1.01 THE REQUIREMENT

A. The Contractor shall furnish, test and commission all low voltage variable frequency drives (VFDs) as specified in the RFP. VFDs will be installed by Fairfax Water personnel. The term Drawings is used herein to indicate elementary control schematics that are not a part of this RFP but would be a part of a potential subsequent IFB that is used to procure VFD equipment.

B. Reference the following Specification Sections:

1. Section 26 09 16 – Electric Controls and Relays

C. The variable frequency drives shall be assembled using NEMA rated components. Components designed and built to International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

1.02 CODES AND STANDARDS

A. VFDs shall be designed, manufactured, and/or listed to the following standards as applicable:

1. NEMA 250 – Enclosure for Electrical Equipment
2. IEEE 519 – Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
3. NEMA ICS 7 – Adjustable-Speed Drives
4. NEMA ICS 61800-2 – Rating Specifications for Low Voltage Adjustable Frequency AC Power Drive Systems
5. UL 508A – Standard for Industrial Control Panels
6. UL 508C – Standard for Power Conversion Equipment

1.03 DEFINITIONS

A. The following definitions are provided for clarity with regard to the language used in this Specification:
1. Variable Frequency Drive (VFD) – The complete custom-engineered VFD as packaged within an overall enclosure, including the VFD unit and all other components within that enclosure as specified herein.

2. VFD Unit – The solid-state power electronic device or devices within the VFD.

1.04 SUBMITTALS

A. In accordance with the procedures and requirements set forth in the RFP, the Contractor shall submit the following:

1. Shop Drawings (for RFP and future IFB as described herein)
2. Operation and Maintenance Manuals (for future IFB)
3. Spare Parts List (for future IFB)
4. Reports of Certified Shop and Field Tests (for future IFB)
5. Manufacturer’s Field Start-up Report (for future IFB)
6. Manufacturer’s Representative’s Installation Certification (for future IFB)

1.05 SHOP DRAWINGS TO BE SUBMITTED FOR RFP

A. Shop drawings for each rating of VFD shall include but not be limited to:

1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

2. Product data sheets for all system components, including but not limited to:
   a. VFD units
   b. Motor protection package
c. Harmonic correction devices and/or equipment, e.g. line reactors, passive filters, and 18-pulse phase-shifting transformers

3. Layout drawings of the VFD that include:
   a. All cabinet or enclosure dimensions, access details, and weights.
   b. Required clearances around and above the enclosure, e.g. ventilation.
   c. Conduit entry areas and/or stub-up locations.

1.06 SHOP DRAWINGS TO BE SUBMITTED FOR IFB (A FUTURE SUBMITTAL)

A. Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's compliance with the Contract Documents.

B. Partial, incomplete, or illegible submittals will be returned to the Contractor without review for resubmittal.

C. Shop drawings for each VFD shall include but not be limited to:

   1. A Compliance, Deviations, and Exceptions (CD&E) letter. If the shop drawings are submitted without this CD&E letter, the submittal will be rejected. The letter shall include all comments, deviations and exceptions taken to the Drawings and Specifications by the Contractor AND Equipment Manufacturer/Supplier. This letter shall include a copy of this specification section. In the left margin beside each and every paragraph/item, a letter "C", "D", or "E" shall be typed or written in. The letter "C" shall be for full compliance with the requirement. The letter "D" shall be for a deviation from the requirement. The letter "E" shall be for taking exception to a requirement. Any requirements with the letter "D" or "E" beside them shall be provided with a full typewritten explanation of the deviation/exception. Handwritten explanation of the deviations/exceptions is not acceptable. The CD&E letter shall also address deviations, and exceptions taken to each Drawing related to this Specification Section.

