SECTION 15040 - MECHANICAL/ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK:

A. This section specifies the basic requirements for electrical components which are either separate components or are an integral part of all mechanical equipment. These components include, but are not limited to factory installed motors, starters, variable frequency drives and disconnect switches furnished as an integral part of packaged mechanical equipment.

B. Wiring of field-mounted switches and similar mechanical-electrical devices provided for mechanical systems, to equipment control panels.

C. Specific electrical requirements (i.e. horsepower and electrical characteristics) for mechanical equipment are scheduled on the Electrical Drawings. In case of conflict, Electrical Drawings shall take precedence. Do not purchase motors or electrical equipment until power characteristics available at building site location have been confirmed by Contractor.

COORDINATE TABLE WITH ELECTRICAL ENGINEER AND ARCHITECT.

Coordinate with Kenny Maxwell

D. Refer to Table in Division 16 for Mechanical/Electrical coordination.

E. See other sections of Division 15 for vibration and seismic control requirements.

1.2 QUALITY ASSURANCE:

A. Manufacturers: Firms regularly engaged in manufacture of motors, motor starters and drives of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Single Manufacturer: Provide all motors and starters for the project by a single manufacturer except when part of factory packaged equipment. All variable frequency drives and soft start starters for the project shall be by a single manufacturer, including packaged equipment except chillers.

C. Installer's Qualifications: Firm with at least 3 years of successful installation experience on projects utilizing motors, motor starters, capacitors and drives similar to that required for this project.

D. NEC Compliance: Comply with NEC as applicable to wiring methods, construction and installation of motors, motor starters, capacitors and drives.

E. NFPA Compliance: Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces".

F. UL Compliance: Comply with applicable requirements of UL 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors", and UL 508, "Electrical Industrial Control Equipment" pertaining to installation of motor starters.

G. UL Compliance: Provide equipment and components which are UL-listed and labeled.

H. ETL Compliance: Provide equipment and components which are ETL-listed and labeled.

I. IEEE Compliance: Comply with applicable requirements of IEEE Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to motor starters and Std 519.

J. NEMA Compliance: Comply with applicable requirements of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies", and Pub No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)", pertaining to motor controllers/starters and enclosures.

K. Standards:

1. NEMA Standards MG 1: Motors and Generators.
2. NEMA Standard ICS 2: Industrial Control Devices, Controllers, and Assemblies.
3. NEMA Standard 250: Enclosures for Electrical Equipment.
4. NEMA Standard KS 1: Enclosed Switches.
5. Comply with National Electrical Code (NFPA 70).

L. Coordination with Electrical Work: Wherever possible, match elements of electrical provisions of mechanical work with similar elements of electrical work specified in Division 16 sections. Comply with applicable requirements of Division 16 sections for electrical work of this section which are not otherwise specified.

1.3 SUBMITTALS:

A. Product Data: Submit in accordance with Section 15010.

B. Shop Drawings: Submit dimensional drawings of VFD's and soft start starters showing accurately scaled equipment layouts. Drawings shall include, as a minimum: physical dimensions of each unit; general arrangements with incoming and outgoing conduit locations, schematic; connection diagram sufficient to install system, and enclosure details.

C. Wiring Diagrams: Submit schematic power and control wiring diagrams, prepared for this project, of complete VFD and soft start starter assemblies. General wiring diagrams with various non-applicable options shown are not acceptable. Clearly differentiate between factory and field wiring.

D. Listing, Motors of Mechanical Work: Concurrently, with submittal of mechanical products listing, submit separate listing showing rating, power characteristics, efficiencies, power factors, application and general location of every motor to be provided with mechanical work. Submit updated information promptly when and if initial data is revised.

1. Include in listing of motors, notations of whether motor starter is furnished or installed integrally with motor or equipment containing motor.

E. Electrical coordination listing. Provide the following information for each field wired electrical power connection. Information shall use nameplate data and nomenclature of actual installed nameplates. Information should list as a minimum:

1. Field connection details such as maximum/minimum wire size lugs can accommodate. Include number of lugs per phase.
2. Number and location of field connections.
3. Field interconnection wiring.
4. Operating voltage and phase.
5. Maximum fuse size or maximum overcurrent protection size (as applies).
6. Minimum circuit ampacity.

7. Full load amperes.
8. Locked rotor current and duration for high inertia equipment.
9. Manufacturers recommended overload setting (if applicable).

The contractor shall fully coordinate these items with all subcontractors prior to submittal.

