PART 1 - GENERAL

1.0. Scope

This specification shall cover the Toshiba Q9 Plus AC Variable Frequency Drive, 6-pulse for 230V and 460V.

1.1. References

A. National Electrical Manufactures Association (NEMA) Safety standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems
B. National Electrical Code (NEC) (NFPA 70)
C. NEMA 250 Enclosures for Electrical Equipment
D. IEC 146 International Electrotechnical Commission
E. ISO 9001
F. UL 508

1.2. Qualifications

Manufacturer's History

Toshiba entered the AC adjustable speed drive market in the US in 1979. Toshiba International Corporation continues to specialize in the design and manufacturing of both AC drives and induction motors at its manufacturing facility located in Houston, Texas.

Certification

Toshiba International Corporation, located in Houston Texas, is an ISO 9001 certified manufacturing facility.

After Sales Support

Support is available direct from Toshiba's Houston facility or from a network of factory-trained distributors and certified service centers located throughout North America and Canada.

1.3. Submittal

Submittals shall include Toshiba's standard VFD installation & operation manual. Schematics can be obtained from factory upon request (must be factory trained to receive schematics).

PART 2 – Q9 PLUS VARIABLE FREQUENCY DRIVE

2.0. General

A. This specification covers the Q9 Plus AC variable frequency drives (VFD) for HVAC applications.

B. The manufacturer shall not have less than fifteen years of experience in the manufacture of VFDs.
C. The manufacturer shall manufacture both AC drives and motors.
D. The drive shall be manufactured in the United States.

2.1. Design Criteria

2.1.1. Input Power

A. The drive main input power shall be:
   I. ~~200V (-10%) to 240V (+10%), 50/60 Hz for 230V models~~
   II. 380V (-10%) to 480V (+10%), 50/60Hz for 460V models
B. The input frequency tolerance shall be ± 2 Hz.
C. The efficiency of the drive shall be a minimum of 97.0% at full load at full speed. Displacement power factor will be greater than 0.97 lagging over the entire speed range.
D. The drive overload current shall be 100% continuous and 110% for 1 minute.

2.1.2. Hardware Design

A. All ratings contain a minimum of three ground termination points.
B. Power Terminations are clearly labeled with both the US (NEMA) standards (L1, L2, L3, T1, T2, T3) and IEC standards (R, S, T, U, V, W).
C. The Q9 Plus drive shall be capable of a Short Circuit Current Rating of 100,000A RMS symmetrical for all power unit ratings when used with the recommended fuses or circuit breaker and Type 1 enclosure.
D. Built in EMI filter shall meet the EMC directive as follows:
   I. ~~230V – 1 to 3 HP: IEC61800-3 Category C2 (EN55011 Class A Group 1).~~
   II. ~~230V – 5 to 125 HP: IEC61800-3 Category C3 (EN55011 Class A Group 2).~~
   III. ~~460V – 1 to 7.5 HP: IEC61800-3 category C2 (EN55011 Class A Group 1).~~
   IV. 460V – 10 to 400 HP: IEC61800-3 category C3 (EN55011 Class A Group 2).

2.1.3. Converter Section

A. The Q9 Plus drive shall employ diodes or silicon-controlled rectifiers (SCRs) as follows to convert AC to DC.
   I. ~~230V – 1 to 25 HP: Full-wave diode bridge rectifier~~
   II. ~~230V – 30 to 125 HP: Full-wave hybrid bridge rectifier~~
   III. 460V – 1 to 30 HP: Full-wave diode bridge rectifier
   IV. ~~460V – 40 to 400 HP: Full-wave hybrid bridge rectifier~~
B. The Converter Section shall be unaffected by phase rotation/phase sequence.
C. PIV Ratings of the rectifier shall be as follows:
   I. ~~230V – rectifier minimum PIV rating of 800V~~
   II. 460V – rectifier minimum PIV rating of 1600V

2.1.4. DC Bus Section

A. The DC bus capacitance voltage ratings are:
   I. ~~230V – 400 VDC (minimum)~~
   II. 460V – 800 VDC (minimum)
B. All capacitors shall have balance/discharge resistors to equalize charge voltage and permit safe discharge on power outage.
C. The DC Bus Section has complete power terminations to allow:
   I. Rectifier Isolation (positive side)
   II. Line regeneration using third party units
   III. DC Link inductor
D. A readily visible LED (when front panel door is opened) indicates when DC voltages are present.
E. Internal DC Link Reactors shall be included as follows:
   I. ~~230V – 15 to 60 HP~~
   II. 460V – 30 to 125 HP

