PROCUREMENT SPECIFICATION

PowerFlex® 7000L Medium Voltage AC Variable Frequency Drive — AFE, Liquid-Cooled

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MEDIUM VOLTAGE AC VARIABLE FREQUENCY DRIVE — LIQUID-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. Note: This specification does not apply to water-cooled VFDs for Marine Propulsion Applications (ABS, DNV, US Coast Guard, RMRS, BV Standards).

1.02 RELATED SECTIONS

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

1.03 CERTIFICATIONS/REFERENCES

A. Design standards shall include:

1. UL –

    a) 347 High Voltage Industrial Control Equipment
    b) 347A Medium Voltage Power Conversion Equipment Preliminary Standard

2. CSA – Industrial Control Equipment C22.2 No. 14
3. CE – European Directives for Safety and EMC
4. NEMA – Medium Voltage Controllers Rated 1501 to 7200V AC ICS (formerly ICS2-324)
5. IEC – 61800-5 AC Drives Standard
6. ANSI – Instrument Transformers C57.13
7. IEEE & EEMAC – Guide for Harmonic Control and Reactive Compensation of Static Power Converters (IEEE 519-1992)

B. The VFD shall also meet the appropriate portions of the following specifications:

1. National Electric Code (NEC)
2. Occupational Safety & Health Act (OSHA)
3. IEC Technical Specifications 60034-17 – Rotating Electrical Machines Part 17, Cage Induction Motors When Fed from Converters

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. Drive 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 -40°C to 70°C (-40°F to 158°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 their 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 7000L 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 2400V, 3300V, 4160V or 6600V at 50/60 Hz with ±10% voltage tolerance.
B. The VFD shall operate on an externally supplied control voltage of 480V, three-phase 50/60 Hz (20A).
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 VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. x Distortion P.F.) of 0.98 from 60-100% load.
E. The efficiency of the VFD system shall be a minimum of 96% at 100% speed and 100% load, including loss calculations for control power supplies, control circuits, cooling components.
F. The overload capacity shall be:

    1. Normal Duty/Variable Torque Load – 110% for 1 minute, every 10 minutes.
    2. Heavy Duty/Constant Torque Load – 150% for 1 minute, every 10 minutes.

G. The VFD shall have an output frequency range of 0.2 to 75 Hz (0.2 to 85 Hz optional).
H. The VFD shall be designed to operate in the following environmental conditions without de-rating:

    1. Ambient temperature range – 0°C to 40°C (32°F to 104°F).
    2. Relative humidity range – 0% to 95% non-condensing.
    3. Elevation – up to 1000 m (3300 ft.).

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 one meter from the front of the equipment (with doors closed at any speed or load condition).
J. VFDs shall comply with the latest edition of IEEE 519 Harmonic Guidelines.

2.03 CONSTRUCTION

A. SYSTEM COMPONENTS

1. The variable frequency drive (VFD) system shall include the drive unit and integrated main components:

    a) Enclosures
    b) Cabling
    c) Active Front End Rectifier (PWM Converter)
    d) PWM Inverter
    e) Cooling System
    f) Auxiliary Relays
    g) Output Filtering
    h) Monitoring Hardware
    i) Motor Heater Control
    j) Human Interface
    k) Input Contactor with Disconnect

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. Liquid-cooled VFD enclosures shall be Type 1 (IP21) [or Type 12 – with forced ventilation (IP42)].

    a) Door vents shall consist of louver-panel assemblies that can be removed from the front in order to replace air filters. Safety screens shall be located behind each louver-panel.
    b) Cabinets and doors shall be fabricated using minimum 12 gauge (2.64 mm thick) steel for sturdy construction. All doors shall be gasketed to provide environmental protection and secure fits.
    c) Door latches shall be heavy-duty 1/4-turn type units which are operated with an Allen wrench.
    d) The converter cabinet door and cabling cabinet door shall be interlocked with up-stream isolators or breakers with a key lock. Interlocking shall be fully coordinated to prevent access to all medium voltage compartments.

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 hybrid epoxy powder paint.
    b) Metal back plates in the power cell and low voltage compartments shall be painted high gloss white for high visibility.
    c) Unpainted steel parts shall be plated with zinc plate/bronze chromate process for corrosion resistance.

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 and shall be available with a removable cover.
3. All power and control terminations and termination strips shall be identified in accordance with all schematics and wiring diagrams.