   2. Complete bill of material and catalog data sheets for all equipment and devices comprising the VFD.

   3. Product data sheets for all system components, including but not limited to:
      a. VFD units
      b. Harmonic correction devices and/or equipment, e.g. line reactors, passive filters, and 18-pulse phase-shifting transformers
      c. Output reactors and/or output filters
d. Pilot lights and pilot devices

e. Control and timing relays

f. Enclosure fans

g. Contactors

h. Power supplies

i. Control power transformers

j. Current transformers

k. Potential transformers

l. Circuit breakers

m. Fuses

n. Terminal blocks (power, control, and shorting)

4. Layout drawings of the VFD that include:

a. All cabinet or enclosure dimensions, access details, and weights.

b. Required clearances around and above the enclosure, e.g. ventilation.

c. Conduit entry areas and/or stub-up locations.

d. Nameplate sizes, colors, and locations.

e. Physical arrangement of door mounted devices located on the variable frequency drive enclosure.

f. Physical arrangement of all interior components, including DIN-rail-mounted devices.

   General "catalog data sheet" layout drawings which are not specific to the systems specified herein are not acceptable.

5. Custom schematic and interconnection wiring diagrams of all electrical work, including but not limited to, circuit breakers, motor circuit protectors, contactors, instrument transformers, meters, relays, timers, control devices, terminal blocks and identification numbers, wire numbers, and other equipment comprising the complete system.
a. These drawings shall be circuit specific for each motor-load combination. Specific equipment names consistent with the Drawings shall appear on each respective diagram.

b. Indicate all devices, regardless of their physical location, on the schematic diagrams.

c. Electrical ratings of all equipment and devices shall be clearly indicated on the schematic diagrams.

Standard schematics and wiring diagrams that are not custom created by the manufacturer for the variable frequency drives for this project are not acceptable.

6. Confirmation of spare parts requirements as specified herein.

D. The shop drawing information shall be completed and organized in such a way that the Engineer can determine if the requirements of these Specifications are being met. Copies of technical bulletins, technical data sheets from catalogs, and similar information which is "highlighted" or somehow identifies the specific equipment items the Contractor intends to provide are to provide are acceptable and shall be submitted.

1.07 OPERATION AND MAINTENANCE MANUALS

A. The Contractor shall submit operation and maintenance manuals in accordance with the RFP.

B. Prior to completion and final acceptance of the project, the Contractor shall furnish "as-built" wiring diagrams for each VFD.

C. The O&M manual shall include the “as-commissioned” parameters of each VFD in both print and searchable PDF formats.

D. If the VFDs require computer software or configuration, the O&M manual shall include copies of all programming guides/manuals.

1.08 WARRANTY

A. Contractor shall warrant that the material and workmanship of all components and the operation of the VFDs and auxiliary equipment is in accordance with the latest design practices and meets the requirements of this Specification.

B. Warranty shall include, but not be limited to the following:

1. Replace components found to be faulty and make changes in equipment arrangement or make adjustments necessary to meet the equipment or functional requirements or this Specification.
2. System rewiring and component substitution/rebuild.

3. All accessories and appurtenances provided by the VFD manufacturer.

C. Warranty shall be in effect for a period of 24 months following installation, startup, and Owner acceptance or 30 months following delivery of each VFD, whichever occurs first.

PART 2 – PRODUCTS

2.01 VFD SYSTEMS

a. Operating Conditions

2. The following operating conditions are applicable for all equipment of this Specification.

a. Humidity: 0-95%.

b. Ambient Temperature: 0 degrees Celsius to plus 50 degrees Celsius.

c. Altitude: up to 3,300 feet

B. Basic Design and Performance

1. Each VFD shall be a complete alternating current electric drive system including all hardware and software necessary to accomplish variable speed operation of a motor and load combination. VFDs shall be provided in accordance with the requirements indicated on the Drawings and as described in these Specifications. The VFD and Accessories shall be listed and labeled as defined in NFPA 70, and marked for intended location and application.

2. Each VFD shall be suitable for operation as part of a 480 VAC, 3-phase, 60 Hertz power distribution system. The complete VFD system shall have a minimum short circuit current rating of 65,000 amperes symmetrical at rated voltage.

