34 MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE (>1000 V)

34.1 GENERAL

34.1.1 Scope

1 This Specification defines the requirements for Medium Voltage Variable Frequency Drive Systems (VFDs) for the operation of pump motors. The system shall consist of the following main components: Isolation breaker, Drive Isolation Transformers, Medium voltage Variable Speed Drives (VFDs), Output Sine Filter, and any necessary power factor correction or harmonic filter components if required to meet this Specification.

2 The Manufacturer shall prepare a complete compliance with the Specification. Any exception shall be included in the compliance statement with an explanation, clearly indicating the paragraph of the Specification to which the exception applies, and concisely stating the reasons.

3 Unless clearly identified as an exception, the Specification shall have precedence where there is conflict between Manufacturer descriptive information and the Specification.

4 The drive manufacturer shall have a proven operation for the proposed drive and active harmonic filter/if provided in the sewage treatment plants or sewage pumping stations (or similar applications –subject to Engineer's approval) for more than 10 years.

34.2 SYSTEM DESCRIPTION

34.2.1 Description

1 The VFD System (VFDS) shall consist of the following main components: Isolation breaker, Drive Isolation Transformers, Medium voltage Variable Speed Drives (VFDs), Output Sine Filter, and any necessary power factor correction or harmonic filter components if required to meet this Specification.

2 The VFD manufacturer shall provide a dedicated fused contactor or circuit breaker (Hereto called Input Isolation Switchgear); rated to protect the VFD from specified short-circuit levels. The Input Isolation Switchgear shall be controlled by the VFD. The VFD doors shall be interlocked to prevent opening when main power is available.

3 The VFD shall be supplied with 11 kV, 3 phase, 50 Hz power and shall be able operate with +/-6% voltage variation.

4 Auxiliary power 415V, 3 phase, 50 Hz and safe-line power 240V, single phase, 50 Hz will be provided on site from a separated UPS. Alarm of missing Auxiliary power supply shall be provided in the VFD and an indication lamp shall be provided on the VFD door.

5 The variable frequency drive shall control a 3-phase squirrel cage induction motor

6 The drive will be suitable for the motor(s) rated 3300V, 3 phases, 50 Hz and above.

7 The power capacity of the converter shall meet the speed-load curve of the application, even at minimum mains supply voltage. An additional service factor or over-dimensioning of the VFD is not required.

8 The VFD shall be suitable for use with a new or an existing standard squirrel cage motor with 1.0 service factor and standard medium voltage insulation and have dv/dt 10 to 50µsec.

9 The VFD shall control the speed by employing advanced torque control techniques and auto tuning that measure and set all constant and critical parameters of the motor automatically.

10 It will be necessary to conduct field tests to measure the harmonics with all VFDs regardless of whether filters, reactors, chokes etc. are installed or not, running at 100 percent and 50 percent loads for the duration of at least 3 hours under each load condition. If drives don't meet the specified performance, the Contractor shall provide an acceptable solution at no extra cost.

11 The VFD shall be selected based on the following as the main advantages:-

(a) User friendly allowing the operator to configure the VFD at site with ease.

(b) Uniform motor running at all speeds.

(c) Power factor close to unity regardless of the speed of the motor.

(d) High overall system efficiency

(e) No increase of noise in the motor.

12 The VFD shall be arranged to prevent nuisance tripping due to failure of supply for a short duration (transient disturbances).

13 The following indication LED lamps with labels as per the relevant QSC Section 21, shall be provided on the VFD door.

(a) Ventilation fan failure.

(b) VFD General fault.

(c) Run/Stop.

(d) Local/Remote.

34.3 STANDARDS

34.3.1 Codes and Standards

1 The specified Variable Frequency Drive System shall be designed and materials shall be furnished in accordance with the latest revisions of applicable sections of the following Codes and Standards.

IEEE 519 .....Guide for Harmonic Control and Reactive Compensation of Static Power Converters.

IEEE 995 .....Recommended Practice for Efficiency Determination of AC Adjustable Speed Drives.

IEEE C57.12.00 .....General Requirements for Liquid-Immersed Distribution Power and Regulating Transformers.

IEEE C57.12.01 .....General Requirements for Dry-Type Distribution and Power Transformers.