D. ACTIVE FRONT END (AFE) RECTIFIER

1. The VFD system shall have an AFE rectifier to ensure dramatically lower line-side harmonics and near-unity power factor.
2. Symmetrical Gate Commutated Thyristors (SGCTs) shall be used in the rectifier.

E. PWM INVERTER

1. The VFD system shall use Pulse Width Modulated (PWM) power modules. SGCTs in the inverter switches allow higher switching frequencies and minimize switching losses.
2. 6500V Peak Inverse Voltage (PIV) rated devices with double-sided cooling and integral gate driver card shall be used to minimize complexity and component count.
3. Failed power switch components (SGCTs) shall be replaceable without removal of the entire power module. Special tools or force measuring transducers shall not be required. Failed power switch components shall be replaceable in less than 5 minutes. Power cells shall weigh less than 50 lbs.

F. COOLING SYSTEM
(Liquid-Cooled Only Accepted)

1. The design for cooling the converter, inverter and DC Link reactor shall utilize direct water cooling. The following features shall be incorporated in the cooling system design:

   a) Heat losses from the power devices shall be removed by a closed-loop system using an ethyl-glycol /de-ionized water (60/40% mixture) as the heat transfer medium.
   b) The pump cubicle shall contain the water pumps, heat exchanger, de-ionization tank, conductivity meter, reservoir tank, and miscellaneous valves, fittings and other plumbing.
   c) Redundant water pumps shall be provided. The control scheme shall equalize use of the pumps by timing their operating periods. Water flow shall be monitored and the loss of the active pump shall automatically cause the standby pump to be started.
   d) To maintain the non-conductive nature of the cooling water, a replaceable de-ionization cartridge shall be included in the cooling system. A dual set point conductivity meter shall continuously monitor the conductivity of the water. If the water conductivity rises above the lower threshold, it shall signal a warning. Further increase in water conductivity shall cause the drive to shut down.

e) The individual chill blocks and chill plates shall be manufactured of copper. The heatsinks shall be specially shaped with bends to minimize laminar flow and ensure maximum heat transfer between the heatsink and the water.
f) All heatsinks will operate at approximately the same temperature.
g) The piping and tubing for the cooling system shall consist of two different materials. The main piping in the pumping cabinet, piping between the cabinets and manifold piping shall be thick wall CPVC. The tubing from the manifold to the chill blocks and the DC link shall be silicone hose. The tubing shall be fitted onto copper hose barbs and secured with standard stainless steel hose clamps.
h) All the small-bore hoses shall be long enough to provide adequate electrical resistance between water circuits at different potentials in conjunction with the use of de-ionized water.
i) The highest point of the low-pressure pipe work shall be directly connected to the reservoir tank, allowing air to bleed into the tank from the low-pressure side.

2. The pump cubicle shall contain all the main cooling circuit components, including de-ionization cartridge, monitoring instrumentation and two 5-HP pumps.

a) The closed-loop liquid coolant shall be circulated continuously, so that if a fault occurs, the standby pump will automatically take over the duty. All the principal components shall have isolating valves to assist in maintenance and replacement if required. The drip tray shall be arranged to collect water leakage. Strainers shall be included to filter out any suspended solids during test and commissioning.
b) On initial start-up there shall be a 10-second delay to allow water pressure to establish itself before a pump changeover is initiated. Provided water pressure reaches rated value within 10 seconds, the changeover shall be inhibited.
c) A pump changeover when the drive is operating shall be initiated by reduction of water flow. A pressure switch shall monitor the pressure. When the flow rate has fallen below minimum rated value, the contactor shall de-energize the running pump and energize the standby pump. Provided the water flow increases above rated value within 10 seconds of calling for the standby pump to start, the drive shall continue to run. If the second pump fails to start within this time, then the complete drive shall be stopped.
d) The system shall be arranged that whenever the drive is re-energized after a shutdown, the coolant pump which is energized is the one that was previously on standby.

3. The system shall consist of the following principal components:

a) Water-to-water heat exchanger [water-to-air optional] – The heat exchanger shall be tube-and-shell or plate construction, and shall permit 100% counterflow of both primary and secondary water, so that the difference in temperature between the two water circuits participating in the heat exchange is fully utilized. The secondary coolant shall be any suitable liquid such as filtered raw water, chilled process water or chilled glycol solution.
b) Redundant coolant pumps – The motor-operated pumps shall be centrifugal close-coupled, driven by three-phase TEFC motors. The pump shall include mechanical seals and shall be selected for use with de-ionized water. The system shall have working pressure as required by the drive manufacturer and the test pressure shall be 2 times the operating pressure (PSIG).

