SECTION 15172

VARIABLE FREQUENCY DRIVES

PART 1. GENERAL

1.01 SECTION INCLUDES

1. Variable Frequency Drive (VFD)

1.02 RELATED SECTIONS

1. Section 16195 - Electrical Identification: Engraved nameplates

1.03 REFERENCES

1. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable Frequency Drive Systems
2. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)
3. UL and cUL approved
4. IEEE Standard 519
5. UL 61800-5-1 (Power Conversion)
6. UL 508A (Industrial Control Panel)
7. CSA 22.2 No. 14-95 (Industrial Control Equipment)
8. EN 61800-5-1 (LVD)
9. EN 61800-3 First Environment Restricted
10. CE mark 2006/95/EC LVD
11. CE mark 2004/108/EC
12. RoHS
13. IBC 2006 Seismic – referencing ASC 7-05 and ICC AC-156

1.04 SUBMITTALS

1. Submit under provisions of Section 01340.
2. 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.
3. Product Data: Provide data sheets showing; voltage, ratings of customer use switching and over-current protective devices, short circuit ratings, and weights.
4. 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 adjustable speed drive. Document the sequence of operation, cautions and warnings, troubleshooting procedures, spare parts lists and programming guidance.

1.05 QUALITY ASSURANCE

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

1.06 OPERATION AND MAINTENANCE DATA

1. Submit under provisions of Section 01700.
2. Include instructions for starting and operating VFD, and describe operating limits, which may result in hazardous or unsafe conditions.

1.07 QUALIFICATIONS

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

1.08 DELIVERY, STORAGE, AND HANDLING

1. Deliver, store, protect and handle products to site, under provisions of Section 01610.
2. Accept VFD on site in original packing. Inspect for damage.
3. 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.
4. Handle carefully, in accordance with manufacturer's written instructions, to avoid damage to components, enclosure, and finish.

1.09 WARRANTY

1. 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

1. VFD shall be GA500 type, manufactured by Yaskawa Electric Corp.
2. Motors should be inverter duty rated, per NEMA MG1 part 31, for motor-drive compatibility.

2.02 DESCRIPTION

1. Provide enclosed 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

1. VFD must have the minimum range of horsepower ratings: 1 to 5 HP at 240 VAC (single-phase), 1 to 30 HP at 240 VAC (three-phase); 1 to 40 HP at 480 VAC (three-phase)
2. VFD must have Heavy Duty and Normal Duty ratings and software switch to optimize the VFD size to the application.
3. VFD shall have a built-in Dynamic Braking Transistor through a minimum of 5 HP at 240 VAC (single-phase), through a minimum of 30 HP (25 HP Heavy Duty) at 240 VAC (three-phase), through a minimum of 40 HP (30 HP Heavy Duty) at 480 VAC (three-phase)
4. 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.
5. VFD shall be \_\_\_\_\_\_\_\_\_\_ volts, \_\_\_\_\_\_\_ Hz, 3 Phase.
6. Displacement Power Factor: 0.98 over entire range of operating speed and load.
7. Service factor: 1.0
8. Operating Ambient Temperature:  
   Protected Chassis: -10°C to 50°C (14°F to 122°F), with derating for up to 60°C (140°F)  
   UL Type 1: -10°C to 40°C (14°F to 104°F)
9. Ambient storage temperature: -20°C to 70°C (-4°F to 158°F).
10. Humidity: 0% to 95%, non-condensing.
11. Altitude: Up to 3,300 feet (1000m), higher altitudes achieved by derating.
12. Vibration: 10 Hz to 20 Hz: 1 G (9.8 m/s2, 32.15 ft/s2)

20 Hz to 55 Hz: 0.6 G (5.9 m/s2, 19.36 ft/s2)

1. Minimum Efficiency: 97% at full load.
2. Starting Torque: 200% starting torque shall be available from 0.3 Hz to 60 Hz.
3. Overload capability: 150% of rated current for 60 seconds for Heavy Duty applications; 110% of rated current for 60 seconds for Normal Duty applications
4. Controlled speed range (induction motor):  
    – Open Loop – 200:1 or greater
5. 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.
6. VFDs must be suitable for use on a circuit capable of delivering not more than 31,000 RMS symmetrical amperes.