1.4 PRODUCT STORAGE:

A. All variable frequency drives shall be protected from dirt, debris, and moisture at all times. Variable frequency drives shall be wrapped air and water tight with dust-tight and moisture proof material until factory start-up of variable frequency drives is initiated.

Exception: Drives may be opened only during wiring terminations by temperature control contractor and/or electrical contractors.

B. All motors not designed for exposure to water or moisture shall be protected at all times.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Subject to compliance with requirements, provide products by one of the following manufacturers for each type of product:

1. Motors

a. Century/MagneTek
b. Baldor
c. Reliance
d. Westinghouse
e. Siemens-Allis
f. General Electric
g. Louis Allis
h. Lincoln
i. U.S. Motors
j. Square D

2. Starters

a. Cutler Hammer
b. Allen-Bradley
c. Sprecher & Schuh
d. Square D
e. Eaton
f. Siemens

3. Soft Start Starters

a. Allen-Bradley
b. U.S. Electric
c. Sprecher & Schuh
d. Square D
e. Siemens

4. Variable Frequency Drives

a. Robicon
b. ABB
c. Reliance
d. Allen-Bradley
e. Square D
f. Toshiba
g. Grahm
h. Eaton
i. Cutler Hammer
j. Siemens

2.2 MOTORS:

A. The following are basic requirements for simple or common motors. For special motors, more detailed and specific requirements are specified in the individual equipment specifications.

1. Torque characteristics shall be sufficient to satisfactorily accelerate the driven loads with a time limit acceptable to the motor manufacturer. Motors shall be capable of starting the driven equipment while operating at 90 percent rated terminal voltage.

2. Motor sizes shall be large enough so that the driven load will not require the motor to operate in the service factor range.

DESIGN NOTE: Use single winding 2-speed motors on full/half speed applications, for full/two-third speed applications specify 2 winding 2-speed motors.

3. 2-speed motors shall have (1) single winding on poly- phase motors.

4. Explosion proof motors shall meet Underwriters Laboratories Standards for use in hazardous locations and National Electrical Code (NEC), Article 500, Class and Group.

5. Temperature Rating: Rated for 40 degrees C environment with maximum 80 degrees C temperature rise for continuous duty at full load (Class B Insulation). Provide Class F insulation for variable frequency drive motors.

6. Starting capability: Frequency of starts as indicated by automatic control system, and not less than 5 evenly time spaced starts per hour for manually controlled motors.

7. Service Factor: 1.15 for poly-phase motors, ~~and~~ 1.35 for single phase motors, and 1.0 for inverter duty motors.

8. Motor construction: NEMA Standard MG 1, general purpose, continuous duty, Design "B", except "C" where required for high starting torque. Design "E" shall not be used.

a. Frames: NEMA Standard No. 48 or 54; Use driven equipment manufacturer's standards to suit specific application.

b. Bearings:

1) Ball bearings with inner and outer shaft seals.

2) Re-greasable, except permanently sealed where motor is normally inaccessible for regular maintenance.

3) Bearings shall be rated for minimum L-10 life of 40,000 hours.

4) Designed to resist thrust loading where belt drives or other drives produce lateral or axial thrust in motor.

5) For fractional horsepower, light duty motors, sleeve type bearings are permitted.

c. Enclosure Type:

1) Open drip-proof motors for indoor use where satisfactorily housed or remotely located during operation.
2) Guarded drip-proof motors where exposed to contact by employees or building occupants.
3) Weather protected Type I for housed outdoor use, TEPC II where not housed.
4) [All cooling tower fan motors shall be TEFC type.] [2-speed] [and reversible with reversible starter at low speed.]

d. Overload protection: Built-in thermal overload protection for all single phase motors and, where indicated, internal sensing device suitable for signaling and stopping motor at starter.

e. Noise rating: "Quiet".

f. Efficiency: All motors shall have a minimum efficiency as scheduled in Table 1 accordance with IEEE Standard 112, test method B and NEMA Chart 12-10. If efficiency not specified, motors shall have an efficiency equal to or greater than the "minimum efficiency standard", in accordance with IEEE Standard 112, test method B and NEMA Chart 12-10.

g. Efficiency: All motors shall be NEMA premium efficiency motors, in accordance with NEMA standard MG-1, 2003, tables 12-12 and 12-13 or as listed below:

Motor Horse-power	Nominal Full-Load Efficiency					
	Open Motors, ODP			Enclosed Motors, TEFC		
	1200 RPM	1800 RPM	3600 RPM	1200 RPM	1800 RPM	3600 RPM
1	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2	87.5	86.5	85.5	88.5	86.5	85.5
3	88.5	89.5	85.5	89.5	89.5	86.5
5	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	924	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0

25	93.0	93.6	91.7	93.0	93.6	91.7
30	93.6	94.1	91.7	93.0	93.6	91.7
40	94.1	94.1	92.4	94.1	94.1	92.4
50	94.1	94.5	93.0	94.1	94.5	93.0
60	94.5	95.0	93.6	94.5	95.0	93.6
75	94.5	95.0	93.6	94.5	95.4	93.6
100	95.0	95.4	93.6	95.0	95.4	94.1
125	95.0	95.4	94.1	95.0	95.4	95.0
150	95.4	95.8	94.1	95.8	95.8	95.0
*Efficiency and power factors may vary from above values, including but not limited to, multi-speed, explosion proof motors and/or special hermetic motors packaged with equipment. For these special applications motors shall be high-efficiency type and are subject to review by the engineer.						

h. Nameplate: indicate the full identification of manufacturer, ratings, characteristics, construction, special features and similar information.

9. Phases and Current Characteristics: Unless indicated otherwise, provide squirrel-cage induction polyphase motors for 3/4 hp and larger, and provide capacitor-start single-phase motors for 1/2 hp and smaller, except 1/6 hp and smaller may, at equipment manufacturer's option, be split-phase type. Tri-voltage motors are not acceptable. Coordinate current characteristics with power specified in Division 16 sections. Do not purchase motors until power characteristics available at building site have been confirmed by contractor.

10. The Contractor shall be responsible for all additional electrical and other costs involved to accommodate any motors which differ from the scheduled horsepower sizes or correct any motor which does not meet the listed efficiency as called for in mechanical or electrical plans and specifications.

11. Motors shall be of the same manufacturer, except those that are an integral part of a factory assembled packaged unit. These motors shall likewise meet the conditions of the specification in this section except motors which are part of a motor/compressor assembly are exempted from this requirement.

12. All motors 75 HP and larger shall be factory test certified for power factor, efficiency, and shall have a three year warranty. Factory certification of motor tests shall be provided to the Owner.

13. All equipment specified to operate with variable frequency drives shall be provided with inverter-duty motors specifically designed for variable speed operation with high efficiency at part load conditions and constructed with Class F inverter grade insulation. Inverter duty motors shall meet requirements of NEMA MG-1 part 31.4 O.4.2.

14. All motors which will be operated by a variable frequency drive shall be warranted against any damage or defects as a result of being used with a variable frequency drive.

2.3 STARTERS, ELECTRICAL DEVICES AND WIRING:

A. Motor Starter Characteristics:

1. Coordinate with the Electrical Contractor for motor control center starters provided by Division 16.
2. Enclosures: NEMA 1, general purpose enclosures with padlock ears, except in wet locations shall be NEMA 3R with conduit hubs, or units in hazardous locations which shall have NEC proper class and division.
3. Type and size of starter shall be as recommended by motor manufacturer and the driven equipment manufacturer for applicable protection and start-up condition.

Edit Note: Delete reversing requirements as applicable.

4. Provide two-speed starters with a High-Low selector switch wired to allow manual speed selection with the H-O-A in HAND or remote speed selection in AUTO. Provide an automatic accelerating relay/timer to assure that the motor will always start at low speed and operate at an adjustable time before switching to high speed. Also, provide an integral automatic decelerating timing relay to prevent damage to the motor and load when switching from high to low speed. High and low speed contactors shall be mechanically and electrically interlocked. Complete instructions shall be provided for adjusting the timer in the field to match the deceleration characteristics of the driven equipment.

    a. For cooling towers or other two-speed motors which are noted to have reversible operation, starters for those applications shall include the features described above for two-speed motors and include Reverse Selector Switch wired to allow manual direction In The Hand Position of the H-O-A. Starters with reverse direction shall have an integral built-in time delay to allow the motor to come to a full stop, prior to reversing for both the In the Hand and Automatic positions of the H-O-A switch.

5. Contacts shall open each ungrounded connection to the motor. Contacts shall be NEMA style, sized and rated, 75 degrees C.

B. Manual switches shall have:

1. Pilot lights and extra positions for multi-speed motors.
2. Overload protection: melting alloy type thermal overload relays.