c) De-ionization cartridge – The cartridge shall consist of a mixed-bed polishing tank with both cation and anion exchange resin contained in a durable transport housing, complete with transport head.

   i. The flow fed to the de-ionizer shall be approximately 5 US gpm. The quality of the water shall be constantly monitored and displayed within the system.
   ii. The monitor system shall include a conductivity cell and meter. Alarm and trips shall be capable of being set at any point between 0-99.9 µS/cm, depending upon the quality of water required. Once water quality falls below a predetermined level, the alarm shall be automatically activated, indicating that the cartridge needs to be changed. Further loss of coolant quality shall trip the drive. The normal working range shall be 0.0 to 0.5 µS/cm. The alarm is typically set at 1.0 µS/cm and the trip at 2.0 µS/cm.
   iii. The de-ionization cartridge shall require replacement at intervals of approximately 6 months, and isolation valves shall be provided to allow replacement while the drive is running.

d) Reservoir tank (make-up water tank) – The reservoir tank shall be open to the atmosphere in the primary system, helping to displace air in the system. It shall also provide some reserve capacity if there is a leak or fault in the cooling system. Level detectors shall be provided to check water evaporation or leakages.
e) Strainers and filters.
f) Instrumentation – The instrumentation shall be designed to protect against major equipment damage.

   i. Monitors for water flow and water over-temperature detection shall be provided and shall include:

      a. Flow trip (Paddle Switch)
      b. Low level alarm (Float Switch)
      c. Temperature and pressure gauges
      d. Water over-temperature alarm and trip (Thermal Switches)
      e. Conductivity alarm and trip (Conductivity Monitor)

   ii. The instrumentation shall be provided to monitor and initiate alarms and corrective action, as well as to trip the drive if necessary. The following failure modes shall be detected:

      a. Loss of pump or power to pump
      b. Loss of secondary water supply or secondary water over-temperature
      c. Leakage of water from system
      d. Obstruction in water pipe work

g) Conductivity meter – The conductivity meter continuously monitors the conductivity of the water.

   i. Because conductivity is itself a measure of soluble chemical content, there is no need to carry out any chemical analysis test of the secondary water. The de-ionization cartridges must be changed when the conductivity reaches 1 µS/cm.

ii. The secondary water circuit is a re-circulating system; therefore, the quantity of insoluble impurities in the system will not increase with time, provided any topping-up water is free from contaminants. The only metals usually in contact with the primary water are stainless steel and copper. Typical materials that may be in contact with water:

a. Copper-thyristor heatsinks
b. Stainless steel
c. CPVC pipes, valves
d. Non-conductive silicone hose
e. EPDM rubber for flanges
f. Polypropylene
g. Bronze

iii. With a maximum operating temperature for this water of 60°C, no adversely appreciable migration or corrosion will occur.

G. AUXILIARY RELAYS

1. Relays shall be available for:

a) Drive Warning, Drive Fault, Drive Run and Drive Ready.
b) 2 additional relays to be provided and wired per custom requirements.

2. The relays shall be Allen-Bradley 700CF relays (2 form C contacts, 2N.O. & 2N.C.). The relay contacts shall be rated for 115 VAC/30 VDC, 5.0 A resistive, 5.0 A inductive.

H. OUTPUT FILTERING

1. If an output filter is required to mitigate reflected waves, or to meet any special requirements of the application, it shall be integral to the VFD controller.

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 constant control of the device as well as constant monitoring of device health and temperature feedback. Fiber optic interface boards shall be used to provide gating and diagnostic feedback signals for power semiconductor devices.
3. High speed digital control systems shall continuously monitor all hardware and software faults including sensing of all power circuit voltage and currents as well as any internal equipment faults. Field programmable gate arrays (FPGA) shall be utilized on drive control boards to provide high speed handling of diagnostics and fault handling routines.
4. A digital elapsed time meter shall be provided to indicate actual Motor Run Time. The digital meter shall be non-resettable and electrically interlocked with the Drive Run relay.
5. Interfaces shall be provided to interact with motor protection as stated in the motor specification.

6. A door-mounted motor temperature monitor/controller shall be provided. [option]

    a) The module shall be TecSystem model T-538 and shall monitor up to eight (8), three (3) wire RTD inputs.
    b) The module shall monitor the quantity and type of RTDs specified in the motor specification.