2.1.5. Inverter Section

A. The inverter section makes use of the latest generation of IGBT power switching transistors to convert DC to three phase, variable frequency, and sinusoidal coded PWM waveform.
B. IGBT testing is performed by the control section and is user selectable to occur at power-on or run command.
C. The IGBT ratings will be as follows:
   I. ~~230V – IGBT minimum V_{ce} rating 600V~~
   II. 460V – IGBT minimum V_{ce} rating 1200V
D. All IGBTs shall have soft recovery free wheeling diodes to prevent IGBT failure when subjected to motor discharge spikes.
E. PWM switching frequencies are adjustable from 1 to 16 kHz (230V: 1 to 60 HP, 460V: 1 to 125 HP) or 1 to 8 kHz (230V: 75 to 125 HP, 460V: 150 to 400 HP). Refer to the operational manual for specific de-rate based on the horsepower.
F. IGBTs are sized to allow the drive to operate at 100% (current) continuous and 110% (current) for up to 60 seconds.
G. The instantaneous current limit is set to 200%. The stall protection limit can be set up to 164%. The stall protection shall limit the output frequency and voltage to prevent the drive from tripping.
H. Output current in each phase shall be monitored using hall-effect current transformers.
I. The inverter section shall be capable of sensing and interrupting a phase to phase or phase to ground fault on the output of the drive.

2.1.6. Control Section

A. The microcontroller logic circuits used is the latest design CPU with adjustable frequency drive specific circuitry and firmware.

B. The microprocessor used is the latest design CPU with adjustable speed drive-specific circuitry and firmware.

C. Proprietary VLP technology and algorithms for sensorless vector speed control reside in EEPROM memory and are utilized by the microprocessor when applicable.

D. Microcontroller logic circuits diagnostics are performed (on application of power) to prove functionality and viability of the microcontroller logic circuits.

E. Memory cyclic redundancy check (CRC) is performed (on application of power) to prove integrity of EEPROM and UVPROM memories.

F. Operating system firmware shall be capable of 'flash' upgrading if enhancements to the operating system firmware are needed.

G. The drive shall have an RS-485 port capable of 2-wire or 4-wire communication.

2.1.7. Interface Section

A. Each drive shall have two user interfaces (in addition to the communication ports) as standard:

I. Electronic Operator Interface – A 132 X 64 graphical backlit LCD display with the ability to display multiple lines on one screen and a 4 character 7-segment LED display. The EOI provides complete operating, monitoring, and programming functionality. The EOI is capable of operation from an external power source. The firmware operating system is flash upgradeable and may be customized for special applications. The EOI contains an RS485 communications port for remote mounting. A real-time clock is standard for the EOI and provides data logging in the event of a fault. Up to 100 faults may be stored on the real-time clock.

II. Terminal Board Interface – Standard terminal board interface provides eight discrete inputs, three discrete outputs, one isolated analog input, three non-isolated analog inputs, two analog outputs, one pulse output, and one input for bringing in external 24Vdc control power. Inputs and outputs are independently configurable for both scaling and functionality.

B. The drive retains the ability to function in remote mode with no attached display unit.

2.1.8. Output Power

A. The output voltage is adjustable from 0 to rated input voltage. The output frequency range is adjustable for a maximum frequency output of 299 Hz. The output (inverter) section of the Q9 Plus will produce a PWM sinusoidal coded waveform.

2.1.9. Q9 Plus Keypad

A. The Q9 Plus keypad shall be comprised of a backlit LCD display that displays configuration information, performance data, and diagnostic information in plain English.

B. The Local/Remote key shall toggle the system to and from the Local and Remote modes.

C. The Remote mode enables the Frequency control functions to be carried out via any one of the following methods:

I. V/I (0 to 10 Vdc / 4 to 20 mA input)

II. RR (0 to 10 Vdc input)

III. RX (-10 Vdc to +10 Vdc input)
IV. EOI Keypad
V. RS485 / BACnet
VI. Communication option board
VII. UP/DOWN frequency

D. The rotary encoder shall be used to access the Q9 Plus menu selections, change the value of a displayed parameter, and perform as the ENTER key function.
E. The Stop / Reset key is used to issue the stop command (decelerates to a stop at the programmed rate) if pressed once while in the Local mode, or initiates an Emergency Off (terminates the ASD output and applies the brake if so configured) if pressed twice quickly from the Local or Remote mode. It also resets active faults and/or active alarms if pressed twice quickly.
F. The Run key shall issue the run command while in the Local mode.
G. The Mode key provides access to the three root menus. Pressing the Mode key repeatedly loops the system through the three root menus.

