SECTION 15172

VARIABLE FREQUENCY DRIVES

PART 1. GENERAL

1.01   SECTION INCLUDES

A. Variable Frequency Drive (VFD)

1.02   RELATED SECTIONS

A. Section 16195 - Electrical Identification: Engraved nameplates

1.03   REFERENCES

A. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable Frequency Drive Systems

B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

C. NFPA 70 – US National Electrical Code

D. UL and cUL approved

E. IEEE Standard 519

F. UL 508C (Power Conversion)

G. CSA 22.2 No. 14-95 (Industrial Control Equipment)

H. EN IEC 61800-5-1 (LVD)

I. EN IEC 61800-5-2 (Machinery)

J. EN 61800-3 First Environment Restricted

K. CE mark 2014/35/EC (LVD)

L. CE mark 2014/30/EU (EMC)

M. CE mark 2006/42/EC (Machinery)

N. RoHS 2

O. RCM/ACMA: Radiocommunications Act 1992 and Telecommunications Act EN 55011

P. IBC 2006 Seismic – referencing ASC 7-05 and ICC AC-156

1.04 SUBMITTALS

A. Submit under provisions of Section 01340.

B. Shop Drawings shall include: Wiring diagrams, electrical schematics, front and side views of enclosures, overall dimensions, conduit entrance locations and requirements, nameplate legends, physical layout and enclosure details.

C. Product Data: Provide data sheets showing; voltage, ratings of customer use switching and over-current protective devices, short circuit ratings, and weights.

D. Manufacturer's Installation Instructions and Technical Manuals: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of variable frequency drive. Document the sequence of operation, cautions and warnings, troubleshooting procedures, spare parts lists and programming guidance.

1.05 QUALITY ASSURANCE

A. VFD shall have a minimum design life of 10 years.

1.06 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 01700.

B. Include instructions for starting and operating VFD, and describe operating limits, which may result in hazardous or unsafe conditions.

1.07 QUALIFICATIONS

A. Manufacturer must have a minimum of 50 years of documented experience, specializing in variable frequency drives.

1.08   DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site, under provisions of Section 01610.

B. Accept VFD on site in original packing. Inspect for damage.

C. Store in a clean, dry space. Maintain factory wrapping, or provide an additional heavy canvas or heavy plastic cover, to protect units from dirt, water, construction debris, and traffic.

D. Handle carefully, in accordance with manufacturer's written instructions, to avoid damage to components, enclosure, and finish.

1.09   WARRANTY

A. Provide VFD warranty, for one year from date of startup, not to exceed 18 months from date of shipment. Warranty shall include parts, and labor allowance for repair hours.

PART 2. PRODUCTS

2.01   MANUFACTURERS

A. VFD shall be FP605 type, manufactured by Yaskawa America Inc.

B. Motors should be inverter duty rated, per NEMA MG1 part 31, for motor-drive compatibility.

2.02   DESCRIPTION

A. The VFD shall be UL Type 1, UL Type 12 or UL Open Type variable frequency drives suitable for operation at the current, voltage, and horsepower indicated on the schedule. Conform to requirements of NEMA ICS 3.1.

2.03   RATINGS

A. VFD must have the minimum range of horsepower ratings: 1 to 150 HP at 208/240 VAC; 1 to 600 HP at 480 VAC

B. VFD must have Normal Duty ratings and software to optimize the VFD size to the application.

C. VFD must operate, without fault or failure, when voltage varies plus 10% or minus 15% from rating, and frequency varies plus or minus 5% from rating.