J. MOTOR HEATER CONTROL

1. The VFD shall provide drive control circuitry to interface with a remote 120VAC/2700W power source to energize the motor heater whenever the motor is not running.
2. The heater shall be interlocked with the drive run relay and shall be energized whenever the motor is not running.
3. A pilot light shall be mounted on the VFD system enclosure door for indication of Motor Heater On (if required).

K. HUMAN INTERFACE

1. The VFD system's pilot devices shall be Allen-Bradley Bulletin 800H (Type 4/4X/13) and shall be mounted on the enclosure door. The system shall include:

    a) LOCAL/REMOTE selector switch for START-STOP control and speed reference.
    b) START and STOP pushbuttons.
    c) Transformer-type LED pilot lights for indication of READY, RUN, FAULT and WARNING.
    d) Type 1/4/12, single-turn speed potentiometer.

2. The VFD system shall have a user-friendly operator interface terminal.

    a) The HMI shall be available in three basic configurations (as specified):

        i. Remotely mounted.
        ii. Locally mounted.
        iii. No HMI (User's laptop becomes the temporary HMI).

    b) The interface terminal shall have the following minimum features:

        i. 10" color touch screen that is easy to read and provides "at a glance" indication of drive operating status.
        ii. Built-in PDF viewer.
        iii. Logic module with 512 Mb of memory.
        iv. Windows CE 6.0 operating system.
        v. HMI interface module for access to executable tools, documentation and reports for commissioning, troubleshooting and maintenance.
        vi. User-configurable metering for motor speed, load, torque and voltage.
        vii. Multi-language capability.
        viii. HMI to VFD Ethernet communication link.
        ix. Elapsed time indication.
        x. Extensive diagnostic functions that provide separate fault and warning queues in non-volatile memory that retain information under all conditions.
        xi. On-line help that provides enhanced fault text messages.

xii. Trend buffers for at least 8 variables that allow one-shot or multi-shot trending.
xiii. Multi-level (minimum of 4 levels) password permission to ensure that only qualified personnel have access to critical parameters, yet to allow easy access to other levels of personnel.
xiv. Extended use of plain language messages to eliminate need to look up error codes or decipher the meaning of error messages.
xv. Auto-tuning that is interactive and user-friendly.

2.04 OPERATIONAL FEATURES

A. The variable frequency drive (VFD) shall be capable of operating a standard AC squirrel cage induction motor (standard AC synchronous motor or standard AC wound rotor induction motor) of equivalent power and speed rating over the speed range specified, with:

1. Near sinusoidal voltage and current waveforms provided to the motor at all speeds and loads.

a) Output current Total Harmonic Distortion (THD) shall be less than 5%.
b) Motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.

2. No compromising of the motor insulation thermally or due to dv/dt stress.

a) Stable operation of the motor shall be provided with motor cable distances that exceed 150 m (500 ft).
b) Dv/dt at the motor terminals (line-to-line) shall comply with IEC Technical Specification 60034-17 – Rotating Electrical Machines Part 17, Cage Induction Motors When Fed from Converters.

3. VFD-induced torque pulsations to the output shaft of the mechanical system at less than 1%, to minimize the possibility of exciting a resonance.
4. Elimination of potential harmonic resonance in the operating speed range via selective harmonic elimination (SHE) switching technique.

B. The VFD shall be capable of producing a variable voltage and variable frequency output to provide continuous operation over the speed range specified.

1. The VFD shall be capable of operating with the output short circuited at full current.
2. The VFD system shall provide controlled speed over the range specified. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.1% of base speed without encoder or pulse tachometer feedback (0.01% with encoder or pulse tachometer feedback).
3. The VFD shall be capable of 100% breakaway torque without tachometer feedback.

C. The VFD shall have a “normal duty” rating of 100% continuous current with a short-time duty rating of 110% overload for one minute, once every 10 minutes (suitable for variable torque loads).
D. The VFD shall be capable of regenerative motor braking for high inertia loads.

2.05 CONFIGURATION/PROGRAMMING

A. The variable frequency drive (VFD) shall be configurable using:

1. The HIM's keypad and display.
2. Connected Component Workbench (CCW) software.
3. Studio 5000™ Logix Designer – This software, a single development environment for the entire control system, includes add-on profiles which minimize the need to individually program the required parameters and tags. (Available to VFDs on EtherNet/IP or ControlNet.)

a) Autogeneration of descriptive tag names and respective tag data types.
b) Wizards available to walk through configuration.
c) Copy and paste function to easily duplicate VFDs.
d) Single development environment – minimizes errors associated with multiple software tools.
e) Configuring entire system from one environment – minimizes I/O mismatch errors.