2.04 DESIGN

1. VFD shall employ microprocessor based inverter logic, isolated from all power circuits.
2. VFD shall include surface mount technology with protective coating, able to meet IEC 60721-3-3, levels 3C2 and 3S2.
3. VFD shall be able to be mounted with the heatsink out the back of the enclosure.
4. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
5. Input Section:
6. 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.
7. Intermediate Section:
8. DC bus as a supply to the VFD output Section shall maintain a fixed voltage with filtering and short circuit protection.
9. DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.
10. Output Section
11. Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
12. The VFD shall employ PWM sine coded output technology to power the motor.
13. 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.).
14. Auto-tuning capability for all motors for easy commissioning.
15. VFD shall offer a low audible noise, low carrier frequency function.
16. VFD should be able to be mounted next to each other with zero clearance for ratings up to 40 HP Normal Duty (30 HP Heavy Duty).
17. VFD shall have embedded Modbus RTU accessible via RS-485 communication terminals. The termination resistor shall be embedded and selectable (enabled/disabled).
18. VFD shall include two independent multi-function analog inputs, individually selectable for unipolar voltage or bipolar voltage. One of the inputs can be selected for 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:
19. Speed Reference
20. PID Setpoint
21. PID Feedback
22. Motor Temperature
23. Torque Limit
24. VFD shall include seven independent multi-function digital input terminals that can be set for sinking/sourcing and internal/external power supplies, with a scan time of 1 ms or faster, programmable for single or multiple scan. The inputs shall be individually programmed for, but not limited to:
25. 16 Multi-step Speed References plus Jog
26. Drive Enable
27. Fault Reset
28. Fast Stop
29. VFD shall include a multi-function 32 kHz pulse train input that shall be programmed for, but not limited to:
30. Frequency Reference
31. PID Setpoint
32. PID Feedback
33. Speed Feedback (V/f mode only)
34. VFD shall include one independent analog output, selectable for unipolar voltage or current. The outputs shall be individually programmed for, but not limited to:
35. Output Frequency
36. Output Current
37. Motor Speed
38. Output Power
39. Output Torque
40. VFD shall include one form "C" programmable contact and two programmable multi-function photocoupler outputs. The form “C” output shall be rated for 1 A at 250 VAC and the photocoupler outputs shall be rated for 50 mA at 48 Vdc. They shall be programmed for, but not limited to:
41. Speed Agree
42. Zero Speed
43. Drive Ready
44. During Run
45. During Reverse
46. VFD shall include a multi-function 32 kHz pulse train output that shall be programmed for, but not limited to:
47. Output Frequency
48. Motor Speed
49. PID Setpoint
50. PID Feedback
51. VFD shall include auxiliary power input for the purpose of powering control circuit while main power is removed. When powered by 24 Vdc, all control circuits including I/O, expansion card, and keypad shall be completely functional.
52. VFD shall include 150 mA of 24Vdc power for customer use. This capacity shall be in addition to power required to operate the VFD’s digital inputs.
53. VFD shall include a control power loss ride through capable of 2 seconds or greater.
54. VFD shall have a fault trace function to capture relevant monitor values at the time of the most recent fault.
55. VFD shall have preventative maintenance monitors for predicting the remaining life of IGBTs, cooling fans, bus capacitors and pre-charge relays.
56. 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.
57. 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.
58. 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.
59. VFD supplier shall provide free cloud storage with secure access, for the purpose of storing drive settings and other data associated with each application.
60. VFD shall have a removable keypad for programming, operating, and monitoring.
61. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL.
62. VFD shall include an embedded category 3 Safe Torque Off (STO) solution, TUV certified to EN/ISO 13849-1 (PLe) and IEC 62061 (SIL3).
63. VFD shall have removable control card to allow drive replacement without removing and re-installing individual wires from the digital input and analog control terminals.
64. VFD shall use 24 VDC cooling fans when present. Fans shall be mounted at the top of the drive for easier access.
65. VFD shall include an embedded programmable function blocks with both logic and analog math functions. Functions blocks shall be capable of connecting to internal drive functions and to standard I/O.
66. VFD shall include the following program functions:
67. Capability to reset all parameters back to the factory settings.
68. Capability to reset all parameters back to a user-defined set of parameters
69. Capability to see only the parameters that have been modified
70. Ability to set the motor speed in Hertz, RPM, percent or custom units.
71. Critical frequency rejection capability: 3 selectable, adjustable dead bands.
72. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
73. Ability to close fault contact after the completion of all fault restart attempts.
74. Kinetic energy braking function for deceleration upon power loss.
75. Overvoltage suppression function for cyclic regenerative loads.
76. Stall prevention capability.
77. "S" curve soft start / soft stop capability with four programmable corners.
78. Four sets of acceleration/deceleration times, selectable via digital input.
79. Acceleration/deceleration adjustment from 0.00 to 6000 seconds.
80. Bi-directional Speed search capability, in order to start a rotating load.
81. Multiple preset and 1 custom volts per hertz pattern.
82. Programmable security code to prevent parameter setting changes.
83. Heatsink over temperature speed fold back capability
84. Terminal status indication.
85. Motor thermistor input.
86. Reverse direction lockout.
87. Torque limit adjustment from 0% to 300% of rated torque of the motor.
88. Input signal or serial communication loss detection and selectable response.
89. Automatic energy saving function.
90. Undertorque/Overtorque Detection.
91. Overexcitation braking function to quickly stop the motor.
92. Seventeen preset speeds.
93. Ability to remove digital operator during VFD operation.
    1. PRODUCT OPTIONS
94. VFD shall have the following optional accessories:
95. Fieldbus Adapters: DeviceNet, Profibus DP
96. Ethernet Media Adapters (single and multiport): EtherNet/IP, Modbus TCP/IP, PROFINET, and EtherCAT.
97. LCD Keypad
98. Bluetooth LCD Keypad
99. UL Type 1 Kit
100. DIN Rail mounting kit
101. Remote Keypad Mounting Kit: rated UL Types 1, 12, 3R, and 4X.

2.06 SOURCE QUALITY CONTROL

1. 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

1. Verify that surface is suitable for VFD installation.
2. Do not install VFD until the installation environment can be maintained, within the service conditions required by the manufacturer.

3.02 INSTALLATION

1. Install VFD where indicated, in accordance with manufacturer's written instructions and NEMA ICS 3.
2. Tighten accessible connections and mechanical fasteners after placing VFD.

3.03 FIELD QUALITY CONTROL

1. Field inspection and testing to be performed under provisions of Section 01400.
2. Inspect completed installation for physical damage, proper alignment, anchorage and grounding.

3.04 MANUFACTURER'S FIELD SERVICES

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

3.05 ADJUSTING

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