ANSI C57.12.10 .....Transformers – 230 kV and Below 833/948 through 8333/10417 kVA, Single-Phase, and 750/862 Through 60000/80000 kVA with load TAP Changing – Safety Requirements.

ANSI C57.12.51 .....Requirements for Ventilated Dry-Type Power Transformers, 501 kVA and Larger, Three-Phase with High-Voltage 601 to 34500 volts, Low-Voltage 208Y/120 to 4160 Volts.

ANSI C57.12.70 .....Terminal Markings and Connections for Distribution and Power Transformers.

IEEE C57.12.90 .....Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers.

IEEE C57.12.91 .....Test Code for Dry-Type Distribution and Power Transformers.

IEEE C57.18.10 .....Practices and Requirements for Semiconductor Power Rectifier Transformers.

IEEE C57.124 .....Detection of Partial Discharge and the Measurement of Apparent Charge in Dry-Type Transformers.

ENV 50141.....Radio frequency common mode.

EN 55011 .....Suppression of Radio disturbances caused by electrical appliances and systems.

EN 50081-2 .....Electromagnetic compatibility (EMC) (IEC 61000-6-4 Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments)

IEC 146-1-1.....Semiconductor Converters

IEC 529 .....Degrees of protection provided by enclosures (IP Code)

NFPA-70.....National Fire Protection Agency (NFPA) –70 National Electric Code (NEC), latest adopted edition.

NEMA ICS7.1.....Safety standard for construction and guide to selection, installation and operation of Adjustable Frequency Drive Systems.

OSHA .....Standard No. 29 CFR 1910.147 – The standard for control of hazardous energy (Lockout/Tagout).

IEC 1000-4-2.....Electrostatic immunity test; (IEC 61000-4-2 Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test)

IEC 1000-4-4.....Fast transient immunity test; (IEC 61000-4-4 Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test)

IEC 1000-4-5.....Surge immunity test; (IEC 61000-4-5 Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test)

IEC 61800 .....Adjustable speed electrical power drive systems

UL 347.....High Voltage Industrial Control Equipment.

UL 508C .....Power Conversion Equipment

UL 467.....Safety Standard for Grounding Equipment

NEMA.....National Electrical Manufacturer's Association Standard MG1 (1987)

34.3.2 Submissions

1 Shop Drawings: All submittals in accordance with Part 1:

1. Elevation drawings showing dimensional information
2. Structure Descriptions showing
   a. Enclosure ratings

b. Fault ratings
c. Other information as required for approval
3. Conduit locations
4. Unit Descriptions including amperage ratings, frame sizes, trip settings, pilot devices, etc.
5. Nameplate Information
6. Schematic wiring diagrams

34.3.3 Quality Assurance

1 The VFD manufacturer shall have ISO 9001 certification.

2 The VFD manufacturer shall be able to provide start-up service, 24 hour/day emergency call service, repair work, maintenance and troubleshooting training of customer personnel.

3 VFD converter shall be UL listed/EC certified.

4 The VFD shall be factory pre-wired, assembled and tested as a complete package by the VFD supplier. Customer specific drive, motor, and application data shall be pre-loaded into the operator interface and tested prior to shipment.

5 All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system. This system must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.

6 All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.

7 All sub-assemblies shall be inspected and/or tested for conformance to Supplier's engineering and quality assurance specifications.

8 All printed circuit boards with active components shall be burned-in per the manufacturer's standards.

9 Third party manufacturers and brand labeling shall not be allowed.

34.3.4 Warranty

1 The drive shall be warranted by the manufacturer for a minimum of three years from the date of commissioning in PWA name.

34.4 PRODUCTS

34.4.1 Ratings

1 The VFD shall convert 11k V - 3 Phase - 50 Hz, power to an adjustable voltage and frequency for controlling the speed of the pump. The output voltage shall vary proportionally with the output frequency to maintain a constant volts/hertz value up to a nominal frequency. Above nominal frequency, the output voltage shall remain constant.

2 The drive shall be designed to operate in ambient temperature between 0°C and 50 °C with a relative humidity of up to 95 % (non-condensing).

