Part 1 General

1.1 GENERAL

.1 All drawings and all sections of the specifications shall apply to and form an integral part of this section.

1.2 RELATED WORK ELSEWHERE

.1 Section 21 05 01.13 – Acceptable Materials & Equipment

.2 Section 23 05 93 – Testing, Adjusting & Balancing for HVAC

.3 Section 25 90 01 –Sequence Of Operation

.4 Division 26 – Electrical

1.3 WORK INCLUDED

.1 Include complete system of variable frequency drives for mechanical equipment.

.2 General

.1 This specification describes a complete Variable Frequency AC Drive (VFD) used to control the speed of induction motors.

.2 The drive manufacturer shall supply the Drive and all necessary controls as herein specified.

.3 The VFD shall be manufactured by a company with at least ten (10) years experience in the production of this type of equipment.

.4 All VFD’s for this project shall be from the same manufacturer.

Part 2 Products

2.1 VARIABLE FREQUENCY DRIVES

.1 Description of System

.1 This specification provides requirements for the supply and installation of Variable Frequency Drives (VFD's) for fans as specified in other sections of this specification. The VFD's shall be capable of variable or constant torque as required by the specifications and schedules. The selection of the VFD shall be coordinated with the manufacturer of the fans, etc. to ensure that the optimum supply and installation of each VFD is achieved. The VFD shall include all alarms and functions as specified in this section and other related sections and schedules. The VFD and its peripheral devices, as required by specifications are to be located in a sprinkler proof enclosure to suit the environment in which it is located.

.2 Integral bypass as required by other sections of this specification. The bypass shall be automatic or manual as specified in other sections. Bypass and all components are to be NEMA rated. Refer to Division 26 Specifications for additional details and requirements on bypass switch components.

.2 References and Regulations

.1 NEMA ICS 3.1 - Safety standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.

.2 UL 508C - Underwriter's Laboratory

.3 CAN/CSA-C22 No. 14 - Canadian Standards Association.

.4 CSA 22.2 No. 100-95.

.5 CSA 22.1 Canadian Electrical Code.

.6 EN61800-3 and European CE marking.

.7 Other applicable Standards and Regulations.

.8 C-UL marking to provide an approved listing for both United States and Canadian users. The Manufacturer will furnish the product as listed and classified by Underwriter's Laboratories as suitable for the purpose specified and indicated.

.9 IEEE 519 - 1992: Conforming but not limited to the following values from the Standard for General Systems, non-hospital and airports.

.1 For the type of environment that is applicable.

.1 THD for Voltage 5%.

.2 THD for Current as per IEEE 519-92

.3 Harmonic levels for each individual voltage and current harmonic to meet IEEE 519-92.

.4 Individual and total voltage and current distortion as per IEEE 519-92.

.5 Voltage notching as per IEEE 519-92. (Notch Area and Depth as per Table 10.2 for General System applications, notch depth 20%, notch area 22,800

.6 Levels shall be limited to the requirements set by IEEE 519-92 for General Systems.

.3 Training

.1 Provide 8 hours of training for each type of VFD in addition to the site specific training supplied by Division 25 for the fan with which the VFD has been supplied.

.2 Ensure that manuals and drawings are available for the training.

.3 The training shall include specific information relating to the application as specified in other sections of the specifications as well as general operation and maintenance of the VFD.

.1 Include procedures for the setting of parameters within the VFD for the particular application(s) specified as well as an explanation of the purpose of each parameter that is accessible to the maintenance personnel and the specific instructions required to alter the parameters.

.2 The instructions will include a written record of the final parameter settings after set-up and commissioning, for each VFD supplied as part of the project. General or generic values are not permitted. Record and turn over the values set in each VFD.

.4 Shop Drawings and Product Data

.1 Shop drawings are to be submitted for each VFD. Shop Drawings shall include but not be limited to the following submissions:

.1 Catalogue and technical data.

.2 A "comply/non-comply" list of the shop drawing submissions, addressing each item of the specification indicating that it complies with the specification, or else stating the deviation.

.3 Outline dimensions, weights etc. including any special locating/installation instructions.

.4 Control drawings and schematic diagrams including all connections to external equipment and devices. Include single line and impedance diagrams. Include internal circuit schematics and the layout of all electronic and electrical components.

.5 Line harmonic calculations, including filter calculations required to comply with the voltage and current distortion levels required by IEEE 519 (IEEE 519-92). Include the voltage distortion level at the electrical distribution equipment. The intent is to reduce the harmonic content to a level that will not create damage to the City of Winnipeg's equipment, and to reduce harmonic content at the point of common coupling.

