Addendum No. 1

EchoWater Project
Tertiary Treatment Facilities (TTF) Project

Request for Equipment Supplier Prequalification
Filter Influent
Vertical Axial/Mixed Flow Pumps

SACRAMENTO REGIONAL COUNTY SANITATION DISTRICT
SACRAMENTO COUNTY, CALIFORNIA

RECEIPT OF THIS ADDENDUM MUST BE ACKNOWLEDGED IN THE SPACE PROVIDED ON THE REQUEST FOR PROPOSAL SUBMITTAL FORM

September 25, 2017

Addendum No. 1 is hereby made part of the Regional San Request for Request for Equipment Supplier Prequalification Filter Influent Vertical Axial/Mixed Flow Pumps Dated August, 2017.

Addendum No. 1

to the Request for Equipment Supplier Prequalification Filter Influent

Vertical Axial/Mixed Flow Pumps

September 25, 2017

Bold indicates added or revised text and strikethroughs indicate deleted text.

Addendum Item	Section and Page or Drawing No.	Location and Description of Change
1.001	iv (top of page)	Revise Proposal Due Date as follows: Delete: ~~September 29, 2017~~, and replace with **October 13, 2017**
1.002	iv (table)	Revise Proposal Due Date as follows: Delete: ~~September 29, 2017~~, and replace with **October 13, 2017**
1.003	iv (table)	Revise Regional San Evaluation as follows: Delete: ~~October 26, 2017~~, and replace with **November 9, 2017**
1.003	iv (table)	Revise Supplier Notifications as follows: Delete: ~~October 27, 2017~~, and replace with **November 10, 2017**
1.004	iv (table)	Revise End Appeals Period as follows: Delete: ~~November 3, 2017~~, and replace with **November 17, 2017**
1.005	V	Revise Date as follows: Delete: ~~September 29, 2017~~, and replace with **October 13, 2017**
1.006	Section 1 page 1	Revise Date as follows: Delete: ~~September 29, 2017~~, and replace with **October 13, 2017**
1.007	Part III.C page 17	Revise specification list as follows: Delete: ~~VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 29 23),~~ and replace with **MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 13 27)**
1.008	Part III.C.l page 18	Revise specification list as follows: Delete: ~~VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 29 23),~~ and replace with **MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 13 27)**

Addendum Item	Section and Page or Drawing No.	Location and Description of Change
1.009	Appendix B Part III.c page B-2	Revise specification list as follows: Delete: ~~VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 29 23),~~ and replace with **MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 13 27)**
1.010	Appendix B Part III.c page B-2	Revise specification list as follows: Delete: ~~VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 29 23),~~ and replace with **MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS Section (26 13 27)**
1.011	Appendix C page C-1	Revise specification list as follows: Delete: ~~Section 26 29 23 – Variable Frequency Motor Controllers~~ and replace with **Section 26 13 27 – MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS**
1.012	26 29 23	Remove existing Specification Section 26 29 23 (VARIABLE-FREQUENCY MOTOR CONTROLLERS) in its entirety and replace with attached Specification Section 26 13 27 (MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS)

Addendum No. 1 is hereby made part of the Regional San Request for Request for Equipment Supplier Prequalification Filter Influent Vertical Axial/Mixed Flow Pumps Dated August, 2017.

END OF ADDENDUM

SECTION 26 13 27

MEDIUM VOLTAGE VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 -- GENERAL

1.01 GENERAL REQUIREMENTS

A. SCOPE:

1. Variable frequency drives for use with medium voltage motors.

1.02 REFERENCES

A. REFERENCED STANDARDS: The publications referred to hereinafter form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The latest edition of referenced publications in effect at the time of the bid shall govern. In case of conflict between the requirements of this section and the listed references, the requirements of this section shall prevail.

Reference	Title
ANSI	American National Standards Institute
CSA	Canadian Standards Association
ETL	ETL Testing Laboratories
IEEE	Institute of Electrical and Electronic Engineers
IEEE 399	Recommended Practice for Industrial and Commercial Power Systems Analysis
IEEE519	Recommended Practices Practices and Requirements for Harmonic Control in Electrical Power Systems
NEMA	National Electrical Manufacturer's Association
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 6	Industrial Control and Systems: Enclosures
NEMA MG 1	Motors and Generators
NFPA 70	National Electrical Code (NEC)
UL 508	Standards for Safety Industrial Control Equipment

B. DEFINITIONS:

1. VARIABLE TORQUE (VT):

   a. Defines a load characteristic in which the torque delivered from the motor to the load is reduced as speed is reduced below full rated.

   b. This type of load permits the VFD and the motor to operate at reduced output current at reduced speed.

2. CONSTANT TORQUE (CT):

   a. Defines a load characteristic in which the torque delivered from the motor to the load remains constant as speed is varied.

   b. This type of load requires the VFD to be able to continuously deliver rated output current over the entire speed range.

3. CONSTANT HORSEPOWER:

   a. Defines a load characteristic in which the torque delivered from the motor to the load is reduced as the speed is increased.

   b. This characteristic is required for operation of the VFD and motor above rated frequency to maintain output current within the rated value.

1. Point of common coupling (PCC):

   a. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the input terminals at each VFD.

1.03 SUBMITTALS

A. The following information shall be submitted for review in accordance with the SUBMITTAL PROCEDURES Section (01 33 00):

1. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.

B. PRODUCT DATA

1. Manufacturer of VFD.

2. Manufacturer of all component parts of VFD.

3. Dimensions:

    a. Height.

    b. Length.

    c. Width.

    d. Weight.

4. Nameplate schedule.

5. Bill of material.

6. Description of operation:

    a. Metering system.

    b. Protective relaying.

7. Ratings:

    a. Voltage.

    b. Phase.

    c. Input current.

    d. Output current.

    e. Interrupting rating (circuit breakers and fuses):

        1) Furnish manufacturer's time current curves on 11- by 17-inch log-log paper for all fuses.

    f. Momentary current rating.

