voltage at motor rated frequency shall be the motor rated voltage as specified in the Annexure.
2. Generally, the output voltage shall be varied in direct proportion to the output frequency.
3. However the inverter control algorithm shall incorporate an energy saver facility which shall adjust the output voltage as a function of load so as to provide maximum motor efficiency.
4. Notwithstanding the above, at frequencies above the motor rated frequency the output voltage shall be limited to the motor rated voltage.

## Common Mode Currents

* 1. Except as per sub-clause 20.7 (b) hereunder, common mode currents in the variable speed controller shall be prevented by the use of common mode voltage filters, by the use of common mode impedances, Type 1 sine filters (to provide both phase to ground and phase to phase filtering) or by other means approved by the Principal.
  2. Special action to eliminate high frequency common mode currents from, the variable speed controller(s) need not be taken provided that:

1. the associated motor(s) are fitted with insulated non drive end bearing(s), insulated motor to driven machine coupling(s) and shaft grounding ring(s), and
2. the variable speed controller(s) are being supplied from the same manufacturer as part of a single contract for the supply and installation of complete variable speed drive system(s), consisting of the variable speed controller(s), motor(s) and motor cabling.

## Soft Starting

* 1. Variable speed controllers shall include a soft starting facility which shall provide the motor with a starting sequence which ensures that the motor does not draw more than 110% of full load current during the starting period
  2. The type of driven load shall be as specified in the Annexure
  3. Assuming standard cage induction motors, the variable speed controllers shall be capable of providing a starting torque margin of not less than 10% over the driven load starting torque requirement
  4. The starting period shall be adjustable over a range of not less than 5 seconds to 2000 seconds

## Ride Through Capability

Each variable speed controller shall incorporate control algorithms which allow the controller to:

* 1. stay on line at reduced load in the event of controller over temperature
  2. stay on line at reduced load in the event of continuous input under voltage not more than -15 %
  3. stay on line at reduced load in the event of continuous input over voltage not more than +10%
  4. ride through a 0.5 second input power voltage dip of up to 30 %
  5. ride through a loss of input power of up to two cycles

## PID Algorithm

Each variable speed controller shall be equipped with a PID control algorithm so as to allow the control of process variables such as pressure, flow or fluid level via control of the driven motor speed. The required input signal to the control algorithm shall be a 4/20 mA analogue current signal.

## Output Sine Filter

Output converters shall be supplied with a Type 1 sine filter when the motor specified in the Annexure is a submersible borehole type.

# Protection and Instrumentation

## Protection Functions

Variable speed controllers shall incorporate the following protection functions:

1. AC input or DC bus over voltage
2. AC input or DC bus under voltage
3. input phase loss
4. output phase loss
5. controller over temperature
6. output over current
7. output earth fault (if output neutral is solidly grounded)
8. output neutral displacement (if output neutral is not solidly grounded)
9. motor overload
10. backspinning start protection (if so required in the Annexure)
11. stall protection (if so required in the Annexure)
12. other protection functions as specified in the Annexure

## Keypad and Display Unit

Each variable speed controller shall be equipped with a keypad and display unit providing status indication, fault indication,and allowing control and parameter settings and adjustments.

## Instrumentation

Each variable speed controller shall be equipped with instrumentation to provide a read out of the following parameters:

* + 1. output voltage
    2. output current
    3. output frequence
    4. output power (kW)
    5. output energy (kWhr)

## Control and Alarm Interfaces

Each variable speed controller shall be able to be equipped with the following control and alarm interfaces and shall be supplied with interfaces selected and assigned as specified in the Annexure:

1. Modicon Modbus bus interface
2. Profibus bus interface
3. Ethernet bus interface
4. Two (2) programmable isolated 4/20 mA inputs
5. Two (2) programmable isolated digital inputs
6. Two (2) programmable isolated 4/20 mA outputs
7. Three (3) programmable isolated digital outputs
8. One (1) programmable non isolated potentiometer input

## Fault Diagnostics

Each variable speed controller shall be equipped with a full suite of diagnostic software tools to facilitate commissioning and fault finding.

# Overall Efficiency

The full load overall efficiency of the variable speed controller(s) including input isolating transformer(s), converter(s), capacitors, inverter(s), filters and cooling fans shall be not less than 96% at specified maximum load and specified maximum frequency.

# Mean Time Between Failure

Variable speed controllers shall have a Mean Time Between Failure rating of not less than 50,000 operating hours.

