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HMS- FLUX VECTOR SPECIFICATION FOR MOVABLE BRIDGE APPLICATIONS

1.0 GENERAL

1.1 Furnish Variable Frequency Drive (VFD's) system in the number and voltages shown on the plans and with the current rating according to application requirements. The VFD system must be specifically manufactured for the movable bridge industry. Systems that do not meet these requirements shall not be acceptable. VFD's shall be UL listed. VFD Systems shall be UL508.

1.2 It is the intent of this specification to describe the minimum performance requirements of the VFD movable bridge system. Any deviation shall be detailed in writing and submitted to the engineer for approval at least 2 weeks prior to bid time. The manufacturer must visit installation site prior to the bid.

1.3 VFD Systems shall be compatible with Reuland Electric Phasor, Saftronics or Steven Drives & Controls vector 3-phase induction motor and shall be sized to insure the motor full load amps (FLA) do not exceed the VFD's continuous current rating, with a minimum overload of **180%** for **20 seconds** and a 150% for 60 seconds. The VFD manufacturer shall supply the motor and drive system as a pair. If the VFD manufacturers standard product is current rated at an 8khz carrier frequency or below, a derating factor of 20% minimum shall be used to derive the maximum continuous current rating of the VFD.

1.4 To minimize the impact during construction and make optimum use of training and spare parts resources, supply responsibility shall be as follows:

1.4.1 One manufacturer shall supply specified VFD systems and motors.

1.4.2 Like components of all VFD Systems, although for different services, shall be interchangeable products of one manufacturer. Control boards shall be interchangeable from 1 to 600 HP. The complete VFD system must be manufactured and warranted by the VFD manufacturer. Third party assemblers are not acceptable.

1.4.3 All VFDs for this project shall be the same model series of one manufacturer.

1.5 VFD Systems specification is based on the HMS-FLUX Drive System as manufactured by Stevens Drives & Controls, Inc. (973-831-9573) or prior approved equal in writing and shall be furnished with the options listed on the contract drawings. Any deviation from this specification including the manufacturer must be approved in writing two weeks prior to the bid date.

2.0 HARDWARE

2.1 VFD Systems shall be 32 bit microprocessor based, closed loop flux vector, fully transistorized with a conservatively rated 3 phase, full wave diode bridge input and a PWM sine-coded output waveform. The input diode bridge shall offer complete immunity against voltage dips, line noise and harmonics. The output transistors must be of the IGBT type (Insulated Gate Bipolar Transistor) to facilitate noiseless motor operation. The VFD's shall be tested and rated for a minimum of 115 years Mean Time Between Failure (MTBF). Provide manufacturers typical test results or calculations with submittal to verify MTBF.

2.1.1 VFD must be a “true” four-quadrant drive. Drive must be able to run in speed and torque mode with adjustable torque limits in all four quadrants.

2.1.2 VFD will be supplied with an encoder feedback card compatible with a Reuland Electric Phasor, Saftronics or Stevens Drives & Controls motor. VFD supplier shall supply the motor and take system responsibility.

2.2 To minimize electrical and acoustical noise, and to eliminate low speed cogging, a minimum switching frequency of 15 kHz shall be used for drives rated 1 through 60HP at 460VAC, 1 through 40HP at 230VAC and a minimum switching frequency of 8 kHz shall be used for drives rated 75 through 250HP at 460VAC and 50 through 125HP at 230VAC. The VFD shall not "cog" at any frequencies with a 1,000:1 speed. There shall be no sudden frequency shifts and associated acoustical noise shifts as the output frequency is varied between 0 and 60Hz. Motor and VFD shall be able to produce full torque at zero speed.

2.3 The VFD's input displacement power factor shall be 0.98 or better over the entire operating frequency and load range. Efficiency shall be measured 96% minimum at rated load. Provide manufacturers typical test results or calculations with submittal to verify efficiency and power factor.