C. Magnetic Starters:

1. Unless otherwise indicated, provide NEMA style, sized and rated magnetic starters including contacts and coils for motors 3/4 hp and larger and for smaller motors where interlock or automatic operation is indicated or required:

    a. Maintained contact H-O-A push buttons and pilot lights, properly arranged for single speed or multi-speed operation as indicated.
    b. Solid state adjustable motor overload. Select range so that upper limit is no more than 150 percent of the connected motor full load amps.
    c. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-15 Controls sections.
    In addition to the interlock & switches specified above each starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.
    d. Built-in 120 volts control circuit transformer, fused from line side, where service exceeds 240 volts.

e. Under-voltage release or protection. Re-start of equipment shall be automatic, except for the following:

1)
2)
3)

f. All 3-phase motors 2 hp and larger shall be protected against loss of phase (single phasing protection) wired into the starter. Reset shall be manual.

EDIT FOLLOWING PARAGRAPHS AS REQUIRED.

g. Where reduced voltage starting is required, the starting method shall be part winding or closed transition auto-transformer/solid state electronic starting. Motors shall be constructed accordingly. Other methods of reduced voltage starting shall not be used unless reviewed by the Engineer prior to bid.

h. All starters used for life safety systems shall have an additional control relay to by-pass all external safeties and internal safeties except for overload protection. Coordinate with 15975.

D. Motor connections:

1. Flexible conduit, except where plug-in electrical cords are specifically indicated.

*** EDIT NOTE: Use soft-starters for large equipment and/or for pumps in open loop piping system which may experience waterhammer.***

2.4 SOFT-START STARTERS:

EDIT NOTE: This spec is relatively old. Verify current state of the art and modify accordingly. (3/99)

A. Provide soft-start starters for the following equipment:

1.
2.
3.
4.

B. Soft start starters shall be provided for the specified service. Soft start starters shall consist of a main disconnect switch, a mechanical contactor, a six-SCR full wave bridge solid state reduced voltage starter, a thermal overload relay factory assembled in a single enclosure, with ratings, features and accessories as specified below. The soft start shall be capable of controlling the starting inrush of a NEMA design B motor, and to reduce water hammer effects of the pumps when the motor is stopped.

C. Ratings and features:

1. Starter voltage as noted on electrical drawings.
2. Enclosure type, NEMA 1 ventilated.
3. Main AC line fused disconnect or circuit breaker mounted and wired, with a door interlock mechanism and padlocking means.

4. Starter shall include a full NEMA style, HP sized and rated series contactor, including contacts and coils, ahead of the solid state electronics. Contactor shall open on normal stop command, and if a shorted SCR is detected.
5. Starter shall be rated for a minimum of 350 percent current for 30 seconds.
6. Starter shall include adjustable thermal overload protection.
7. Starter shall include maintained contact H-O-A selector switch and red running pilot light.
8. Starter shall include an integral 120V control circuit transformer with primary and secondary fusing.
9. Starter shall be rated for full current operation at 40 degrees C ambient temperature.
10. Interlocks, pneumatic switches and similar devices as required for coordination with control requirements of Division-15 Controls sections.
    In addition to the interlock & switches specified above each soft start starter shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open & (2) two normally closed.

D. Protective features and adjustments:

1. SCR's shall be rated 1600 PIV minimum.
2. Instantaneous overcurrent trip shall be included if current exceeds 900 percent FLA.
3. Metal Oxide Varistor (MOV) suppressors shall be provided.
4. Heat sink overtemperature switch shall be provided.
5. Starter shall include shorted SCR detection and lockout.
6. Starter shall not start if a phase loss condition is present.
7. Diagnostics shall include LED indicators for:

    a. 3 phase power present
    b. Shorted SCR detected
    c. Motor overload
    d. Instantaneous overcurrent
    e. Starter ready
    f. Starter on
    g. Power supply failure

8. A fault relay shall be included to trip the series contactor in the event of motor thermal overload, instantaneous overcurrent, of presence of a shorted SCR.
9. Adjustments shall include ramp time, current limit, jog voltage, jog time, and deceleration time.

E. Operational Features:

1. On starting, the starter shall be capable of applying an adjustable "jog" voltage to the motor for an adjustable time to magnetize the motor, then automatically switch to a controlled current ramp mode to accelerate the load.