~~**2.1.10. Integrated Enclosure**~~

~~A. The Integrated Enclosure shall contain the Q9 Plus power unit, MCP, and/or bypass, and/or reactor in one NEMA 1 enclosure.~~
~~B. The Integrated Enclosure shall be designed to incorporate the following options:~~
~~I. MCP and 3-contactor bypass (IE option)~~
~~II. MCP and 2-contactor bypass (IC option)~~
~~III. MCP (IA option)~~
~~C. The Integrated Enclosure shall be available for the following ratings:~~
~~I. 230V – 1 to 25hp~~
~~II. 460V – 1 to 40hp~~
~~D. The maximum Short Circuit Current Rating of the Integrated Enclosure shall be 100,000A RMS symmetrical for all ratings.~~
~~E. The Integrated Enclosure can include a DC link or input line reactor as an option.~~
~~F. Input fuses shall be included for all 460V integrated enclosures.~~

2.1.11. Extended Enclosure

A. The Extended Enclosure shall contain the MCP, and/or bypass, and/or reactor in a NEMA 1 enclosure. An extender box containing the MCP, and/or bypass, and/or reactor is connected to the bottom of the Q9 Plus power unit.
B. The Extended Enclosure shall be designed to incorporate the following options:
I. MCP and 3-contactor bypass (EE option)
~~II. MCP and 2-contactor bypass (EC option)~~
~~III. MCP (EA option)~~
C. The Extended Enclosure shall be available for the following ratings:
~~I. 230V – 30 to 40 HP~~
II. 460V – 50 to 125 HP

D. The maximum Short Circuit Current Rating of the Extended Enclosure shall be 100,000A RMS symmetrical for all ratings.
E. The Extended Enclosure can include an input line reactor as an option, excluding the 460V 125 HP rating.
F. Input fuses shall be included for all Extended Enclosures.

2.2. Functionality

2.2.1. Acceleration and Deceleration

A. The Q9 Plus drive shall contain two sets of independently configurable acceleration / deceleration ramps. Each set is configurable as to both time and V/Hz pattern. Times are adjustable from 0.01seconds to 6000 seconds.
B. Available acceleration / deceleration patterns are:
   I. Linear
   II. S-pattern 1 for quick acceleration and deceleration
   III. S-pattern 2 acceleration and deceleration that decreases the rate of change above the base frequency.
C. An automatic acceleration/deceleration selection is available to adjust the acceleration and deceleration rates in accordance with the applied load automatically.
D. Two acceleration and deceleration settings.

2.2.2. Volt/Hz (V/Hz) Pattern

A. The Volts/Hertz (V/Hz) setting functions establishes the relationship between the output frequency and the output voltage.
B. The Q9 Plus drive shall be configurable to the following V/Hz patterns:
   I. Constant Torque
   II. Variable Torque
   III. Automatic Torque Boost
   IV. Sensorless Vector Control (Speed)
   V. V/f 5-Point Setting
   VI. PG Feedback Vector Control (Speed)
   VII. Auto Power Save (Energy Saving)
   VIII. Dynamic Power Save (Advanced Energy Saving)

2.2.3. Current detection / protection

A. The Q9 Plus drive shall have Underwriter Laboratories approved overload protection.
B. Programmable current detection and protection include:
   I. Overcurrent stall setting adjustable from 10 to 165%
   II. UL recognized speed sensitive motor FLA trip curves adjustable from 10 to 100% inverter current rating

III. OL Reduction Frequencies to optimize the speed sensitive motor overload to the application/motor characteristics

2.2.4. Overvoltage Stall

A. Overvoltage stall shall prevent faults caused by regeneration.
B. During deceleration, overvoltage stall shall extend deceleration time when bus levels reach a user configurable level.

2.2.5. Electronic Thermal Motor Protection

A. The Electronic Thermal Protection shall specify the overload current level for the motor.
B. The drive contains two independently configurable electronic thermal motor protection levels.

2.2.6. Soft Stall

A. Soft Stall allows the Q9 Plus to protect the motor from an overcurrent condition by automatically reducing the output frequency when approaching an overload condition.
B. If the current drops below the motors overload protection level within the specified time, the output frequency of the Q9 Plus will return to the commanded output frequency.