8. List of recommended spare parts.

9. Name of dealer's repair facility and parts stocking agreement with the factory:

    a. Agreement shall outline in detail the manufacturer's parts stocking requirements and the method by which the manufacturer's representative verifies that the stock is at an acceptable level.

    b. Agreement should also outline the method by which the manufacturer's representative determines that the service personnel meet factory standards.

10. For equipment installed in structures designated as seismic design category C, D, E, or F submit the following as specified in COMMON WORK RESULTS FOR ELECTRICAL Section (26 05 00):

    a. Manufacturer's statement of seismic qualification with substantiating test data.

    b. Manufacturer's special seismic certification with substantiating test data.

C. SHOP DRAWINGS:

1. Submit VFD Shop Drawings concurrently with driven equipment and motor Shop Drawings.

    a. Unit Description including amperage rating, frame sizes, trip settings, pilot devices, etc.

    b. Complete Schematic, wiring, and interconnection diagrams.

    c. Three (3) line diagrams showing AC schematic of VFD, input and output devices including device ratings.

    d. Field wiring diagrams showing locations and sizes of all electrical connections, ground terminations, and requirements for shielded wire usage or any other special installation considerations.

    e. Complete 1-line diagrams and 3-line diagrams for each VFD:

        1) Drawings shall indicate devices comprising the switchgear assembly including, but not limited to, circuit breakers, control power and instrument transformers, meters, relays, control devices and monitoring devices.

    f. Clearly indicate device electrical ratings on Drawings.

    g. Design data:

        1) Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions at the different locations, the reference signals and commands and the auxiliary supplies (i.e. air, oil, cooling water, electrical auxiliary supplies).

        2) Electrical single line diagram showing main and auxiliary circuitry, including main power input, switchgear, transformer, VFD, system grounding and auxiliary supplies - showing all CTs, PTs, relays, meters, etc., for the control, protection and operation of the drive system with electrical data (i.e. voltage, current, time ratings, impedances, tolerances).

        3) Efficiency and power factor values.

4) Harmonic distortion analysis.

2. Schedule of VFDs for the project listing for each VFD:
    a. Equipment Tag Number.
    b. VFD Complete Catalog Number.
    c. VFD Frame Size.
    d. Variable or Constant Torque Rating Basis.
    e. Rated Input Current.
    f. Rated Continuous Output Current.
    g. Rated Short Circuit Current.
    h. VFD Maximum Motor Lead Length.
    i. Motor Manufacturer.
    j. Motor Frame Size.
    k. Motor Full Load Amps.
    l. Motor Service Factor.
    m. Motor Lead Length as Determined by Contractor.
    n. VFD options provided to meet harmonic or motor protection specifications.
3. Fully dimensioned and to scale equipment fabrication and/or layout drawings:
    a. Structure Descriptions showing:
        1) Shipping splits
        2) Enclosure rating
        3) Fault rating
    b. Conduit locations
    c. Elevation drawings showing dimensional information.

d. Top, front and side exterior views, with details showing maximum overall dimensions of enclosure, mounting provisions and conduit/cable entry provisions.

e. Identify minimum clearances from other VFDs or electrical equipment required for proper cooling at top, bottom, sides, and back of enclosure.

f. Interior layout drawings showing location of all components within enclosure, field wiring terminal boards, and power and grounding connections.

g. Assembly drawings, cross-section as a minimum, for each VFD with major dimensions indicated.

4. Installation instructions:

a. Detail the complete installation of the equipment including rigging, moving, and setting into place.

b. For equipment installed in structures designated as seismic design category C, D, E, or F:

1) Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic and wind loads as specified in Section (26 05 00).

2) Submit anchoring drawings with supporting calculations.

3) Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

5. Calculations:

a. Harmonic study

1) A preliminary harmonic analysis shall be performed. A power system short circuit ratio of 10 shall be assumed, with all VFDs operating at maximum speed and maximum load. Short circuit current (ISC) utilized for harmonic analysis calculations is defined as: I_{sc} = 10 * (Sum of total full load amps of All VFD system).

2) The harmonic analysis must be submitted by the VFD system manufacturer at the time of bid, which includes all voltage and current harmonics up to the 99th. The harmonic analysis must be performed at the defined point of common coupling.

b. Complete protective device and drive parameter study based upon the actual power system configuration and the actual motor protection parameters.

6. Certification: Submit with Shop Drawings:

    1) Letter from the VFD manufacturer stating that the specific application has been reviewed and that the VFD will satisfy the drive duties required with the actual motor furnished.

    2) Efficiencies meet the requirements of this Section.

    3) Certificate that the VFD system proposed has been in operation for a minimum of 5 years.

    4) Provide a letter from the VFD manufacturer that lists each paragraph, subparagraph, etc. of this Section and state compliance/non-compliance with said paragraph. If non-compliance is indicated, provide an explanation for the deviation and alternative method to address the non-compliance.

    5) Identification and location of closest authorized service organization.

    6) Harmonic analysis required by PART 2 of this Specification Section.

    7) Certified factory test reports confirming compliance with specified requirements.

    8) Submit certified field service reports after installation showing:

        a. Certification letter from manufacturer that VFD system has been inspected and is installed in accordance with the manufacturer's requirements.

        b. Each VFD is operational.

        c. Each VFD and its driven equipment motor are compatible.

        d. Each VFD responds correctly to the input control signals.

        e. Critical frequencies of the drive system and that the VFD has been set to lockout these frequencies.

7. Test forms and reports:

    a. Submit complete factory acceptance test procedures and all forms used during the test.

    b. Certified subassembly test results.

    c. Certified system level test results.

d. Harmonic compliance test results.

e. Manufacturer to furnish a certified report after the shop tests.

f. Manufacturer's startup representative to furnish a written report after the startup:

1) Report must state that the installation is complete and satisfactory, or list items requiring additional attention and proposal for the actions.

g. If any items require attention after the initial startup, a final report is required stating that the installation is complete and satisfactory.