3 The drive shall be capable of being stored at a temperature between -0 °C and 70 °C.

4 The drive shall be capable of operating at altitudes up to 200 meters above sea level.

5 The drive shall be capable of operating at a minimum efficiency of 95% at full load and full speed

6 The incoming line power factor shall range between 1.0 and 0.95, lagging, over the entire operating speed range.

34.4.2 Design Characteristics

1 VFD

(a) Converter shall be offered with minimum 18 Pulse or higher to mitigate Harmonics generated at the line side and shall confirm to IEEE 519-1992 standards

(b) The VSD shall have a fixed and alternatively variable V/f curve characteristic suitable for the required application.

(c) The VSD shall be capable of varying the motor speed from a maximum speed at full load and at any intermediate speed down to 10% full load speed.

(d) The drive shall be designed to be selectable for variable or constant torque. When selected for constant torque, the drive shall supply 150% of rated current for up to one minute. When selected for variable torque the drive shall supply 110% of rated current for one minute every 10 minutes.

(e) The rectifier shall make use of three phase Rectifier Bridge consisting of diodes for power conversion from AC to DC. The inverter section shall use latest IGCT or non-transistor based modules for minimal loss, high speed switching and very low harmonics.

(f) The VFD shall be trouble free operation.

(g) The VFD shall have a fuse less design, which detects failures and acts within 25 microseconds. The device should be non-rupture type.

(h) VFDs, using electrolytic high voltage capacitors or fuses, are not acceptable.

(i) The manufacturer shall not use any control or power components that require replacement before 50,000 hours of operation minimum.

(j) The Mean Time Between Failure (MTBF) of the VFD shall be greater than 50,000 hours minimum. All components of the VFD shall be considered for MTBF calculations.

(k) The calculated Availability of the VFD shall be greater than 99.95%. The Availability shall be calculated based on the expected downtime due to corrective and preventive maintenance.

(l) The VFD shall be capable of continuous operation (“ride-through”) in the event of a power loss of up to 1 second or more. The time limit shall be defined by the load inertia and not by the VFD’s capability.

(m) The VFD shall be able to safely operate, without tripping, at down to 30% under voltage of the mains supply.

(n) The drive shall be a medium voltage VFD system. All power semiconductors and passive power components in both the rectifier and inverter part shall be medium voltage rated components. Low voltage components are not acceptable in the power part sections

(o) The drive must be capable of switching on to a motor already rotating in either direction.

(p) The starting arrangement must include a ramp speed control, to achieve starting currents not exceeding normal full load current.

(q) The drive shall make use of medium voltage semiconductor power devices. Cascading of low voltage power devices is unacceptable.

(r) Drives rated >1MW shall be of water-cooled type. The secondary cooling system shall include chiller and running TSE (Treated Sewage Effluent); in duty/standby mode.

2 Drive Isolation Transformer

(a) A drive isolation transformer shall be furnished to provide power conversion from the 11 KV line voltage to the required VFD voltage and to isolate the line from harmonics and common mode voltages. The transformer shall conform to ANSI/IEEE C57.

(b) The transformer shall be designed to withstand a short circuit. It shall maintain electromagnetic symmetry when only one secondary winding is in short circuit in order to minimize the resulting short circuit forces. The transformer shall be capable of thermally withstanding a short circuit for 2 seconds.

(c) Transformers shall be of a high efficiency type with full load losses of less than 2%.

(d) Transformer winding material shall be copper.

(e) Suitable vibration dampers shall be provided with the transformer and its enclosure in order to attenuate mechanical resonance and to reduce the operational sound level.

(f) The cable distance between the VFD and Drive Isolation transformer shall be designed for up to 50 m minimum.

(g) The transformer shall include electrostatic shielding between the windings to carry high frequency capacitive currents to ground.

(h) Transformer designs shall be indoor / outdoor, mounted dry type /ONAN type.

(i) Only Rectifier grade K-factor transformers shall be utilized, with K-Factor of 6 for diode rectifiers. VFD manufacturers providing SCR type rectifiers shall include K Factor of 12 transformers for variable torque applications and K Factor of 20 for constant torque applications.

(j) Dry type transformers shall be protected with an over-temperature protection, and any other protections as per the relevant standards, device with alarm and trip contacts and subject of Engineer's approval

(k) Liquid cooled transformer / ONAN shall be equipped with an oil level indicator, an overpressure device (Buchholz or overpressure relay) and a top oil thermometer with alarm and trip contacts and subject of Engineer's approval.