2.4 All VFD's shall have, but not be limited to the following protective features:

2.4.1 Solid-state output ground fault protection shall be provided.

2.4.2 Adaptive electronic motor overload protection shall be provided which shall protect both the motor and the VFD at all frequencies. This overload must be UL approved. An electronic thermal overload circuit, which only protects the motor at full speed, shall not be acceptable. The VFD shall sense the load and speed and shall recalibrate the thermal trip curve to insure low speed motor protection. The initial trip point shall be adjustable from at least 40% of the VFD continuous rating to account for motor magnetizing current.

2.4.3 Input surge protection shall be performed by MOV'S (metal oxide varistors) in accordance with ANSI Specification C63.41-1991.

2.4.4 Input and output phase loss detection must be provided and protect the VFD.

2.4.5 Output short circuit protection must be provided.

2.5 Opto-coupled isolated control inputs shall be provided with 11-bit D/A converter. The motor speed shall be directly proportional, or inversely proportional to 0 - 10 VDC, 4 - 20mA,

and variable resistance signals. In addition, the VFD shall have independent settings adjustable on the fly for input reference offset (positive and negative) and gain to facilitate signal setting/matching. Three analog inputs shall be available.

2.6 The VFD shall employ modular PC board design for ease of troubleshooting. All connectors must be polarized type and clearly marked on both the connector and PC board to ensure proper connection.

2.7 VFD operation options shall be programmable via a door mounted digital keypad, and include as a minimum the following functions:

2.7.1 Maintaining output frequency after loss of frequency reference or Setpoint feedback signal, with user programmable Holding speed.

2.7.2 DC injection braking at start for energizing the flux before starting with independently adjustable current and time.

2.7.3 Adjustable hand jog.

2.7.4 Automatic voltage reduction with load reduction, adjustable on the fly to maximize energy savings, without sacrificing acceleration and deceleration torque.

2.7.5 Electronic motor reversing

2.7.6 Three independently adjustable prohibited frequencies each with adjustable bandwidths.

2.7.7 Independently adjustable levels to engage stall prevention function during acceleration, deceleration, or running.

2.7.8 True PID setpoint control embedded in the microprocessor programmable by the operator via the digital keypad.

2.7.9 Programmable, "intelligent" auto-restart function. Intelligent Auto-restart precludes any attempt at restart in the event of trips typically indicative of component failure. Programmable up to 10 restarts with a programmable 0-255 sec time delay.

2.7.10 Auto/Manual button - this shall give the option of either a speed reference from an analog input or manually from the keypad.

2.7.12 “Speed search" transfer. The VFD shall have the ability to start into a spinning load without stopping the motor or creating a fault condition. The VFD shall match the motor's speed and then drive the motor to its proper speed reference. . This must be performed without the use of a digital input.

2.7.13 Minimum of 1,000:1 controllable constant torque speed range. Speed regulation shall be 0.02% or better over the entire speed range. Motor and drive combination shall develop 100% motor torque at zero speed.

2.7.14 Minimum of 2 second power loss ride-through capability. In the event of a loss of three-phase power lasting 2 seconds or less, the VFD must maintain operation and prevent nuisance trips upon return of power.

2.7.15 4 levels of password security

2.8 The Flux Vector drive system shall have the following inputs and outputs:

2.8.1 Eight programmable digital inputs, each input shall be programmable for the following:

Run forward command
Run reverse command
Multi-step frequency selection
Acceleration/Deceleration time selection
Stop command
Coast to stop command
Alarm reset
Trip command (external fault)
Jogging operation
Frequency setting 2 and Frequency setting 1
Motor 2 and Motor 1 setting
DC brake command
Torque limiter 2 and Torque limiter 1
Switching operation between line and inverter (50 and 60 Hz)
Speed Increase command
Speed Decrease command
Write enable for keypad
PID control cancel
Inverse mode changeover
Interlock signal
Torque control cancel
Link enable
Universal DI
Pick up start mode
Feedback enable command
Zero speed command
Forced stop command
Forced stop command with Deceleration time
Pre-excitation command

2.8.2 Four (4) Programmable digital open collector outputs and a dry contact output for:

Inverter running
Frequency equivalence signal
Frequency level detection
Torque polarity
Torque limiting
Auto-restarting
Overload early warning
Keypad operation mode
Inverter stopping
Ready input
Line/Inverter changeover
Motor 2 / Motor 1
Auxiliary terminal
Time-up signal