2. On stopping, the starter shall include an "anti-water hammer" circuit which is capable of accepting a 0-10V DC signal proportional to flow from the building automation system and controlling the voltage to the motor to obtain a smooth reduction in flow without excessive pipe movement or water hammer. As a backup, a linear voltage ramp deceleration mode shall be available.

3. Field Start-up and Service: Soft starter supplier shall provide authorized factory trained service personnel to do on-site start-up and adjustment for each soft start starter.

2.5 DISCONNECT SWITCHES:

A. See Division 16 for requirements.

2.6 DRIVES:

A. V-Belt Drives:

1. Capacity of V-Belt Drives at rated RPM shall be not less than 150 percent of motor nameplate horsepower rating.
2. V-Belt Drive combinations shall be limited to A, B, C and fractional horsepower belts. 3V, 5V and 8V belts and sheaves shall not be used.
3. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15 HP; fixed pitch for use with motors larger than 15 HP. Select pulley so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
4. All fixed pitch sheaves, including single groove fan sheaves, shall be of the bushed type. Fixed bore sheaves will not be acceptable for adjustable pitch sheaves.
5. Belts: Oil-resistant, nonsparking, and nonstatic.
6. Unit manufacturer shall provide OSHA approved belt guard with tachometer holes.
7. For equipment serving hazardous or critical systems (i.e., fume hoods, bio-hazards, life safety, etc.), all fans shall be provided with 1.5 times the number of belts normally required to meet above requirements, with a minimum of 2 belts.

2.7 VARIABLE FREQUENCY DRIVES:

DESIGN NOTES: ENGINEER SHOULD VERIFY IF RELIEF AIR BY-PASS IS REQUIRED FOR AHU'S WITH VFD'S AND BY-PASS STARTER. LOCATE VFD AS CLOSE TO MOTOR AS POSSIBLE, OTHERWISE MOTOR DAMAGE IS MORE PROBABLE AND/OR WIRING SIZES WILL HAVE TO BE INCREASED.

DESIGN NOTE: This spec is valid for a stand-alone VFD. Certain features, (particularly control, enclosure, and by-pass) may not be obtainable in “standard” packaged equipment (such as a RTU) or in a MCC. Verify with equipment manufacturer and either modify this spec; or accept the cost of a custom design. Also, this spec may be overkill for 10 HP and below, but drive economics are limited below 10 HP anyway. Review on a case by case basis.

A. General:

1. Comply with NEMA (including NEMA ICS 7.1), and IEEE (including IEEE 519-1992) Standards as applicable to wiring methods, construction and installation and operation of VFDs. Comply with applicable requirements of UL 908. “Power Conversion Equipment” and UL 508 C. Provide units which have been UL-listed and labeled by Underwriters Laboratory or ETL Testing. The entire unit shall carry this label, not just components.

2. Provide the following factory tests on VFD assembly as a complete package (not just individual components):

a. High pot test per UL 508.
b. Test assembled panel with a motor load.
c. Test operation of all components and pilot lights.

3. The manufacturer shall verify compatibility of each VFD unit with the motor being supplied under Division 15. The vendor shall be responsible for reviewing Division 15 specifications sections, plans and schedules related to motors prior to bid and shall notify the Engineer at least ten (10) days prior to the bid of any discrepancies or incompatibilities between VFD units and motor characteristics.

EDIT NOTE: NEMA 1 suitable for normal indoor conditions. Contact manufacturer for wet, dusty, outdoor, etc locations. Provide filters if moderately dirty.

B. Enclosure:

1. Mount VFD and all components within a NEMA 1 metal enclosure. By-pass components shall be in a separate compartment or enclosure as noted below.
2. Provide floor stand where building walls are not suitable for mounting drive.
3. Provide filtered, fan powered ventilation for drive cooling. Fan shall be sized for "dirty filter" condition, at project altitude.
4. Drive and by-pass enclosure doors shall have provisions for locking with a padlock or integral lock, keyed to the building standards.
5. Switches and pilot lights shall be labeled with engraved plastic laminate tags riveted or similarly permanently fastened.