2.2.7. Critical (Skip) Frequencies

A. To avoid mechanical resonant frequencies, the Q9 Plus contains three programmable jump frequencies with adjustable bandwidths.
B. The jump frequencies may be any frequency less than or equal to the programmed value of maximum frequency.
C. The jump frequency bandwidths are independently programmable from 0.00 to $\pm$ 30.0 Hertz.

2.2.8. Ride Through

A. Ride through mode shall use regenerative energy to maintain the control circuitry settings for the duration of the ride through; it is not used to drive the motor.
B. The ride through time is adjustable up to 320 seconds.

2.2.9. Retry/Restart

A. The retry/restart drive function shall allow the Q9 Plus drive to smoothly start a rotating load regardless of the direction of rotation.
B. When enabled, the drive will attempt to clear and restart after a fault.
C. The number of attempts can be programmed up to ten (10) times.

2.2.10. Process Control (VLP Technology)

A. The Q9 Plus contains Toshiba's proprietary VLP (Virtual Linear Pump) technology as a simple and efficient alternative to complex PID control algorithms. A Start-up Wizard assists the user in the configuration of pump and fan curves to regulate a system's flow rate, level, or pressure. (See Section 2.4 for more details.)

2.2.11. Process Control (PID)

A. The Q9 Plus contains an internal PID control algorithm with adjustable proportional, integral, and differential.
B. Feedback may be configured for direct or inverse reaction and is adjustable to span. PID may be enabled via discrete input, Q9 Plus keypad, or communications.
C. The Q9 Plus contains an adjustable PID Feedback Delay Filter which determines the delay in the ASD output response to the motor-control feedback signal.
D. PID deviation limits determine the maximum and minimum amount that the feedback may increase the output signal.

2.2.12. Emergency Off Modes and Settings

A. Emergency off response is configurable to deceleration Stop, coast stop, or DC injection stop regardless of the standard stop mode.
B. Emergency stop may be operator initiated via:
    I. Q9 Plus Keypad
    II. Discrete input (multiple E-Stop inputs allowed)
    III. Communication protocol

2.2.13. Preset Speeds

A. The Q9 Plus drive shall have 15 preset speeds.
B. The preset speeds shall be selected via input terminals (using BCD selection) or communication function.

2.2.14. Damper Circuit

A. The drive shall have damper permissive circuit to operate both in the inverter mode and bypass mode.
B. A discrete terminal shall be programmed to disable the system to run if the damper is not fully open.
C. Damper status shall be conveyed to the drive via a limit switch (provided by others).
D. The limit switch shall close when the damper is fully open and shall provide 120VAC to the damper coil.
E. The damper coil shall energize a damper contact closure and this shall enable the system to run the drive.

F. In both inverter and bypass mode a contactor shall be closed to energize damper motor (provided by others).

2.2.15. Wire-Break Function

A. The drive shall trip or run at a preset speed (user defined) if the analog signal drops below a specified level for 0.3 seconds.

2.2.16. Fire-Speed Function

A. Any of the discrete input terminals may be programmed to function as a fire-speed function.
B. The discrete terminal shall be connected to a fire management system and shall close the contact and run the motor during a fire.

2.3. Operational Functions

A. The drive shall have the capability of storable special custom user setting.
B. The drive shall be able to start and stop from a two-wire control (dry contacts), three wire momentary contact closure, keypad, and serial interface.
C. The drive shall have an analog input filter adjustment to limit the effects of noise on the control signal.
D. The drive shall be provided with “anti-windmilling” or “motor shaft stationary control”.
E. The drive shall be provided with the “My Function” feature. “My Function” is used to enhance the programmability of the Q9 Plus ASD by providing basic comparison and logic functionality.

2.4. Virtual Linear Pump (VLP Technology)

A. The Q9 Plus contains VLP technology, a proprietary algorithm that utilizes a start-up wizard to linearize traditional variable torque curves, allowing precise control over a system’s pressure, flow rate, level, or temperature.
B. The VLP technology algorithm maintains consistent mass-flow while varying the operational frequency of the drive within a set of user-defined bounds.
C. Once VLP technology is configured and enabled, it load balances with other Q9 Plus drives running VLP technology and can maintain the given set point despite rapid system transients (including across-the-line loads). VLP technology self-calibrates, eliminating common variable torque load anomalies.

