

**Section 16680 – VARIABLE SPEED DRIVE SYSTEMS OR AFD**

## Part I - GENERAL

## I.01 Description

- A. This specification is to cover a complete adjustable frequency motor drive consisting of a pulse width modulated (PWM) inverter for use on a standard NEMA Design B induction motor. The drive shall be manufactured in the USA. The drive shall be manufactured by ABB, be designed specifically for variable torque applications, and shall be designated "ACS 400". It is required that the drive manufacturer have an existing:
- sales representative with expertise in AFD applications,
  - an independent service organization, and
- B. The drive and all necessary controls, as herein specified shall be supplied by the drive manufacturer. Manufacturer shall have been engaged in the production of this type of equipment for a minimum of ten years
- C. Provide integral bypass motor starter package.

## 1.02 QUALITY ASSURANCE

- A. Referenced Standards:
1. Institute of Electrical and Electronic Engineers (IEEE)
    - a. Standard 519-1992, IEEE Guide for Harmonic Content and Control.
  2. Underwriters Laboratories
    - a. UL508
  3. National Electrical Manufacturer's Association (NEMA)
    - a. ISC 6, Enclosures for Industrial Controls and Systems
  4. IEC 801-2, 801-4, 255A
- B. Testing:
1. All printed circuit boards shall be completely tested and burned-in before being assembled into the completed AFD. The AFD shall then be subjected to a preliminary functional test, minimum eight hour burn-in, and computerized final test. The burn-in shall be at 104~o F (40~o C), at full rated load, or cycled load. Drive input power shall be continuously cycled for maximum stress and thermal variation.
- C. Failure Analysis:
1. AFD manufacturer shall have an analysis laboratory to evaluate the failure of any component. The failure analysis lab shall allow the manufacturer to perform complete electrical testing, x-ray components, and decap or delaminate components and analyze failures within the component.
- D. Qualifications:
1. AFD's shall be UL Listed.
  2. AFD's shall be CUL listed or CSA Approved.

## 1.03 SUBMITTALS

- A. Submittals shall include the following information:
1. Outline Dimensions
  2. Weight
  3. Typical efficiency vs. speed graph for variable torque load
  4. Compliance to IEEE 519 - Harmonic analysis for particular jobsite including total voltage harmonic distortion and total current distortion.
    - a. The AFD manufacturer shall provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5%. Input line filters shall be sized and provided as required by the AFD manufacturer to ensure compliance with IEEE standard 519-1992, Guide for Harmonic Control and Reactive Compensation for Static Power Converters. The acceptance of this calculation must be completed prior to AFD installation.
    - b. Prior to installation, the AFD manufacturer shall provide the estimated total harmonic distortion (THD) caused by the AFD's. The results shall be based on a computer aided circuit simulation of the total actual system, with information obtained from the power provider and the user.
    - c. If the voltage THD exceeds 5%, the AFD manufacturer is to recommend the additional equipment required to reduce the voltage THD to an acceptable level.

## 1.04 WARRANTY

- A. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time, and expenses.
- B. Contractor shall offer a subsequent service warranty. It shall be priced and submitted with the bid.

**PART 2 - PRODUCTS**

## 2.01 ADJUSTABLE FREQUENCY DRIVES

- A. The adjustable frequency drives (AFD's) shall be solid state, with a Pulse Width Modulated (PWM) output waveform (VI, six-step, and current source drives are not acceptable). The AFD package as specified herein shall be enclosed in a NEMA I enclosure, completely assembled and tested by the manufacturer. The AFD shall employ
- a full wave rectifier (to prevent input line notching), DC Line Reactor, capacitors, and Insulated Gate Bipolar Transistors (IGBT's) as the output switching device (SCR's, GTO's and Darlington transistors are not acceptable). The drive efficiency shall be 97% or better at full speed and full load. Fundamental power factor shall be 0.98 at all speeds and loads.
- B. Specifications for the ACS 400 3 HP to 400 HP at 480 Volts and 2 to 40 HP at 230 volts:
1. Input 440/460/480/500 VAC +1-10% (capable of operation to 550 VAC), 3 phase, 48 - 63 Hz or Input 208/220/230/240 VAC +110%, 3 phase, 48 - 63 Hz.
  2. Output 0 - Input Voltage, 3 phase, 0 to 500 Hz for drives up to 75 HP; 0 to 120 Hz for drives over 75 HP. Operation above 60 Hz shall require programming changes to prevent inadvertent high speed operation.