C. By-pass and Disconnects:

1. Provide manual by-pass circuitry in a separate compartment.
2. Provide a door fused disconnect with Type "J" fuses, with a through-the-door handle, pad lockable in the OFF position. The door interlock shall be defeatable with a tool to allow service access without de-energizing the system. The disconnect shall remove power from all components within both compartments.
3. Provide a three position "VFD/OFF/BY-PASS" switch to control VFD line side, VFD load side, and by-pass contactors. Contactors shall be interlocked to completely isolate the VFD in the by-pass mode for service.
4. Provide control relays to operate by-pass contactor due to remote start/stop, safety interlock, or via the HAND-OFF-AUTO switch. See "Controls and Operation".
5. Provide a three pole motor overload relay connected to shut down the motor in both the VFD and by-pass modes.
6. 120V control power transformer with fused secondary and primary. Primary power shall be derived ahead of the VFD input contactor.
7. Panel shall be arranged to allow power-off maintenance of the VFD while motor is operating on by-pass. By-pass or control circuitry in the same compartment as the VFD will not be allowed.

D. Input Power:

1. The drive shall be capable of accepting facility power as specified on the drawings. Variations of up to plus or minus 10 percent of line voltage and plus or minus 2HZ of line frequency shall be permitted without the drive shutting down on a fault.
2. Power line interruptions of up to 0.5 seconds shall be permitted without the drive shutting down on a fault.
3. The drive input circuitry shall not generate line notches or large voltage transients on the incoming line.
4. The drive efficiency at rated load and frequency shall be 95 percent or better.
5. The drive shall present a displacement power factor of 0.95 or better to the AC line at any speed or load.

6. Manufacturer shall guarantee that harmonic voltage and current distortion, on the line side (input terminals) of the VFD does not exceed 5 percent total voltage Harmonic distortion, and 15 percent total current Harmonic distortion.

    a. Manufacturer shall correct harmonic voltage and current distortion with an AC line reactor, an isolation transformer, or a tuned filter to stay within the above limit.
    b. Manufacturer shall review electrical drawings to determine optimum characteristics of the reactor/filter system.
    c. The installed drive shall be tested to verify the above distortion limits. The manufacturer shall replace the reactor/filter system if the installed drive does not meet the THD criteria. See Part 3.

E. Output Power:

1. The variable frequency AC drive shall convert 3 phase, 60 HZ input power to an adjustable AC frequency and voltage for controlling the speed of any standard NEMA B Design, AC squirrel cage motors driving variable torque loads. The drive shall be rated for continuous duty at the NEC standard full load current of it's associated motor.
2. Transistors (IGBT) to produce a sine weighted PWM three phase output for the load.
3. The drive shall have sufficient capacity to provide stepless speed control of the motor throughout the operating range as specified herein.
4. The drive output will be adjustable from 0 to 60 HZ.
5. The drive shall have the capability to adjust the frequency above 4 kHz. The drive shall not operate with a frequency above 12 kHz.
6. The IGBTs shall have a minimum rating of 1200 VDC on 480 V units and 600 VDC on 230 V units.
7. The drive shall be suitable for operating at the altitude of the project location with no degradation or loss of performance.

F. Control and Operation Features:

1. Adjustable acceleration and deceleration, with automatic acceleration rate limiting to avoid overload and automatic deceleration rate limiting to avoid excessive regeneration voltage.
2. Speed/frequency settings to limit the maximum and minimum motor speed, to avoid up to 3 system critical resonance points and to provide a preset speed for operation in the event of loss of the remote speed signal.
3. Capability to set drive to a pre-determined speed upon a contact closure input from the BAS.
4. Capability of restarting into a rotating motor.
5. The following operator control and monitoring functions shall be accessible without opening the door of the enclosure.

    a. HAND/OFF/AUTO (or Local/Off/Remote) selector switch.

        1) With the "H-O-A" switch in the "HAND" or "LOCAL" position, the motor shall start in either VFD or by-pass mode as determined by VFD/OFF/BYPASS switch, and if in the "VFD" mode, the speed shall be controlled by the manual speed adjustment on the drive door.
        2) With the "H-O-A" switch in "AUTOMATIC" or "REMOTE", the motor shall start from the remote start/stop input in either VFD or by-pass mode as determined by the VFD/OFF/BYPASS switch and, if in the "VFD" mode, its speed shall be controlled by the BAS input speed signal.
        3) With the "H-O-A" switch in the "OFF" position, the run circuit will be open and the VSC will not operate.
        4) This must be a physical switch, not a keypad input function.

b. Manual (local) speed adjustment.

c. Frequency (speed) indication.

d. Output amperage indication.

e. Pilot lights for:

1) Power On (green)
2) VFD Fault (red)
3) External Fault (red)
4) Motor on VFD (green)
5) Motor on By-pass (red)
6) Motor Overload (red)

6. The following control interfaces shall be provided:

EDIT NOTE: Coordinate with points list and 15975-Sequence of Controls, a-d standard. Edit other as required.