B. With Studio 5000 software,

1. VFD configuration settings shall be stored in the project file and embedded in the control system's PACs. This VFD I/O packet shall consist of:

a) VFD status and feedback, command and reference.
b) At least 8 data words of inputs and 8 data words of outputs that can be configured to access any parameter.

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. Through an option module, the EtherNet/IP network is supported.
2. Through a dual-port EtherNet/IP option module, Device Level Ring topology is supported.
3. Through other option modules and adapters, the VFD shall also support:

a) DeviceNet
b) ControlNet
c) Interbus
d) CANopen
e) Modbus/TCP
f) Modbus RTU
g) Profibus DP
h) RS-485 DF1
i) Remote I/O

B. The VFD shall be able to communicate with at least 2 networks at the same time (as required).
C. VFD communications adapters shall have individually selectable fault actions in the case of a communications loss.

2.07 CONTROL FEATURES

A. The variable frequency drive (VFD) shall utilize:

1. Digital sensorless direct vector control, or
2. Full vector control with encoder feedback. [option]

B. The VFD shall have an auto tuning function, capable of being disabled and programmable for:

1. Commutation inductance.
2. DC link time constant.
3. Motor stator resistance.
4. Motor leakage inductance.
5. Flux regulator.
6. Total inertia.

C. The VFD shall offer 2 starting modes:

1. S-Curve Profile, consisting of both nonlinear and linear portions, programmable to:

   a) Specify the duration that the drive is ramping in the non-linear portion.
   b) Define the total time to accelerate to rated speed in S-Curve.

2. Ramp Mode with 4 ramp speed break points and programmable:

   a) Acceleration and deceleration times.
   b) Ramp start delay.

D. The VFD shall have 3 stop modes:

1. Ramp Mode – programmable with four deceleration times.
2. Coast Mode – programmable to specify the speed at which the drive shuts off and coasts when stopping.
3. Regen Mode.

E. The VFD shall be capable of automatically restarting in the event of a momentary loss of power. The automatic restart delay shall be adjustable in a range of 0-10 seconds. [option]

F. The VFD shall be capable of flying re-start — restarting and taking control of a motor attached to a spinning load in the forward or reverse direction.

G. The VFD shall have 3 preset speeds, programmable between 0.5 and 75.0 Hz.

H. The VFD shall have 3 skip speeds, programmable between 1.0 and 75.0 Hz with a programmable bandwidth between 0.0 and 5.0 Hz.

I. The VFD shall be capable of riding through a loss of power of 5 cycles and capable of operating with a 30% voltage sag on the input power line.

1. The motor shall not be allowed to reach a pull out condition.
2. A UPS shall be supplied inside the VFD controller for an extended ride-through of up to 2 minutes. [option]

J. 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 terminal voltage
3. Motor output power in kilowatts
4. Motor speed in revolutions per minute

K. The response of the VFD to a loss of load condition shall be programmable to disable, warn or fault.

L. Fault classes shall be programmable to disable the fault input, shut down the drive immediately, perform a controlled shutdown or display a warning. Fault classes shall define:

1. Drive input protection.
2. Rectifier magnetic protection.
3. DC link protection.
4. Motor protection.
5. Auxiliary trip.
6. External fault.

M. The VFD shall have fault and warning masks.

N. For functional safety, the VFD shall have a Safe Torque Off (STO) feature. The VFD shall be able to remove rotational power to the motor and reliably monitor this state. The STO feature shall be rated Safety Integrity Level (SIL) 3 according to IEC 61508, IEC 62061, IEC 61800-5-2 and Category 3 Performance Level (PL) according to 13849-1. [option]

O. The VFD shall be capable of providing 100% torque at zero speed. [option – tachometer required]

P. When motors are provided with brakes, the VFD shall include:

1. A Torque Prove feature to ensure that there is torque on the motor before releasing the brake. [option – tachometer on the motor required]
2. A Brake Prove feature to ensure that the brake is holding prior to removing torque from the motor. [option – tachometer on the motor required]

2.08 CONTROL I/O

A. The variable frequency drive (VFD) shall have isolated analog and digital interfaces.

B. Analog interfaces shall be configurable for:

1. Speed reference input (4-20 mA input signal).
2. Speed output (4-20 mA output signal).

C. Digital interfaces shall be rated 12 to 260 VAC/VDC. The VFD shall have available as standard:

1. 16 isolated digital inputs.
2. 16 isolated digital outputs.