# Audible Sound Level

At full load the sound power level of each variable speed controller (including the input isolating transformer if the latter is integral with the controller) shall be not more than 80 dBA (i.e. the sound pressure level at 1 metre shall be not more than 69 dBA), unless a lower value is specified in the Annexure, in which case the latter shall apply.

# Corrosion Protection

* 1. All metallic parts shall be provided with appropriate corrosion protection by metallic plating or by paint finishes.
  2. Outside steel surfaces of the variable speed controller enclosure shall with medium term protection to category 3 in accordance with ISO 9223 (industrial and marine environments), either by gloss paint or by powder coating finish.
  3. Outside aluminum surfaces of the variable speed controller enclosure shall be protected by anodic oxide coatings with a minimum average coating thickness of 25 microns and a minimum local coating thickness of 20 microns.
  4. The variable speed controller(s) shall be supplied with high grade conformal coated electronics to ensure the drives are suitable for installation in harsher environments as classified by IEC 60721-3-3, Class 3C3.

# Works Tests

## Variable Speed Controller Type Tests

* 1. Variable speed controller(s) proper including control, protection and auxiliary sections shall be type tested in accordance with AS 60146.1.1.
  2. In addition, variable speed controller(s) shall be impulse voltage type tested in accordance with IEC 61800.5.1, Table 16, Category III.

## Variable Speed Controller Routine Tests

Variable speed controller(s) proper including control, protection and auxiliary sections shall be routine tested in accordance with AS 60146.1.1.

The variable speed controller shall be submitted to testing in order to substantiate that all of the other performance values included are in accordance with the Contractor’s tender.

## Other Performance Tests

The converter shall be submitted to testing in order to substantiate all of the other performance values included on the Contractor’s tender.

## Test Certificates

Type test and routine test certificates certifying successful completion of such tests shall be presented to the Principal prior to the equipment leaving the equipment manufacturer’s works and equipment shall not leave the manufacturer’s works until the Principal has accepted in writing that the test certificates are in accordance with the Contract.

# Liquidated Damages for Low Efficiency

In addition to any damages specified in the General Conditions of Contract, the Contractor shall be liable to the Principal for liquidated damages in respect to failure of the variable speed controller to achieve the level of full speed efficiency quoted previously in the Tender Response Schedule. Such liquidated damages shall be calculated on the basis of the capitalised cost of losses quoted in the Annexure and by the amount by which the full load full speed efficiency falls short of 99% of the quoted full load speed efficiency.

# Delivery and Installation

## Pump Tests

* 1. If so specified in the Annexure the Contractor shall deliver one complete variable speed controller to the pump manufacturer’ works specified in the Annexure, so as to facilitate pump acceptance tests.
  2. In such cases, the Contractor shall deliver to, and unload unpack and assemble as necessary the complete variable speed controller at the pump manufacturer’s works.
  3. The Contractor shall supervise the connection and operation of the variable speed controller during pump testing.
  4. Once pump testing is complete, the Contractor shall dissemble (to the extent necessary) the variable speed controller and pack, load and deliver the complete variable speed controller to the site as specified hereunder.

## On Site Delivery and Installation

* 1. The Contractor shall deliver to, and unload, unpack and assemble as necessary the complete variable speed controllers at the site.
  2. The Contractor shall inspect all of the unpacked variable speed controllers and shall ensure that the variable speed controllers are undamaged.
  3. The Contractor shall give the Principal seven days’ notice when the variable speed controllers will be ready for installation. The Contractor shall install the variable speed controllers in their permanent positions ready for connection by others.

# On Site Testing

* 1. The Contractor shall carry out an insulation resistance test on each variable speed controller before connection of the variable speed controller to the associated motor and supply is commenced, regardless of whether such connections are required to be undertaken by the Contractor or by the Principal.
  2. Once each variable speed drive has been connected, the Contractor shall commission each variable speed controller in association with the Principal.
  3. Each variable speed controller shall be operated on load for a period of 3 hours during which time the Contractor shall monitor its operation
  4. The Contractor shall supply all equipment, materials and labour for such testing and commissioning of the variable speed controller.
  5. The Contractor shall make the results of commissioning tests available to the Principal within 7 days of the completion of such tests.

# As Constructed Information

* 1. The Contractor shall provide as-constructed information on all drawings.
  2. As-constructed drawings shall be provided in an electronic form with A3 size hard copies.

# Manuals

* 1. The Contractor shall supply 3 copies of comprehensive instruction manuals, written in English and covering the complete operation and maintenance requirements of all equipment supplied under the Contract.
  2. The manuals shall be printed on high grade A4 size paper and shall be bound in a high grade A4 size loose leaf binder.
  3. 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.