a. Remote start/stop (run enable input

1) Provide a control relay and a terminal block in the by-pass compartment to allow remote start/stop in either the VFD or by-pass mode.

b. Remote speed input signal

1) 4-20 mA, 0-5 VDC, 0-10 VDC, or as required by control system. Coordinate with 15971.

c. Safeties interlock input

1) Provide a control relay and terminal block in the by-pass compartment to allow hardwired safety shutdown in either the VFD or by-pass mode.

d. Fault indication output contacts. Indicate fault for the following:

1) Drive protection features
2) Safety interlock
3) Drive hardware fault
4) Input power fault
5) Others as provided by manufacturer

e. Speed indication output (isolated)

f. Amperage indication output.

g. Run forward input.

h. Run backward input.

i. Drive running (status) output.

j. Drive on by-pass output.

k. Drive on manual output.

l. Pre-set speed input.

m. RS 485 communications to DDC system.

n. Complete open protocol communications with DDC system.

7. Provide a key pad and scrolling LCD display for operator interface with programming capabilities, fault diagnostics, fault reset, and security lockout code. Information shall be presented in plain English, not requiring codes.

EDIT NOTE: Edit for Owner preference.

a. Key pad shall not be accessible without opening enclosure panel door.

8. In addition to the interlock and switches specified above, each variable frequency drive shall be provided with (4) four additional spare sets of auxiliary contacts, (2) two normally open and (2) two normally closed.

G. Drive protection and safety features:

1. Ground fault protection.
2. Electronic motor overload protection.
3. Over-voltage/under-voltage protection.

a. The VFD shall be arranged to provide automatic restart after a trip condition resulting from over-voltage or under-voltage.

b. For safety, the drive shall shut down and require manual reset and restart if the automatic reset/restart function is not successful within a maximum of five attempts.

4. Inverse characteristic time-overcurrent overload protection for the motor sized in accordance with NEC requirements.
5. Drive shall be capable of withstanding random application of an output short circuit without damage to drive components or fuses.
6. Input phase loss and undervoltage protection.
7. Torque/current limit control which will slow the motor without tripping when the motor is subjected to an overload, or slow the acceleration ramp when accelerating a high inertia load.
8. High/over temperature protection.
9. VFD shall include a “Bus Charged” warning indicator, and shall be provided with automatic circuitry to discharge the bus within 120 seconds after main power is disconnected.

H. For variable frequency drives serving multiple motors, the following shall be provided:

1. For drives controlling multiple motors, provide automatic transfer for each motor where primary/standby equipment operation sequence is specified in Temperature Controls Section, Sequence of Operation.

2. Provide motor contactors for each motor for drives serving more than one motor, each contactor shall have auxiliary contacts to prevent drive damage if remote motor disconnect switch is open or closed. Temperature control contractor will provide all field wiring to each motor contactor to initiate the drive to automatically transfer load from one motor to another motor as selected by the temperature control system. All

automatic transfer equipment and time delays shall be a part of the variable frequency drive equipment and enclosed within the drive cabinet.

3. Each drive shall have contactors for each motor(s) it serves with individual thermal overload protection for each motor.

4. All multiple motor variable frequency drives shall be capable of operating even if one of the motors is off.

5. Provide [ ] ( ) pre-set speeds. Speed pots shall be located inside of cabinet.

I. For drive manufacturers who use portable test meter for diagnostics, provide not less than one test meter for every five (5) variable frequency drives for each model or type used. Meters shall be supplied to the Owner upon completion of the project.

J. Each drive shall include an RS 232 port with 25 pin "D" connector to allow downloading of parameter settings and fault history logs to a standard IBM compatible portable computer or printer. Software to allow download of setting shall be included.

K. The audible dBa sound level of the complete system (motor & VFD) when operated over the full speed range shall be not more than 10 percent above the sound level of the motor operated in the by-pass mode (60 hZ building power). This test will be performed during initial startup. Corrections needed to achieve this requirement shall be made by the VFD supplier at not cost to the Owner.

L. All variable frequency drives shall be warranted for 36 months after the building has been accepted by the Owner. This warranty shall include all parts, labor, materials, shipping cost, travel, lodging and meals with no cost to the Owner.