3. The Contractor is fully responsible for the review of the full Contract Documents to determine specified motor speed, horsepower and full load ampere requirements for each motor-driven load. In addition, the Contractor shall size and select the VFD and components as follows:

a. Each VFD shall provide, continuously, motor load current equal to 100% of the direct on-line motor nameplate full load current.

b. Each VFD shall be selected for Variable Torque (Normal Duty), as no Constant Torque (Heavy Duty) applications are anticipated.
4. Each VFD shall be suitable to operate, at times, on a limited power source engine-generator set. The VFD shall be provided with equipment and devices to prevent waveform distortion as specified herein.

5. Each VFD shall be provided with control and sequence logic as specified herein and indicated on the Drawings. Control and sequence logic shall be designed such that the motor-load combination can be operated in the manual mode upon control and sequence logic failure, including all necessary personnel and equipment safety interlocks. Each VFD shall be designed such that specific control and protection functions can be attained through simple programming by either factory engineers or Owner's trained operating personnel.

6. Where indicated in the RFP or IFB, VFDs shall be provided with output reactors or filters to prevent elevated voltage levels at the motor terminals that exceed the ratings of the associated motor winding insulation.

   The VFD manufacturer shall select and size the output reactors or filters based on the cable lengths provided by Fairfax Water. The output filters or reactors shall be as manufactured by TCI, MTE Corporation, Mirus International, or engineer approved equal.

7. Motor control circuits shall be wired in accordance with the requirements specified herein and/or indicated on the Drawings.

C. Components

1. Each VFD shall contain the harmonic correction equipment as indicated in the RFP and required for the applications. Harmonic correction equipment shall be as specified elsewhere in this Specification.

2. Each VFD shall contain the number of auxiliary contacts, control power transformer(s), pilot devices and indicating lights, control relays, elapsed time meters, and other devices as specified herein, shown on the Drawings and as required for the applications. The following components shall meet the requirements of Section 26 09 16 – Electrical Controls and Relays:

   a. Pilot devices (switches, indicating lights, etc.)

   b. Relays and timers

   c. Terminal blocks

3. Power terminal blocks for VFD output to the motor shall be fixed-mounted to a backplane or the enclosure. Mounting the terminal blocks on DIN rails is not acceptable.
4. Electrical bus, including ground bus, shall be tin-plated copper. Power and control wiring shall be copper, color coded and identified in accordance with these Specifications.

5. Each VFD shall be of modular construction allowing normal maintenance and repair to be done with ordinary hand tools. Design and install power electronic component assemblies so that, where practicable, components can be individually removed and replaced.

6. Auxiliaries, including fans, that are required for rated load operation at maximum ambient temperature, shall be 100% redundant. New and unused spare replacement fan(s) or air conditioning unit(s), shipped in original carton, may be provided in lieu of 100% redundant auxiliaries.

7. Circuit boards and electrical components shall meet the corrosion protection requirements specified in these Specifications. Varnished or epoxy encapsulated circuit boards and tropicalized contactors suitable for corrosive environments shall be furnished.

8. Circuit Breakers
   a. Each VFD shall be protected by a circuit breaker.
   b. Unless otherwise indicated, circuit breakers shall be manually operable and shall provide thermal-magnetic, inverse-time-limit overload, and instantaneous short-circuit protection.
   c. Circuit breakers shall be molded case type, rated 480 VAC, 3 pole and have 100 ampere or larger frames. The interrupting rating shall match or exceed that of the VFD short circuit rating at 480V.
   d. Overload protection shall be provided on all poles with trip settings as indicated on the Drawings. Breakers of 225-ampere frames and larger shall have interchangeable solid-state electronic trip units.
   e. Where indicated on the Drawings, shunt trip devices shall be provided to trip a circuit from a remote location by means of a trip coil energized from a separate circuit. A 120V shunt trip shall be capable of operating at 55% or more of rated voltage. All other shunt trips shall be capable of operating at 75% or more of rated voltage.

9. Motor Protection Relays
   a. Where indicated on the Drawings, VFDs shall be furnished with motor management and protection relays as specified elsewhere in this Specification.

D. Controls
1. Each VFD shall be provided with automatic and manual controls as shown on the Drawings and as required to comply with all Specifications. Controls and indicators to accomplish operation and maintenance shall be located on the variable frequency drive equipment assembly as specified herein and indicated on the Drawings.