2.4.1. VLP Technology Start-Up Wizard

A. The Start-up Wizard allows the user to program the drive in a matter of minutes by supplying the following fundamental application information:
    I. Motor ratings
    II. Transducer specifications

III. VLP technology maximum value
IV. VLP technology minimum value
V. Save data and complete wizard

2.4.2. VLP Technology Control Modes

A. VLP technology has two modes of operation
   I. Direct Mode (without transducer feedback)
   II. Process Hold (with transducer feedback)
B. The VLP technology control mode can be switched off while running via a discrete input.

2.4.3. VLP Technology Start and Stop Points

A. VLP technology has the ability to use transducer feedback information to manage system starts and stops.
B. Start or stop conditions can be specified by the user in units of the process variable. The bounds of these points are dependent on the range of the transducer settings entered into the Start-up Wizard.
C. A programmable delay timer specifies the intervals in which the start and stop points must be maintained for an action to happen. The range of this timer is 0.1-6553.5 seconds.
D. Start and stop points can be handled in two operating modes:
   I. Forward acting
   II. Reverse acting
E. When forward acting is enabled, the drive starts when the transducer feedback is below the programmed low threshold, and stops when the feedback reaches the high threshold.
F. When reverse acting is enabled, the drive starts when the transducer feedback is above the programmed high threshold, and stops when the feedback reaches the low threshold.
G. In order for the Start and Stop point functionality to be active, one of the discrete input terminals must be programmed to enable this function by selecting the Start/Stop HOA action and activating the corresponding input terminal.

2.4.4. Configurable Display Units

A. When a transducer is being utilized in the system, the units to be displayed for feedback can be selected from a list of commonly used units or arbitrary units created by the user. Preprogrammed units include PSI, GPM, Inches of Water Column, Feet of Water Column, Cubic Feet per Minute, °C, and °F.
B. This feature allows the Q9 Plus interface to provide clear feedback for the application.

2.4.5. Low Suction/No Flow Cut Off Detection/Protection

A. The Low Suction/No Flow Cut Off feature provides pump cavitation protection that can be activated by either an external physical switch or electronic detection.

B. Electronic detection is performed by monitoring output current and time spent running at the Upper Limit frequency.
C. The Q9 Plus will alert the user if any issues arise related to lack of flow, low suction, or the presence of cavitation.
D. This protection can either provide a fault or an alarm. This protection can be disabled, or programmed to initiate a timer before restarting after a Low Suction/No Flow fault occurs.
E. The Low Suction/No Flow detection time that these monitored conditions must meet is programmable to suit different systems and avoid nuisance tripping. The detection time is programmable between 1-255 seconds.

2.4.6. VLP Technology Sealing Water

A. The VLP Technology Sealing Water function prevents the pump from being run without positive flow, thus protecting the pump's internals. A discrete input and output and three programmable parameters are all that is needed to implement this feature.
B. When the drive is given a run command, the Sealing Water function on a discrete output closes a set of dry contacts. These dry contacts are commonly used to open a solenoid valve.
C. The Sealing Water function prevents the drive from running until an external flow switch closes, activating a discrete terminal on the drive. Any discrete input terminal may be used.

2.4.7. VLP Technology Sleep Timer

A. An included sleep timer may be used to stop operation if the drive has remained within the VLP technology minimum zone for a specified time.
B. The time required for the drive to run at the VLP technology minimum in order for the drive to go to sleep is programmable and the delay timer has a range of 1-63335 seconds.

2.4.8. VLP Technology Run External Devices

A. VLP technology can control external devices including:
   I. Loads connected across the line
   II. Loads connected to a solid state soft starter
   III. Loads connected to another drive
B. This functionality controls these external devices when the load increases or decreases.
C. When using external devices, a maximum and minimum zone must be programmed. The user will determine and program a band below the VLP technology maximum and above the VLP technology minimum to set the zones per the application. The range is 0 to 30 VLP technology numbers away from the VLP technology minimum and maximum established in the VLP Technology Start-up Wizard.
D. A timer can be used to run/stop the external devices when running in a VLP technology maximum or minimum zone is programmable after an interval of 0.1-6553.5 seconds.
E. The drive comes standard with two Form A output terminals, allowing the drive to control two external devices. If an additional option terminal board is purchased, the Q9 Plus can control up to six external devices.