.6 Instruction manuals for programming and installation.

.7 Include a list of all initial values of parameter settings. Optimize the parameter settings for this application.

.8 Manufacturer's installation instructions for the VFD, line and load reactors, control cabling, filters, VFD shielded cabling, motor etc.

.5 Maintenance Data

.1 Provide maintenance data.

.2 Include as-built shop drawings with the O&M manuals.

.3 Provide all schematics, diagrams, and as-built drawings including interconnections to other equipment.

.4 Provide programming manuals c/w the actual setting of all parameters. Provide all site-specific programming etc.

.6 Products

.1 The Variable Frequency Drive (VFD) shall include, but not be limited to, the supply and installation of the following: pulse width modulated VFD, with IGBT inverter section, NEMA enclosure, filtering, wiring, grounding, line reactors, load reactors and/or dv/dt filter, relays, motor starters, protective devices, programming, software etc. required by this section and all other sections to make a complete working system.

.2 Voltage is to be as described in Division 26 specifications and schedules.

.3 VFD size is to be as per Division 22 & 23 and Division 26

.4 The Variable Frequency Drive (VFD) including but not limited to the enclosure, RFI filters, reactors, grounding etc. is to be the manufacturer's tested and certified assembly.

.5 The VFD shall conform to the European Electromagnetic Compatibility Directive, a requirement for CE marking. The VFD shall meet with the First Environment restricted level of EN61800-3, through the use of EMI/RFI filters. Filtration shall enable the VFD to be CE marked (CE marking is not required).

.1 The manufacturer's installation and grounding instructions are to be included with each VFD.

.2 Output cables to motors for mechanical assemblies provided in other sections of this specification are to be shielded and are to be specifically manufactured for variable frequency drives. Installation is to be as specified by the manufacturer. Refer to Division 26 Specifications and Drawings.

.3 Provide instructions to the Division 26 contractor for termination of shielded cables (Teck Drive RX cables are provided) from the output of the VFD to the motor and input feeder to the VFD from its point of supply.

.4 Provide grounding instructions to the Division 26 contractor. All equipment including, filters, reactors, variable frequency drive, motor, enclosure, control cabling are to be grounded according to manufacturer's requirements. Grounding instructions are to be included in installation manuals included with each drive. The VFD manufacturer or his representative are to examine grounding once the cabling has been installed and terminated to ensure that it meets the manufacturer's written instructions.

.5 The VFD manufacturer or his representative is to examine the installation of the VFD to ensure that the installation complies current codes and regulations.

.7 System includes:

.1 The VFD and its peripheral devices are to be fully enclosed in an approved enclosure to suit the environment in which it is located (e.g. weatherproof if located in wet environments). Enclosures are to be sprinkler proof even if the drive is located in a location without sprinklers. Sprinklers may be installed in the future.

.2 Disconnecting means for the drive is to be located in the VFD enclosure and interlocked to the door of the enclosure. An input circuit breaker is an acceptable disconnecting device).

.3 Thermal overloads suitable for use with the motor.

.4 Thermistor input for motor over-temperature shutdowns.

.5 Control power transformer rated for drive power. The power supply shall be fused.

.6 Diode or fully gated bridge on the input.

.7 DC Bus inductor on all VFD's with ratings of 7.5HP (5.5KW) or greater.

.8 Switching logic power supply operating from the DC bus.

.9 Microprocessor based inverter logic isolated from power circuits.

.10 Latest generation IGBT inverter section.

.11 Phase to phase and phase to ground MOV protection.

.12 Auxiliary contacts - 2 form C contacts for each of the following signals:

.1 Drive Alarm

.2 At Speed

.3 Control power on

.4 Drive fault

.5 Drive run

.6 Reversing

.7 Jogging

.8 Peripheral Interface to enable attaching common options.

.9 Others as provided with the VFD of as described in other Sections of this Specifications.

.13 Line reactors are to be include but not be limited to the following, as required to meet IEEE 519-92. The intent is to reduce the following harmonic indices to an acceptable level as per IEEE 519-92 at all points in the electrical distribution system, in the building at the time of installation of the VFD. The recommended harmonic indices are, but not limited to:

.1 Depth of notches, total notch area and distortion of bus voltage by commutation notches (low voltage notches)

.2 To comply with IEEE 519-92 for General Systems.

.3 For the type of environment that is applicable.

.4 THD for Voltage 5%

.5 THD for Current as per IEEE 519-92

.6 Harmonic levels for each individual voltage and current harmonic to meet IEEE 519-92.

.7 Individual and total voltage and current distortion as per IEEE 519-92.

