SECTION XXX VARIABLE FREQUENCY CONVERTERS (INVERTERS)

1. DESCRIPTION

1.1. This section describes the type of frequency converter to be supplied for fan and pump speed control. The frequency converter shall not be a general purpose product, but a dedicated HVAC engineered design.

1.2. The manufacturer shall demonstrate a continuous period of manufacture and development for at least 30 years.

The frequency converter shall be supported locally by the manufacturer who will provide full technical support, spares holding and trouble shooting capability from their own local facility. A training course shall be provided by the manufacturer to the consultant / contractor / maintenance engineers.

1.3. The manufacturer shall provide full technical detail of the product, with catalogues, dimension drawings, weights etc. and each drive shall be provided with a full technical manual.

1.4. Equipment supplied must conform to recognized International Standards and be manufactured to ISO 9001 quality standards and carry the CE and C-tick mark on EMC Compliance.

1.5. Frequency converters shall be suitable for use in either a ‘Stand Alone’ mode complete with all necessary protection or as part of a centrally controlled system via a serial communication loop to the main Building Management System (BMS) via in-built EIA 485 port or other high level interface as required by the BMS.

2. TECHNICAL REQUIREMENT

2.1. The frequency converter (FC) shall be rated for 3 phase, *Local Voltage* V +/-10%, 50/60 Hz mains supply. At full speed, full load the FC shall be able to deliver full rated motor voltage (*Local Voltage* V) and therefore full rated motor output torque over the +/- 10% mains voltage range.

The FC shall continue to deliver full motor output torque even if the supply is at *Local Voltage* V -10% continuously.

The voltage to frequency ratio shall be suitable for centrifugal pump and fan control to optimize energy usage.

2.2. The FC shall incorporate an automatic energy optimization function to dynamically optimize the voltage to the motor throughout the operating range of application. This function is to ensure the magnetization of the motor is optimum at all speeds and loads to optimize motor energy consumption.
The use of high efficiency motors with the FC shall be considered as an acceptable alternative to this function.

2.3. The FC shall be rated for connection to any point in the supply network with a prospective short circuit current of up to 100kA.
If additional components are required to meet this rating, these should be housed inside the FCs enclosure.

2.4. The FC shall work in conjunction with any IEC standard design motor and shall not require the motor to be derated, or cause the motor temperature to rise above the Class B rise expected on normal mains operation.

If the FC cannot maintain Class B temperature rise even when running at low speeds (<10Hz), then the motor shall be oversized and derated or an external blower for cooling the motor shall be required.

2.5. The FC shall limit motor terminal pulse voltage (peak voltage and rise time) to below that defined in IEC 60034-17 with a minimum 30m motor cable. If the motor terminal peak voltages are above these limits, the FC shall include an output filter or inverter duty rated motors shall be required.

2.6. The FC shall incorporate an Automatic Motor Adaptation (AMA) function which tunes the FC to the motor to optimize motor performance, improve start capabilities and compensate for motor cable variances. This function shall be carried out with the motor at standstill (i.e. without spinning the motor) and without the need to decouple the motor from the driven load.

2.7. The FC shall be capable of controlling parallel motors of mixed ratings, and allow disconnection of any motor whilst running without causing tripping. The FC shall be capable of running with no motor connected for service functions.

2.8. The FC shall be fully tested at the converter manufacturers works, including motor loading. Certificates of Compliance should be available on request.

2.9. The FC shall be of sufficient capacity to provide a quality wave form so as to achieve full output torque of the motor, without causing additional heat rise under the following operating conditions:

a) Rated input voltage *Local Voltage* V +/- 10%, 3 phase, 48-62Hz +/- 1%.

b) Output voltage range 0 to full mains input voltage, 3 phase even at full mains voltage -10% input.

c) Minimum efficiency at 100% load= 96%
at 20% load = 92%

d) Working ambient temperature range -10°C to +45°C, humidity to 95% RH, and vibration of 0.7G RMS in 3 directions. To ensure continued operation of the plant during times of extreme ambient temperature conditions it shall be capable of operation at reduced performance in temperatures from -10°C to +55°C.

2.1 The FC shall allow connection of motors one frame size larger and 4 sizes smaller than the nominal converter rating.

2.2 The FC shall be limited to 110% of rated current for 60 seconds.

2.3 The FC shall accept 0-10 VDC and 0/4-20 mA inputs as a control signal.

2.4 The FC shall provide two output relays to provide status signals including - ready, run and tripped and be programmable for other selected information.