2. The Elementary Control Schematics shown on the Drawings are representative of design intent only. The manufacturer shall be responsible for providing all additional components, controls, and internal wiring necessary to meet the design intent.

3. VFD circuitry shall be designed such that the enclosure cooling fans only run when the VFD unit is producing output power. Designs that allow the enclosure cooling fans to run continuously when the VFD unit is energized but not producing output power are not acceptable. Fans that are used exclusively to provide cooling for the VFD unit (and not the overall enclosure) are permitted to run continuously if required by the VFD manufacturer’s design standards/practices.

E. Enclosures

1. Equipment within the VFD enclosure shall be arranged so that it does not interfere with the entry of conduits and cables into the enclosure. VFDs shall be installed within NEMA 1, painted steel enclosures.

2. NEMA 1 VFD enclosures shall be force ventilated with front accessibility and the following:
   a. Enclosures shall be provided with washable enclosure air intake filters that can be replaced while the enclosure door remains closed.
   b. Enclosures shall be designed for bottom or top entry of conduits and cables as required.
   c. Enclosures shall be finished in ANSI-61 gray enamel or in a color to match the complete line-up of equipment as indicated on the Drawings and accepted by the Engineer.

3. Each VFD shall be designed such that rear access to the enclosure is not required for operations, maintenance, or repair tasks.

4. The Contractor shall reference the RFP for maximum dimensions of the VFDs.

5. Integrating VFDs into a motor control center assembly is not permitted.

6. Enclosure doors shall have full length piano type hinges and shall be braced to prevent sag when fully open.
7. Each VFD enclosure shall be supplied with an industrial, heavy-duty flange-mount handle mechanism for the operation of the VFDs disconnecting means as follows:
   a. The mechanism shall be engaged with the disconnect device at all times as an integral part of the unit regardless of the unit door position.
   b. The operator handle shall have an up-down motion with the down position as off. The ON-OFF condition of the disconnecting means shall be permanently marked on the handle operator.
   c. It shall be possible to lock the handle in the "OFF" position with up to three (3) 3/8-inch diameter shackle padlocks and in the "ON" position with one (1) 3/8-inch diameter shackle padlock.
   d. The operator handle shall be mechanically interlocked such that the disconnecting means cannot be closed with the enclosure door open, nor can the enclosure door be opened when the disconnecting means is closed. A defeater mechanism shall be provided so that qualified personnel can bypass these interlocks for maintenance and testing purposes. The defeater mechanism shall allow the enclosure door to be opened without interrupting the operation of the VFD.

8. Enclosure shall be equipped with space heaters, with NC auxiliary contacts, to mitigate condensation due to humidity and temperature swings.

F. Nameplates and Legend Plates
   1. Provide engraved plastic nameplates and legend plates to identify each VFD and associated door mounted devices and internal components. Nameplates shall be engraved, high pressure plastic laminate, white with black lettering.
   2. Equipment names and/or numbers and device identification text shown on the Drawings shall be used as the basis to engrave the nameplates and legend plates. Where the equipment identification text would exceed the capacity of the VFD manufacturer’s standard nameplate/legend plate size, the manufacturer shall provide larger nameplates and/or additional nameplates as necessary. Abbreviating equipment names/numbers and device identification text is not acceptable.
   3. Control components mounted as part of the assembly, such as fuse blocks, control relays, pushbuttons, switches, and similar devices, shall be suitably marked with identification corresponding to appropriate designations on the manufacturer’s wiring diagrams.

2.02 VFD UNITS
   A. Basic Design and Performance
1. Each VFD unit shall be of adjustable frequency, adjustable voltage, pulse width modulated (PWM) design. The units shall be microprocessor controlled, fully digitally programmable, and capable of precise and repeatable speed regulation of three phase 480 VAC NEMA Design A or B induction motors.