1.04 OPERATION AND MAINTENANCE INSTRUCTIONS

A. Submit operation and maintenance (O&M) instructions in accordance with the OPERATION AND MAINTENANCE DATA Section (01 78 23) by submitting a copy of the OPERATION AND MAINTENANCE DATA Section (01 78 23) with each paragraph check marked to show compliance. O&M instructions shall be submitted after all submittals specified above have been returned mark "No Exceptions Taken" or "Make Corrections Noted." O&M instructions shall reflect the approved materials and equipment.

1. OPERATION AND MAINTENANCE MANUALS:

a. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of equipment of every nature furnished and/or installed under this Contract.

b. The operating instructions written descriptions must detail the operational functions of all normally used controls, which have been placed on the front panel of the VFD.

c. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as data identifying all parts. These manuals shall include but are not limited to the following:

1) Initial test, adjustment and start-up procedures.

2) Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.

3) All schematic, wiring and external diagrams furnished in reduced 11- by 17-inch format and shall be fully legible at the drawing size.

d. Approved copy of VFD schedule.

e. Manufacturer's instruction manuals.

f. Troubleshooting procedures with a cross-reference between symptoms and corrective recommendations.

g. Connection data to permit removal and installation of recommended smallest field-replaceable parts.

h. The manufacturer's recommended spare parts and special tools lists shall be in accordance with the OPERATION AND MAINTENANCE DATA Section (01 78 23) Commissioning sheets showing "as-left" values of all user-programmable or adjustable drive parameters.

1.05 QUALITY ASSURANCE

A. The entire VFD System shall be factory assembled and tested with UL label by the VFD manufacturer.

B. Adjustable frequency drives shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in conformance with ISO Standard 9001.

C. Coordination:

1. VFD manufacturer shall verify with the driven equipment manufacturer that the VFD and the drive motor are compatible and that the VFD will operate the driven equipment motor over its required operating range and will do so without exceeding the motor or VFD safety factors.

2. VFD shall be supplied complete with all required control components.

a. Provide control as indicated on the electrical drawings, specified in this Specification Section and specified in the control system sequences of operation and loop descriptions.

b. VFD manufacturer shall review the application and provide, at no additional cost to the District, the hardware and software necessary to allow the VFD to control the driven equipment motor over its required operating range.

1) These may include, but are not limited to, analog and digital interface modules, communication interface modules, switches, lights and other devices.

c. Coordinate control devices with devices furnished with driven equipment such as vibration switches, thermal sensors, leak detectors, etc.

3. Verify plan dimensions with equipment space requirements as indicated on the Drawings.

    a. Equipment which exceeds the allotted maximum dimensions may not be acceptable.

    b. Equipment which reduces clear work space below the minimums established by the NEC will not be acceptable.

D. QUALIFICATIONS:

1. It is the intention of this document to specify dependable and reliable equipment offering the best performance available from currently proven technology. All equipment furnished under this Contract must, therefore, have documentation showing proof of actual operation for a minimum of 3 years in similar service:

    a. New components or design topologies that have less than 5 years of actual operating experience will not be acceptable.

2. VFD supplier shall have a minimum of 10 years' experience in medium voltage VFDs.

3. VFD supplier shall maintain an authorized service organization within 300 miles of the project site.

    a. Measured harmonic levels as required by PART 2 of this Specification Section.

1.06 DELIVERY, STORAGE, AND HANDLING

A. As specified in COMMON WORK RESULTS ELECTRICAL Section (26 05 00).

B. Packing, shipping, handling and unloading:

1. VFD system shall be delivered to the site pre-assembled and wired with all specified interconnecting wiring and cable:

    a. Cabling for connection across shipping splits shall be neatly coiled and identified.

    b. Exposed sections of equipment shall be fully protected from damage during shipment.

    c. All necessary hardware for reconnecting shipping splits shall be provided.

2. Complete instructions for handling and storage shall be provided before delivery of the equipment:

    a. All equipment shall have adequate provisions for handling by overhead crane or forklift truck.

3. VFDs shall be shipped to the Site in dedicated air ride vans.

C. Acceptance at Site:

1. Upon arrival at the Site, the Contractor and the VFD manufacturer shall inspect the equipment and identify any shortcomings or damage.

2. Repair all damage and correct all shortcomings within 30 days of delivery at the Site.

D. Furnish temporary equipment heaters within the switchboard to prevent condensation from forming.

1.07 PROJECT OR SITE CONDITIONS

A. As specified in COMMON WORK RESULTS FOR ELECTRICAL Section (26 05 00).

B. VFD system shall be capable of continuous operation of the rated load at its nameplate horsepower and amperage without de-ration under the installed conditions.

1.08 WARRANTY

A. As specified in Section COMMON WORK RESULTS FOR ELECTRICAL Section (26 05 00).

B. Extended warranty:

1. Provide an additional 2 years manufacturer’s warranty for all equipment provided under this Section.

1.09 SYSTEM START-UP

A. As specified in COMMON WORK RESULTS FOR ELECTRICAL Section (26 05 00).

B. The VFD system manufacturer shall be responsible for starting up the VFD in the presence of the driven equipment manufacturer, motor manufacturer, District Representative and District.

C. Any difficulties of problems that arise as a result of start-up shall be documented by the VFD manufacturer and shall be corrected within 5 working days at no cost to the District.

1.10 MAINTENANCE

A. Maintenance service:

1. The VFD manufacturer shall provide maintenance service throughout the warranty period at no additional cost to the District:

   a. Maximum response time to a maintenance call shall not exceed 24 hours.