2.5 The FC shall provide two analogue outputs of 0/4-20 mA, programmable to transmit motor current, motor power, sensor feedback, speed or other variables to the BMS. These shall alternatively be programmable as two digital outputs providing 24Vdc to signal a choice of 27 status conditions to the BMS.

2.6 The FC shall log and display total kWh consumed and total hours run by the motor without additional instrumentation with the facility to reset these counters.

2.7 20 preset speeds shall be available (programmable values) for duties such as night setback, smoke extract and morning boost settings.

2.8 The FC shall provide 4 skip frequencies of adjustable bandwidth to overcome mechanical or air resonance.

2.9 A parameter lock shall be incorporated to prevent unauthorized resetting of parameters.

2.10 FC acoustic noise shall not exceed 75dBA at full load and 60dBA at 50% load.

3 FC DESIGN REQUIREMENTS

3.1 Harmonics:

The FC shall be fitted with a harmonic filter (D.C. link or equivalent) on both inductive and capacitive elements to control the main borne harmonics. The same standard shall also be used as a basis of calculation for the total harmonic distortion at point of common coupling**.** The filter shall be mounted within the same enclosure of the FC. Any externally fitted harmonic filter or harmonic filter that causes voltage drop shall be rejected.

3.2 EMC:

The FC shall be CE marked in accordance with European Union (EU) legislation and C-Tick marked in accordance with Australian Communications Authority (ACA) regulations.

The FC shall include a radio frequency suppression filter, within its enclosure, to ensure compliance with the following:

a) The FC shall comply with the emission and immunity requirements of IEC61800.3 2nd Edition 2004 for Category C1 (EN55011 Class B) products with 50m screened motor cable up to 90kw.

b) Alternatively if the electrical installer verifies they have the skills and experience in installing FCs with respect to their EMC aspects, the FC shall comply with the emission and immunity requirements of IEC61800.3 2nd Edition 2004 for Category C2 (EN55011 Class A1) products with 150m screened motor cable up to 450kw.

The FC manufacturer shall supply correct EMC installation recommendations to ensure compliance with this specification.

3.3 The FC design shall comprise a diode input bridge, fixed voltage DC link section with both inductors and capacitors to form a filter, and inverting bridge comprising IGBTs (Insulated Gate Bipolar Transistors). All equipment must be housed within the FC enclosure.

3.4 The FC shall monitor the output current on all three phases and the current protection feature shall be sufficiently fast to allow the FC to survive a continuous short circuit on the output terminals without damage to any drive components.

3.5 The FC shall protect itself against:

a) Input transients to VDE0160 class W2
b) Burst transients to IEC61000-4-4
c) Surge transients to IEC61000-4-5
d) Loss of mains phase (programmable to either trip or continue operation (with or without autoderating) and initiate warning of this condition)
e) Loss of motor phase (3 phase measurement)
f) Grounding of any output phase
g) Loss of speed reference (with programmable ability to trip, stop, or continue operation at last setting or preset speed).

3.6 The FC shall use overriding frequency fold back control techniques to prevent damage in the event of excessive load during either running or starting.

3.7 The FC shall model the motor in its software to predict motor overheating without the use of thermistors in the motor. When overheat is predicted, an alarm or warning shall be initiated.

3.8 For motors fitted with thermistors, the FC shall include a thermistor input as standard to provide motor thermal protection without the need for external thermistor interface relays.

3.9 The FC shall exhibit near unity displacement fundamental power factor at all loads and speeds, and should not require the addition of external AC/DC line reactors for power factor improvement, harmonic control or prevention of zero voltage notching.

3.10 The output circuit shall be of such a design as to allow unlimited switching of the motor circuit, at any load/speed without causing damage to the FC. Otherwise an auxiliary early break, late make contact must be supplied to the output disconnect switch and the control wiring routed back to a safety circuit via conduit or cable tray.

3.11 FCs shall have self adjusting modulation frequency control. The control form shall be such as to allow the FC to deliver full output at all times without derating, by optimizing the switching frequency dependent on the output load.

3.12 Full galvanic isolation between power and control components shall be incorporated to ensure compliance with VDE 0160 PELV (Protective Extra Low Voltage) to prevent damage to BMS interface and ensure operator safety. Short circuiting of the control terminals shall not damage the control card

3.13 The FC shall be capable of automatically reconnecting to a spinning fan, forward or reverse running, without tripping, following mains interruption or on transfer from bypass running.