2. Each VFD unit shall consist of a semiconductor rectifier system, direct current link, and pulse width modulated inverter. The inverter shall invert the direct current voltage into an alternating current voltage at a frequency which shall be proportional to the desired speed. This alternating current voltage and frequency shall both vary simultaneously at a constant “Volts-Per-Hertz” ratio to operate the motor at the desired speed.

3. Each VFD unit shall operate the motor and produce full rated nameplate horsepower at the motor output shaft without exceeding motor nameplate full load current and with the motor not exceeding rated total temperature not including the additional temperature increment that constitutes the motor service factor. Motor shall retain its service factor when operated by the variable frequency drive.

4. The overall efficiency of each VFD unit shall be a minimum of 95% when operating the specified motor-load combination at rated voltage, frequency, and current.

5. Each VFD unit shall provide smooth, stepless changes in motor speed and acceleration over the entire operating speed range from minimum to maximum speed. The VFD unit shall be provided with adjustable maximum and minimum frequency limits.

6. Each VFD unit shall maintain a desired output frequency (setpoint) with a steady state accuracy of 0.5% of rated frequency of 60 Hertz for a 24-hour period and a repeatability of 0.1% of rated frequency of 60 Hertz.

7. Each VFD unit shall be capable of operating the specified load continuously at any speed within the operating speed range of 10% to 100% of rated speed. The minimum and maximum continuous operating speeds shall each be adjustable within this speed range. The variable frequency drive shall provide for field adjustment of these setpoints.

8. Each VFD unit shall be capable of controlled linear acceleration and deceleration. Each VFD unit shall be capable of ramping the speed of the motor-load combination from the minimum selected operating speed to the maximum selected operating speed in a minimum of 30 seconds. Each VFD unit shall have two (2) field-adjustable speed setpoints for the variable frequency drive to skip equipment resonant frequencies. The acceleration and deceleration time limits shall be field adjustable to values up to 120 seconds.

9. Voltage or current unbalance between phases of the VFD unit output voltage shall not exceed 3% of the instantaneous values. The VFD unit shall continuously monitor the output voltages and generate an alarm condition when the unbalance
exceeds 3%. The system shall detect and generate a separate alarm for loss of any output phase voltage (single phasing). Phase unbalance shall be as defined by NEMA Standard MG-1.

10. Each VFD unit shall operate continuously without interruption of service or damage to equipment during transient input voltage variations of plus or minus 10% for a duration of 15 cycles. Unacceptable voltage fluctuations on the supply bus shall cause under or overvoltage protection to trip and remove supply voltage from the drive system. VFD unit output voltage regulation shall be plus or minus 2%.

B. Features and Characteristics

1. Surge Suppression: Factory installed as an integral part of the VFD, complying with UL 1449 SPD, Type 2.

2. Each VFD unit shall be furnished with a Human Machine Interface (HMI) to provide controls and indication to accomplish maintenance and operational functions as specified herein and shown on the Drawings. The HMI shall be password protected after startup to prevent unauthorized personnel from making changes. The HMI shall at minimum provide indication of the following:
   a. Input Voltage
   b. Output Voltage
   c. Output Current
   d. Output Frequency
   e. Output Speed from 0-100%
   f. Alarm Read-out

3. Each VFD unit shall provide a 4-20 mADC output signal that is proportional to the drive output frequency for use as speed feedback and remote speed indication.

4. Each VFD unit shall accept a 4-20 mADC input command signal to control the output frequency in the automatic and/or manual control modes as specified herein or indicated on the Drawings. The system shall accept the input increase/decrease command with a resolution that permits incremental changes in speed equal to or less than 0.1% of rated speed.

5. When operating in the automatic mode, the VFD unit shall shut down during a power outage or sustained undervoltage event. A sustained undervoltage event is defined as voltage that is less 75% of nominal, for more than 0.5 seconds. Upon restoration of normal power and after an adjustable time delay (0-2 minutes; motor has coasted to zero speed and there is no backspin), the VFD unit shall automatically restart and then ramp up to speed as required by the control system.
Personnel shall not be required to reset the system manually after a shutdown caused by a power outage or sustained undervoltage event.

