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 25 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 P1000 type, manufactured by Yaskawa America Inc.
2. Motors should be inverter duty rated, per NEMA MG1 parts 30 and 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: 0.75 to 175 HP at 240 VAC; 0.75 to 1000 HP at 480 VAC; 1 to 250 HP at 600 VAC.
2. VFD must have Variable Torque ratings and to optimize the VFD size for fan and pump applications.
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: 0.98 over entire range of operating speed and load.
6. Service factor: 1.0
7. Operating Ambient Temperature: NEMA 1 (IP20): -10°C to 40°C (14°F to 104°F); Open Chassis: -10°C to 50°C (14°F to 122°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), higher altitudes achieved by 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: 96% at half speed; 98% at full speed.
13. Starting Torque: 120% starting torque shall be available from 3 Hz to 60 Hz.
14. Overload capability: 120% of rated FLA for 60 seconds; 170% of rated FLA peak.
15. Controlled speed range: 40:1.
16. The VFD’s shall have optional external EMI/RFI filters. The RFI filters shall allow the entire VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted. No Exceptions.
17. 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.
18. VFDs must be suitable for use on a circuit capable of delivering not more than 100,000 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.
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. A minimum of 3% DC bus impedance to minimize reflected current (40 HP and larger).
8. Intermediate Section:
9. DC bus as a supply to the VFD output Section shall maintain a fixed voltage with filtering and short circuit protection.
10. DC bus shall be interfaced with the VFD diagnostic logic circuit, for continuous monitoring and protection of the power components.
11. Output Section
12. Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
13. The VFD shall employ PWM sine coded output technology to power the motor.
14. VFD shall offer a low noise, low carrier frequency setting.
15. VFD shall have an adjustable carrier frequency, from 1 kHz to 15 kHz below 100 HP; 1 kHz to 10 kHz from 100 HP to 300 HP; 1 kHz to 5 kHz 350 HP and larger. (480 V Class).
16. VFD must have a motor noise control function that monitors the load at all times and reduces the output voltage automatically, reducing motor audible noise.
17. VFD shall be able to be mounted next to each other with zero clearance for ratings up to 30 HP.
18. VFD shall have embedded Modbus RTU/Memobus accessible via a RS-422/485 communication port. The termination resistor shall be built-in.
19. VFD shall include three independent multi-function analog inputs, individually selectable for 0-10 VDC, -10 to +10 VDC, 0-20 mA or 4-20 mA. Each input shall have a programmable bias and gain. The inputs shall be individually programmed for, but not limited to:
20. Speed Reference
21. PID Set Point
22. PID Feedback
23. Motor Temperature
24. Differential PID Feedback
25. 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:
26. PID Enable/Disable
27. Drive Enable
28. Preset Speeds
29. Fault Reset
30. Emergency Override
31. VFD shall include one multi-function 32 kHz pulse train input that shall be programmed for, but not limited to:
32. Frequency Reference
33. PID Set Point
34. PID Feedback
35. VFD shall include two individually selectable 0-10 VDC, -10 to +10 VDC, or 4-20 mA analog outputs. The outputs shall be individually programmed for, but not limited to:
36. Output Frequency
37. Output Current
38. Output Power
39. PID Feedback
40. VFD shall include one fixed form "C" Fault contact, two programmable multi-function form "A" contacts, and one programmable form “C” contact. These output relay contacts shall all be rated for 1A at 250 VAC and shall be programmed for, but not limited to:
41. Speed Agree
42. Zero Speed
43. Drive Ready
44. During Run
45. Underload Detection
46. VFD shall include a control power loss ride through capable of 2 seconds.
47. VFD shall provide 24 VDC, 150ma transmitter power supply.
48. VFD shall include an external fault input function to be programmed a digital input, which shall be programmable for a normally open or normally closed contact. These terminals can be used for the connection of firestats, freezestats, high-pressure limits or similar safety devices.
49. VFD shall have DC injection braking capability, to prevent fan “wind milling” at start or stop, adjustable, current limited.
50. VFD shall have a bidirectional speed search function to catch a spinning motor, regardless of its direction.
51. VFD unit shall include the following meters to estimate use of energy:
52. Elapsed Time Meter
53. Kilowatt Meter
54. Kilowatt Hour Meter
55. VFD shall have a fault trace function to capture relevant monitor values at the time of the most recent fault.
56. VFD shall include diagnostic fault history with the last 10 fault indications and time stamp as well as heatsink cooling fan operation hours.
57. VFD shall have preventative maintenance monitors for predicting the remaining life of the IGBTs, cooling fans, bus capacitors and pre-charge relay.
58. 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.