.8 Voltage notching as per IEEE 519-92 (Notch Area and Depth as per Table 10.2 for general systems).

.14 Output line reactors and or dv/dt filters. Provide additional filters where necessary due to cable lengths.

.15 Output filtering for RFI and EMI emissions caused by high speed switching. Sinusoidal filters are preferable.

.16 Filters shall be constructed and installed so that they will not supply any existing or future loads.

.17 Common mode choke sized to the amperage of the drive.

.18 Copper ground bus.

.19 Operator interface to the drive shall be provided by a module with integral display.

.1 The display shall be a 2 line, 16 character alphanumeric, backlit LCD that is used to show drive operating conditions, fault indications and programming information. The display shall be customer programmable to show faults, operating temperatures and pressures, etc and programming information. The module shall provide programming information plus an operation keypad with Start, Stop, Speed Reference (analog pot or digital keys), direction control / indication and Jog. The module shall be connected to the drive via a cable and installed in the main door of the VFD enclosure. The units shall be capable of allowing the operator to change set points, temperature and pressures, lead/lag pumps etc. as required by other sections of this specification and the manufacturer of the pumps and fans.

.2 The keypad is to be accessible without opening the door of the VFD enclosure.

.8 Operation

.1 The drive is programmable or self-adjusting for operation under the following conditions.

.1 Controlled shut down with no component failure in the event of an output phase to phase or phase to ground short circuit and annunciation of the fault condition.

.2 Selectable Sensorless Vector or V/Hz mode.

.3 The VFD shall include, but not be limited to the following protective parameters that are to be displayed at the LCD interface: overcurrent, overvoltage, inverter fault, undervoltage, overtemperature, motor overtemperaturre, phase loss - input and output etc.

.4 As described in other Sections of this Specification.

.2 Selectable for variable or constant torque loads. Selection of variable torque provides 115% of rated VT current for up to one minute. Selection of constant torque provides 150% of rated CT current for up to one minute.

.3 Multiple programmable stop modes including - Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.

.4 Multiple acceleration and deceleration rates from 0 to 3600 seconds.

.5 Adjustable output frequency up to 400Hz.

.6 Inputs and outputs

.1 Two analogue Inputs shall consist of single ended inputs, isolated inputs, and bipolar inputs that can be configured as 0-10 VDC or 0-20 ma. The analogue inputs shall be able to be programmed to process control, trim pre-set speeds and frequency control, etc. Provide three single ended inputs and other types as described and as required by other sections of this specification.

.1 Refer to other sections of this specification for additional requirements.

.2 Digital Inputs and Outputs shall consist of the following:

.1 Six digital inputs, positive or negative logic; nominal voltage to be 24VDC.

.2 A minimum of two programmable Form C relay outputs.

.3 One digital outputs open collector 50mv/48V

.4 Refer to other sections of this specification for additional requirements.

.3 Analogue Outputs

.1 0(4) to 20ma: RL 50 ohm max. 10 bit accuracy.

.2 Refer to other sections of this specification for additional requirements.

.7 Adjustable minimum and maximum motor speeds set in consultation with the motor and equipment manufacturers to prevent damage to the motor. The motor selection shall be coordinated with the selection of the VFD by the fan or pump supplier.

.8 Communications to include but not be limited to RS232/422/485 and industry standard communication protocols e.g. DeviceNet, Modbus RTU, LonWorks,

Backnet, Johnson Controls N2L. The use of 3rd party boards is acceptable to connect LonWorks for example to the VFD, providing the supplier of the VFD has tested and certified the use of the 3rd party product with the VFD, partnering is preferable.

.1 Other protocols may be requested. Refer to other sections of this specification for additional requirements.

.9 Manufacturers

.1 Cutler-Hammer, Siemens, Danfoss, ABB, Allen Bradley.

Part 3 Installation

3.1 Installation

.1 The drive is to be installed to CSA 22.1, current codes, standards, and other sections of this specification. The drive is to be installed to manufacturer's recommendations.

.2 Install the variable frequency drive, cabling, ancillary equipment etc. to the manufacturer's instructions.

.3 The manufacturer of the VFD is to coordinate and review the installation of the VFD with Division 26.

.4 The drive is to be wired to achieve the following functions:

.1 Remote start and stop (isolated input at 24 VDC or 120 VAC)

.2 Speed to be adjusted by a remote analogue input i.e. 4-20ma.

.3 Wire and connect control wiring to pre-set speed control equipment. Set and adjust as pre-set speeds as indicated in other sections of this specification. Configure trimming of pre-set speeds by analogue inputs to the VFD from remote equipment as indicated in other sections.