Cycle completion time
Stage No Indication (1, 2, and 4)
Alarm Indication (1, 2, 4, and 8)
Fan operation signal
Auto resetting
Universal DO
Overheat early warning
Synchronization completion signal
Second frequency level detection
Second overload early warning
Terminal C1 off signal

2.8.2 A programmable analog outputs 0-10 VDC. These outputs shall be programmable for the following:

1: Output frequency 1
2: Output frequency 2
3: Inverter output current
4: Output voltage
5: DC bus voltage
6: Output power
7: Torque output
8: Load rate
9: PG Feedback
10: PID feedback

2.8.3 Three analog inputs with a minimum of 11 bit resolution. The inputs shall be programmable for the following:

0 Output frequency 1
1 Frequency gain
2 Frequency bias
4 Voltage bias
5 Acce/decel change
6 DC Injection Braking current
7 Overtorque detection level
8 Stall Prevention level during run
9 Frequency reference lower limit
A Jump frequency
B PID feedback
10 Forward torque limit Motor's rated torque
11 Reverse torque limit Motor's rate torque
12 Regeneration torque limit Motor's rated torque
13 Torque reference/torque limit
14 Torque compensation bias
15 Forward/reverse speed limit
16 Torque set point

2.8.5 Two preset torque limits activated by a contact closure. The torque limits must be able to be set through a PC and/or the digital operator.

2.9 The VFD shall be suitable for installation under the following conditions:

2.9.1 +14 to +122 degrees F (-10 to +50 degrees C) ambient temperature (non-freezing).

2.9.2 -13 to +149 degrees F (-25 to +65 degrees C) storage temperature

2.9.3 95% Relative Humidity, non-condensing.

2.9.4 Up to 3300 feet (1000 meters) elevation. Derating shall be acceptable for elevations over 3300 feet (1000 meters).

2.9.5 Input voltage shall be 3 phase, 200 - 240 VAC +10% -15%, 380-460VAC +10% -15%.

2.10 When a fault occurs, the Drive shall have a controlled shut down sequence. The reason for the fault condition shall be enunciated on the LED display, and the LCD graphic screen shall display the current, temperature, frequency, and voltage at the time of the fault as well as potential reasons for the condition. The Drive shall monitor, sense, and display the following fault conditions:

2.10.1 Over-current during acceleration
2.10.2 Over-current during deceleration
2.10.3 Over-current during constant speed operation
2.10.4 Ground fault
2.10.5 Input phase loss
2.10.6 Fuse blown
2.10.7 Over-voltage during acceleration
2.10.8 Over-voltage during deceleration
2.10.9 Over-voltage during constant speed operation
2.10.10 Under-voltage
2.10.11 Overheating of heatsink
2.10.12 External thermal relay
2.10.13 Over-temperature of internal air
2.10.14 Overheating at Dynamic Braking circuit
2.10.15 Motor 1 overload
2.10.16 Motor 2 overload
2.10.17 Inverter unit overload
2.10.18 Over-speed
2.10.19 PG Error
2.10.20 Memory Error
2.10.21 Keypad panel communication error
2.10.22 CPU error
2.10.23 Option error (quantity 2)
2.10.24 Operational procedure error
2.10.25 Output wiring error / Impedance imbalance
2.10.26 Modbus-RTU error

2.11 Programming/Operating Station.

2.11.1 Drive operator (keypad) shall have an LCD back lit display as well as an LED display. The following shall be available for display: frequency reference, output frequency, output current (accurate +/- 3%. regardless of output frequency), output voltage, DC bus voltage, output power (kW), elapsed time meter, input terminal status, output terminal status, LED lamp check, and all programming parameters, motorized pot. LCD shall have the capacity to display four of the

above outputs simultaneously or the enclosure **must** have four separate meters mounted on the door to display – elapsed time, output current, speed/torque reference, speed/torque output and percent torque. The LED display shall offer nine (9) different display settings. Digital meters shall be 3.5" size.