(l) Each primary winding shall be provided with taps, adjustable in a range of +/-2.5% and +/-5% above and below nominal voltage. All taps shall be full capacity, no load type lockable type.

(m) If a dry type transformer is provided, the transformer shall be of Temperature Class 180°C and average winding temperature rise of 115°C.

(n) If a liquid cooled transformer / ONAN is provided, the transformer shall have an average temperature rise of 60°C for the oil and 65°C for the windings.

34.4.3 Control System

1 The VFD shall have a sensorless vector torque control or Direct torque control algorithm with static speed error of less than 0.2% and open loop torque step rise time under 10 milliseconds

2 Unless specified, the VFD shall not require the use of a tachometer.

3 The VFD shall be able to catch and take control of a spinning load if started while rotating equipment is already spinning. Appropriate safeguards shall be included in this operation to prevent damaging torque excitations, voltages or currents from impacting any of the equipment. The user shall have the option of employing this feature or disabling it.

4 The VFD to provide an automatic current limit feature to control motor currents during startup and provide a “soft start” torque profile for the motor-load combination. Current and torque limit adjustments shall be provided to limit the maximum VFD output current and the maximum torque produced by the motor.

5 The VFD shall accept a start/stop command and speed reference from a local VFD panel, or from a remote panel.

6 The VFD shall have the capability to avoid up to five critical operating ranges. The critical operating ranges (skip frequencies) shall have selectable bandwidth, configurable via the operator interface

7 Upon restoration of power following a power loss, if the VFD status is healthy, the VFD shall be capable of re-starting upon receiving a start signal from the main processor.

8 The VFD shall be capable of passing through a momentary power outage of 3 cycles without causing the drive to trip.

9 The modulating control scheme shall closely approximate actual sine wave current throughout the speed range of the drive. The frequency resolution of the VFD shall be 0.01Hz.

10 Each VFD shall be equipped with a front mounted operator control panel consisting of a back lighted alphanumeric display and a keypad with the functions:

(a) Run/Stop command including indication lamps on the door.

(b) Local/Remote command including indication lamps on the door.

(c) Increase/Decrease command

(d) Forward/Reverse command

(e) Menu navigation and parameter selection

11 All parameter names, fault messages, warnings and other information shall be displayed in plain text to allow the user to understand what is being displayed without the use of a manual or cross-reference table. A display contrast adjustment shall be provided to optimize viewing at any angle.

12 During normal operation, the speed reference, and run/stop forward/reverse and local/remote status shall be displayed. At least 3 additional user selectable analogue values shall be available for display including the following values as a minimum:

(a) Motor speed, current and power.

(b) Output frequency, voltage and torque

(c) DC bus voltage.

(d) Cooling air or water temperature.

(e) Status of discrete inputs and outputs.

(f) Values of analog input and output signals.

13 Password protection shall be provided for prevention of unauthorized parameter access.

14 If specified, hardware inputs and outputs shall be provided to interface with external operator and supervisory control and monitoring equipment. The following galvanically isolated I/O points shall be included:

(a) Analogue inputs shall be 4 - 20 mA. Analogue input signals processing functions shall include scaling adjustments, adjustable filtering and signal inversion. Analogue signal functions shall include speed reference signals.

(b) Discrete (binary) inputs shall be designed for 24 VDC. Discrete input functions shall include ‘run/stop’ and ‘remote reset’.

(c) Analogue outputs shall be 4 to 20 mA signals. Analog outputs shall be programmable to provide signals proportional to at least output motor speed and current.

(d) Relay contact outputs shall be rated to switch in minimum 6 A at 24 VDC or 250 VAC. Function selections shall include ‘VFD ready’, ‘running’, ‘alarm’ and ‘trip’ indications.

15 The VFD output frequency shall be controllable between 0 – 66 Hz.

16 The VFD memory shall retain and record, run and fault status with a minimum of 8 last fault conditions.

17 The VFD cubicle shall be provided with additional control and accessories if any are deemed necessary to meet the operating logic as described in the particular requirement.

18 The VFD shall include any additional protective features not detailed in the specification but recommended by the manufacturer in order to avoid damage to the VFD or Motor.