# Spare Parts

* 1. The Contractor shall supply as a minimum, one complete set of power electronics modules.
  2. The Contractor shall guarantee to hold in Australia, one complete set of electronics spare parts for one variable speed controller.

# Technical Support

The Contractor shall maintain an adequate level of technical support within Australia.

# Training

The Contractor shall supply as part of the Contract, training for the number of Water Corporation electrical technicians specified in the Annexure. Such training shall cover commissioning as well as first line fault finding and first line servicing.

**Annexure to Specification**

**for**

**HV Variable Speed Controllers with Unit Isolating Transformers**

**Project:**

**Site Location:**

**Access to Site:**

**Title(s) of Driven Load(s):**

**Number of Variable Speed Controllers Required:**

Type of Arrangement Required (i.e. Type A or Type B)

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

**Work by the Principal:**

**Address of Pump Manufacturer’s Works:**

**Number of Technician Training Places to be Provided:**

**Annexure to Specification**

**for**

**HV Variable Speed Controllers with Unit Isolating Transformers**

**VSC Max. Full Load Audible Sound Power Level** (if <93 dBA) dBA

*(including integrally mounted Input Isolating Transformer if applicable)*

**VSC Operating Environment**

*(including integrally mounted Input Isolating Transformer if applicable)*

Maximum Ambient Air Temperature oC

Minimum Ambient Air Temperature oC

Maximum Ambient Air Relative Humidity %

Ambient Air Borne Contaminants

**Type of Input Converter** (i.e. 18-pulse uncontrolled rectifier, active front end rectifier, 24 pulse uncontrolled rectifier, or

36 pulse uncontrolled rectifier)

**VSC Enclosure**

*(including integrally mounted Input Isolating Transformer if applicable)*

Protection Class as per AS 60529

Cable Connection *(i.e. top or bottom entry)*

Front Access Only *(required or not required)*

Arcing fault detector relay output contacts Volts

Amps

AC or DC

**VSC Cooling**

Type of Secondary Coolant *(i.e. air or water)*

**Annexure to Specification**

**for**

**HV Variable Speed Controllers with Unit Isolating Transformers**

**Input Power Supply Power**

Frequency and Tolerance +/- %

Phase to Phase Voltage kV

Source Impedance at the above voltage + j Ohms

Maximum Allowable Input Current Total Harmonic Distortion %

5th harmonic current limit of Amps at above Voltage

**Motor Characteristics**

Type of Motor (i.e. conventional or submersible)

Type of Duty as per AS 60034.1

Motor Full Load Ratings

Voltage 3 phase …………. kV Current …………. Amps Frequency Hz

Output Power …………... kW Speed …………… rpm

Motor Rated Torques

Locked Rotor Torque % full load torque

Breakdown Torque % full load torque at rpm

**Harmonic Limits**

7th harmonic current limit of Amps at above Voltage

11th harmonic current limit of Amps at above Voltage

13th harmonic current limit of Amps at above Voltage

17th harmonic current limit of Amps at above Voltage

19th harmonic current limit of Amps at above Voltage

23rd harmonic current limit of Amps at above Voltage

25th harmonic current limit of Amps at above Voltage

29th harmonic current limit of Amps at above Voltage

31st harmonic current limit of Amps at above Voltage

35th harmonic current limit of Amps at above Voltage

37th harmonic current limit of Amps at above Voltage

41st harmonic current limit of Amps at above Voltage

43rd harmonic current limit of Amps at above Voltage

47th harmonic current limit of Amps at above Voltage

49th harmonic current limit of Amps at above Voltage

**Annexure to Specification**

**for**

**HV Variable Speed Controllers with Unit Isolating Transformers**

**Operating Mode**

Required kVA rating at maximum specified frequency kVA

Required Operating Frequency Range Hz to Hz

Required Short Time Over Current Capacity % VSC Rated Current

Motor Load at Specified Minimum Frequency: kW

Load Torque versus Speed Characteristics

Newton\*m … 0 rpm Newton\*m rpm

…………………….. Newton\*m rpm Newton\*m rpm

**Type of Motor Feed Cable:**

**Length of Motor Feed Cable:** metres

**Additional Protection Functions:**

Back Spin Protection (required or not required)

Stall Protection (required or not required)

Other Protection Functions Required:

Sine Filter (Type 1) required………………………….……………………………………Yes/No**Annexure to Specification**

