WATER SUPPLIES DEPARTMENT

STANDARD SPECIFICATION E-86-02

LOW VOLTAGE VARIABLE SPEED DRIVES

1. GENERAL

This Specification outlines the technical requirements of Variable Speed Drives (VSD) for low voltage squirrel cage induction motors. The VSD shall include all necessary sub-units and components to form a complete working system for the control of motor speed and torque.

The VSD shall comply with the prevailing requirements on energy efficiency and power quality as stipulated in the latest edition of the Code of Practice for Energy Efficiency of Electrical Installations issued by the Electrical and Mechanical Services Department (EMSD). It shall also comply with the relevant requirements of WSD Standard Specifications E-00-01, E-11-02, E-11-03, E-80-01 and E-98-01 for various elements of the complete drive systems.

The VSD manufacturer shall have a local setup to provide full technical support such as adequate stock of spares, technical expertise in testing, commissioning and trouble-shooting and training on operational and maintenance aspects including trouble-shooting techniques.

2. DESIGN

2.1 General Requirements

The VSD shall be of microprocessor based design working on the principle of pulse width modulation (PWM). It shall be capable of converting a 3-phase 380V, 50 Hz supply to adjustable frequency and voltage output for pumping system and process plant applications.

The output rating of the VSD shall be suitable for continuous operation at the rated motor load at a power factor of 0.8 lagging. The motor starting current under direct-on-line starting condition will be seven times of the motor's full load current at a power factor of 0.2 lagging. The VSD shall be capable of continuously delivering the rated output voltage even when the mains supply voltage is down by 10% of its nominal value. It shall match the motor characteristics and be able to control the motor over a speed range of 20% to

100% continuously without the need to derate the motor. During motor starting, the current shall rise from zero gradually as the load accelerates without exceeding the full load motor current.

Harmonic filters shall be provided with the VSD to comply with the statutory and local power companies' requirements on harmonic distortion and power quality.

2.2 Performance Requirements

The VSD shall meet the following performance requirements:-

(a) Power Supply

The power supply to the VSD shall be 380V ±10% 3 phase 50 Hz±2 Hz with neutral solidly earthed. The input power supply circuits of the VSD shall be protected by HRC fuses to IEC 60269.

(b) Output Frequency

The output frequency under steady state shall be adjustable from 10 Hz up to the rated frequency of 50 Hz controlled by an automatically generated 4-20mA DC current, a manual input from potentiometer or fieldbus control input via the VSD controller. The start-up frequency shall be adjustable between 0.5 Hz to 10 Hz. At least 4 programmable preset speeds shall be provided. In addition to the preset speeds, a minimum of 2 skip frequencies of adjustable bandwidth shall also be provided to avoid mechanical resonance.

(c) Output Voltage

The output voltage shall have a linear or quadratic relation with the output frequency up to rated voltage at 415V 3-phase and rated frequency at 50 Hz under voltage/frequency control mode.

(d) Frequency Regulation

The VSD steady state output frequency shall not deviate by more than ±1% of the setting due to temperature, load and input voltage variations.

(e) Slip Compensation

The VSD shall have slip compensation function to automatically increase its output frequency with load to regulate the speed.

(f) Overload Capability

The VSD shall be capable of operating at 110% rated output for 1 minute in every 5 minutes, or otherwise specified in the Particular Specification.

(g) Efficiency

Efficiency of the VSD shall not be less than 97% at rated output and not less than 90% at any other operating loads within the speed range.

(h) Electromagnetic Compatibility

The VSD shall comply with IEC 61000-6-3, IEC 61000-6-4 and IEC 61800-3 or other similar recognised international standards on Electromagnetic Compatibility (EMC).

(i) Audible Noise

Noise level of the VSD shall not exceed 76 dB(A).

(j) Line Reactor / Harmonic Filter

AC line reactor or harmonic filter shall be provided at the incoming power supply side to protect against voltage spikes and suppress the total harmonic distortion at the power supply terminals for compliance with the statutory and local power companies' requirements on harmonic distortion and power quality.