3. Environmental operating conditions: 0 to 40~ C @ 3 kHz switching frequency, 0 to 3300 feet above sea level, less than 95% humidity, non-condensing.
  4. Enclosure shall be rated for the location used.
- C. The drive type designations shall be as applicable for the size of the associated motor.
- D. All AFD's shall have the following standard features:
1. All AFD's shall have the same customer interface, including digital display, keypad and customer connections; regardless of horsepower rating. The keypad is to be used for local control (start/stop, forward/reverse, and speed adjust), for setting all parameters, and for stepping through the displays and menus.
  2. The AFD shall give the user the option of either (1) displaying a fault, (2) running at a programmable preset speed, (3) hold the AFD speed based on the last reference received, or (4) cause a Warning to be issued, if the input reference (4-20mA or 2-IOV) is lost; as selected by the user. The AFD shall provide a programmable relay output for customer use to indicate the loss of reference condition.
  3. The AFD's shall utilize plain English digital display (code numbers and letters are not acceptable). The digital display shall be a 40-character (2 line x 20 characters/line) LCD display. The LCD shall be backlit to provide easy viewing in any light condition. The contrast should be adjustable to optimized viewing at any angle. All set-up parameters, indications, faults, warnings and other information must be displayed in words to allow the user to understand what is being displayed without the use of a manual or cross-reference table.
  4. The AFD's shall utilize pre-programmed application macro's specifically designed to facilitate startup. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time.
  5. The AFD shall have the ability to automatically restart after an overcurrent, overvoltage, undervoltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between reset attempts shall be programmable. If the time between reset attempts is greater than zero, the time remaining until reset occurs shall count down on the display to warn an operator that a restart will occur.
  6. The AFD shall be capable of starting into a rotating load (forward or reverse) and accelerate or decelerate to setpoint without safety tripping or component damage (flying start).
  7. The AFD shall be equipped with an automatic extended power loss ride-through circuit which will utilize the inertia of the load to keep the drive powered. Minimum power loss ride-through shall be one-cycle, based on full load and no inertia. Removing power from the motor is not an acceptable method of increasing power loss ride-through.
  8. The customer terminal strip shall be isolated from the line and ground.
  9. The drive shall employ three current limit circuits to provide trip free operation:

- a. The Slow Current Regulation limit circuit shall be adjustable to 125% (minimum) of the AFD's variable torque current rating. This adjustment shall be made via the keypad, and shall be displayed in actual amps, and not as percent of full load.
  - b. The Rapid Current Regulation limit shall be adjustable to 170% (minimum) of the AFO's variable torque current rating.
  - c. The Current Switch-off limit shall be fixed at 255% (minimum, instantaneous) of the AFD's variable torque current rating.
10. The overload rating of the drive shall be 110% of its Variable torque current rating for 1 minute every 10 minutes, and 140% of its torque current rating for 2 seconds every 15 seconds.
  11. The AFD shall have input line fuses standard in the drive enclosure.
  12. The AFO shall have a DC Link Choke to reduce the harmonics to the power line and to increase the fundamental power factor.
  13. The AFD shall be optimized for a 3 kHz carrier frequency to reduce motor noise and provide high system efficiency. The carrier frequency shall be adjustable by the start-up engineer in ACS 402 units.
- E. All AFD's to have the following adjustments:
1. Five (5) programmable critical frequency lockout ranges to prevent the AFD from continuously operating at an unstable speed.
  2. P1 Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the AFD, using the microprocessor in the AFD for the closed loop control; thus eliminating the need for external controllers.
  3. Two (2) programmable analog inputs shall accept a current or voltage signal for speed reference, or for reference and actual (feedback) signals for P1 controller. Analog inputs shall include a filter; programmable from 0.01 to 10 seconds to remove an oscillation in the input signal. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0 - 20 mA and 0 - 10 Volts. Additionally, the reference must be able to be scaled so that maximum reference can represent a frequency less than 60 Hz, without lowering the drive maximum frequency below 60 Hz.
  4. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. One digital input is to be utilized as a customer safety connection point for fire, freeze, and smoke interlocks (Enable). Upon remote, customer reset (reclosure of interlock), drive is to resume normal operation.
  5. Two (2) programmable analog outputs proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, or Active Reference.
  6. Three (3) programmable digital relay outputs. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 amps at 250 VAC; Maximum voltage 300 VDC and 250 VAC; Continuous current rating 2 amps RMS. Outputs must be true form C type contacts; open collector outputs are not acceptable.
  7. Seven (7) programmable preset speeds.
  8. Two independently adjustable accel and decel ramps. These ramp times shall be adjustable from 1 to 1800 seconds.