2.4.9. VLP Technology Time Based Alternation (TBA)

A. Time Based Alternation reduces machine wear by evenly distributing the run-time of the system on a multi-load system. TBA varies which system pump or fan plays the role of the lead, and can be performed across up to 32 different drives.
B. The duration between load alternations can be programmed from one minute to 41 days and 15 hours
C. Through the use of the real-time clock on each drive, TBA will allow multiple drives to automatically transfer loads without the need for external communication or switches.
D. TBA requires the all drives to share the same transducer feedback information
E. VLP technology monitors transducer feedback to control the operation of all of the drives running in TBA.
F. Each drive in the system, a maximum of 32, has a user defined unique number and needs to know how many total devices are in the system.
G. A programmable emergency timer can be initiated if the lead drive trips or loses transducer feedback. When the timer hits zero, if there is demand in the system, a lag drive will turn on. The timer can be programmed from 1-65535 minutes.

2.5. Input / Output Capabilities

A. The standard control terminal board contains:
   I. Eight (8) multifunctional programmable discrete inputs
   II. Sink or source logic selectable
   III. One (1) configurable form ‘C’ discrete relay output
   IV. Two (2) configurable form ‘A’ discrete relay outputs
   V. Three (3) analog inputs with adjustable gains and bias
      a. Isolated 0 to 10 Vdc / 0 to 20 mA
      b. 0 to 10 Vdc
      c. ±10 Vdc differential input
   VI. Two (2) analog outputs with adjustable gain and bias
      a. One (1) 0-20 mA/0-10 Vdc switchable
      b. One (1) 0-20 mA

2.6. Protective Features

A. The drive shall contain three critical frequency jump points with individual bandwidth.
B. The drive shall have discrete inputs that can be programmed as external fault inputs.
C. The drive shall be capable of re-setting faults remotely and locally.
D. The drive shall protect against the following faults and disable the system in the event that a subsystem of the drive is malfunctioning.
   1. Overvoltage at an analog input terminal

2. Over-speed error
3. Loss of signal at analog input terminal
4. CPU communication error
5. Speed/Torque/Direction control signal transfer error
6. Stack Overflow Error
7. Improper input voltage at discrete input terminal
8. Expansion Card Option 1 hardware error
9. Expansion Card Option 2 hardware error
10. CPU fault
11. EEPROM Write error
12. EEPROM Read error during parameter initialization
13. Ground/Earth fault
14. Emergency Off
15. Input Phase Loss
16. Output Phase Loss
17. RAM Read error
18. ROM Read error
19. Serial Communications time-out error
20. ASIC (gate array) error
21. Current Detection Hardware error
22. Network Option Card error
23. Overcurrent during acceleration
24. Overcurrent during deceleration
25. Overcurrent during run
26. Overcurrent at phases of IGBT (U, V, or W)
27. Output Short Circuit at U-V-W phases
28. Over Temperature error
29. ASD Overload error
30. Motor Overload error
31. Overvoltage during acceleration
32. Overvoltage during deceleration
33. Overvoltage during Run
34. Overtorque error
35. Permanent Magnet Motor pull out trip
36. Low Current error
37. Main Power Undervoltage

2.7. Operating Panel and Monitor Functions

A. The Monitor mode allows for the monitoring of motor performance variables, control settings, and configuration data during motor operation.
B. The Monitor mode is read-only.
C. Settings cannot be changed from the Monitor mode.
D. The Q9 Plus EOI shall be NEMA 1 rated.
E. The drive's keypad shall be capable of being extended 1000 feet from the drive with the appropriate EOI mounting kit.
F. The drive shall contain a reset of all parameters to factory default settings or user defaults (whichever one is chosen).
G. The drive shall retain the most recent faults.
H. The drive shall have an elapsed time meter and will save up to the past one hundred faults in memory.

2.8. Communication Options Available

A. BACnet MS/TP (Built-in standard)
B. Modbus RTU (Built-in standard)
C. LonWorks
D. Metasys N2
E. APOGEE FLN

2.9. Drive Environmental Conditions

A. Environment – Indoors NEMA 1 enclosure.
B. Ambient operating temperature is 14°F to 104°F.
C. Altitude – 1,000 meters without derating.
D. De-rate current 1% per 100 meters between 1,000 and 3,000 meters. Relative humidity - 95% maximum (no condensation allowed).

PART 3 – STARTUP TRAINING AND WARRANTY

A. Start-up and service is available at an additional cost.
B. The drive manufacturer's standard warranty on all ASDs is eighteen (18) months from date of shipment or one (1) year from date of startup, whichever comes first.