(k) Displacement Power Factor

Input displacement power factor shall be maintained between 0.9 and 0.99 lagging, without the need of adding external chokes or power factor correction capacitors, at any operating loads within the speed range.

(l) Output Reactor

Output reactor shall be provided to limit the potential voltage spikes caused by cable capacitance to 150% of the applied voltage at the motor terminals and reduce the electrical stress of motor insulation for motor cable run exceeding 100m, or otherwise specified in the Particular Specification.

(m) Temperature Limit

The external surface temperature of the enclosure liable to physical contact of human body shall not be more than 65°C.

2.3 Facilities

The following features shall be included in the VSD:-

(a) Control Provisions

(i) DC voltage boost for maximum motor output torque; and

(ii) Adjustable acceleration and deceleration rates.

(b) Protection Functions

(i) Input undervoltage and overvoltage;

(ii) DC bus undervoltage and overvoltage;

(iii) Output overcurrent and overvoltage;

(iv) Loss of mains and motor phase;

(v) Motor short circuit;

(vi) Input transients;

(vii) Earth fault;

(viii) VSD over temperature;

(ix) Motor over temperature;

(x) VSD and motor overload; and

(xi) Safe torque off.

Input contacts shall be provided in the VSD for connection to thermistor or RTD controller for motor thermal/overload protection. Volt-free changeover output contacts for VSD tripped and fault alarm shall be provided for remote alarm initiation.

(c) Control and Monitoring

The VSD can be operated in either automatic or manual frequency control mode. The output frequency of the VSD shall be varied by a control input of 4-20mA DC under automatic operation and be manually operated on a flush mounted local control unit.

The local control unit functions as a human machine interface (HMI) for operator's information as well as providing control and programming functions of the VSD unit. Self-diagnostics and fault/event log memory functions shall be incorporated and displayed in both English and Chinese. Each VSD shall have its own unit. The local control unit shall include all the controls and indicators showing the operating status of the VSD and shall include but not limit to the following:-

(i) Display and keypad for function / data programming;

(ii) Output frequency, output voltage, output current, DC bus voltage, output power, motor speed, faults and alarms indications;

(iii) VSD on/off/bypass switch;

(iv) Automatic / Off / Manual selector switch;

(v) Local / Remote selector switch;

(vi) Manual motor speed setting;

(vii) Digital and analogue 4-20 mA control signal; and

(viii) Programmable pre-set speed control.

The VSD shall provide analog outputs for external connection of the output current ammeter and output frequency meter. Bypass function shall be provided in the VSD for the changeover to mains supply during failure of the drive system or maintenance of drive components.

(d) Communication and Interfaces

The VSD module shall be equipped with built-in RS485/232 serial communication port and/or two RJ45 ethernet ports for remote communication with computer servers or programmable logic controllers (PLC). At least one of the following forms of output or communication protocol shall be supported to suit the application environment:-

(i) Modbus

(ii) PROFIBUS DP

(iii) EtherNet/IP

(iv) BACnet

(v) PROFINET IO

3. CONSTRUCTION

3.1 Panel Enclosure

The VSD unit shall be enclosed in a panel with degree of protection of IP32 or better to IEC 60529. It shall be capable of continuous operation inside the panel under ambient temperature of 40^{o}C without de-rating.

The VSD panel enclosure shall be fabricated with 2mm mild steel with front access doors in accordance with WSD Standard Specification E-11-03. Where the panel width exceeds 800mm, double-leaf doors shall be provided. For floor-mounted or wall-mounted VSD enclosure, a detachable cable gland plate shall be provided to facilitate bottom cable entry.

3.2 VSD Functional Units

The VSD shall incorporate a minimum 6-pulse full-wave uncontrolled diode bridge, fixed voltage-fed d.c. link with inductors and capacitors to form a filter,

a mains filter for EMC compliance, a pulse width modulation (PWM) inverter bridge utilising insulated gate bipolar transistors (IGBTs) and output inductors in the motor lines. The inverter bridge shall be controlled by a microprocessor to produce a PWM waveform or similar technique which would result in full motor voltage and sinusoidal current mains supply in the motor circuit.