**for**

**HV Variable Speed Controllers with Unit Isolating Transformers**

**Converter Input Isolating Transformer**

**Project:**

**Site Location:**

**Transformer Ambient Conditions**

Maximum Temperature oC

Maximum Average Temperature over any one day *(if > 30oC)* oC

Location

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

**Transformer Requirements**

**Type** *(i.e. oil filled or dry type):*

**Mounting**

*(i.e. integral with converter or separately mounted)*

**Operating Mode:** Single Operation

**Type of Load:** Variable Speed Drive

**Number of windings:** To suit the particular converter offered

**Vector Group:** To suit the particular converter offered.

**Primary Winding**

Rated Voltage kV

Connection: To suit the particular converter offered

Terminals to be Brought Out:

Method of System Earthing:

Continuous Rating: To suit the particular converter offered

System Highest Voltage: kV

System Fault Level: kV

**Annexure to Specification**

**for**

**HV Variable Speed Controllers with Unit Isolating Transformers**

**Converter Input Isolating Transformer (continued)**

**Secondary Winding:** To suit the particular converter offered

**Tertiary Winding** *(if required):* To suit the particular converter offered

**Overall Impedance:** To suit the particular converter offered

**IP Rating of Enclosure** (not less than IP21): IP

**Maximum Audible Sound Power Level** (when supplying converter offered)

If separately mounted *(AS 60076.1 refers)* dBA

If mounted integrally with inverter: (refer clause 24) ................................. dBA

**Type of Winding Temperature Sensor:**

**Type of Cable Terminations Required:**

At Primary Winding Termination

At Secondary Termination

At Tertiary Winding Termination

**Special Requirements:**

The transformer shall comply with the additional requirements of:

AS 60146.1.3 – Semiconductor converters – General requirements and line commuted converters – Transformers and reactors

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| --- | --- | --- | --- | --- | --- |
| **Type Specification for HV Variable Speed Controllers with Unit Isolating Transformers**  **Tender Technical Response Schedule** | | | | | |
| DS26.14 | Subject | Noted | Compliance | | Comments |
| **Clause No.** |  |  | **Yes** | **No** |  |
| **1.** | **General** |  |  |  |  |
| 1.1 | Scope |  |  |  |  |
| 1.2 | Arrangements |  |  |  | Type A or Type B |
| 1.3 | VSC Components |  |  |  |  |
| **2.** | **Site** |  |  |  |  |
| **3.** | **Operating Mode** |  |  |  |  |
| **4.** | **Ambient Conditions** |  |  |  |  |
| **5.** | **Work by Principal** |  |  |  |  |
| **6.** | **Information from Contractor** |  |  |  |  |
| **7.** | **Contractor’s Drawings** |  |  |  |  |
| **8.** | **Standards** |  |  |  |  |
| **9.** | **Quality Assurance** |  |  |  |  |
| **10.** | **Electrical Work** |  |  |  |  |
| **11.** | **Input Power Supply** |  |  |  | VSC input rated voltage kV = |
|  |  |  |  |  | VSC input voltage tolerance % = |
|  |  |  |  |  | VSC input Hz tolerance % = |
| **12.** | **Input Isolating Transformer** |  |  |  | Separate response required |
|  | Mounting and Type |  |  |  | Integral or separate |
| **13.** | **Overcurrent Protection and Earth Fault Protection** |  |  |  | Type of semi-conductor protection  offered = |
| **14.** | **Enclosure** |  |  |  | Enclosure IP rating = |
| **15.** | **Cooling** |  |  |  |  |
|  | If air cooled |  |  |  | Cooling air flow rate, litres/sec = |
|  |  |  |  |  | Allowable duct head loss, mm Hg = |
|  | If water cooled |  |  |  | Cooling water flow rate, litres/sec |
|  |  |  |  |  |  |
| **16.** | **Locking** |  |  |  |  |
| **17.** | **Fault Current Rating** |  |  |  | VSC fault current rating kA = |
| **18.** | **Arcing Fault Protection** |  |  |  |  |
| **19.** | **Input Converters** |  |  |  |  |
| 19.1 | Input Converter Type |  |  |  | Type offered = |
| 19.2 | Input Harmonic Currents |  |  |  | Input THD(i) = for ISC/IL = 35 |
|  |  |  |  |  | Input THD(i) = for site conditions |
| 19.3 | Input Total Power Factor |  |  |  | P.F. at 100% current = |
|  |  |  |  |  | P.F. at 70% current = |
|  |  |  |  |  | P.F. at 30% current = |
| 19.4 | Ripple Filtering |  |  |  |  |
| 19.5 | Radio Frequency Interference |  |  |  |  |