2. All parts supplied with the equipment shall be properly labeled for ease of identification and to permit the shortest possible time to repair:

   a. Any parts that come from a sub-supplier shall be labeled with that manufacturer's name and part number.

3. Manufacturer shall state closest point where spare parts are stocked and where service can be obtained:

   a. Minimum response time for trouble calls shall be 2 hours.

   b. A qualified service technician shall be on site within 24 hours of a qualified request.

4. Manufacturer shall warrant that all parts shall be available for a minimum of 10 years.

PART 2 -- PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. VARIABLE FREQUENCY DRIVES:

   a. Siemens-Robicon - Perfect Harmony Series;

   b. Rockwell Automation Allen Bradley - Powerflex 7000;

   c. No equal.

2.02 RATINGS

A. Voltage:

1. The VFD shall accept nominal plant power of 4160V at 60Hz .

2. The supply input voltage tolerance shall be ± 10% of nominal line voltage with an imbalance of up to 2%.

3. Low voltage, 3 phase auxiliary power to power the VFD cooling system and VFD control circuits will be provided by CPTs internal to VFD.

B. Displacement power factor:

1. The VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. X Distortion P.F.) of 0.95 from 60-100% load.

2. If the VFD vendor cannot meet the true power factor requirement, then a power factor correction unit shall be quoted as an option.

3. The true power factor that can be met (with and without power factor correction unit) shall be stated clearly in the proposal.

C. Efficiency:

1. VFD system efficiency shall be a minimum of 96% at 100% speed & 100% load. System efficiency shall include VFD, input transformer or line reactor, harmonic filter (if applicable) power factor correction unit (if applicable), and output filter (if applicable).

2. Control power supplies, control circuits, cooling fans or pumps, shall be included in all loss calculations.

D. Environmental Ratings:

1. Storage ambient temperature range: -40 degrees C to 70 degrees C.

2. Operating A. ambient temperature range: 5 degrees C to 40 degrees C without derating.

3. The relative humidity range is 0% to 95% non-condensing.

E. Audible Noise Level:

1. The maximum audible noise from the variable frequency drive shall comply with OSHA standard 3074, Hearing Conservation, which limits noise level to 85 dB(A).

2. The variable frequency drive shall comply with the OSHA standard at a distance of one meter from the front of the equipment (with doors closed at any speed or load condition).

3. Variable frequency drives with audible noise in excess of this limit must be provided with sufficient noise abatement treatment to reduce the sound pressure level below 85dB(A).

F. Motor Compatibility:

1. The variable frequency drive shall be capable of operating a standard AC squirrel cage induction motor (standard AC synchronous motor, standard AC wound rotor induction motor) of equivalent power and speed rating over the speed range specified. Drives which require motors with higher insulation values will not be acceptable.

2. The variable frequency drive shall provide near sinusoidal voltage and current waveforms to the motor at all speeds and loads. Output current THD shall be less than 5%. Standard induction or synchronous motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.

3. The motor insulation system shall not be compromised thermally or due to dv/dt stress. Dv/dt at the motor terminals (line-to-line) shall be limited to 10 volts per microsecond. If dv/dt at the motor terminals (line-to-line) exceeds 10 volts per microsecond, the vendor must state the actual value in the attached data sheets and include steps taken to guarantee the long term life of the motor insulation system.

4. The variable frequency drive shall provide stable operation of the motor without compromising the motor insulation system, regardless of motor cable distance. The vendor shall clearly state the limitations in motor cable distance with the proposal. If an output filter is required to mitigate reflected waves, or to meet any special requirements of the application, it must be integral to the VFD controller.

5. If output filters are used in the variable frequency drive, a selective harmonic elimination (SHE) switching technique must be available to eliminate a potential harmonic resonance in the operating speed range.

    a. The output filter components shall be integral to the VFD system lineup:

        1) If it is not possible to integrate the output filters into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or

contracted by the VFD system manufacturer, and approved by the District Representative.

b. Any inductors used shall be iron-core with a maximum temperature rise of 115 degrees Celsius with minimum 220 degrees Celsius insulation and over-temperature protection:

1) Reactors shall be designed to prevent saturation under maximum fault current conditions. Reactors shall be in accordance with IEEE C57.16.

6. Variable frequency drive induced torque pulsations to the output shaft of the mechanical system shall be less than 1% to minimize the possibility of exciting a resonance.

2.03 DRIVE UNIT DESIGN

A. Hardware:

1. The VFD converter section shall be Active Front End with selective Harmonic Elimination OR shall be designed for 24 pulse or more to meet harmonic mitigation requirements. Harmonic shall be maintained with line voltage imbalance of up to 2% and from 60-100% load.

2. Input isolation:

a. Provide air gap type input isolation to isolate the entire VFD from the power source.

b. Input isolation switch may be:

1) Load break.

2) Non-load break if interlocked with the VFD control system so that the VFD is stopped before opening of the isolation.

3. The VFD shall have a minimum availability of 99.9% with a Mean Time Between Failures (MTBF) of 100,000 hours.

4. In order to optimize reliability and minimize complexity, inverter power switch component count shall be minimized by utilizing high peak inverse voltage (PIV) rated devices.

5. Use a control power monitoring system that monitors all power supply voltages and signals.

6. Fiber optic interface boards to provide gating and diagnostic feedback signals for power semiconductor devices. The diagnostic feedback system shall allow constant

control of the device as well as constant monitoring of device health and temperature feedback.

7. Power switch device diagnostics shall detect and protect against device short, over or under gate voltage, loss of gating, loss of diagnostic feedback, heat sink temperature feedback as well as overload monitoring and protection.

8. All internal firing signals, and other communications, which link operational controls with power components such as status and diagnostic signals, must meet noise immunity and safety requirements as defined by applicable EN Norms and IEEE Standards.