2.8 EQUIPMENT FABRICATION:

A. General: Fabricate mechanical equipment for secure mounting of motors and other electrical items included in work. Provide either permanent alignment of motors with equipment, or adjustable mountings as applicable for belt drives, special couplings and similar indirect coupling of equipment. Provide safe, secure, durable, and removable guards for motor drives, arranged for lubrication and similar running-maintenance without removal of guards.

PART 3 - EXECUTION

3.1 TEST AND TEST DATA:

A. A factory load test shall be performed on each motor of 1000 watt input or greater to assure compliance with the energy-efficiency section of this specification.

B. Typical test data on every motor to be used on this project shall be made available upon request.

3.2 INSTALLATION:

A. Install motors on motor mounting systems in accordance with motor manufacturer's instructions, securely anchored to resist torque, drive thrusts, and other external forces inherent in mechanical work. Secure sheaves and other drive units to motor shafts with keys and Allen set screws, except motors of 1/3 hp and less may be secured with Allen set screws on flat surface of shaft. Unless otherwise indicated, set motor shafts parallel with machine shafts.

B. Deliver starters and wiring devices which have not been factory-installed on equipment unit to electrical installer for installation.

C. Install power and control connections for motors to comply with NEC and applicable provisions of Division 16 sections. Install grounding except where non-grounded isolation of motor is indicated.

D. Provide 4 inch high concrete housekeeping pad for floor mounted variable frequency drive.

E. Where a separate disconnect switch is provided in the motor feeders between a VFD and the motor, provide an end switch at the disconnect to open the remote interlock shutdown circuit power circuit.

3.3 VFD START-UP SERVICES:

A. Provide field start-up service by an authorized factory trained service representative. The factory representative shall be trained in the maintenance and troubleshooting of the equipment as specified herein. Start-up services shall include system check-out, start-up and system run.

B. Start-up adjustments shall include optimizing frequency, optimizing volts/Hz ratio, identifying and avoiding resonant speeds, setting accel/decel ramps, and setting overload and circuit breaker trip points.

3.4 VFD HARMONIC DISTORTION TESTING:

A. After installation is complete, measure the harmonic voltage and current distortion of each VFD with the drive assembly in by-pass mode, with the VFD running at 50 percent operating speed and with the VFD running at highest operating speed. Take measurements on each phase (L-L) on the line side (input terminals) of the VFD.

B. If measurements exceed the limits as specified in Part 2, install corrective reactors or filters at no additional cost to the owner and retake measurements after corrective equipment is installed.

C. Include all measurements (before and after) in the harmonic distortion report. Provide the Engineer with a copy of the harmonic distortion report.

D. The Harmonic Distortion Test and Report shall be conducted by an approved independent testing agency.

3.5 VFD NOISE TEST:

A. Measure the dBa sound level of the motor with the drive in by-pass mode, and with the drive operating at 25 percent, 75 percent, and 100 percent speed output.

B. If the measurements exceed the limits specified in part 2, correct as required at no cost to the Owner, and retake measurements.

C. Report all tests to the Engineer.

3.6 VFD INDUCED SHAFT VOLTAGE TEST:

A. After installation is complete, and system is operating under normal conditions, measure and report any voltage potential between the motor shaft and the motor frame, this test may occur

anytime between substantial completion and the end of the overall project warranty period. Report findings to the Engineer. Costs for any corrective measures required shall not be included in the bid.

3.7 INSTALLATION COORDINATION:

A. Furnish equipment requiring electrical connections to operate properly and to deliver full capacity at electrical service available.

B. Verify windings of multi-speed or reduced voltage starters are compatible with the connected motor prior to installation.

C. All control wiring to be in accordance with manufacturer's recommendations; all wiring shall be color coded to facilitate checking.

D. It is the intent of this specification that one "General" Contractor enters an agreement with the Owner. The use and coordination of subcontractors is at the option of the General Contractor. All mechanical equipment, motors and controls shall be furnished, set in place, and wired. The schedule contained in Division 1 / 16 is provided as a guide only. The exact furnishing and installation of the equipment is left to the Contractors involved. Contractor should note that the intent of the schedule is to have the Division 15 and 16 Contractors responsible for coordinating all control wiring as outlined, whether or not specifically called for by the mechanical or electrical drawings and specifications. Comply with the applicable requirements of Division 16 for all electrical work which is not otherwise specified. No extras will be allowed for Contractor's failure to provide for these required items. The Contractor shall refer to the Division 16 and Division 15 specifications and plans for all power and control wiring and shall advise the Architect/Engineer of any discrepancies prior to bidding.

END OF SECTION 15040