

[PROJECT NUMBER]  
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ROCKWELL AUTOMATION

PROCUREMENT SPECIFICATION

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**PROCUREMENT SPECIFICATION**  
**PowerFlex® 6000T Medium Voltage**  
**AC Variable Frequency Drive -**  
**IEC/CE Version, Air-Cooled,**  
**0...680 A**

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SECTION XX XX XX

**MEDIUM VOLTAGE AC VARIABLE FREQUENCY DRIVE —  
AIR-COOLED**

PART 1 GENERAL

1.01 SUMMARY

- A. The Variable Frequency Drive (VFD) system shall contain all components required to meet the performance, protection, safety, and certification criteria of this specification.

1.02 RELATED SECTIONS

- A. Section 26 00 00 – Electrical – General Provisions
- B. Section XX XX XX

1.03 CERTIFICATIONS/REFERENCES

- A. IEEE 519 Electrical and Electronics Engineers Institute Harmonics Control Requirements
- B. IEC 60146 Semiconductor Converters – Specification of Basic Requirements
- C. IEC 60038:1983 IEC Standard Voltages
- D. IEC 60050-151:2001 International Electro technical Vocabulary, Chapter 151: Electrical and Magnetic Devices
- E. IEC 60050-551:1999 International Electro technical Vocabulary, Chapter 551: Power Electronics
- F. IEC 60076 Electric Power Transformer
- G. IEC 61378-1: Converter Transformers- Part 1: Transformers for Industrial Applications
- H. IEC6378-3: Converter Transformers- Part 3: Applications Guide
- I. IEC 60721-3-1:1997 Classification of Environmental Conditions, Part 3: Classification of Groups of Environmental Parameters and their Severities. Section 1: Storage
- J. IEC 60721-3-2:1997 Classification of Environmental Conditions, Part 3: Classification of Groups of Environmental Parameters and their Severities
- K. IEC 60721-3-3:2008 Classification of Environmental Conditions, Part 3: Classification of Groups of Environmental Parameters and their Severities. Stationary Use at Weather-protected Locations
- L. IEC 61000-2-4:2002 Electromagnetic Compatibility (EMC), Part 2, Environment, Chapter 4: Compatibility Levels in Industrial Plants for Low Frequency Conducted Disturbances
- M. IEC 61000-4-7:2002 Electromagnetic Compatibility (EMC) Part 4: Testing and Measurement Techniques, Chapter 7: General Guide on Harmonics and Inter-harmonics Measurements and Instrumentation, for Power Supply Systems and Equipment Connected Thereto
- N. IEC 61800-3:2004 Adjustable Speed Electrical Power Drive Systems, Part 3: EMC Requirements and Specific Test Methods
- O. IEC 61800-4:2004 Adjustable Speed Electrical Power Drive Systems, Part 4: General Requirement – Rating Specifications for AC Power Drive Systems above 1000V AC and Not Exceeding 35 kV

- P. IEC 60757-1983 Code for Designation of Colors
- Q. IEC 106:1989 Environment Condition Guides for Specifying Performance Rating of Equipment
- R. IEC 61508.1-7 Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems

#### 1.04 PRE-MANUFACTURE SUBMITTALS

- A. Submittals shall be made under provisions of Section 01 30 00.
- B. Shop Drawings – for approval – shall include:
  - 1. Elevation drawings, with dimensional information
  - 2. Structure descriptions, with enclosure ratings, fault ratings, other information as required for approval
  - 3. Conduit locations
  - 4. Unit descriptions, with amperage ratings, frame sizes, trip settings, pilot devices
  - 5. Nameplate information
  - 6. Schematic wiring diagrams
- C. Product Data Sheets and Publications shall include:
  - 1. VFD system publications
  - 2. Data sheets and publications on all major components
  - 3. Spare parts lists of critical spares and maintenance spares
- D. Test procedures shall be per the manufacturer's standards.