3.14 The FC shall include a Smart Logic Controller within its enclosure that offers a wide range of PLC functions that include logic operators, comparators and timer functions.

3.15 The FC shall have an automatic "sleep" mode function timer complete with boost function, operating when loads are below minimum settings.

3.16 The design shall include a full 3-zone, 3 setpoint PID controller as standard to provide closed loop control direct from up to 3 signal transmitters without the need for external signal conditioning. The PID controller shall permit the FC to control the motor speed based on the following feedback selections: highest/lowest, average, sum, difference, 3-zone min, 3-zone max. FCs without a 3-zone controller must add this capability to their package.

3.17 The FC shall not exhibit an inrush current when a 'start' signal is given, and current must not exceed 110% at any time to prevent damage to connected equipment.

3.18 The FC design shall include a motor preheat circuit to prevent condensation forming in the motor during shutdown periods.

3.19 The FC shall not be damaged if it is energized with a 'start' signal without a motor connected.

3.20 The FC shall provide as standard:

a) Heat sink over temperature protection.
b) Under voltage protection.
c) Over voltage protection.
d) 4 line LCD alpha-numeric display with free programmable text array capable of displaying 4 operating variables simultaneously with all information displayed in clear language, e.g. "Earth Fault".
e) Display to be in 9 selectable languages.
f) FC "On" light.
g) FC "Warning" light.
h) FC "Alarm" light.
i) Selectable display from 20 readouts including output current,

voltage, frequency, speed, power, motor thermal load %, FC thermal load %, total energy consumed kWh and total hours run.

j) Hand/Off/Auto or Local/Remote pushbuttons and raise and lower speed pushbuttons shall be on the keypad as standard to allow control or testing and commissioning of the FC. If these are not included an H/O/A selector switch and potentiometer must be added to the FC control panel.

k) Rest pushbutton shall be on the keypad to enable local/manual resetting of faults.

l) Auto Reset in event of trip condition with ability to program the number of reset attempts (up to 20 or infinite) and the time between each attempt.

m) Ability to display setpoint and feedback (e.g. static duct pressure or condenser water return temperature) in engineering units (e.g. Pa, ^{o}C)

3.21 FC shall not include any buttons on the keypad allowing the motor direction to be reversed.

3.22 FC shall incorporate a fault diagnostic memory storing the last 10 trips displayed in alpha-numeric format. The data immediately proceeding the last fault shall also be stored to assist fault finding.

3.23 The FC shall provide the following additional features as standard;

a) Auto ramping shall be employed to ensure "No Trip" ramping if too rapid acceleration/deceleration is called for.

b) It shall be possible to select a "Run Permissive" function to accept a "system ready" signal to ensure the FC does not start until dampers or other auxiliary equipment are in the proper state for FC operation. The run permissive circuit shall also be capable of sending an output signal as a start command to actuate external equipment before allowing the FC to start (e.g. damper actuator). If this function is not included in the FC, comparable control circuits must be added to the FC package.

c) The FC shall be capable of autoderating when either the ambient temperature is sustained above the nominal rating or when losing a mains phase.

d) The FC must annunciate the loss of running load indicative of mechanical failures resulting from broken belt, coupler etc. If this function is not included, delta-P switches across the fan or pump must be added and wired to the FC control system.

3.24 The design technology and operator keypad shall be common through the whole series of FC offered. The FC shall be factory pre-commissioned for building services use and require minimal site setting.

3.25 Real Time Clock (RTC). For applications without a BMS the FC shall provide a RTC option with the following functionality:

a) Ability to display current time and date on FC display.
b) Capable of initiating functions including start/stop, change of speed and change of setpoint (e.g. for night setback).
c) Capable of controlling FC relay outputs for control of remote devices.
d) Provide up to 20 programmable events.
e) Ability to enable/disable the RTC by external control signal for disabling during shut down periods (e.g. holidays).
f) The RTC option shall be installed inside the FC to ensure it cannot easily/accidentally be removed by operating or maintenance personnel thereby ensuring once commissioned the FC continues to operate according to the RTC settings.
g) Maintain its setting with power removed from the FC for up to 100 hours allowing maintenance to be carried out without resetting the time.
h) When fitted with the RTC, the FC shall date/time stamp the last 10 faults in the fault log.