.4 Those as required by other sections of the specification.

.5 Install the VFD drive securely on a flat wall surface, as close to the motor as possible, within the distance allowed by the maximum conductor length specified by the drive manufacturer.

.6 Install the VFD as far as practical from telecommunications equipment, control equipment and wiring. Maintain a minimum of distance of three meters between the VFD and its feeders from telecommunication and control cables. VFD input and output cables are to cross communication and control cables at 90 degrees.

.7 Division 26 to provide Teck Drive RX cable from the VFD to the motor. The Teck Drive RX cable is specifically manufactured for use with variable frequency drives. Connectors for the Drive RX cables are to be specifically designed for use with this type of cable, as per the cable manufacturer's instructions. The cable is to be bonded as per the VFD manufacturer's instructions. Division 25 is to coordinate with Division 26.

.1 Grounding is to be as per the manufacturer of the VFD's instructions and CSA requirements for safety and to reduce RFI and EMI.

.2 All control conductors are to be shielded of a type specified by the manufacturer. The shields are to be grounded as per the manufacturer's instructions. All control wiring shall be in conduit. All conduits used for control wiring shall include a separate insulated ground conductor, #12 AWG minimum.

.3 The conduit for the control conductors shall not be installed within 600mm of the power conductors for the VFD. The shields of the cables shall be grounded according to the manufacturer's instructions for:

.1 Analogue signals

.2 Digital signals

.4 The control cables shall be terminated in terminals (supplied with the VFD enclosure). Shielded cables shall be grounded according to the VFD manufacturer's instructions.

.5 The VFD shall be programmed, commissioned, set-up and tested by the manufacturer's representative. The drive shall be set-up to optimize the operation with the specific equipment that the drive has been specified with, in other Sections of this Specification.

.6 The contractor shall examine the Division 23 shop drawings for the motor that is supplied by the fan supplier. The motor must be suitable for the intended use and shall be labelled as such, as required by CSA C22.2 No. 100-95. Ensure that the labels are on the motor before connecting. If the motor is not suitable for use with the VFD and/or is not labelled, notify the Division 23 contractor immediately.

.7 Division 26 to provide a three pole disconnect switch with an auxiliary contact at the motor. The auxiliary contact is to open prior to the main switch blades. Division 1r is to provide a 2/C #14 Teck cable from the VFD to the disconnect switch. Connect the switch in the VFD to stop the output to the motor prior to the opening of the disconnect switch.

END OF SECTION

Part 1 General

1.1 SUMMARY

.1 Section Includes:

.1 At minimum detailed narrative description of Sequence of Operation of each system including ramping periods and reset schedules.

.1 Control Description Logic (CDL) for each system.

1.2 SEQUENCING

.1 General

.1 Provide a complete and operational temperature control and building automation system based on the following sequences of operation. The system shall be complete as to sequences and standard control practices.

.2 Provide all required inputs/outputs to meet the sequence or operation specified.

.3 Utilize the factory supplied control panel for the new MAU-1, and provide any additional BAS controller, accessories, wiring, and control components to achieve the sequence described below.

.4 The existing facility has installed Johnson Control Metasys BAS. The new BAS controllers provided under this project shall communicate with the existing BAS front end. The existing front end OWS graphics and programming shall be updated to indicate the operational status and alarm status of the new makeup air unit and the new exhaust fan.

.5 Any line voltage wiring installed shall comply with CEC requirements.

.2 Makeup Air Unit Control Monitoring

.1 New makeup air unit will be supplied with packaged controls to manage the operation mode, discharge air temperature, and interlock, and monitor equipment status.

.2 The packaged controls for the MUA shall have the following capability:

a) Accept a 0-10VDC discharge air temperature reset signal for the BAS

b) Accept a dry contact MUA Enable/Disable signal from the BAS

c) Accept a dry contact MUA heating Enable/Disable signal from the BAS

.3 Package controls shall be enabled continuously.

.4 Provide makeup air unit operating status and alarms on BAS.

.5 Spray mode operation (Controlled by BAS):
Summer/Off/Winter switch in “Summer” position: Outside air damper opens to 100% position, return damper closed, switch closed which enables spray exhaust fan (interlocked) to start. Supply fan starts and runs continuously.
The low velocity air switch is proven closed, the compressed air solenoid valve is energized.
If supply air low velocity air switch is not closed within 1 min., or exhaust fan interlock opens, unit shut down.

Summer/Off/Winter switch in “Winter” position: The functions are the same as in the “Summer” position with exception that the burner circuit is energized.