2.09 PROTECTION FEATURES

A. The variable frequency drive (VFD) fault information shall be accessible through the Human Interface.
B. The VFD shall have the following minimum *line side* protective features:

1. Line current unbalance trip with programmable delay.
2. Line overcurrent trip with programmable delay.
3. Line overload warning and trip with programmable delay.
4. Line overvoltage trip with programmable delay.
5. Line undervoltage trip with programmable delay.
6. Line voltage unbalance trip with programmable delay.
7. Ground fault overvoltage trip with programmable delay.
8. Ground fault overcurrent trip with programmable delay.

C. The VFD shall have the following minimum *system level* protective features:

1. DC overcurrent trip with programmable delay.
2. DC overvoltage trip with programmable delay.
3. Rectifier heatsink temperature warning and trip.
4. Cabinet temperature warning and trip.
5. Inverter heatsink temperature warning and trip.
6. Control power warning and fault.
7. Adapter (communication port) loss warning and fault.
8. XIO adapter loss.

D. The VFD shall have the following minimum *load side* protective features:

1. Ground fault overvoltage trip with programmable delay.
2. Ground fault overcurrent trip with programmable delay.
3. Machine side DC link overvoltage trip with programmable delay.
4. Motor overcurrent trip with programmable delay.
5. Motor overload warning and trip with programmable delay.
6. Motor overvoltage trip with programmable delay.
7. Motor stall delay.
8. Motor overspeed trip with programmable delay.
9. Motor flux unbalance trip with programmable delay.
10. Motor current unbalance trip with programmable delay.
11. Load loss level, speed and programmable delay.

PART 3 GENERAL

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 Canadian Standards Association (CSA), Underwriters Laboratories (cULus), National Electrical Manufacturers Association (NEMA), European Standard (EN) and International Electrotechnical Commission (IEC).
2. Functional checks shall be performed wherever possible; otherwise, inspection and continuity checks shall be made.
3. A “HI-POT” dielectric withstand test shall be performed on all buswork and cables from phase-to-phase and phase-to-ground (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.
5. Instruments, meters, protective devices and associated controls shall be functionally tested by applying the specified control signals, current and/or voltages.
6. Medium Voltage Drives shall be inspected for the following:

    a) Control Power Failure Test
    b) Rectifier Gating Checks
    c) Inverter Gating Checks
    d) Line Converter Tests
    e) Machine Converter Tests
    f) Load Tests

7. Cycle Testing

    a) Drives shall be accelerated to the test motor’s nominal frequency, under load on a dynamometer.
    b) Drives shall be decelerated to 10 Hz and then accelerated back to test motor’s nominal frequency with a ramp time of approximately ten seconds.
    c) This cycle shall be repeated continuously for up to one hour.

8. Load Testing – Drives shall be tested under full load at the test motor’s nominal frequency on a dynamometer. Testing on load banks not acceptable.

3.04 START-UP SERVICE

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

1. Pre-power check:

    a) Inspect the drive’s mechanical and electrical devices.
    b) Tug test internal connections and verify wiring.
    c) Verify critical mechanical connections for proper torque.
    d) Verify and adjust mechanical interlocks.

e) Check all sectional wiring.
f) Verify control wiring from external devices.
g) Set up all internal power supplies and thyristor control circuits.
h) Verify phasing to drive.
i) Check cabling from drive.
j) Megger motor resistances.

2. Drive power-up and commissioning:

a) Apply medium voltage to the drive and perform operational checks.
b) Bump motor and tune drive to system attributes.
c) Run the drive motor system throughout the operational range to verify proper performance.

B. All measurements shall be recorded.
C. Drive parameter listing shall be provided.
D. A minimum of 5 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 liquid-cooled drive:

1. One pump seal kit.
2. One de-ionization cartridge.
3. One de-ionization filter.
4. Five gallons of pre-mixed de-ionized water / ethyl glycol.
5. Three of each type power and control fuse.
6. Two power module SGCTs or 20%, whichever is greater.
7. Two spare LEDs of each type used.
8. Two spare control relays of each type used.
9. Two sets of all replacement air filters.
10. One set of all control printed circuit boards.

3.06 REMOTE SUPPORT AND MONITORING

A. A Virtual Support Engineer (VSE) shall be available to monitor VFD critical parameters, collect performance analytics, and notify Rockwell Automation of any events that could impact VFD performance. [option]
B. The VSE shall be configurable to monitor VFD parameters including:

1. Speed
2. Current
3. Voltage
4. Power
5. Drive Warning Queue
6. Drive Fault Queue
7. Drive Status

END OF SECTION