

**SECTION 16001**  
**SPECIFICATION FOR**  
**ELECTRICAL REQUIREMENTS FOR PACKAGED EQUIPMENT**

**PART 1 GENERAL**

**1.01 GENERAL REQUIREMENTS**

- A. Terms and Conditions of the Contract apply to Work of this Section.

**1.02 SUMMARY**

- A. Work Included:

1. Electrical systems furnished as an integral part of process and mechanical equipment packages.

- B. Work Not Included:

1. Not Applicable.

**1.03 RELATED DOCUMENTS**

- A. Reference Specifications:

1. 16000 – General Provisions for Electrical Work.
2. 16120 – Conductors and Cables.
3. 16150 – Low Voltage Induction Motors.
4. 16269 – Variable Frequency Controllers.

- B. References:

1. Refer to Section 16000 for general references.
2. IEC:
  - a. 60529 - Degrees of Protection Provided by Enclosures (IP Code).

- C. Attachments:

1. Not Applicable.

**1.04 SUBMITTALS**

- A. Refer to Section 16000 for general submittal requirements.

- B. Provide dimensioned layout and elevation drawings that indicate general equipment and device locations, conduit routing and seal locations, grounding and Owner connections, and a project North arrow.
- C. Provide bill of materials, control enclosure drawings, point-to-point interconnection wiring diagrams, annotated schematic ladder type elementary diagrams, loop diagrams, and installation details. Wiring diagrams or bill of materials shall show exact equipment being supplied and compliance with CE or other applicable testing agency acceptable to authority having jurisdiction.
  - 1. Documentation shall be in Korean language with ANSI standard symbols.
  - 2. Equipment and devices shall be identified by manufacturer, model, catalog number, and electrical ratings (i.e. – voltage, amperes, frequency, short circuit, etc.).
  - 3. Annotated schematic ladder type elementary diagrams shall be numbered and relay contact locations shall be identified with appropriate line number.
  - 4. Installation details shall be a set of drawings depicting the mounting, piping, tubing, tracing, and wiring of all field devices.
- D. Provide drawings of local control and/or remote supervisory enclosures for approval:
  - 1. General enclosure layout, arrangement, and fabrication drawings including overall dimensions, mounting requirements, and bill of materials as part of a drawing (not a computer generated printout).
  - 2. Complete connection diagrams showing instruments and devices in their relative physical relationship. Diagrams shall include interconnecting wiring and termination identification.
  - 3. Wiring and elementary diagrams shall differentiate field wiring from panel wiring and shall identify Owner's termination requirements. Specify any special requirements for field wiring such as shielding.
  - 4. Functional operation of circuit shall be clearly evident without reference to other drawings, instruction books, or equipment. Identification and operation of contacts, interlocks, and other devices shall be indicated adjacent to each device wherever practical. Contacts of a relay or switch, including those appearing in other circuits, shall be shown on drawing of device.
- E. For equipment packages with more than one skid, the Supplier shall provide a cable schedule and block diagram identifying cable number, quantity of wires, recommended wire size, and point-to-point terminations.
- F. Provide as-built drawings including electronic copies on CD-ROM in latest version of Autocad prior to shipment of packaged equipment.
- G. Provide test procedures with quote. Provide test performed, expected results, and measured results with shipment.

- H. All drawing deliverables except loop diagrams shall be submitted as “D” size drawings. Loop diagrams shall be submitted as “B” size drawings.

#### 1.05 SPARE PARTS

- A. Refer to Section 16000 for minimal requirements.

#### 1.06 QUALITY ASSURANCE

- A. Equipment and materials shall be CE listed and labeled in accordance with IEC.
- B. When applicable, equipment and materials shall be certified by an industry certification, label, or standard (i.e. CE, CSA).
- C. Material shall be new, and conform to grade, quality, and standards specified. Equipment or materials of same type shall be product of same manufacturer.

#### 1.07 DELIVERY, STORAGE, HANDLING

- A. Equipment shall not be prepared for shipment before Purchaser has inspected equipment or waived inspection.
- B. Pack control panels to prevent damage from handling, shipment, weather, and storage.
- C. Remove fragile devices from panel, packed according to manufacturer's instructions, and shipped separately.
  - 1. Provide complete instructions for reassembly or reinstallation of devices by field contractor.
- D. Provide panels for shipment with provisions for lifting. Lifting points shall be clearly marked.
- E. Shipping splits shall be clearly labeled with Owner's purchase order number, sequence and quantity within shipment, manufacturer's order number, and any other relevant information necessary to distinguish creates, boxes, or packages at the Owner's site.

### PART 2 PRODUCTS

#### 2.01 GENERAL

- A. Operating Voltages:
  - 1. 380V, 3 phase, 3 wire – 0.37 KW and larger.
  - 2. 220V, 1 phase - less than 0.37 KW.