9. Failed switch bypass/ride-through capability:

    a. The failure of any power switching device (SCR, GTO, diode, IGBT, IGCT, etc.) or switching device control shall not result in a process trip and shall allow for continued operation of the VFD system. In the event of a device or device control failure, the VFD shall annunciate and identify the specific location of the failed device and allow for continued operation, although at a reduced capacity, until such time as repairs can be scheduled.

10. Power bus and wiring:

    a. Main power bus shall be high-conductivity copper and tin-plated for chemical and corrosion resistance and low losses:

        1) Bus shall be appropriately sized for the VFD continuous current rating and braced to withstand the mechanical forces caused by a momentary short circuit current of a minimum of 40 kA or the actual calculated fault current level, whichever is greater, expected at the bus.

        2) All connections shall be bolted or continuously welded.

        3) Main grounding of the VFD system shall have a common loop consisting of 4/0 minimum copper cable placed in the enclosure base.

        4) This cable shall loop the perimeter of the base and shall be attached to stainless steel grounding pads welded to the base in 2 locations, one at each end of the enclosure.

    b. All control wiring shall be physically separated from the power wiring:

        1) Low and high voltage cables shall be physically isolated from each other.

2) The VFD system shall be pre-wired within the enclosure:

3) Only ring type connectors are allowed, spade type connectors are not acceptable.

4) No soldering shall be used in connection with any wiring.

5) Wiring shall be adequately supported to avoid tension on conductors and terminations.

6) All wiring shall be run in surface mounted conduit or wire-ways:

7) Any section of wiring outside of conduit or wire-way shall be securely tied with cable ties at intervals not exceeding 6 inches.

8) No cables shall be tied off to or in any way supported from power busses.

9) Wherever wiring passes metal edges or through holes, suitable guards or grommets shall be provided to prevent cutting or chafing of the insulation.

10) All terminal blocks shall have at least 20 percent spares:

11) No more than 2 wires shall be terminated on 1 terminal.

12) All wiring shall be tagged with permanent labels at each termination, junction box, and device:

13) Labels shall correspond to the schematic and wiring diagrams.

14) Ground connection:

15) Stainless steel grounding pads shall be provided in each power cubicle.

16) A tin-plated copper ground bus shall be provided for grounding of control circuits.

11. The VFD system shall be protected from damage due to the following, without requiring an output contactor:

a. Single-phase fault or 3-phase short circuit on VFD system output terminals.

b. Failure to commutate inverter thyristor due to severe overload or other conditions.

c. Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.

d. Loss of 1 phase of input power.

e. Motor regeneration due to backspin or loss of VFD input power.

12. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:

    a. Failure to connect a motor to the VFD output.

    b. VFD output open circuit that may occur during operation.

13. Data displays:

    a. A door-mounted flat panel display shall be furnished, capable of displaying the VFD operational status and drive parameters:

        1) The digital display must present all diagnostic message and parameter values in plain English, engineering units when accessed, without the use of codes.

    b. As a minimum, the following door mounted digital indications shall be supplied:

        1) Speed in percent.

        2) Input current in amperes.

        3) Output current in amperes.

        4) Output frequency in Hertz.

        5) Input voltage.

        6) Output voltage.

        7) Total 3-phase kilowatt output.

        8) Kilowatt hour meter.

        9) Elapsed time running meter.

14. User input/keypad:

    a. The door of each power unit shall include:

        1) Manual speed device.

        2) A mode selector marked “Manual/Automatic”.

        3) A “POWER ON” light.

4) A VFD “FAULT” light.

5) A VFD “RUNNING” light.

6) Start pushbutton.

7) Stop pushbutton.

8) A Reset pushbutton.

b. A door-mounted keypad with integral digital flat panel display shall be furnished, capable of controlling the VFD and setting drive parameters:

1) The display must present all diagnostic message and parameter values in standard engineering units when accessed, without the use of codes.

2) The keypad shall allow the operator to enter exact numerical settings in standard engineering units.

3) An English language user menu, rather than codes, shall be provided in software as a guide to parameter setting.

c. Drive parameters shall be factory set in non-volatile EEPROM registers and re-settable in the field through the keypad:

1) A minimum of 6 levels of password security shall be available to protect drive parameters from unauthorized personnel.

2) The EEPROM stored drive variables must be able to be transferred for programming of new or spare boards.

d. The keypad module shall contain a “self-test” software program that can be activated to verify proper keypad operations.

e. The VFD system shall have the user selectable option of programming up to 3 speed avoidance bands.

15. Serial communication/protocols/modem or cable:

a. VFD shall be capable of direct communication to an IBM or compatible computer for:

1) Serial link setup of parameters.

2) Fault diagnostics.

3) Trending.

4) Diagnostic log downloading.

b. An RS-232 port shall be door-mounted for computer or printer interface.

c. VFD parameters, fault log and diagnostic log shall be downloadable for hard copy printout via the RS-232 port and a standard serial printer.

d. The VFD shall be provided with single port digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system:

e. An Ethernet I/P communications link shall be provided.

16. Printed circuit boards:

a. All printed circuit boards shall be new.

b. They shall be conformably coated for moisture and chemical resistance, in addition to any dielectric coating properties.

17. Direct current link inductors:

a. Direct current link inductors, if required, shall be air core to prevent saturation.

b. Separate inductors, split dual winding type, shall be provided in the positive and negative leg of the direct current link to minimize stray magnetic fields.

c. Maximum temperature rise shall not exceed 115 degrees Celsius with minimum 220 degrees Celsius insulation and over-temperature protection.

d. The inductors shall be integral to the VFD system lineup.

e. If it is not possible to integrate the inductors into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system manufacturer, and approved by the District Representative.

f. Inductors shall meet the requirements of ANSI C57.16 and shall be designed to prevent saturation under maximum fault current conditions.