Flame safeguard relay is energized and discharge air controller modulates gas valve to maintain 70 degree F discharge air temperature.

.6 Dry mode operation (Controlled by BAS):
Dry mode can be activated in either summer or winter position. With the dry timer is set and the dry "On" button is depressed, the booth lights are de-energized. The paint booth is purged for 3 minutes (remains in spray mode). Once the purge mode is complete, dry mode is on. The compressed air solenoid valve is de-energized. Outdoor air damper revert back to 20% OA position (80% RA), the exhaust fan (VFD) remains on. Exhaust fan interlock remains closed, and supply air fan still run continuously.
Flame safeguard relay is energized and discharge air controller modulates gas valve to maintain 140 degree F discharge air temperature.
If exhaust fan interlock opens, unit shut down.

.7 Cool down operation (Controlled by BAS):
Outdoor air damper opens to 100% position, exhaust fan return to spray mode. The unit will run in the spray mode temperature setting until the cool down time expires. Upon completion of cool down time, the unit shuts down.

.3 Water wash spray booth exhaust fan EF-1 (Controlled by BAS):

.1 Controls contractor to provide VFD to EF-1.

.2 Interlock the exhaust fan EF-1 with makeup air unit MAU-1.

.3 When the makeup air unit outdoor air damper is open, the exhaust Fan EF-1 is energized.

.4 The exhaust air volume shall modulate to track the supply air volume in order to maintain negative room pressure.

Spray, Purge and cool down mode operation: 100% to match MAU-1 spray mode SA volume.

Dry mode operation: 20% to match MAU-1 drying mode SA volume.

Makeup air unit MAU-1 outdoor air damper closed: EF-1 shut down.

.4 Water wash spray booth circulation pump

.1 Interlock the existing circulation pump with the new exhaust fan EF-1.

.2 Exhaust fan EF-1 will be cut off and not turned on until the circulation pump is proved to be in operating condition

.5 Compressed air solenoid valve (Controlled by BAS)

.1 Provide solenoid valve to the new ¾" compressed air line as indicated on the drawings.

.2 Interlock the compressed air solenoid valve to the new makeup air unit MAU-1.

.3 When the makeup air unit is in spray mode, the compressed air solenoid valve is energized. When the makeup air unit is in purge, dry and cool down mode, the compressed air solenoid valve is de-energized.

.6 Booth lights (Controlled by BAS)

.1 In spray mode and cool down mode, lights are "on". In purge mode and dry mode, lights are "off".

.7 Booth doors (Controlled by BAS)

.1 Provide door switch to each booth access door, including the overhead door.

.2 Interlock the door switches to the makeup air unit MAU-1.

.3 In purge and dry operation mode, when a booth door is open, the makeup air unit switches to spray mode.

1.3 DDC point schedules

.1 At a minimum, the DDC will monitor/control the following points:

Type	Name	Description	Signal
AI	BLDG-P	Room Static Pressure	4-20mA
AI	DA-F	MUA Discharge Air Flow	0-10VDC
AI	DA-T	MUA Discharge Air Temperature	Nickel 1K RTD
AO	OAD-O	MUA Outdoor Air Damper Output	0-10VDC
AO	PH-O	MUA Heat Output	0-10VDC
AO	RAD-O	MUA Return Air Damper Output	0-10VDC
BO	RLF-C	Exhaust Fan Command	24VAC Maintained
AI	RLF-F	Exhaust Air Flow	0-10VDC
AO	RLF-O	Exhaust Fan Output	0-10VDC
BI	RLF-S	Exhaust Fan Status	Dry Contact Maintained
BO	BL-C	Booth Lights Command	24VAC-240VAC Maintained
BO	SOL-C	Compressed Air solenoid	24VAC-240VAC Maintained
BO	SF-C	MUA Supply Fan Command	24VAC Maintained
BI	SF-S	MUA Supply Fan Status	Dry Contact Maintained
BI	DRY-S	Dry Mode Start Switch status	Dry Contact Maintained
BI	DRY-T	Dry Mode timer status	Dry Contact Maintained
BI	BD-S	Booth Access door status	Dry Contact Maintained
BI	OHD-S	Overhead Door Status	Dry Contact Maintained
BI	SW-S	MUA Summer/Winter switch status	Dry Contact Maintained
BI	MUA-S	MUA unit off switch status	Dry Contact Maintained
BI	SP-S	Water wash spray booth pump status	Dry Contact Maintained
BO	SP-C	Water wash spray booth pump command	Dry Contact Maintained

Part 2 Execution

2.1 NOT USED

.1 Not Used.

END OF SECTION