3. The Owner shall provide a single feeder in accordance with the voltages mentioned above; the Supplier shall be responsible for all other voltages necessary for a completed equipment package.
- B. Equipment shall be suitable for continuous operation in 0 deg C to 40 deg C ambient temperature. Equipment located in cold rooms shall be suitable for continuous operation at temperature specified in equipment specifications or datasheets.
- C. IEC hazardous area classification will be specified in equipment specifications or datasheets. Components, materials, wiring, and enclosures shall be suitable for classification specified.
- D. Manufacturer is responsible for correctness of internal wiring and for proper functioning of equipment provided. Install wiring exactly as shown on wiring diagrams.
- E. Supplier shall provide all motors, motor starters, contactors, variable frequency controllers, instrumentation, devices, and control systems for a complete equipment package, unless otherwise stated.
- F. Low voltage induction motors (260 KW and less) shall be provided in accordance with Section 16150.
- G. Motors larger than 22 KW shall be provided with power factor correction capacitors. Supplier shall properly size capacitors to maintain minimum 0.95 pf properly mounted near the motor.
- H. The Supplier shall furnish and install all skid-mounted devices, unless otherwise noted, including receptacles required for auxiliary equipment, such as clean-in-place units, etc. In addition, the Supplier shall furnish and install all conduit systems (including seals as may be required) and wiring required between the devices and to terminal boxes on the skids for external connections by others. If the equipment has water services or a potential of water within 2 meters of the equipment, all power components shall be ground-fault protected.
- I. When equipment must be furnished or shipped in different sections (or skids), the vendor shall provide a terminal box on each section of the packaged system for interconnection wiring.

## 2.02 SAFETY

- A. Comply with all safety requirements, regardless of type of equipment package.
- B. Each motor shall be provided with an isolation switch that has lock-out/tag-out provisions.
- C. Accessible external surfaces of equipment shall not exceed 60 degrees C.

- D. Products containing insulating liquids with polychlorinated biphenyl (PCB) shall not be used.
- E. Live parts shall be incapable of being inadvertently touched by personnel.
- F. Control voltage shall not exceed 24 Volts. Where residual voltage may exist after disconnection of power source, provide proper warning labels.
- G. Areas of panel where voltages are above 24 Volts shall be clearly identified using proper warning labels.
- H. Earthing
  - 1. Earth all metallic surfaces in accordance with IEC and Owner's requirements.
  - 2. Route insulated earthing conductors with cable, unless otherwise stated. Exposed noncurrent-carrying metal parts of equipment package shall be bonded and connected to earthing pad or terminal for connection to Owner's earth system.
  - 3. Include ground wires within cable assemblies and connect at both ends to provide continuous fault current path.
  - 4. Cases of instruments receiving power shall be connected to earth with individual insulated wires.
  - 5. Provide two (2) earth pads 180 degrees apart for connection of Owner's 25 sq. mm earthing conductor.
  - 6. All equipment mounted on the skid shall be bonded to the skid chassis via external and visible ground lugs and straps. Provide ground bus inside control cabinet for connection from incoming earth wire and to skid earth lugs.
  - 7. All motors located in hazardous areas shall have an external earthing conductor connected to the base.

## 2.03 ENCLOSURES

- A. Enclosures shall be rated in accordance with IEC IP5x or IP6x for field conditions as specified in equipment specifications and datasheets. Enclosures located in cleanroom areas shall be stainless steel.
- B. Enclosures located in hazardous areas shall be in accordance with IEC rated for the environment with the proper temperature rating.
- C. Space heaters shall be provided for dew point control if in outdoor location or damp indoor location. Heaters shall be accessible for replacement and provided with protective screens if located where contact by personnel is possible. Protect each space heater with properly rated renewable fuses and control using thermostat.
- D. Enclosures that are floor mount shall be at least 900 mm nominal in height but shall not exceed 3000 mm nominal. Thickness of sheet metal used to fabricate enclosures shall

conform to requirements of IEC. Provide floor mount enclosures on mounting legs with provisions for bolting to floor.

- E. Floor mount enclosures 600 mm deep and more shall be provided with the following:
  - 1. Interior lighting to illuminate enclosure interior controlled from a door activated switch.
  - 2. One (1) earth protection (RCD) type duplex receptacle located inside enclosure in readily accessible position.
  - 3. Copper earthing bar (1" x 1/4") running full length of enclosure.
- F. Provide flush-hinged access doors with maximum width of 750 mm. Construct doors with stiffening members if necessary to ensure rigidity. Door handles shall be corrosion resistant and capable of being padlocked.
- G. Provide engraved nameplates for each instrument or device mounted on face of panel, within panel enclosure, isolation switches, relays, fuses, etc. Nameplates shall be in accordance with Section 16000 suitable for specified environmental conditions. Self adhesive types are not acceptable.
- H. Enclosures shall be suitable for cable entry from above and below provided with knock-out plates. Panel drawings shall show areas for cable entrance including dimensions.
- I. Provide means for skidding or lifting and handling by cranes or hoists without damage to enclosure, or enclosed equipment, when unloading or moving into position.