#### 1.05 CLOSEOUT SUBMITTALS

- A. Submittals shall be made under provisions of Section 01 30 00.
- B. Certification shall be provided by the supplier that:
  - 1. The VFD has been installed in accordance with the manufacturer's instructions
  - 2. The supplier has adjusted any timing devices required in the starting circuitry
- C. Shop drawings shall be final as shipped and updated by supplier to reflect any field modifications.
- D. Operation and maintenance data shall include:
  - 1. VFD installation instructions and user manuals
  - 2. Major component installation instructions and user manuals
  - 3. VFD parameter listing
  - 4. Spare parts lists

#### 1.06 QUALITY ASSURANCE

- A. All inspection and testing procedures shall be developed and controlled under the guidelines of the supplier's quality system and must be registered to ISO 9001 and regularly reviewed and audited by a third party registrar.
- B. The VFD shall be factory pre-wired, assembled, and tested as a complete package.
- C. The VFD manufacturer shall:

1. Have a minimum of 10 years' experience in the manufacture of medium voltage variable frequency drives for use in similar applications at the specified voltage and power ratings. A user list, complete with contact names and telephone numbers, shall be furnished upon request.
2. Have at least a 10-year record of service and own and operate factory-trained and authorized service facilities located within 100 miles of the project. Support personnel shall be direct employees of the manufacturer.

#### 1.07 DELIVERY, STORAGE, AND HANDLING

- A. The supplier shall coordinate the shipping of equipment with the manufacturer
- B. The supplier shall store the equipment in a clean and dry space at an ambient temperature range of -25°C to 55°C (-13°F to 131°F)
- C. The supplier shall protect the units from dirt, water, construction debris, and traffic
- D. During storage, the supplier shall connect internal space heaters [if specified] with temporary power

#### 1.08 WARRANTY

- A. The manufacturer shall provide its standard parts warranty for eighteen (18) months from the date of shipment or twelve (12) months from the date of being energized, whichever occurs first.
- B. This warranty applies to variable frequency drive systems.

### PART 2 PRODUCTS

#### 2.01 MANUFACTURERS

- A. Allen-Bradley / Rockwell Automation – PowerFlex 6000 Medium Voltage AC Variable Frequency Drive (No substitutions)

#### 2.02 RATINGS

- A. The variable frequency drive (VFD) shall be designed to accept input voltage of 3/3.3 kV, 4.16 kV, 6/6.6 kV, or 10/11 kV at 50/60 Hz with  $\pm 10\%$  voltage tolerance.
- B. The VFD shall operate on an externally supplied control voltage of 120V/240V 60 Hz or 110V/220V 50 Hz, single-phase (1.5 kVA) with Branch Circuit Protection. In the event of loss of control power from customer, power will switch to the tertiary winding of MV transformer.
- C. The VFD shall have a power rating that matches the driven load as shown on the electrical drawings. The VFD supplier shall coordinate with the motor manufacturer and the manufacturer of the driven equipment to ensure the VFD is sized to run at the full load rating of the equipment without overload or VFD failure.
- D. The combined efficiency of the VFD and isolation transformer system shall be a minimum of 96% at 100% speed and 100% load, including loss calculations for control power supplies, control circuits, and cooling components.
- E. The overload capacity shall be:
  1. Normal Duty– minimum 110% for 1 minute, every 10 minutes
  2. Heavy Duty– minimum 150% for 1 minute, every 10 minutes

Normal Duty and Heavy Duty VFDs shall both be capable of either variable torque or constant torque operation.

- F. The VFD shall have an output frequency range of 1 to 75 Hz.
- G. The VFD shall be designed to operate in the following environmental conditions:
  - 1. Ambient temperature range – 0°C to 40°C (32°F to 104°F), 0°C to 50°C (32°F to 120°F) with derating
  - 2. Relative humidity range – 0% to 95% non-condensing
  - 3. Elevation – up to 1000 m (3300 ft.), 1000-5000 m (3300-16,400 ft.) with derating
- H. The maximum audible noise from the VFD shall comply with OSHA standard 3074, Hearing Conservation, which limits noise level to 80 dB(A) at a distance of 1 m (3.3 ft.) from the front of the equipment (with doors closed at any speed or load condition). [for VFDs rated from 0-215A]
- I. The maximum audible noise from the VFD shall comply with OSHA standard 3074, Hearing Conservation, which limits noise level to 85 dB(A) at a distance of 1 m (3.3 ft.) from the front of the equipment (with doors closed at any speed or load condition). [for VFDs rated from 215A-680A]
- J. VFDs shall comply with the latest edition of IEEE 519 Harmonic Guidelines.