3.3 Ventilation

The VSD together with its panel enclosure shall be designed with adequate ventilation. The heat generated by the VSD during operation shall be adequately ventilated to avoid overheating of its components. When the total installed capacity of VSD exceeds 500kW, the Contractor shall design and provide forced ventilation for the VSD as part of the VSD installation in a dedicated plant room preferred. For VSD requiring forced ventilation, ambient air shall be drawn in at the bottom of the cabinet through air filters and discharged via ventilation duct system to the atmosphere outside the plant room.

Based on the heat generated by the VSD, pump motors, various building service loads, the plant room size and layout, etc., the Contractor shall devise a ventilation solution such that the temperature rise of the plant room will not be greater than 5°C above the atmosphere throughout the entire operating range of the VSD installation. The Contractor's proposal for the forced ventilation to be submitted for the Engineer's approval shall include relevant design calculations and the following technical information:

(a) the proposed number of air changes per hour (ACPH);

(b) the size and layout of ventilation duct;

(c) the maximum velocity of air flow in the ventilation duct;

(d) the capacity of the proposed axial flow exhaust fan;

(e) the size and layout of ventilation louver; and

(f) the civil work requirements, if any.

If built-in fan units are provided within the VSD enclosure, air filters shall be installed at the air inlet to suppress ingress of dust. A suitable detection system shall be provided to monitor satisfactory operation of the built-in fan units and initiate alarm to alert plant operators upon ventilation failure.

Unless otherwise specified, liquid cooling for VSD equipment is not permitted.

4. INFORMATION FOR EQUIPMENT APPROVAL

4.1 Descriptive Literature and Performance Data

Descriptive literature and performance data relevant to the VSD and its control unit shall be submitted for assessment.

4.2 Design Calculations for VSD

The Contractor shall submit design calculations to substantiate that the offered rating of the VSD will be adequate and suitable for continuous and stable operation of the squirrel cage induction motor taking into account the VSD enclosure IP rating, motor characteristics, operational conditions, ventilation requirements, harmonic filters, etc.

Design calculations for sizing the line reactor/harmonic filter and output reactor, if applicable, shall also be submitted for assessment.

5. INSPECTION AND TESTING

5.1 General

The VSD unit with nominal rating above 70kW shall be inspected by the Independent Inspection Body (IIB) at manufacturer's works according to WSD Standard Specification EM-00-01.

For VSD units of smaller rating, inspection and test reports/certificates of the manufacturer together with test arrangement drawings, circuits, calculations, and test results shall be submitted to WSD within one week after the inspection and testing.

5.2 Inspection

The scope of inspection shall in general cover the following:-

(a) General inspection checks including physical dimensions, workmanship, quality, quantity, standards and any visual damages.

(b) Check on model and nameplate data.

(c) Functional checks of correct operation, alarms, indications and setting of equipment.

(d) Verification of calibration reports of testing instruments for tests witnessed by IIB.

(e) Certificate of compliance shall be issued for each rating of VSD supplied.

(f) Packing and protection checks.

5.3 Test Requirements

The Contractor shall perform the following tests at manufacturer's works to demonstrate that the equipment complies with the Specification:-

(a) Performance test for 8 hours each at 20%, 50% and 100% speed.

(b) Load characteristic test (including temperature rise measurement).

(c) Efficiency test by direct measurement of input and output power.

(d) Line side current distortion content.

(e) Demonstration of the operation of all protective devices.

(f) Checking of auxiliary devices.

(g) Functional checks of all alarms and indication facilities.

(h) Other routine tests as required for the L.V. switchgear under IEC 60947.

The Contractor shall repeat the above tests at site as a site acceptance test.

5.4 Type Test Certification

Type test certificates complete with design drawings, photographs, test setup, test procedures, test result and conclusion shall be submitted upon requested by the Engineer. Type test certificates shall be issued by international accredited laboratories or organisation.

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