6. Each VFD unit shall have a multiple attempt restart feature.

7. Each VFD unit shall have an automatic current limit feature to control motor currents during startup and provide a "soft start" torque profile for the motor-load combination. The VFD unit shall also limit current due to motor winding or motor lead phase-to-phase short circuit or phase-to-ground short circuit. The current limit protection setting shall be field adjustable.

8. Each VFD unit shall be furnished with programmable electronic overload and torque limits.

9. Each VFD unit shall have an automatic trip feature which will remove the drive output from the motor and allow it to decelerate safely. This automatic system shall lock-out the VFD unit and indicate the fault only upon the following conditions:
   a. Output voltage unbalance (trip threshold field set).
   b. Open phase.
   c. Reverse phase.
   d. Motor overload.
   e. Motor stator winding fault (phase-to-ground, phase-to-phase).
   f. Unacceptable voltage variation.
   g. High variable frequency drive equipment temperature.
   h. VFD failure as determined by the manufacturer.
   i. Component failure.
   j. Overcurrent.

10. Provide each VFD unit with transmitted and received radio interference protection. In addition, provide protection against starting a rotating motor, both directions (coasting to zero speed and backspin). In the event that a motor automatic restart feature (catch the motor "on-the-fly") is provided in the VFD unit as standard, this feature shall be capable of being disabled.

11. Each VFD unit shall include on-line diagnostics, with an automatic self-check feature that will detect a variable frequency drive failure which in turn affects motor operation and generates an alarm contact output rated for 125 VDC suitable for interfacing with the control system.
a. Diagnostics shall operate a visual alarm indicator that is visible on the variable frequency drive equipment cabinets without opening the cabinet doors.

b. Diagnostics shall provide an easily readable output that can be used to isolate a failure.

c. Provide an event and diagnostic recorder to printout in narrative English of the specific fault(s) and the sequence in which the faults occurred. An indication of the "First Out" failure is a minimum for fault sequence detection.

d. Provide a normally open dry contact for each alarm function to enable remote indication.

12. Each VFD unit shall communicate the following parameters to the plant control system via Ethernet/IP protocol. Provide any necessary hardware gateways to provide this communication capability. The following parameters, at a minimum, shall be communicated:

   a. Current (all phases)
   b. Voltage (all phases)
   c. KW, KVAR, KVA
   d. Power Factor
   e. Speed
   f. Status and alarm conditions noted above

13. Each VFD unit shall be provided with input/output (I/O) expansion cards as necessary to facilitate connection of all I/O specified herein and shown on the Drawings.

2.03 HARMONIC CORRECTION

A. Harmonic correction devices for each VFD shall be as specified herein and in the RFP.

B. Input Line Reactors

   1. 6-pulse VFD units shall be provided with input line reactor and/or integral DC link reactor. Total reactor impedance shall be a minimum of 3% and shall not exceed 5%.

C. Passive Filters
1. Where indicated in the RFP, 6-pulse VFD units shall be provided with a passive harmonic filter in addition to the integral DC link reactor specified above (if present.)

2. Passive harmonic filters shall be sized to attenuate harmonics resulting from operation of the VFD-driven motor load to no more than 5% THID when operating at full load, and no more than 8% THID when operating at 30% of full load. The filter shall be equipped with power contactors configured to remove the capacitors from the circuit when the VFD-driven loads are not in operation. The harmonic filters shall be as manufactured by TCI, MTE Corporation, Mirus International, or engineer approved equal.

3. Passive filters shall be integrated into the VFD enclosure.

D. 18-Pulse and Active Front End (AFE) VFDs

1. Where indicated in the RFP, VFDs shall consist of either:
   a. an 18-pulse VFD unit with an 18-pulse phase-shifting transformer, or
   b. a VFD unit with an IGBT-based active front end (AFE).

2.04 MOTOR PROTECTION RELAYS

1. For VFDs rated 500hp and above, the motor controller shall be provided with a microprocessor based, motor protector in each individual starter to protect, monitor, and control the motor.