D. Displacement Power Factor: 0.98 over entire range of operating speed and load.

E. Service factor: 1.0

F. Operating Ambient Temperature:
Open Chassis: -10°C to 50°C (14°F to 122°F), with de-rating for up to 60°C (140°F)
UL Type 1: -10°C to 40°C (14°F to 104°F), with de-rating for up to 60°C (140°F)
UL Type 12: -10°C to 40°C (14°F to 104°F), with de-rating for up to 50°C (122°F)

G. Ambient storage temperature: -20°C to 70°C (-4°F to 158°F).

H. Humidity: 0% to 95%, non-condensing.

I. Altitude: Up to 3,300 feet (1000m), higher altitudes achieved by de-rating.

J. Vibration: 9.81 m/s² (1 G) maximum at 10 to 20 Hz; 208V/240 V, up to 10HP, 460 V, up to 25 HP; 5.9 m/s² (0.6 G); 208 V/240 V, 15 HP and above, 460 V, 30 HP and above; 1.96 m/s² (0.2 G) at 20 Hz to 55 Hz

K. Minimum Efficiency: 97% at full load.

L. Starting Torque: 140% starting torque shall be available from 0.3 Hz to 60 Hz.

M. Overload capability: 110% of rated current for 60 seconds for Normal Duty applications.

N. Controlled speed range:
– Open Loop (Induction motor) – 40:1
– Open Loop (Permanent Magnet motor) – 20:1

O. Total Harmonic Distortion (THD) compliance: Given the information provided by the customer's electric power single line diagram and distribution transformer data, the VFD manufacturer shall carry out an analysis of the system. The analysis reviews the potential for the proposed equipment, and any existing equipment, to meet IEEE 519 (tables 10.2 and 10.3) recommendations at the Point of Common Coupling (PCC). The result of the analysis shall determine if additional power quality improvement measures should be included in the proposal to meet the THD recommendations of IEEE 519. The PCC shall be at the primary side of the main distribution transformer.

P. VFDs must be suitable for use on a circuit capable of delivering not more than 100,000 RMS symmetrical amperes.

2.04   DESIGN

A. VFD shall employ microprocessor based inverter logic, isolated from all power circuits.

B. VFD shall include surface mount technology with protective coating, able to meet IEC 60721-3-3, levels 3C2 and 3S2.

C. VFD shall be able to be mounted with the heatsink out the back of the enclosure to achieve UL Type 12 on the backside: 208V/240 V, up to 60 HP, 460 V, up to 125 HP.

D. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:

1. Input Section:
    a. VFD input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid-state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection
    b. An internal 5% split choke on both positive and negative sides of the DC bus reduces harmonics for cleaner power and power line transient protection.
    c. Protected chassis models will have an internal 3% DC choke on the positive side of the DC bus reduces harmonics for cleaner power and power line transient protection.

2. Intermediate Section:
    a. DC bus as a supply to the VFD output section shall maintain a fixed voltage with filtering and short circuit protection.
    b. DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.

3. Output Section:
    a. Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
    b. The VFD shall employ PWM sine coded output technology to power the motor.

E. VFD shall have selectable control methods to control induction, interior permanent magnet (IPM), surface permanent magnet (SPM), and synchronous reluctance motors. VFD shall be able to control the motor without (open loop) a feedback device (encoder, resolver, etc.).

F. Auto-tuning capability for all motors for easy commissioning.

G. VFD shall offer a low noise, low carrier frequency function.

H. VFD should be able to be mounted next to each other with zero clearance for UL Type 1 ratings 208 V/240 V up to 40 HP and 480V up to 100 HP.

I. VFD shall have embedded Modbus RTU accessible via a RS485 communication port. The termination resistor shall be embedded and selectable (enabled/disabled).

