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 508C (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 G7 type, manufactured by Yaskawa America Inc.
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 500 HP at 480 VAC
2. VFD shall have a built-in Dynamic Braking Transistor through a minimum of 25HP
3. 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.
4. VFD shall be \_\_\_\_\_\_\_\_\_\_ volts, \_\_\_\_\_\_\_ Hz, 3 Phase.
5. Displacement Power Factor: 0.95 over entire range of operating speed and load.
6. Service factor: 1.0
7. Operating Ambient Temperature:  
   Open Chassis: -10°C to 45°C (14°F to 113°F)  
   UL Type 1: -10°C to 40°C (14°F to 104°F)
8. Ambient storage temperature: -20°C to 60°C (-4°F to 140°F).
9. Humidity: 0% to 95%, non-condensing.
10. Altitude: Up to 3,300 feet (1000m) without derating, capable of higher altitudes with derating.
11. Vibration: 9.81m/s2 (1 G) from10 to 20 Hz; 2.0 m/s2 (0.2 G) from 20 Hz to 55 Hz.
12. Minimum Efficiency: 95% at full load.
13. Starting Torque: 150% starting torque shall be available from 0.3 Hz to 60 Hz.
14. Overload capability: 150% of rated current for 60 seconds for Heavy Duty applications; 110% of rated current for 60 seconds for Normal Duty applications
15. Controlled speed range (induction motor):  
     – Open Loop – 200:1 or greater  
     – Closed Loop – 1000:1 or greater.
16. 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.
17. VFDs must be capable of being connected to power systems with available faults currents of 100,000 RMS symmetrical amperes.

2.04 DESIGN

1. VFD shall employ microprocessor based inverter logic, isolated from all power circuits.
2. VFD shall be able to be mounted with the heatsink either inside or out the back of an enclosure
3. VFD shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
4. Input Section:
5. 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.
6. A minimum of 3% DC bus impedance to minimize reflected current (40 HP and larger).
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 via sine coded PWM to power the motor.
12. Architecture shall be 3-level neutral point clamp or standard VFD architecture with supplemental solutions to achieve the same result as described below in items D through F
13. VFD voltage output shall not exceed the limits according to motor standard NEMA MG1, part 31, regardless of cable length between drive and motor.
14. VFD shall reduce motor bearing currents to no greater than 50% as compared to standard VFDs
15. VFD shall reduce common mode noise to no greater than 50% as compared to standard VFDs.
16. VFD shall have selectable motor control methods for open loop and closed loop (with encoder feedback).
17. Auto-tuning capability for all motors for easy commissioning.
18. VFD shall be able to dynamically switch between speed control and torque control.
19. VFD shall be able to produce 100% continuous torque at zero speed when running in a closed loop control mode.
20. VFD shall offer a low noise, low carrier frequency function.
21. VFD shall have embedded Modbus RTU accessible via a RS485 communication port.
22. VFD shall include one dedicated and two programmable analog inputs configurable as unipolar voltage, bipolar voltage, or current, with bias and gain adjustments. The programmable inputs shall be selectable for, but not limited to:
23. Speed Reference
24. PID Setpoint
25. PID Feedback
26. Motor Temperature
27. Torque Limit
28. VFD shall include 12 multi-function digital inputs with a scan time of 2.5ms or faster that can be set to sinking or sourcing for use with internal or external power supplies. Ten of these inputs shall be individually programmable for, but not limited to:
29. 16 Multi-step Speed References plus Jog
30. Drive Enable
31. Speed/Torque Changeover
32. Fault Reset
33. VFD shall include a multi-function 32 kHz pulse train input that shall be programmed for, but not limited to:
34. Frequency Reference
35. PID Setpoint
36. PID Feedback
37. VFD shall include two independent analog outputs, selectable for unipolar voltage, bipolar voltage, or current. The outputs shall be individually programmed for, but not limited to:
38. Output Frequency
39. Output Current
40. Motor Speed
41. Output Power
42. Output Voltage
43. VFD shall include one dedicated form C dry contact that indicates a fault condition, three programmable form A dry contacts, and two programmable transistor outputs. The programmable outputs shall be selectable for, but not limited to:
44. Speed Agree
45. Zero Speed
46. Drive Ready
47. During Run
48. During Reverse
49. VFD shall include a multi-function 32 kHz pulse train output that shall be programmed for, but not limited to:
50. Frequency Reference
51. Output Frequency
52. Motor Speed
53. PID Feedback
54. VFD shall include a control power loss ride through capable of 2 seconds or greater.
55. 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.
56. VFD supplier shall provide free PC software that includes online and offline parameter management, application wizards, oscilloscope function, network configurator for Ethernet, and diagnostic functions.
57. VFD shall have a removable LCD keypad for programming, operating, and monitoring with support for the following languages: English, French, Spanish, Portuguese, German, Italian, and Japanese. The keypad shall have memory to backup all drive settings.
58. VFD shall have a PID loop that can be used to vary the VFD output to maintain a set point of an independent process.
59. VFD shall include loss of input signal protection, with a selectable responses including running at a preset speed.
60. VFD shall have pluggable control wire terminals (or pluggable terminal board) that allow drive replacement without removing and re-installing individual wires from the digital input and analog control terminals.
61. VFD shall include embedded programmable function blocks with both logic and analog math functions. Functions blocks shall be capable of connecting to internal drive functions and to both standard and expansion I/O.
62. VFD shall include the following program functions:
63. Capability to reset all parameters back to the factory settings.
64. Capability to reset all parameters back to a user-defined set of parameters
65. Capability to see only the parameters that have been modified
66. Ability to set the motor speed in Hertz, RPM, percent or custom units.
67. Critical frequency rejection capability: 3 selectable, adjustable dead bands.
68. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
69. Ability to close fault contact after the completion of all fault restart attempts.
70. Kinetic energy braking function for deceleration upon power loss.
71. Stall prevention capability.
72. "S" curve soft start / soft stop capability with four programmable corners.
73. Four sets of acceleration/deceleration times, selectable via digital input.
74. Acceleration/deceleration adjustment from 0.00 to 6000 seconds.
75. Bi-directional Speed search capability, in order to start a rotating load.
76. Multiple preset and 1 custom volts per hertz pattern.
77. Programmable security code to prevent parameter setting changes.
78. Terminal status indication.
79. Motor thermistor input.
80. Reverse direction lockout.
81. Torque limit adjustment from 0% to 300% of rated torque of the motor.
82. Input signal or serial communication loss detection and selectable response.
83. Automatic energy saving function.
84. Undertorque/Overtorque Detection.
85. Overheat alarm action.
    1. PRODUCT OPTIONS
86. VFD shall have the following optional accessories:
87. Network Adapters: Modbus TCP/IP, EtherNet/IP, DeviceNet, Profibus DP.
88. Expansion I/O for both analog and digital
89. Incremental Encoder Interface
90. UL Type 1 Kit
91. Remote Keypad Mounting Kit

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.