18. Direct current link capacitors:

a. Capacitors (if used) in the converter direct current link shall be integral to the VFD system lineup.

b. Capacitors used in the converter direct current link shall contain discharge resistors and capable of reducing the residual charge to 50 volts or less within 5 minutes after the capacitor is disconnected from the source of supply.

B. Control Logic:

1. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors.

2. Fault log data storage memory shall be stored in non-volatile memory.

3. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

4. A “FAULT LOG” shall record, store, display and print upon demand, the following 50 most recent events:

    a. VFD mode (Auto/Manual).

    b. Date and time of day.

    c. Type of fault.

    d. Reset mode (Auto/Manual).

5. A “HISTORIC LOG” shall record, store, display and print upon demand, the following control variables at an adjustable time interval for the 50 intervals immediately preceding a fault trip and 100 intervals following such trip:

    a. VFD mode (Manual/Auto/Inhibited/Tripped/etc.).

    b. Speed demand.

    c. VFD output frequency.

    d. Demand (output) amps.

    e. Feedback (motor) amps.

    f. VFD output volts.

    g. Type of fault.

    h. Drive inhibit (On/Off).

    i. The fault log record shall be accessible via an Ethernet communication link, as well as line by line on the keypad display.

6. A “Windows-Based” graphical tool suite shall be supplied with the VFD:

    a. This graphical PC tool shall be able to plot and display up to 8 different VFD parameters and have the ability to freeze plotting and print hard-copy versions of the plots.

    b. It shall be capable of displaying at least 8 different VFD system parameters, all parameters displayed on the PC tool shall be synchronized with the standard keypad display.

7. Produce a variable voltage and variable frequency output to provide continuous operation over the application speed range.

8. Capable of operating with the output short circuited at full current.

9. The drive system shall provide controlled speed over the range specified. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.5% of base speed without encoder or pulse tachometer feedback (0.1% with encoder or pulse tachometer feedback).

10. 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).

11. Capable of 100% breakaway torque without tachometer feedback.

2.04 DRIVE UNIT FEATURES

A. Control Mode:

1. The variable frequency drive shall utilize sensor less direct vector control or full vector control, with pulse tachometer feedback, for optimum performance.

B. Auto Tuning:

1. The variable frequency drive shall have a programmable auto tuning function.

2. The function shall be capable of being disabled.

3. The function shall be programmable for the following tuning options.

    a. Commutation inductance

    b. DC link time constant

    c. Motor stator resistance

d. Motor leakage

e. Inductance

f. Flux regulator

g. Total Inertia

C. Starting Mode:

1. The variable frequency drive shall offer two starting modes.

2. The S-Curve profile shall consist of both nonlinear and linear portions.

a. A parameter shall exist that specifies the duration that the drive is ramping in the non-linear portion.

b. A parameter shall define the total time to accelerate to rated speed in S-Curve.

3. The Ramp Mode shall be programmable with four ramp speed break points

a. The Ramp Mode shall have programmable acceleration and deceleration times.

b. The Ramp Mode shall have a parameter for Ramp Start Delay that specifies the time the speed reference remains at zero after the drive is started.

D. Stopping Mode:

1. The variable frequency drive shall have three stop modes.

2. The Ramp Mode shall be programmable with four deceleration times.

3. In the Coast Mode, a programmable parameter shall be set to specify the speed at which the drive shuts off and coasts when stopping.

E. Auto-Restart Capability:

1. Capable of automatically restarting in the event of a momentary loss of power, or a clearing of a drive trip.

2. An automatic restart delay parameter shall be available in the drive with an adjustment range of 0 -10 seconds.

3. The VFD system shall provide the user with the choice of automatically restarting or not.

4. The user shall be able to selectively apply this feature to some, but not necessarily all, conditions as determined by the user to be appropriate for the specific application.

F. Flying Re-Start:

1. Capable of restarting and taking control of a motor attached to a spinning load in the forward or reverse direction.

2. Appropriate safeguards must be included in this operation to prevent damaging torque(s), voltages, or currents from impacting any of the equipment.

3. The user shall have the option of employing this feature or disabling it.

G. Preset Speeds:

1. The variable frequency drive shall have three (3) preset speeds.

2. The preset speeds shall be programmable between 0.5 and 75.0 Hz.

H. Skip Speeds:

1. The variable frequency drive shall have three (3) skip speeds.

2. The skip speeds shall be programmable between 1.0 and 75.0 Hz.

3. The skip speeds shall have a programmable band width between 0.0 and 5.0 Hz.

I. Load Loss Detection:

1. The drive shall have a parameter to specify the response of the drive to a loss of load condition.

2. The parameter shall have the following configuration options: disabled, warning or fault.

J. Digital I/O:

1. Sixteen (16) isolated digital inputs shall be available as standard on the drive.

2. Sixteen (16) isolated digital outputs shall be available as standard on the drive.

3. Digital I/O shall be rated 12V to 260V AC or DC.

K. Fault Configuration:

1. The variable frequency drive shall have fault classes that define the following.

    a. Class of drive input protection

    b. Class of rectifier magnetic protection

    c. Class of DC link protection

    d. Class of motor protection

    e. Class of isolation transformer protection

    f. Auxiliary trip class

    g. External fault class

2. Each fault class shall have the following configurations.

    a. Disable the fault input

    b. The drive will shut down immediately

    c. The drive will perform a controlled shutdown

    d. The drive will not shutdown but a warning will be displayed

3. The variable frequency drive shall have fault and warning masks.

L. Protection Features:

1. Power component protection:

    a. VFD system shall include distribution class surge arrestors to protect the input transformer and VFD against voltage surges.

    b. The VFD system shall include power fuses on the input to the converter rectifier devices to protect the secondary of the transformer from any potentially harmful fault currents.

        1) Alternative arrangements that involve coordinated protection with an input circuit breaker are not as desirable, if proposed, the VFD system manufacturer must include all coordinating elements including the circuit breaker itself and must provide a detailed description.