## 2.03 CONSTRUCTION

### A. SYSTEM COMPONENTS

- 1. The VFD system shall use Voltage Source Inverter (VSI) topology - Cascaded H Bridge (CHB) and shall include the VFD unit and integrated components:
  - a) Enclosures
  - b) Cabling
  - c) Multiphase Isolation Transformer
  - d) Multi-Pulse Rectifier
  - e) Power Modules
  - f) Cooling System
  - g) Output dv/dt Filtering [Option for motor cable greater than 800 m (2625 ft.)]
  - h) Monitoring Hardware
  - i) Motor Space Heater Control [Option]
  - j) Operator Interface
- 2. The VFD system shall be designed for:
  - a) Minimum availability of 99.9%
  - b) Mean Time Between Failures (MTBF) of 100,000 hours
  - c) Minimum life expectancy of 20 years

### B. ENCLOSURES

- 1. VFD enclosures shall be air-cooled.
  - a) The enclosure rating shall be minimum IP31. An IP42 rating shall also be available [Option].

- b) Door filters shall be removable from the front while the VFD is running. They shall be washable and made of flame-retardant material.
  - c) Cabinet doors shall be gasketed to provide environmental protection and secure fits.
  - d) The converter cabinet door and cabling cabinet door shall be electrically interlocked with up-stream circuit breaker. Interlocking shall be fully coordinated to prevent access to all medium voltage compartments. [Option].  
A mechanical key interlock shall be available. [Option].
2. The VFD system shall be designed for front access to allow for installation with no rear access.
  3. Total paint thickness for VFD finish shall be 0.002" (0.051 mm) minimum.
    - a) Exterior metal parts shall be painted with epoxy powder paint, Sandtex Light Grey (RAL 7038), and Black (RAL 8022).
    - b) Metal back plates in the power cell and low voltage compartments shall be painted High Gloss White (RAL 9003) for high visibility.
    - c) Unpainted steel parts shall be plated with zinc plate/bronze chromate process for corrosion resistance.
  4. A thermostatically controlled enclosure space heater shall be available to be powered from an external source. [Option]

#### C. CABLING

1. The VFD system shall contain a power cable termination assembly designed for easy termination and access to line and load cables. The termination assembly cabinet shall allow for top and bottom entry and exit of line and load cables.
2. A low voltage wire way shall be provided at the top front of the VFD.
3. All power and control terminations and termination strips shall be identified in accordance with all schematics and wiring diagrams.
4. A control wiring quick connector shall be provided for connections between shipping splits to ensure fast site installation

#### D. MULTIPHASE ISOLATION TRANSFORMER

1. The phase-shifting isolation transformer shall be integrally mounted in the VFD enclosure.
2. The isolation transformer thermal protection shall be done using an internal RTD monitoring system that directly interfaces with the firmware and user interface for monitoring and annunciation of alarm and trip conditions.
3. The isolation transformer shall provide power to the VFD cooling fans through a tertiary isolation transformer winding. No external fan power shall be required.
4. The isolation transformer cabinet cooling system shall be monitored continuously for proper operation.
5. Surge arrestors shall be provided at the primary side of the isolation transformer.

#### E. MULTI-PULSE RECTIFIER

1. The VFD system shall have a multi-pulse rectifier with a rectifier-duty phase-shifting isolation transformer to ensure lower line-side harmonics.
2. Rectifier configurations shall have the following minimum pulse number:

- a) 18-pulse for 3/3.3 kV.
- b) 24-pulse for 4.16 kV.
- c) 30-pulse for 6 kV.
- d) 36-pulse for 6.6 kV.
- e) 48-pulse for 10 kV.
- f) 54-pulse for 11 kV.

#### F. POWER MODULES

1. The VFD system shall use Pulse Width Modulated (PWM) power modules. IGBTs in the inverter switches allow higher switching frequencies and minimize switching losses.
2. All power cells shall be composed of:
  - a) Input power fuses
  - b) Three-phase diode rectifier
  - c) DC bus capacitor network
  - d) Single-phase IGBT inverter
  - e) Output terminals
  - f) Power cell bypass circuit [Option]
3. Power cells up to and including 350A shall be fixed-mounted.
4. Power modules shall be designed for easy removal and replacement in 15 minutes for fixed-mounted, 30 minutes for draw-out.