## 2.04 MOTOR CONTROLS

- A. Motor Starter
  - 1. Approved Manufacturers:
    - a. Asea Brown Boveri (ABB)
    - b. Groupe Schneider Electric (Square-D)
    - c. Siemens
  - 2. Supplier shall provide all motor starters and controls necessary for a complete equipment package as specified in applicable specifications, unless otherwise noted.
  - 3. Motor starters furnished by the Supplier shall be minimum 32 amps, full voltage, non-reversing, combination type with main isolation means, and contactor with solid state type overload relays.
  - 4. The contactor, overload relays, and protective devices shall provide Type 2 coordination in accordance with IEC 947-4-1.
  - 5. Thermal overload relays shall be provided with external reset capabilities.
  - 6. Provide two normally open (NO) and two normally closed (NC) auxiliary contacts wired to terminal blocks for Owner connections.

7. Provide a hand-off-auto (H-O-A) selector switch with each motor starter. "Hand" position shall be used for local control and "Auto" position shall be used either by the Supplier's packaged control system or by an Owner's control system.
8. Starters shall be rated for available short circuit and earth fault protection as indicated on datasheets, or the Supplier shall request ratings from the Engineer.
9. Provide starters in enclosures suitable for the areas where installed.
10. Starters shall be equipped with dual element-time delay fuses.
11. When manufacturer's equipment package contains multiple motors, a single short circuit protective device may be furnished. The protection device may be circuit breaker, motor circuit protector, or fused isolator switch with dual element fuses.
  - a. When single protection for multiple motors is provided, each individual motor shall be provided with an individual motor starter and solid state overload relays.

B. Variable Frequency Contoller (VFC)

1. Approved Manufactures:
  - a. Refer to Section 16269.
2. General Requirements:
  - a. Supplier shall provide all VFC and controls necessary for a complete equipment package as specified in Section 16269, unless otherwise noted.
  - b. Submit manufacturer's complete motor data, as necessary, to select and size each VFC using mechanical equipment schedules and other information in order to provide coordinated motor drive package.
  - c. Coordinate enable (permissive), digital, and analog input and output signals with the Owner as required.
  - d. Supplier shall be responsible for programming, start-up, and commissioning of VFC provided with packaged equipment.
3. Design Requirements
  - a. General: Variable torque, microprocessor-based, PWM (pulse width modulated), adjustable frequency design for 3-phase high efficiency AC motors.
  - b. VFC shall not cause line side displacement power factor of less than .95 over entire range of operating speed and load condition.
  - c. VFC shall contain 120VAC control power, overload relays, incoming fuses, and an main isolation switch.
  - d. Provide terminal blocks for external power and control wiring by the Owner with 20% spare.
  - e. VFC shall be capable of a sequential automatic restart following power outage.

## 2.05 AUXILIARY CONTROLS

- A. Auxiliary relay and timer contact developments shall be in accordance with applicable elementary diagrams. Mount relays inside control panels or in separate relay cabinets. Relays shall have convertible contacts rated 400VAC or 110 VDC insulation class, as appropriate, except if system design dictates otherwise. Number of contacts required shall be in accordance with appropriate control and/or alarm system design. Contacts shall be rated for an interrupting duty in inductive circuits of 6A at 220V AC (35 percent power factor) and 5A at 24 VDC.
- B. Electrical instruments for measuring electrical quantities (current, voltage, frequency, etc.) shall be mounted on front face of panel.
- C. Instrument switches, selector switches, and push buttons shall be miniature LED, recessed, oil-tight type.
- D. Provide an E-Stop, red mushroom head, maintained, twist-to-release push button at each operator location to de-energize the equipment package during emergency conditions. The E-Stop shall maintain a safe de-energized state until the E-Stop has been reset.
- E. LED indicating lights shall be replaceable from front. Colors shall be as follows unless otherwise specified:
  - 1. Green - meaning is as follows:
    - a. Operating.
    - b. "On" when motor is running.
    - c. Device is energized.
    - d. Valve is open.
  - 2. Red - meaning is as follows:
    - a. Not Operating.
    - b. "On" when motor is not running.
    - c. Device is de-energized.
    - d. Valve is closed.
  - 3. Amber - meaning is as follows:
    - a. "Warning" or to indicate abnormal equipment or status.
    - b. "On" when system or subsystem is in a mode other than normal or steady state mode.
  - 4. White – meaning is as follows:



- a. “On” when power supply available to packaged equipment.
- F. Where skid assemblies are to be controlled from the Building Automation System (BAS), remote input/output (I/O) enclosures and field terminal boxes shall be provided for termination of all instrumentation and control wiring. The I/O field terminal boxes may also house instrument air solenoid valves, which the vendor shall pipe to the “on-off” valves.