19 The drive shall facilitate configurable controlled-stop (within a maximum of 30 sec.) of motor & load without causing any damage or tripping of the Drive.

34.4.4 Controller Keypad

1 The VFD shall be provided with a unit mounted but detachable LCD display unit, provided with a three meter length of cable, suitable for mounting on the cubicle door. The VFD shall allow the program stored in one drive to be copied to another drive by using the display unit and supplied software. Interconnecting cables and associated accessories together with a user manual must accompany the VFD.

2 The VFD shall include any additional protective features not detailed in the specification but recommended by the manufacturer in order to avoid damage to the VFD or Motor

3 All parameters shall be password protected to prevent tampering and unauthorised changes.

34.4.5 Communications Interface

1 The drive shall incorporate an RS 485 serial communications interface to allow full drive control, programming, monitoring and diagnostics, including access to history record.

2 The VFD shall be provided with communication interface and facility to integrate the operation of the system. The facility employing communication protocols e.g. profibus, modbus etc. shall be compatible with other system equipments such as the PLC, RTU etc.

3 The Contractor shall provide a suitably sized programming device (laptop) complete with all necessary connection cables, software and licenses for configuration and maintenance of the VFD's.

34.4.6 Fault Detection

1 The drive shall keep a record of the last ten trips, plus a 100 sample history record of up to ten pre-defined parameters to enable fast diagnosis and minimum down time. Automatic printout of history record to a serial printer shall be an available feature.

2 The VFD shall have a programmable fold back function that will sense a controller/motor overload condition and fold back the frequency to avoid a fault condition.

3 A dedicated microprocessor based electronic motor protection system to be provided for the protection of the motor.

4 The VFD shall be protected against short circuit between output phases and ground, analogue outputs and logic circuit.

5 For each programmed warning and fault protection function, the VFD shall display a message in complete English words or Standard English abbreviations. At least 40 time tagged fault messages shall be stored in the drive's fault history

6 In order to guarantee correct fault indications and trip sequence in the event that auxiliary power source feeding the drive is lost, the drive system processor shall be connected to an uninterrupted Power supply source (either within the drive or provided externally) to supply control power for display and signals.

34.4.7 Protection Features

1 For personal safety reasons all power capacitors have to be hard grounded (mechanical interlock), before accessing any MV section of the VFD. The grounding has to be mechanically and electrically interlocked with the cabinet doors. It shall be only possible to open the doors when the capacitors are grounded.

2 For each programmed warning and fault protection function, the VFD shall display a message in complete English words or Standard English abbreviations. At least 40 time tagged fault messages shall be stored in the drive's fault history.

3 An Emergency-stop push button (E-Stop) shall be provided on the VFD door and one additional remote located near the motor shall be provided.

4 The VFD shall provide input phase loss protection.

5 The system offered shall incorporate adequate protection and alarms properly coordinated by the Vendor for the drive control and for motor but not limited to the following :

6 The drive shall be protected against supply-phase loss and mains discontinuity.

7 The drive shall have a selectable auto-restart after trip.

8 The drive shall be designed to shut down with no component failure in the event of any of the above fault conditions arising.

(a) Main Drive Motor & Supply Cables

(i) The Motor Phase Loss

(ii) Short Circuit in the Rectifier Bridge

(iii) Supply Phase Loss

(iv) Overload of the Inverter.

(v) Short Circuit of the Inverter

(vi) Battery Test if applicable

(vii) Communication Fault

(viii) External Motor Protection Trip

(ix) External Transformer Protection Trip

(x) Process Stop

(xi) External Emergency Off

(xii) Overcurrent (through current control limiter)

(xiii) Overvoltage

(xiv) Phase unbalance/Single phasing

(xv) Earth fault

(xvi) Locked Rotor

(xvii) Overspeed – 105% / Under speed – 95%

(xviii) Over temperature in stator through Motor model

(xix) Line breaker tripped

(xx) Cooling medium temperature high

(xxi) Loss of one cooling system in case of redundant cooling system

(b) Following minimum control are envisaged on front of the panel unless otherwise specified.

(i) Start/stop

(ii) Speed control

(iii) Raise/lower

(iv) Forward/Reverse

(v) Auto/Manual mode

(vi) Local/Remote.