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| **Type Specification for HV Variable Speed Controllers With Unit Isolating Transformers Tender Response Schedule** | | | | | |
| **DS26.14** | **Subject** | **Noted** | **Compliance** | | **Comments** |
| **Clause No.** |  |  | **Yes** | **No** |  |
| **20.** | **Output Inverters** |  |  |  |  |
| 20.1 | Output Inverter Type |  |  |  | Inverter type offered = |
| 20.2 | Control Power |  |  |  |  |
|  | If not internal |  |  |  | kVA = |
|  |  |  |  |  | Volts = |
|  |  |  |  |  | No of phases = |
| 20.3 | Output Power Supply |  |  |  | Maximum frequency, Hz = |
|  |  |  |  |  | Minimum frequency, Hz = |
|  | Isolating/Earth Switch Rating |  |  |  | …………………….. kA/s |
| 20.4 | Output Ratings |  |  |  | 60 Hz Rated kVA = |
|  |  |  |  |  | 10 sec. O/C Amps = |
| 20.5 | Output Frequency Control |  |  |  | Max. control error % = |
| 20.6 | Output Voltage |  |  |  | At maximum frequency kV = |
| 20.7 | Common Mode Currents |  |  |  | Type of mitigation offered = |
| 20.8 | Soft Starting |  |  |  | Starting current limit, FLC % = |
|  |  |  |  |  | Maximum start time, seconds = |
|  |  |  |  |  | Minimum start time, seconds = |
| 20.9 | Ride Through Capability |  |  |  | At 85% Volts, output kVA = |
|  |  |  |  |  | At 110% Volts, output kVA = |
|  |  |  |  |  | Max. Ride through volts dip. % = |
|  |  |  |  |  | Max. ride through time, cycles = |
| 20.10 | PID Algorithm |  |  |  |  |
| 20.11 | Sine Filter |  |  |  | Type = |
|  |  |  |  |  | Rating = ……………… A at …… …°C |
| **21.** | **Protection and Instrumentation** |  |  |  |  |
| 21.1 | Protection Functions |  |  |  | *Attach details separately* |
| 21.2 | Keypad and Display Unit |  |  |  |  |
| 21.3 | Instrumentation |  |  |  |  |
| 21.4 | Control and Alarm Interfaces |  |  |  | *Attach details separately* |
| 21.5 | Fault Diagnostics |  |  |  | *Attach details separately* |
| **22.** | **Overall Efficiency** |  |  |  | Efficiency at max. frequency % = |
|  |  |  |  |  | Efficiency at 60 Hz, % = |
|  |  |  |  |  | Efficiency at min. frequency, % = |
| **23.** | **Mean Time Between Failure** |  |  |  | MTBF, hours = |
| **24.** | **Audible Sound Power Level** |  |  |  | VSC Sound Power, dBA = |
|  |  |  |  |  | VSC Sound Pressure @ 1m, dBA = |
|  |  |  |  |  | Tfr. Sound Power, dBA = |
| **25.** | **Corrosion Protection** |  |  |  |  |

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| **Type Specification for HV Variable Speed Controllers With Unit Isolating Transformers Tender Response Schedule** | | | | | |
| DS26.14 | **Subject** | **Noted** | Compliance | | **Comments** |
| **Clause No.** |  |  | **Yes** | **No** |  |
| **26.** | **Works Tests** |  |  |  |  |
| 26.1 | VSC Type Tests |  |  |  |  |
| 26.2 | VSC Routine Tests |  |  |  |  |
| 26.3 | Other Performance Tests |  |  |  |  |
| 26.4 | Test Certificates |  |  |  |  |
| **27.** | **Liquidated Damages for Low Efficiency** |  |  |  |  |
| **28.** | **Delivery and Installation** |  |  |  |  |
| 28.1 | Pump Tests |  |  |  |  |
| 28.2 | On Site Delivery and Installation |  |  |  |  |
| **29.** | **On Site Testing** |  |  |  |  |
| **30.** | **As Constructed Information** |  |  |  |  |
| **31.** | **Manuals** |  |  |  |  |
| **32.** | **Spare Parts** |  |  |  |  |
| **33.** | **Technical Support** |  |  |  | Technical support function location is located in |
| **34.** | **Training** |  |  |  |  |
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*If oil filled transformer(s) are offered, DS26.13 Tender Response Schedule to be completed by the Tenderer and attached herewith.*

*If dry type transformer(s) are offered, DS26.16 Tender Response Schedule to be completed by the Tenderer and attached herewith.*

END OF DOCUMENT