2. Fault information shall be accessible through the Human Interface.

3. The variable frequency drive shall have the following minimum line side protective features.

    a. Line current unbalance trip with programmable delay

    b. Line overcurrent trip with programmable delay

    c. Line overload warning and trip with programmable delay

    d. Line overvoltage trip with programmable delay

    e. Line undervoltage trip with programmable delay

    f. Power loss protection

    g. Line voltage unbalance trip with programmable delay

    h. Ground fault overvoltage trip with programmable delay

    i. Ground Fault overcurrent trip with programmable delay

4. The variable frequency drive shall have the following minimum system level protective features.

    a. DC Overcurrent trip with programmable delay

    b. DC overvoltage trip with programmable delay

    c. Rectifier heatsink temperature warning and trip

    d. Cabinet temperature warning and trip

    e. Inverter heatsink temperature warning and trip

    f. Control Power warning and fault

    g. Adapter (communication port) loss warning and fault

    h. XIO adapter loss

5. The variable frequency drive shall have the following minimum load side protective features.

    a. Responsive action to motor winding resistive temperature detectors, RTDs, 100-ohm platinum, where specified.

b. Ground fault overvoltage trip with programmable delay

c. Ground fault overcurrent trip with programmable delay

d. Machine side dc link overvoltage trip with programmable delay

e. Motor overcurrent trip with programmable delay

f. Motor overload warning and trip with programmable delay

g. Motor overvoltage trip with programmable delay

h. Motor stall delay

i. Motor overspeed trip with programmable delay

j. Motor flux unbalance trip with programmable delay

k. Motor current unbalance trip with programmable delay

l. Load loss level, speed and programmable delay

M. Metering:

1. The variable frequency drive shall display metered parameters through the operator interface.

2. The variable frequency drive shall meter the following.

a. Input current, individual phase RMS values and average RMS value

b. RMS value of the motor current

c. Average RMS value of input voltage

d. RMS value of the motor terminal voltage

e. Motor output power in kilowatts, KVAR

f. Motor speed in revolutions per minute

g. Input frequency

h. Power factor

i. Input kilowatt hour.

j. Input current THD, average of 3 phases.

k. Single harmonic calculation in input voltage and current, phases A, B or C.

l. Drive efficiency.

m. Motor flux in percent.

n. Motor torque in percent.

o. Drive output power (kilowatt).

p. Output kilowatt hour.

3. The metered values shall be capable of being assigned to an analog output to drive an optional output meter.

N. Input Contactor Configuration:

1. The variable frequency drive shall have parameters for specifying input contactor.

2. The input contactor configuration parameter shall specify under what conditions the input contactor shall be commanded to open the drive. The parameter options shall be: open when not running, open for all faults or open for critical faults.

2.05 DRIVE SYSTEM

A. Structure:

1. ENCLOSURE:

a. Air-cooled VFD enclosures shall be NEMA 1G (IP42). 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. 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.

b. Door latches shall be heavy-duty ¼-turn type units which are operated with an Allen wrench. 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.

c. Front access to allow for installation with no rear access. Equipment that requires rear or side access shall not be accepted.

B. Ground fault withstand:

1. In the event of a ground fault, the VFD shall be capable of annunciating the ground fault condition, safely operating and, by user selection, either trip or continue operation.

2. As a result of a ground fault trip, the VFD shall be capable of being reset and operating normally.

3. There shall be no risk of fire or electric shock as a result of the ground fault.

C. Interlocks:

1. Mechanical key interlocks shall be provided on all doors.

2. Interlocking shall be fully coordinated to prevent access to all high voltage compartments, including transformer, filters, or any switchgear that is part of the supply, when line power is applied to the VFD system.

3. Interlocks must be mechanical to provide positive lock-out prevention and safety:

4. Electrical interlock switches alone are not acceptable.

D. Cooling System:

1. The VFD system shall be air-cooled unless otherwise specified.

2. Air-cooled VFDs shall be provided with a redundant, mixed flow cooling fans, mounted integral to the VFD enclosure. The VFD shall include temperature detectors to monitor proper operation of the air cooling system. If a fan fails, the system must generate alarm indication of the fan failure. Vane type air flow switches are not acceptable.

E. Auxiliary Relays:

1. Provide relays for Drive Warning, Drive Fault, Drive Run and Drive Ready.

2. Provide (2) additional relays to be wired per custom requirements.

3. 2 form C contacts, 2N.O. & 2N.C.The relay contacts shall be rated for 115V AC/30V DC, 10 Amp.

F. Communications:

1. The VFD shall be provided with digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system.

2. Provide Ethernet I/P or Modbus TCP

G. Motor Heater Control:

1. 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. Provide a pilot light mounted on the drive system enclosure door for indication of Motor Heater On.

H. Pilot Devices:

1. Pilot devices shall be Allen-Bradley Bulletin 800E (NEMA Type 4/4X/13) and shall be mounted on the drive system enclosure door.

2. Provide an Auto/Manual selector switch for Speed Reference

3. Provide a "Hand/Off/Auto" selector switch for start-stop control and pilot lights for indication of the "Hand" and "Auto" modes.

4. Provide Start and Stop pushbuttons.

5. Provide pilot lights, mounted on the enclosure door, for indication of Ready, Run, Fault and Warning. Pilot lights shall be transformer type.

6. Provide speed control via keypad mounted on the drive system enclosure door.

I. Motor Run Time Meter:

1. Provide a digital, non-resettable, door-mounted elapsed time meter.

2. The meter shall be electrically interlocked with the Drive Run relay to indicate actual motor operating hours.

J. Monitoring and Editing Software:

1. Provide a Windows-based application software to monitor and edit drive parameters, upload and save parameters to a file, download parameters to the drive, print parameters, and view and clear faults/alarms in the drive.