(vii) Emergency stop

(c) The system shall monitor the status of the following and provide indications.

(i) Drive on

(ii) Drive off

(iii) Motor over speed

(iv) System ready to start

(v) Remote breaker trip

(vi) Ventilation fan failure.

(vii) VFD General fault.

(d) Fault Annunciation Display of forty maximum previous faults shall be provided with a minimum of the these features

(i) Inverter overload

(ii) Inverter high temperature

(iii) No cooling of panel/motor

(e) Following control / metering shall be provided on local control panel.

(i) ON/OFF push button

(ii) Speed Raise/Lower push button

(iii) Emergency stop push button

(iv) Local/remote selection indication

(v) Speed indicator

(vi) Ammeter

(vii) ON/OFF indication

(viii) Drive ready to start indication

34.4.8 Emergency Stop Control

1 An Emergency-stop (E-Stop) shall be provided on the VFD door in addition to inputs for customer supplied E-Stop command to ensure effective direct stopping of the drive if dangerous situations arise. The means provided should include direct connection to an Breaker, arranged such that its opening on-load:

(a) does not inhibit any in-built deceleration provided by the variable speed controller

(b) does not produce additional safety hazards

(c) does not cause damage to the controller.

34.4.9 Drive Enclosures

1 The converter and inverter section shall be suitably housed in sheet steel panels and shall be fabricated with 2 mm thick cold rolled sheet steel and structural steel. The panel shall be suitable for indoor installation if not otherwise specified. The panel shall be free standing, dust and vermin proof and degree of protection IP- 4X for air cooled or for water cooled if not otherwise specified. The cabinet shall be riveted/welded type construction to provide effective protection against Electromagnetic emissions.

2 The followings minimum thickness shall apply:.

(a) Plinth/bed frame - 3.00 mm

(b) Frames - 2.00 mm

(c) Covers and Doors - 2.00 mm

(d) Gland Plate - 3.00 mm

3 The VFD Converter shall require front access only.

4 The VFD Converter enclosure doors shall include an electromechanical interlocking system with a safety grounding switch. The enclosure doors can be opened only if the safety ground switch connects all DC buses to ground, to ensure all stored VFD and motor energy is discharged before opening any medium voltage compartment door.

5 The Output Sine Filter, Input Harmonic Filter and Power Factor Correction filter, if required, shall be factory mounted and wired into the Converter enclosure.

6 All painted surfaces shall be (ZINTEC) and must have a minimum of priming coat, undercoat and finishing coat. The undercoat and finishing coat shall be stove enamelled. The exterior shall be green to BS 4800, shade 14E53. Interior surfaces shall be white painted or shall be bright (unpainted) galvanized steel.

7 All bus bars shall be copper and corrosion protected.

8 The enclosure must be designed to avoid harmonic and inductive heating and eliminate radio frequency interference.

9 VFD noise level shall be less than 85 dB(A) for air cooled and less than 70 dB(A) for water cooled drives at 3 feet distance.

10 Anti-condensation heaters shall be provided with a thermostat and humidistat and have OFF/AUTO control on the cubicle front door. The heater shall not be in operation when the inverter is functioning.

11 The VFD shall be of Fuse less design.

12 All panels shall be same height so as to form a bank, which shall give good aesthetic appearance.

13 All the control wiring shall be enclosed in plastic channel. Each wire shall be identified at both ends by wire marker tapes or PVC ferrules.

14 Power and control wiring inside the panel shall be done with PVC insulated copper conductor.

15 All Power modules and components shall be accessible from front of panel only.

16 PCB construction shall be rigid and robust. Components shall be wave soldered to the PCBs. Each component on the board must be clearly identified.

17 Suitable lifting hooks shall be provided for lifting the panel.

18 All FVD components shall be individually provided with identification engraved label.

34.4.10 Factory Witness Inspections

1 Where specified in the tender documents, the stand-alone Drive (VFDs) shall be witness tested at the manufacturing facilities in the presence of Engineer and/or his representative. The detailed and complete Factory Acceptance testing procedure including the testing sheets shall be subject of Engineer's approval, and shall be approved by the Engineer 30 days before FAT dates are proposed. Internal test reports shall be provided to Engineer before the FAT test is performed.