#### G. COOLING SYSTEM

1. VFDs shall be air-cooled and shall be provided with top-mounted cooling fans to ensure sufficient cooling of the power modules.
  - a) Cool air shall be drawn into the enclosure through vents in the power module doors and exhausted through the top of the enclosure.
  - b) If a fan fails, the system shall generate warning indication of the fan failure.
2. The VFD shall be equipped with a redundant fan cooling system with either automatic switchover in the event of a fan failure or automatic cyclic operation. [option]
3. An air ducting interface shall be made for ducting VFD exhaust air outside the control room. [Option]
4. The main VFD and isolation transformer cooling fans shall be Eco design per the following standards:
  - a) ErP directive 2015/125/EG
  - b) EC Regulation 327.

#### H. OUTPUT FILTERING

1. The VFD shall accommodate a motor cable distance of up to 800 m (2625 ft.) without requiring an output dv/dt filter.
2. An output dv/dt filter shall be supplied to accommodate a motor cable distance of greater than 800 m (2625 ft.) [Option]



I. MONITORING HARDWARE

1. The VFD shall provide a control power monitoring system for all power supply voltages and signals.
2. A diagnostic feedback system shall allow for continuous control of the power devices as well as constant monitoring of the power devices health and over temperature status. Fiber optic interface boards shall be used to provide this gating and diagnostic feedback signals for the power semiconductor devices.
3. A High speed digital control system shall continuously monitor all hardware and software faults including sensing of input and output power circuit voltages and currents as well as any internal equipment faults. Field-programmable gate arrays (FPGA) and Central Processing Units (CPU) shall be utilized on VFD control boards to provide high speed handling of diagnostics and fault handling routines.
4. Motor temperature monitoring shall be provided as an option. Monitor shall use I/O modules and shall monitor up to 12 two or three-wire RTD or thermocouple inputs.

J. MOTOR SPACE HEATER CONTROL [Option]

1. The VFD shall provide an option for a motor space heater control circuit in the LV panel, to energize the motor heater whenever the motor is not running. Power shall be provided from a separate source.

K. OPERATOR INTERFACE

1. Pilot devices shall be mounted on the enclosure door. The system shall include:
  - a) LOCAL/REMOTE or LOCAL/REMOTE/DCS selector switches [Option] for START-STOP control and speed reference.
  - b) START, STOP, EMERGENCY STOP and JOG pushbuttons. [Option]
  - c) LED pilot lights for indication of DRIVE READY, SYSTEM READY, RUNNING, FAULT, FORWARD, REVERSE, and ALARM. [Option]
  - d) Speed control potentiometer. [Option]
2. The VFD system shall have a monitoring, control and diagnostics interface – all in an operator interface terminal [Option]. The interface terminal shall have the following minimum features:
  - a) 10" color touch screen
  - b) Logic module with 4Gb of memory
  - c) Windows 10 IoT Enterprise operating system
  - d) Access to executable tools, documentation, troubleshooting, and maintenance
  - e) Monitoring parameters for motor speed, voltage, current, and frequency
  - f) Multi-language capability. Operator interface terminal shall support English, Chinese, French, Portuguese, Spanish, German, Italian, Polish, Korean, and Japanese
  - g) EtherNet/IP communication link
  - h) Extensive diagnostic functions that provide chronological event logging for improved root cause analysis
  - i) Extended use of plain language messages to eliminate the need to look up error codes or decipher the meaning of error messages

- j) Customizable parameter groups for quick configuration and personalized monitoring

#### 2.04 OPERATIONAL FEATURES

- A. The variable frequency drive (VFD) shall be capable of operating a standard AC squirrel cage induction motor (standard AC asynchronous motor) of equivalent power and speed rating over the speed range specified, with near sinusoidal voltage and current waveforms provided to the motor at all speeds and loads.
  - 1. Output current Total Harmonic Distortion (THD) shall be less than 5%.
  - 2. Motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.
  - 3. Inverter-duty motor shall not be required.
- B. The motor insulation shall not be compromised thermally or due to dv/dt stress. Stable operation of the motor shall be provided regardless of motor cable distance.

#### 2.05 CONFIGURATION/PROGRAMMING

- A. The variable frequency drive (VFD) shall be configurable using the operator interface terminal's display.