2.11.2 The Drive shall display operating data, fault information, and programming prompts in English with graphic (bar) representations of functions where applicable. The Drive shall have six (6) different language LCD readout capabilities (English, French, German, Italian, Spanish, and Japanese)

2.11.3 The Drive shall have digital LED readouts providing display of: Output Current, Output Voltage, Output frequency, Frequency reference, Motor synchronous speed (adjustable for 2 to 12 pole motors), Line speed (calibration adjustable from 0 to 200% of frequency, with 0.01% resolution), kW power consumption, PID setting value, PID remote set value, PID feedback value, and Torque calculations value.

2.11.4 The Drive shall also have a built in keypad that shall be extendible, by optional cable, to a remote location up to 100 feet from the Drive. The keypad shall include the following buttons, allowing 3 modes of operation: Forward/Reverse/Stop/Jog keys, Drive reset key, and Reference increment/decrement keys.

2.11.2 Alphanumeric display of faults. Up to 4 sequential faults shall be retained in non-volatile memory (maintained even after removal of input power).

2.12 VFD Systems shall be mounted in a vented NEMA 12 enclosure. All VFD systems shall fit into existing space requirements without major modifications, with the following additional equipment requirements:

2.12.1 Door mounted digital operator control station with the following features:

a) Local/Remote switch for selecting operation either from the digital operators control station or from a remote location. Both start/stop and speed reference signals shall be selected by a single switch.

b) Jog push button.

c) Reset push button.

d) Start push button.

e) Stop push button

f) Red LED's shall be supplied as a standard on the digital operators station for indication of Hand, Auto, Running, stopped, and drive running with no speed reference signal applied (zero speed).

2.12.2 Input circuit breaker disconnect with through the door handle. Handle must be able to be locked with a padlock in the off position.

2.12.3 A blower motor starter with door mounted fault light shall be included with all systems containing a vector motor with a blower.

2.12.4 A DC link choke and a 5% input reactor mounted and wired in the VFD enclosure.

2.12.5 A dV/dT filter mounted and wired in the VFD enclosure or the VFD must have the "soft switching" dV/dT minimization circuit option. The manufacturer must also guarantee the motor/drive system with motor cable lengths of 1300 feet. This must be in writing with the submittal at time of bid.

2.12.6 An output contactor to disconnect the load from the drive when the drive is not running. Contactor must be rated for across the line motor starting.

2.12.7 The system and its components shall be housed in a single NEMA 12 dust tight enclosure. External reactors, transformer, filters or other components are not acceptable.

2.12.8 A fluorescent enclosure light shall come on when the enclosure door is opened.

2.12.9 A fused 120 VAC duplex receptacle shall be mounted in the enclosure for any operator auxiliary equipment. Power is to come from an internal control transformer.

3.0 ELECTRONIC BRAKING

3.1 The VFDs must be capable of decelerating the load in the specified time allowed. In order to do this; the VFD must have 100% continuous duty regeneration braking torque, with a 150% for 120 seconds overload capacity. Full line regeneration braking is the **only acceptable** braking method.

3.2 The line regeneration package shall have phase loss detection and shutdown.

3.3 Heatsink overtemperature detection and shutdown.

3.4 If SCRs are used, they must have a minimum rating of 1600 PIV.

4.0 TESTING

4.1 VFD PC Boards shall be cycle tested at 70 degrees C for 96 hours.

4.2 VFD PC Boards shall be spray and brush coated in accordance with MIL-1-46058C.

4.3 VFD Systems shall be full load tested prior to shipment.

5.0 START-UP/WARRANTY

5.1 Certified factory start-up shall be provided for each drive by a factory authorized service center.

5.2 All VFD system components, including braking, shall carry a 12-month manufacturers standard warranty from date of start up, 18 months maximum from date of shipment. An optional 60 month warranty from date of shipment shall be submitted as a separate line item. Warranty shall include all parts and labor as per the manufacturers standard terms and conditions.

6.0 APPROVED MANUFACTURERS

6.1 Stevens Drives & Controls, Inc. (973) 831-9573 or prior approved equal.
Any deviation from this specification including the manufacturer must be approved in writing two weeks prior to the bid date.