2 The VFD shall be tested at 25%, 50% and 100 % load, minimum 3 hours recording the temperature rise.

3 The VFD System shall undergo standard manufacturing testing and as approved by the Engineer.

4 Each VFD shall be factory 100% load tested with a similar induction motor size on a dynamometer test stand at manufacturing facilities.

5 The FAT inspection procedure shall be submitted to Engineer for approval, and approved 30 days before performing the FAT witness test at manufacturing facilities.

6 Internal Factory test report shall be provided before preparation of the FAT witness date.

7 It will be necessary to conduct field tests to measure the harmonics with all VFDs regardless of whether filters, reactors, chokes etc. are installed or not, running at 100 percent and 50 percent loads for the duration of at least 3 hours under each load condition. If drives do not meet the specified performance, the Contractor shall provide an acceptable solution at no extra cost.

34.5 INSTALLATION

34.5.1 Documentation

1 The following documentation shall be provided:

(a) load de-rating (with tender)

(b) harmonic distortion (with tender)

(c) circuit diagrams

(d) maintenance instructions

(e) fault diagnosis

(f) parts list with part numbers

(g) commissioning instructions

(h) general arrangements drawings

2 A recommended spares list for two years continuous operation shall be submitted at the time of tender. Where multiple, identical units are being supplied a rationalised list, i.e. not a summation of individual drives, requirements, should be produced.

34.5.2 Commissioning

1 The manufacturer of the drive system shall have a factory trained service representative residing in the Qatar for commissioning, programming and to provide training and after sales service.

2 The representative shall be trained in the installation, maintenance and trouble-shooting of the equipment specified and shall assist the Contractor to set-up and commission the variable speed motor drives and controls.

3 System validation tests shall be performed on all VSD's.

4 The integrated site test on the VFD, motor and all other associated devices shall be conducted to verify the input and output current, voltage, frequency, power factor, acceleration and deceleration rate etc. in accordance with the operating characteristics as approved by the Engineer.

5 Test VFD at different operating conditions by adjusting parameters (25, 50, 75 and 100%). Record the performance and verify.

6 The power system shall be tested for harmonics, line notching and for RFI/EMI in cable circuits and in the air.

7 Tests shall be performed during normal plant operation and during operation with the emergency generator.

8 The test results so obtained shall be used to calculate the Total Harmonic Distortion (%THD) and compare the same with IEEE 519

9 The manufacturer's engineer or their trained and qualified engineer working full time with the local supplier shall conduct all tests on site.

10 Upon completion of site tests a duly signed report listing all tests and checks, together with all supporting documents and drawings where applicable, shall be submitted to the Engineer for review. The Owner's representative shall be invited to witness the tests.

11 Submit all test reports, drawings and supporting documents to the Engineer and obtain written approval from both prior to the system being accepted by the Owner.

34.5.3 Maintenance Data

1 Submit the following documents:-

1. Variable frequency drive installation instructions and User Manual
2. Installation / Operation instructions for major components such as circuit breakers, contactors, isolation transformers, etc.
3. Drive Parameter Listing

4. Field Service report from drive start-up service
5. Variable Frequency spare parts listing and pricing
6. Include name and phone number for a local distributor for the spare parts.

34.5.4 Training

1 Site Training. The AC drive manufacturer shall provide an on-site training program for the operating personnel of minimum 7 working days. This program shall provide operating and instruction manuals, training in equipment operation, and troubleshooting of the AC drive. The training program shall include, but not be limited to:

(a) Instruction on the basic theory of pulse width modulation control

(b) Instruction on the layout of the variable frequency controller indicating the location and purpose of each component

(c) instruction on troubleshooting problems related to controller

(d) installation and removal of printed circuit boards

(e) actions to take under failure of controller

(f) necessary cleaning of component parts.

Factory training. Duration of training program shall be minimum 10 days for two client persons at the manufacturing facilities. The training shall include:

(a) Theory of operation

(b) Layout and component level study

(c) Hands-on training on assembly & configuration of the drive

(d) Installation & commissioning procedures

(e) Hands-on training on trouble shooting and working with various components

(f) Routine maintenance practices

(g) Spare part ordering & inventory control.

END OF PART