#### 2.06 COMMUNICATIONS

- A. The variable frequency drive (VFD) shall be capable of communications through standard protocols. EtherNet/IP shall be the preferred network.
  - 1. The VFD shall also support the following protocols through Anybus modules:
    - a) Modbus RTU (RS484)
    - b) Modbus TCP (RJ45)
    - c) Modbus Plus (RS485)
    - d) Profibus DPV1
    - e) Single Port ProfiNet
- B. Add on Profiles (AOP) shall be provided for fast and easy integration into ControlLogix® systems (if ControlLogix control system is being used).

#### 2.07 CONTROL SYSTEM

- A. The variable frequency drive (VFD) control system shall be common across the manufacturer's low voltage and medium voltage product lines.
- B. The VFD shall provide digital interfaces and isolated analog interfaces
- C. Analog interfaces shall be configurable for:
  - 1. Speed reference input (+/- 10V, 4-20mA input signal, configurable)
  - 2. Speed output (0-10V, 4-20mA input signal, configurable)
  - 3. Current output (0-10V, 4-20mA input signal, configurable)
  - 4. Load (kW) output (0-10V, 4-20mA input signal, configurable)
  - 5. Torque output (0-10V, 4-20mA input signal, configurable)

- D. The VFD shall have the following digital interfaces available as standard:
1. Digital inputs, rated at 24Vdc
  2. Isolated Digital Outputs used for power device control and status information rated 5A each.

## 2.08 CONTROL FEATURES

- A. The variable frequency drive (VFD) shall have 3 Motor Control modes for Induction Motor:
1. Induction Volts per Hertz - The V/Hz control mode creates a fixed relationship between output voltage and output frequency.
  2. Induction Sensorless Vector - The SV control mode improves motor performance by regulating the VFD output based on motor characteristics and operating conditions.
  3. Induction Economize - Economizer mode consists of the SV control with an additional energy savings function. When steady state speed is achieved, the economizer becomes active and automatically adjusts the VFD output voltage based on applied load.
- B. The VFD shall offer 2 starting ramp profiles:
1. S-Curve Profile, consisting of both nonlinear and linear portions, programmable from 0 to 100% of ramp time
  2. Two independently programmable acceleration and deceleration times. Each time may be programmed from 0.1...3600 seconds in 0.1 second increments and defines the time for VFD to ramp from 0 to motor nameplate speed.
- C. VFD shall allow following control methods (Speed Reference and Runtime signals)
1. Local/Remote/DCS Control
  2. Local/Remote Control
  3. Auto/Manual Control
- D. Speed Reference Selection  
The speed reference can come from a variety of sources.
1. From Operator Interface Terminal
  2. Analog Input
  3. Preset Speed Parameters
  4. Jog Speed Parameters
  5. Auxiliary Velocity Feedback
  6. Network Communication
  7. Process PID Loop
  8. MOP Reference
  9. DeviceLogix software
- E. VFD shall offer a Motor Operated Potentiometer. This features uses digital inputs to increment or decrement the Speed reference at a programmed rate.

- F. The VFD shall have 2 programmable Jog Speed Commands
- G. VFD shall have built-in PID control for Process control
- H. Preset Speeds - Preset Speeds are discrete speed references that are activated by a digital input function or by Logic Command (sent over a communication network or DeviceLogix). The product shall offer 7 Preset Speeds.
- I. The VFD shall have 3 programmable Skip Frequency speeds with a programmable Skip band.
- J. The VFD shall have programmable stop modes:
  - 1. Ramp Mode
  - 2. Coast Mode
  - 3. Decel to Hold
- K. This product shall include a configurable Power Loss feature following a loss of AC power. The options are: Coast, Decel and Continue as described below:
  - 1. "Coast" mode will immediately disable the VFD and allow the motor to coast.
  - 2. "Decel" mode will decelerate the motor at a rate that regulates the DC bus until the load's kinetic energy can no longer power the VFD.
  - 3. Continue mode will allow the VFD to power the motor until the DC bus level decays below a pre-set limit.
- L. When configured for Coast mode, the VFD shall be capable of automatically restarting in the event of a loss of power. This interval is programmable and shall be adjustable in a range of 0-30 seconds with a default of 2 seconds.
- M. The VFD shall be capable of riding through a loss of power for 5 cycles (depending on load)
- N. The VFD shall be capable operating with a voltage sag down to 70% on the input power line with de-rated capability.
- O. The VFD shall have the option of a Precharge circuit.
- P. The VFD shall comply with IEEE-1566: IEEE Standard for Performance of Adjustable-Speed AC Drives Rated 375 kW and Larger, with optional UPS.
- Q. The VFD shall comply with SEMI-F47 Standard: Specification for Semiconductor Processing Equipment Voltage Sag Immunity, with optional UPS.