2. The motor protector shall be capable of monitoring electrical current; receive commands from remote sources either by contact closures or digital data; give commands (e.g. fail, trip, etc.) to the motor controller and other devices under its control; and communicate by alphanumeric display with the operator and by digital signals with other equipment.

3. True rms current shall be constantly monitored, separated into positive and negative sequence components to determine the heating effects caused by both, and processed to provide maximum motor utilization. The motor protector shall be mounted on the low voltage compartment door. Current transformers shall be provided as indicated on the Drawings and as required.

4. Specific data entry to suit the actual motor application shall be accomplished by means of an operator panel. Entered data shall be stored in “non-volatile” memory so as not to require battery back-up.

5. Protection relays shall have inputs to monitor up to ten 100-ohm RTDs, and up to two vibration monitor units (analog 4-20ma input).
6. A digital display of monitoring functions including, but not limited to, the following shall be provided:
   a. Line current in each phase in rms amperes
   b. Running time (cumulative in hours)
   c. Remaining starts
   d. Motor starts exceeded
   e. Total energy consumption
   f. Power factor
   g. Power in kilowatts
   h. Voltage reading
   i. Alarm status

7. The following protection and control functions including, but not limited to, the following shall be provided:
   a. Motor running time overcurrent: Device 49/51
   b. Zero-sequence ground fault: Device 50G/51G
   c. Adjustable instantaneous overcurrent: Device 50
   d. Underload trip with start and run time delays: Device 37
   e. Current unbalance: Device 46
   f. Incomplete sequence delay: Device 48
   g. Limitation on number of starts per time-period: Device 66
   h. JAM trip with start and run time delays
   i. Phase loss (voltage)
   j. Phase unbalance (current)
   k. Phase reversal (voltage)
   l. Undervoltage
B. Motor protectors shall be model 869 as manufactured by GE/Multilin, or model 710-5 as manufactured by SEL.
2.05 SEISMIC PERFORMANCE

A. VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The units shall be fully operational after a seismic event.

PART 3 – EXECUTION

3.01 INSTALLATION

A. The VFDs will be installed by Fairfax Water personnel.

3.02 TESTING

A. The following tests are required:

1. Witnessed Shop Tests
   a. None required.

2. Certified Shop Tests and Reports
   a. Submit description of proposed testing methods, procedures, and apparatus.
   b. Factory test the complete VFD in accordance with IEEE and NEMA standards.
   c. Submit factory bench-test data to indicate that the manufacturer’s proposed equipment has been tested in the specified arrangement and found to achieve specified accuracy.

3. Field Tests
   a. Field testing shall be done in accordance with the requirements specified in NETA Acceptance Testing Specifications (ATS), latest edition.

B. Submit signed and dated certification that all of the factory inspection and testing procedures described herein have been successfully performed by the Contractor prior to shipment.

3.03 SERVICES OF A MANUFACTURER’S REPRESENTATIVE

A. The Contractor shall provide the services of a qualified manufacturer’s factory-trained technical representative who shall adequately supervise the installation and startup of all equipment furnished under this Contract. The manufacturer’s representative shall certify in writing that the equipment has been installed in accordance with the manufacturer’s recommendations. No further testing or equipment startup may take place until this certification is accepted by the Owner.
B. The manufacturer’s technical representative shall perform all startup and field acceptance testing as specified herein.

C. The Contractor shall provide training for the Owner’s personnel. Training shall be conducted by the manufacturer’s factory-trained representative who shall instruct Owner’s personnel in operation and maintenance of all equipment provided under this Section. Training shall be provided for two (2) sessions of four (4) hours each. Training shall not take place until after the VFDs have been installed and tested. Training shall be conducted at times coordinated with the Owner.

D. The services of the manufacturer’s representative shall be provided for a period of not less than as follows:

1. One (1) trip of one (1) working day to perform startup and field acceptance testing of the motor controllers.

2. One (1) trip of one (1) working day to perform training as specified herein.

3. One (1) trip of one (1) working day two (2) months before the expiration of the warranty to identify any issues to be corrected under warranty.

E. Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor.

END OF SECTION