9. The AFD shall Ramp or Coast to a stop, as selected by the user.
- F. The following operating information displays shall be standard on the AFD digital display. The display shall be in complete English words (alpha-numeric codes are not acceptable):
1. Output Frequency
  2. Motor Speed (RPM, % or Engineering units)
  3. Motor Current
  4. Calculated Motor Torque
  5. Calculated Motor Power
  6. DC Bus Voltage
  7. Output Voltage
  8. Heatsink Temperature
  9. Analog Input Values
  10. Keypad Reference Values
  11. Elapsed Time Meter
  12. kWh meter
- G. The AFD shall have the following protection circuits. In the case of a protective trip, the drive shall stop, and announce the fault condition in complete words (alpha-numeric codes are not acceptable).
1. Overcurrent trip 315% instantaneous (225% RMS) of the AFD's variable torque current rating.
  2. Overvoltage trip 130% of the AF D's rated voltage
  3. Undervoltage trip 65% of the AFD's rated voltage
  4. Overtemperature +700 C (ACS 501); +85~ C (ACS 502)
  5. Ground Fault either running or at start
  6. Adaptable Electronic Motor Overload (12t). The Electronic Motor Overload protection shall protect the motor based on speed, load curve, and external fan parameter. Circuits which are not speed dependant are unacceptable. The electronic motor overload protection shall be UL Listed for this function.
- H. Speed Command Input shall be via:
1. Keypad.
  2. Two Analog inputs, each capable of accepting a 0-20 mA, 4-20mA 0-1 OV, 2-IOV signal. Input shall be isolated from ground, and programmable via the keypad for different uses.  
  
Analog inputs shall have a programmable filter to remove any oscillation of the reference signal. The filter shall be adjustable from 0.01 to 10 seconds. The analog input should be able to be inverted, so that minimum reference corresponds to maximum speed, and maximum reference corresponds to minimum speed. The minimum and maximum values (gain and offset) shall be adjustable within the range of 0 - 20 mA and 0 - 10 Volts. The active analog input shall have loss of reference protection, if selected.
  3. Floating point input shall accept a three-wire input from a Dwyer Photohelic (or equivalent type) instrument.
  4. Upon loss of speed input VFD shall be able to select fault, pre-set speed or last know speed.
- I. Serial Communications
1. The AFD shall have an RS-485 port as standard.

2. The AFD shall be able to communicate with PLC's, DOC's, and DDC's.
  3. Serial communication capabilities shall include, but not be limited to, run-stop control, speed set adjustment, proportional/integral P1 controller adjustments, current limit, and accel/decel time adjustments. The drive shall have the capability of allowing the DDC to monitor feedback such as output speed/frequency, current (in amps), % torque, % power, kilowatt hours, relay outputs, and diagnostic fault information.
- J. Accessories to be furnished and mounted by the drive manufacturer.
1. Customer Interlock Terminal Strip - provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external interlocks and start/stop contacts shall remain fully functional whether the drive is in Hand, Auto or Bypass.
  2. All wires to be individually numbered at both ends for ease of troubleshooting.
  3. Door interlocked thermal magnetic circuit breaker which will disconnect all input power from the drive and all internally mounted options. The disconnect handle shall be thru-the-door type, and be padlockable in the "Off" position.
  4. Manual transfer to line power via contactors. Include motor thermal overload and fuse or circuit breaker protection while in bypass operation. A three position selector switch to control the bypass contactor and the drive output contactor is to be mounted on the enclosure door. When in the "normal" mode, the bypass contactor is open and the drive output contactor is closed. In the "Test" position both contactors is closed. The drive output contactor shall also open when a stop command is given, isolating the motor from the drive. Start/stop signals and safety interlocks will work in drive and bypass modes. Pilot lights shall be provide d for indication of "Normal" operation, "Bypass" operation, and "External Fault". All pilot lights shall be push-to-test type.
  5. Service contactor (drive input contactor) which provides the ability to service the drive (electrically isolate the drive while in bypass operation without having to remove power from the motor). The service contactor shall open when the drive is switched to bypass, and also be controlled by a switch which is mounted inside the drive enclosure so that its access is limited to service personnel only.
  6. A class 20 bimetallic thermal motor overload relay shall be provided to protect the motor in bypass.
  7. 3 - 15 PSI pneumatic speed reference shall be via direct connection to the AFD, without the use of external pressure to electrical transducers. A connector outside the AFD enclosure shall be provided for connection of pneumatic tubing.
  8. The AFD shall have a manual speed potentiometer in addition to using the keypad as a means of controlling speed manually.

### 3.01 INSTALLATION

- A. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the AFD manufacturer as outlined in the installation manual.
- B. Power wiring shall be completed by the electrical contractor. The contractor shall complete wall wiring in accordance with the recommendations of the AFD manufacturer as outlined in the installation manual.

- C. Install programmable controls at 5'-6" to center line.

**3.02 START-UP**

- A. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the owner, and a copy kept on file at the manufacturer.

**END OF SECTION 16680**