- R. The product shall include a Flying Start feature which is used to start into a rotating motor, as quickly as possible, and resume normal operation with a minimal impact on load or speed. The VFD shall be able to detect motor speed either forward or reverse direction and have the capability to ramp in either direction.
- S. Sleep/Wake Mode - This product shall include the Sleep Wake Modes feature in which VFD can be controlled using Analog signals coming from a Customer Process.
- T. The VFD shall provide a comprehensive Energy monitoring functions: kWh, MWh, kVARh, MVARh, kVAh, MVAh, Demand and Projected Power, True and Displacement Power Factor.
- U. The VFD shall offer a programmable Class 1 to Class 60 Motor Overload protection according to NEMA standards.
- V. The VFD shall include the Auto Restart/Auto Reset feature which provides the ability for the VFD to automatically perform a fault reset followed by a start attempt without user or application intervention provided the VFD Run signal is maintained. This enables remote or unattended operation. Only certain faults are allowed to be reset.
- W. Start at Power Up - This product shall include the Start at Power Up feature. This feature allows the VFD to automatically start after a power cycle, if a VFD RUN signal is maintained HIGH. This enables remote or unattended operation.
- X. The VFD must offer an Emergency Override feature which provides the VFD with the ability to ignore many protective features. The product will continue to run even if these disabled protection functions cause damage to the VFD. This feature is useful in applications where the consequences for stoppage are worse than replacing the VFD.
- Y. The VFD shall provide Simplified VFD Configuration and Programming by offering connectivity to Logix controller and Software packages. This will be accomplished by use of EDS files and Add on Profiles.
- Z. The product shall have an Automatic Device Configuration (ADC) feature that will allow Logix controllers to detect and download all configuration parameters automatically, minimizing the need for manual reconfiguration.
- AA. VFD shall have a built in Logic capability (DeviceLogix™ Control) to process logic locally and reduce demands on the controller and network.
- BB. VFD shall provide the capability of Redundant Cooling Fan Option
- CC. VFD shall display Run time accumulated for each cooling fan in the VFD
- DD. VFD shall monitor the health of each cooling fan in the VFD.
- EE. The VFD shall be capable of displaying metered values for the motor and shall be capable of assigning them to analog output. Metered values shall include:

1. Root Mean Square value of the Motor Current.
  2. Root Mean Square value of the Motor Voltage.
- FF. The VFD shall be capable of displaying metered values on the line side and shall be capable of assigning them to analog output. Metered values shall include:
1. Root Mean Square value of the Line Voltage.
  2. Root Mean Square value of the Line Current.
  3. Display individual Line to Line Voltage [RS, ST and TR Line Voltages]
  4. Display individual Phase Currents [R, S, T]
  5. 5-minute history of AC Line Voltage
  6. 5-minute history of DC Bus Voltage
- GG. The VFD shall be capable of 5-cycle Control Power Ride Through. For extended control power loss durations, a UPS will be available as an option.
- HH. The VFD shall provide an option of an on-line UPS with minimum 15-minute back-up.
- II. VFD must automatically switch to Transformer Auxiliary Winding Voltage in less than 5 cycle upon losing the Customer Power Source. VFD can switch back to the Customer Power Source once power is back and by manually Resetting.
- JJ. Every peripheral board including the Power Cell shall have the capability of being Flash Updated automatically by the Firmware in the Main Control Board.