J. VFD shall include three independent multi-function analog inputs, individually selectable for unipolar voltage or current. One of the inputs shall also be selectable for PTC. Each input shall have a programmable bias and gain. The inputs shall be individually programmed for, but not limited to:
    1. Frequency Reference
    2. PID/Emergency Override PID Setpoint
    3. PID/Emergency Override Feedback
    4. Motor Temperature
    5. Torque Limit

K. VFD shall include eight independent multi-function digital input terminals that can be set for sinking/sourcing and internal/external power supplies. The inputs shall be individually programmed for, but not limited to:
    1. 16 Multi-step Frquency References plus Jog
    2. Local/Remote Selection
    3. Drive Enable
    4. Fault Reset
    5. Fast Stop
    6. Low City Water Alarm
    7. Low/High Water Alarm

L. VFD shall include a multi-function 32 kHz pulse train input that shall be programmed for, but not limited to:
    1. Frequency Reference
    2. PID Setpoint
    3. PID Feedback

M. VFD shall include two independent analog outputs, selectable for unipolar voltage or current. The outputs shall be individually programmed for, but not limited to:
    1. Output Frequency
    2. Output Current
    3. Motor Speed
    4. Output Power
    5. Output Torque
    6. Anti-No-Flow Timer

N. VFD shall include one fixed form "C" Fault contact and three programmable multi-function form "A" contacts. These output relay contacts shall all be rated for 2A at 250 VAC or 30 VDC and shall be programmed for, but not limited to:
1. Speed Agree
2. Zero Speed
3. Drive Ready
4. During Run

O. VFD shall include auxiliary power input for the purpose of powering control circuit while main power is removed. When powered by 24Vdc, all control circuits including I/O, expansion cards, and keypad shall be completely functional.

P. VFD shall include enhanced pump control features and shall be programmed for, but not limited to:
1. Easy Sleep/Wakeup PID
2. No Flow/Deadhead Protection
3. Submersible Motor Thrust Bearing Control
4. Automatic System Restart
5. Sleep Boost
6. Low and High Pressure Feedback Detection
7. Power Loss Utility Start Delay Timer
8. Loss of Prime/Pump Dry-run Protection
9. Pre-charge Control
10. Optional Dual Transducer Feedback or Redundancy
11. Impeller De-scaling/De-ragging Control

Q. VFD shall include contactor multiplexing features and shall be programmed for, but not limited to:
1. Stage/De-stage Control
2. Speed Reduction After Lag Pump Staging
3. Setpoint Boost After De-staging
4. Hard Current Limit
5. Back Spin Timer

R. VFD shall include 150mA of 24Vdc power for customer use. This capacity shall be in addition to power required to operate the VFD's digital inputs.

S. VFD shall include a control power loss ride through capable of 2 seconds or greater.

T. VFD shall have a fault trace function to capture relevant monitor values at the time of the most recent fault.

U. VFD shall include a battery powered real time clock and history of the most recent 10 fault with associated time stamps based on the real time clock.

V. VFD shall include memory card slot, capable of accepting up to 32GB memory for capturing high speed drive data with programmable sample rate. Drive data on memory card shall be accessible via stand card reader and displayable in VFD supplier's free graphical computer program.

W. VFD shall have preventative maintenance monitors for predicting the remaining life of IGBTs, cooling fans, bus capacitors and pre-charge relays.

X. VFD shall have the following minimum protective functions: overheat, motor overload, VFD overload, short circuit, overvoltage, undervoltage, input phase loss, output phase loss, output ground fault and overcurrent.

Y. VFD shall have a USB-OTG port for easy connection to a computer or mobile device (tablet or smartphone). VFD shall not require any other power source (other than what is provided from the USB connection) to gain read/write access to all VFD settings, and to flash VFD firmware. Neither main input power nor auxiliary control input power shall be necessary.

Z. VFD supplier shall provide free PC and Mobile software that includes online and offline parameter management, application wizards, oscilloscope function, network configurator for Ethernet, parameter conversion tool and diagnostic functions.

AA. VFD supplier shall provide free cloud storage with secure access for the purpose of storing drive settings and other data associated with each application.

BB. VFD shall have a removable keypad for programming, operating, and monitoring. Keypad shall have an LCD display with backlight and contrast adjustment, and shall be viewable in direct sunlight. Keypad shall have memory to backup all drive setting. Keypad shall be capable of 32 character descriptions and support at least the following languages: English, French, Spanish, Portuguese, German, Italian, Greek, Polish, Czech, Turkish, Russian, Japanese, and Chinese.