K. Tachometer Interface Feedback (if required):

1. Provide interface for speed feedback by pulse tachometer. Minimum speed regulation shall be 0.1 percent with tachometer feedback.

L. Control Power Transformers (CPTs):

1. Control power transformers (CPTs) shall be provided within the enclosure.

2. The CPTs shall internally derive all necessary control power for the VFD cooling system and VFD low voltage control circuits.

3. The kilovolt-ampere rating of the CPTs shall be determined by the manufacturer and shall have a minimum of 25% spare capacity.

4. The CPTs primary shall be fused with current limiting fuses with an interrupting rating no less than 100,000 amperes.

5. The CPTs secondary shall be fused and have one terminal grounded.

M. Integrated Drive Isolation Transformer:

1. If required for harmonic mitigation, a drive isolation transformer shall be integrated in the VFD enclosure to provide power conversion from the line voltage to the required VFD voltage and to isolate the line from harmonics and common mode voltages. The transformer shall conform to ANSI/IEEE C57 or to corresponding IEC standards. Active Front End drives will be designed as “Direct-to-Drive” so as to not require this transformer.

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

3. Dry type transformers shall be provided rated for a maximum 130 degrees Celsius rise and minimum 220 degrees Celsius insulation with over-temperature protection:

   a. Transformers shall be OA rated and applied in a FA installation.

4. Transformers shall be of a high efficiency type with full load losses of no greater than 2%.

5. Transformer winding material shall be copper.

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

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

8. Transformer designs shall be open type mounted

9. The transformer shall be of the air-cooled type and be forced ventilated.

10. Only rectifier grade with K-factor of 20 transformers shall be utilized, with K-Factor of 6 for diode rectifiers. VFD manufacturers providing scr type rectifiers shall include K Factor of 12 transformers for variable torque applications and K Factor of 20 for constant torque applications.

2.06 HARMONIC PROTECTION REQUIREMENTS

A. All VFDs shall be capable of satisfactory operation from a source having voltage distortion and notch characteristics identified as acceptable for a "dedicated system" in IEEE 519, Table 10.2.

1. With all VFDs operating under worst-case harmonic current conditions, and the facility supplied from either or both the utility and generator sources, the VFDs shall not produce harmonic effects in excess of the following limits at the 4.16 kV bus.

a. VOLTAGE DISTORTION AND NOTCH CHARACTERISTICS: IEEE 519, Table 10.2 for Special Applications.

b. CURRENT DISTORTION: IEEE 519, Table 10.3 based on $I_{SC}/I_L < 20$.

2. VFD manufacturer shall determine, for their proposed equipment, uncorrected harmonic distortion levels and mitigation techniques required to meet the specified limits and shall furnish the VFD types and all accessory items and equipment necessary to do so, whether specified herein or not.

3. Following start-up, with facility at full load operation, provide measurement of harmonic voltage, current and notch characteristics at each PCC according to the requirements of IEEE 519, Section 9.

a. Values in excess of specified limits require correction by contractor and re-measurement.

b. Provide certification of compliant measurements as part of Field Service Engineer's final report.

2.07 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Conduct all standard tests in accordance with NEMA and ANSI standards to ensure conformance to specification requirements.

2. PRIOR TO FINAL ASSEMBLY:

    a. Incoming inspection of all components.

    b. 100 percent test and inspection of all power devices and integrated circuits.

        1) Functional tests.

        2) Temperature cycling test, 0 to 50 DegC for 50 HRS.

3. SUBSEQUENT TO FINAL ASSEMBLY:

    a. Continuity and insulation test of 4160 Vac circuits.

        1) Use minimum test voltage of 10 kV DC.

    b. DRIVE TESTS:

        1) Line-to-line and line-to-ground fault tests with VFD at full load.

            Electronic fault protection circuitry shall initiate trip prior to any device failure.

        2) Verify all auxiliary circuits operational.

        3) After all testing is complete VFD shall undergo a 24 HRS burn-in test at 100 percent motor load without an unscheduled shutdown.

        4) After burn-in cycle is complete, VFD shall undergo a 30-minute cycling motor load test.

    c. SYSTEMS TEST:

        1) Provide inputs to field connections and simulate on-site operation.

        2) Test all auxiliary equipment.

4. EFFICIENCY EVALUATION:

    a. Each VFD system shall be factory tested for efficiency using a dynamometer, or test with a calibrated resistive/inductive load.

    b. The system will include all transformer losses, filters, and all other auxiliaries.

2.08 MAINTENANCE MATERIALS

A. The manufacturer’s recommended spare parts and special tools lists shall be in accordance with the OPERATION AND MAINTENANCE DATA Section (01 78 23).

PART 3 -- EXECUTION

3.01 GENERAL (NOT USED)

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions and as indicated on the Drawings.

B. Verify the installed motor nameplate electrical requirements do not exceed the VFD capacity.

3.03 TESTING

A. Employ and pay for services of manufacturer's Field Service Engineer to perform start-up services:

1. Supervise final adjustments, calibration, and installation check.

2. Simulate input signals to operate equipment.

3. Complete start-up to full operational status.

4. Provide start-up services report certified by manufacturer stating that drive is installed in accordance with manufacturer's instructions, has been fully tested, and is operating properly.

B. Field service engineer to test bus voltages with drive in service under load for compliance with "Certifications" previously specified.

1. Provide certified test report.

3.04 TRAINING

A. Training shall conform to TRAINING Section (01 79 10). The number of training session and hours for each craft shall conform to the requirements of TRAINING Section (01 79 10).

B. Provide on-site instruction and training for District's personnel in drive theory, operation, maintenance and repair:

1. Allow a minimum of three (3) days on-site for training and start-up supervision.

2. Provide instruction manuals and training materials for a minimum of six (6) people.

3. Provide training personnel qualified by education, factory-training and field experience with the specific equipment furnished on this Project.

****END OF SECTION****