59. VFD shall have a USB port for easy connection to a computer (PC) for startup and troubleshooting.
60. VFD manufacture shall provide free PC software that includes online and offline parameter management, application wizards, oscilloscope function, network configurator for Ethernet, parameter conversion tool and diagnostic functions.
61. VFD shall have an eight-language removable digital operator with an illuminated LCD display. The operator shall have program copy and storage functions to simplify the set up of multiple drives. The digital operator shall be interchangeable for all drive ratings. The operator will provide complete programming, operating, monitoring, and diagnostic capabilities.
62. VFD shall have an internal time clock. The internal time clock shall include a back up via battery. The time clock will be used to date and time stamp faults and record operating parameters at the time of fault. The internal time clock can be programmable to control start/stop functions, running speeds, PID parameter sets and digital output relays.
63. 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, heatsink temperature in degrees, digital input terminal status, and fault conditions.
64. VFD shall have selectable and user-customizable engineering units for easy configuration of keypad displays to match process and feedback labels in units such as PSI, GPM, and Feet.
65. VFD shall include a user selectable PID control loop, to provide closed loop set point control capability, from a feedback signal, eliminating the need for closed loop output signals from a building automation system. The PID controller shall have a differential feedback capability for closed loop control of fans and pumps for pressure, flow or temperature regulation in response to dual feedback signals.
66. VFD shall have an independent, PID loop that can be used with an analog input that will vary a VFD analog output and maintain a set point of an independent process (valves, dampers….).
67. VFD shall include fan and pump specific application presets. The parameter presets can be used to help facilitate start-up. The presets will program all parameters and customer interfaces for a particular application (Fans, Pumps) to reduce programming time.
68. An energy saving sleep function shall be available in both open loop (follower mode) and closed-loop (PID) control, providing significant energy savings while minimizing operating hours on driven equipment. When the sleep function senses a minimal deviation of a feedback signal from set point, or low demand in open loop control, the system reacts by stopping the driven equipment. Upon receiving an increase in speed command signal deviation, the drive and equipment resume normal operation.
69. VFD shall include loss of input signal protection, with a selectable response strategy including running at a preset speed.
70. VFD shall have an underload detection function that monitors the load and will stop the system in the event of a fan belt or pump shaft failure.
71. VFD shall include electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL.
72. VFD shall have a removable control wiring terminal board that stores the drive’s parameter settings. The terminal board can be installed into a new drive and transfer all settings to the new drive. The control wiring shall not need to be removed.
73. VFD shall use 24 VDC cooling fans for all ratings. Fans shall be mounted at the top of the drive for easier access. No tools shall be required to replace the fans.
74. VFD shall include the following additional program functions:
75. Capability to reset all parameters back to the factory settings.
76. Capability to reset all parameters back to a user-defined set of parameters.
77. Capability to see only the parameters that have been modified.
78. Ability to set the motor speed in Hertz, RPM, percent or custom units with units label.
79. Critical frequency rejection capability: 3 selectable, adjustable dead bands.
80. Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
81. Ability to close fault contact after the completion of all fault restart attempts.
82. Kinetic Energy Braking (KEB) function for stopping at power loss.
83. Overvoltage suppression function for cyclic regenerative loads.
84. Stall prevention capability.
85. "S" curve soft start / soft stop capability with four programmable corners.
86. Four sets of acceleration/deceleration times, selectable via digital input.
87. Acceleration/deceleration adjustment from 0.00 to 6000 seconds while running.
88. Fourteen preset and 1 custom volts per hertz patterns.
89. Programmable security code to prevent parameter setting changes.
90. Heatsink over temperature speed fold back capability.
91. Terminal status indication.
92. Motor thermistor input.
93. Reverse direction lockout.
94. Current limit adjustment from 30% to 200% of rated current of the motor.
95. Input signal or serial communication loss detection and response strategy.
96. Automatic energy saving function.
97. Undertorque/Overtorque Detection.
98. Overexcitation braking function to quickly stop the motor.
99. Cooling fan failure detection and selectable drive action.
100. Select any of seventeen preset speeds while running.
101. Ability to remove of digital operator during VFD operation.
	1. PRODUCT OPTIONS
102. VFD shall have the following optional accessories:
103. Network Communication: DeviceNet, EtherNet/IP, Modbus TCP/IP, PROFIBUS-DP, PROFINET, BACnet, Lonworks, Metasys (N2), Apogee (P1).
104. Analog Outputs: Option card providing three additional programmable analog outputs.
105. Auxiliary Control Power Unit: VFD control circuit can be powered using separate 24 VDC supply.
106. Remote Operator Mounting Kit: VFD’s operator can be mounted in the control cabinet behind a UL Type 4X membrane.
107. Outdoor Operator: VFD operator with special LCD capable of being seen outside in bright sun at high ambient temperatures.

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.