CC. VFD shall provide plain language readouts of output frequency in hertz, PID feedback in percent, output voltage in volts, output current in amps, output power in kilowatts, DC bus voltage in volts, interface terminal status, heatsink temperature and fault conditions.

DD. VFD shall have an independent PID loop that can be used to vary the VFD output to maintain a set point of an independent process.

EE. VFD shall include loss of input signal protection with a selectable responses including running at a preset speed.

FF. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL with thermal memory selection.

GG. VFD shall include an embedded category 3 Safe Torque Off (STO) solution, TUV certified to EN/ISO 13849-1 (PLe) and IEC 62061 (SIL3).

HH. VFD shall use 24 VDC cooling fans for all ratings. Fans shall be mounted at the top of the drive for easier access.

II. VFD shall include the following program functions:
1. Capability to reset all parameters back to the factory settings.
2. Capability to reset all parameters back to a user-defined set of parameters
3. Capability to see only the parameters that have been modified
4. Ability to set the motor speed in Hertz, RPM, percent or custom units.
5. Critical frequency rejection capability: 3 selectable, adjustable dead bands.
6. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
7. Ability to close fault contact after the completion of all fault restart attempts.
8. Kinetic energy braking function for deceleration upon power loss.
9. High Slip Braking function stops the motor in up to half the time.
10. Overvoltage suppression function for cyclic regenerative loads.
11. Stall prevention capability.
12. "S-curve" soft start / soft stop capability with four programmable corners.
13. Four sets of acceleration/deceleration times, selectable via digital input.
14. Acceleration/deceleration adjustment from 0 to 6000 seconds.
15. Bi-directional Speed search capability, in order to start a rotating load.
16. Multiple preset and 1 custom volts per hertz pattern.
17. Programmable security code to prevent parameter setting changes.
18. Heatsink overtemperature speed fold back capability
19. Terminal status indication.
20. Motor thermistor input.
21. Reverse direction lockout.
22. Torque limit adjustment from 0% to 300% of rated torque of the motor.
23. Input signal or serial communication loss detection and selectable response.
24. Automatic energy saving function.
25. Undertorque/Overtorque Detection.
26. Overexcitation braking function to quickly stop the motor.
27. Cooling fan failure detection and selectable drive action.
28. Ability to remove digital operator during VFD operation.
29. Motor preheat function
30. Self-regulating lead/lag control for multiple drives (up to 5 fans or pumps)
31. Drive/motor alternation control (share motor run time for lead drive/motor)
32. Up to four PID setpoints
33. Emergency override modes

2.05 PRODUCT OPTIONS
A. VFD shall have the following optional accessories:
1. Fieldbus Adapters: DeviceNet, Profibus DP
2. Ethernet Media Adapters (single and/or multiport): EtherNet/IP, Modbus TCP/IP, ProfiNet RT, and EtherCAT.
3. Expansion I/O for both analog and digital
4. Remote Keypad Mounting Kit: rated UL Types 1, 12, 3R, and 4X.

2.06 SOURCE QUALITY CONTROL

A. Inspect and test, under load, each completed VFD at the completion of production using a computerized, automated testing fixture. All test results shall be stored as detailed quality assurance data.

PART 3. EXECUTION

3.01 EXAMINATION

B. Verify that surface is suitable for VFD installation.

C. Do not install VFD until the installation environment can be maintained, within the service conditions required by the manufacturer.

3.02 INSTALLATION

A. Install VFD where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3.

B. Tighten accessible connections and mechanical fasteners after placing VFD.

3.03 FIELD QUALITY CONTROL

A. Field inspection and testing to be performed under provisions of Section 01400.

B. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

3.04 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Section 01400.

3.05   ADJUSTING

    A. Carry out adjusting work under provisions of Section 01700. Make final adjustments to installed VFD, to assure proper operation of the system.