## 2.09 PROTECTION FEATURES

- A. The variable frequency drive (VFD) fault information and online help text shall be accessible through the Operator Interface.
- B. The VFD shall have the following minimum protective features:
  1. IGBT overcurrent trip
  2. Power cell communication error
  3. DC capacitor unbalance
  4. Power cell over-temperature
  5. Internal power supply fault
  6. Control power warning and fault
  7. Transformer over-temperature
  8. Cooling fan fault
  9. Analog signal loss
  10. Line Overcurrent
  11. Line Overvoltage
  12. DC Bus Overvoltage
  13. DC Bus Under voltage
  14. Motor Overcurrent
  15. Motor Overvoltage

16. Motor Neutral Overvoltage
17. Motor Overspeed
18. Output Phase Loss
19. Load Loss
20. Ground fault

- C. The VFD shall have an automatic cell bypass feature to allow continued operation in the event a failed power cell. [Option]
- D. VFD shall have automatic capturing of fault data/fault logs (Forensic data) which shall allow the factory to carry out a detailed Root Cause Failure Analysis (RCFA).
- E. This product shall have the ability to extract the encrypted Forensic data from the VFD.

## PART 3 EXECUTION

### 3.01 EXAMINATION

- A. The supplier shall verify that location is ready to receive equipment.
- B. The supplier shall verify that the building environment can be maintained within the service conditions required by the manufacturer of the VFD.

### 3.02 INSTALLATION

- A. Installation shall be in compliance with all manufacturer requirements, instructions, and drawings.

### 3.03 MANUFACTURE TESTING AND INSPECTION

#### A. Standard Testing

1. The following tests shall be carried out in accordance with applicable requirements and/or specifications of European Standard (EN) and International Electrotechnical Commission (IEC).
2. Actual operation checks shall be performed wherever possible. Otherwise, inspection and continuity checks shall be made. These checks shall include:
  - a) Continuity checks on all parts of the control circuit that cannot be verified by cycling.
  - b) Tracing or continuity checks on all power wiring.
  - c) Ensuring control wiring is the same as shown on the electrical drawings, using both sides of the terminal blocks as indicated.
3. "HI-POT" dielectric withstand tests shall be performed on all buswork and cables (except solid-state components, low voltage controls, and instrument transformers). The voltage level used for this test depends on the product's nominal AC voltage.
4. Component devices shall be functionally operated in circuits as shown on electrical diagrams or as called for by specific test instructions.
  - a) Voltage test.
  - b) Optical fiber calibration.
  - c) Simulation test.
5. Instruments, meters, protective devices, and associated equipment shall be functionally tested by applying the specified control signals, current and/or voltages.
6. Functional testing in accordance with the electrical drawing shall include:
  - a) Control system test.
  - b) Power module fault test.
  - c) Control power failure test.
  - d) Open door fault test.
  - e) Temperature controller test.
  - f) Cooling fan fault test.
  - g) DCS test.
7. Load Testing – VFDs shall be tested at rated voltage and full speed on a dynamometer for 2 hours. Individual power cells shall be tested at full current rating.

### 3.04 START-UP SERVICE

- A. A service engineer from the manufacturer shall perform commissioning in accordance with an agreed-upon commissioning schedule. The manufacturer shall have responsibility for commissioning as outlined in its documentation.



B. At a minimum, the start-up service shall include:

1. Pre-power check:

- a) Inspect the VFD's mechanical and electrical devices.
- b) Verify interconnections between cabinets.
- c) Perform a tug test on all internal connections within the VFD and verify wiring.
- d) Verify critical mechanical connections for proper torque requirements.
- e) Verify and adjust mechanical interlocks for permanent location.
- f) Confirm all inter-sectional wiring is connected properly.
- g) Re-verify control wiring from any external control devices such as PLCs.
- h) Confirm cooling fans are operational and with correct rotation.
- i) Verify proper phasing from isolation transformer to VFD.
- j) Confirm cabling of VFD to motor, isolation transformer, and line feed.
- k) Collect test reports indicating megger/hipot test has been performed on line and motor cables.

2. VFD power-up and commissioning:

- a) Apply medium voltage to the VFD and perform operational checks.
- b) Bump motor and tune VFD to the system attributes. (If the load is unable to handle any movement in the reverse direction, the load shall be uncoupled prior to bumping the motor for directional testing.)
- c) Run the VFD motor system throughout its operational range to verify proper performance.

C. All measurements shall be recorded.

D. VFD parameter listing shall be provided.

E. A minimum of 2-3 days of on-site start-up service for each VFD shall be provided.

### 3.05 SPARE MATERIALS

A. The following spare parts shall be furnished for each size VFD:

1. One spare power cell of each rating.
2. One set of control boards.
3. Three of each type power and control fuse.
4. Two sets of replacement air filters.

**END OF SECTION**