3.26 Fire safety function. The FC shall have a digital input which can be used in the event of a fire signal from the fire system. Depending on the application and system design the function of this input should force the FC into one of the following operating states:

a) Stop the FC
b) Start and run the FC at a fixed (programmable) speed in the forward direction.
c) Start and run the FC at a fixed (programmable) speed in the reverse direction (e.g. smoke extract)
d) Start and run the FC at a fixed (programmable) speed in the forward direction and if the FC trips, automatically activate a relay output which can be used to control a by-pass starter

When operating in states b) or c) the FC should continue to operate overriding all its warnings and alarms, normal application parameter settings and motor protection features in order to secure continued operation until such time that the fire command is manually overridden or that a fire has rendered the FC inoperable. In the event of serious fault conditions, such as earth fault or short circuit fault on the FC output, the FC should trip but then continuously attempt to automatically reset and restart, even if that results in running to destruction.

3.27 The FC shall have proven serial communication protocol capabilities with BMS systems to include Johnson Controls Metasys N2, Siemens FLN, Andover X-driver, Modbus RTU, Lonworks and BACnet. The FC manufacturer shall be responsible for technical support to the BMS vendor in the implementation of serial communication interface to the

BMS System. The BMS vendor shall be responsible for the complete "integration and interoperability" of the FC through the BMS via the serial interface.

3.28 When integrated into the BMS serial communication network the FC's hardware I/O points shall be made available as remote I/O for the BMS. The FC shall provide at least the following status/control I/O points:

a) 6 x digital inputs
b) 2 x digital outputs (provided by relays with changeover volt free contacts (rated for 240V AC) and on/off delay timers)
c) 2 x analogue inputs (each selectable for voltage or current signals, direct or reverse acting, with the minimum and maximum range independently scaleable from 0-10V DC and 0-20mA)
d) 1 x analogue output (0/4-20mA)

3.29 he VSD shall have the facility to expand its I/O capability through the addition of option modules. These should be available as factory mounted modules, with the complete VSD including the modules tested at the manufacturer's works and also available as simple field mounted options using rigid connectors to plug into the VSD. The following I/O points should be provided by these option modules:

a) Additional digital inputs
b) Additional digital outputs including additional relay outputs
c) Additional analogue inputs
d) Additional analogue outputs (0/4-20mA and 0-10V DC)
e) Pt1000/Ni1000 temperature sensor inputs

3.30 It shall be possible to read the status of all digital and analogue inputs (including those on I/O expansion modules) via the high level interface making them available as remote inputs for the BMS.

3.31 It shall be possible to control all digital and analogue outputs (including those on the I/O expansion modules) via the high level interface making them available as remote outputs for control by the BMS. When controlled by the BMS in the event of the high level interface network failing the digital/analogue outputs shall override to a programmable default condition/value.

3.32 Voltage dip Ride Through. The FC shall comply to voltage dip ride through requirement and perform in accordance to the characteristic as describe:

a) The FC should meet the demands stated in Semi F47 without the need of disabling any protective feature of the FC.
b) The FC shall continue to operate without trip for voltage dip of 10% to 100%.

c) On voltage dip, the FC shall export export a warning and reduce the output
current to 30% of I_{FC} to maintain operation.
d) On 100% voltage dip, the VSD shall be able to re-start by itself when voltage recovered.

4 MECHANICAL REQUIREMENTS AND INSTALLATION

4.1 For plantroom use the FC shall be contained in a single metal enclosure minimum IP54 rating up to 1MW incorporating all of the accessories necessary to meet the specification without having to use a secondary enclosure.
Any local / non-proprietary made enclosures will be strictly unacceptable.

4.2 The FC shall include load dependant in-built cooling fans. This increases life expectancy of the in-built cooling fans. FCs without this facility shall include as a part of their offer, spare parts and labour to replace.

4.3 The manufacturer shall provide all sizes, weights, mounting dimensions and wiring details with his offer.

4.4 The operating keypad shall be detachable to allow upload/download function to copy programming from one drive to another. An optional remote keypad kit shall be available for mounting the keypad in a secondary fascia enclosure maintaining a minimum IP54 rating.

4.5 No rear access shall be necessary during normal service function.

4.6 The design of the FC shall allow up to at least 100 meters of SWA (Single Wire Armour) cable to be used between the FC and the motor and allow the use of MICS (Mineral Insulated Copper Sheath) cable in the motor circuit for fire locations.