## 2.06 POWER SOURCE

- A. Owner shall furnish a single feeder that is a solidly grounded supply circuit with a maximum short circuit rating in accordance with single line diagrams. Supplier shall be responsible for all other voltages and power distribution for packaged equipment operation.
- B. Transformers for controls shall be mounted in an enclosure with suitable fused overcurrent protection. One un-fused secondary lead of the transformer shall be earthed to frame. Other secondary transformer lead and primary leads shall be fused in accordance with the IEC.
- C. Supplier shall furnish (1) main isolator switch or circuit breaker to isolate the power source; it shall be interlocked with the enclosure door and capable of being locked in open position.
- D. Power source circuits to control equipment shall include fuses to protect control equipment.

## 2.07 RACEWAY AND WIRING METHODS

- A. Wiring shall be installed in accordance with IEC.
- B. Conductors and cables shall be furnished and installed in accordance with Section 16120.
- C. Raceways shall be furnished and installed in accordance with Section 16130.
- D. Interconnection wiring within the control panel that is connected to an external source and not isolated when control panel is de-energized shall be “Yellow”. Intrinsically safe wiring shall be “Blue with Yellow Tracer”.
- E. Terminal blocks shall be DIN rail mounted. Clearly mark terminal blocks (TB1, TB2, etc.) and mark wire numbers on each terminal block terminal. Wires terminating at terminal blocks shall carry the same designation as the block. Where skid I/O and terminal boxes are provided by the Owner, wire and terminal numbers shall be in accordance with the loop diagrams provided. Wires shall not be spliced between terminal points.

- F. Electrical wiring within all equipment cabinets shall be neatly arranged, properly supported, and terminated on one side of the terminal blocks so that all external connections for control, instrumentation, and auxiliary power can be made to the other side. Minimum 20 percent spare unused terminals shall be provided in each group of terminal blocks.
- G. Control circuits and power circuits shall be completely separated by use of divided or separate terminal blocks.
- H. No more than two (2) wires shall be connected to any one terminal block screw. All wire connections shall be made with horseshoe or ring-tongue compression terminals unless the terminal block is specifically designed for bare wire connection. All stranded wire shall connect to the terminal block with insulated ferrules.
- I. Wiring shall be complete with control, metering, and relaying circuits requiring external connections and unused contacts on relays and auxiliary contacts brought to conveniently located terminal blocks.
- J. Connect current transformer secondary leads directly to short-circuiting type terminal blocks.
- K. Identify each wire at each termination in accordance with Section 16120. Wire numbers shall be as shown on wiring diagrams.
- L. Raceways
  - 1. Raceways shall be furnished and installed in accordance with Owner's requirements.
  - 2. All wiring shall be run in tray installed in accordance with IEC.
  - 3. Tray system shall be earthed in accordance with IEC and considered a continuous earth conductor.
  - 4. Equipment located in cleanroom areas shall be stainless steel.

## 2.08 HAZARDOUS AREA

- A. Electrical systems located in hazardous areas shall be in full compliance with IEC.
- B. Explosion proof enclosures located in cleanroom areas shall be stainless steel rated for the environment.
- C. Intrinsically safe barriers are permitted for instrumentation installations.
- D. Purged enclosure systems shall comply with IEC.

- E. Provide all cable glands as required.

## 2.09 MANUFACTURERS

- A. Devices and materials listed below shall be used, unless otherwise approved by Purchaser. Generally, substitutions will be accepted only when use of specified material results in significant redesign of a manufacturer's standard equipment. Substitutions must meet same level of quality as specified material.

- B. Control Devices

- 1. LED Push-To-Test Indicating Lights, Pushbuttons, Selector Switches, Control Devices:
    - a. General Purpose: Groupe Schneider Electric (Square D) or ABB.
    - b. Hazardous Areas: Killark or Crouse-Hinds.
  - 2. Relays: Groupe Schneider Electric (Square D).
  - 3. Circuit Breakers: ABB, Groupe Schneider Electric (Square D), or Siemens.
  - 4. Disconnect Switches: Clipsal, Groupe Schneider Electric (Square D), or Siemens.

- C. Panel Accessories

- 1. Receptacles, Hazardous Areas: Killark.
  - 2. Terminal Blocks: Groupe Schneider Electric (Square D).

## 2.10 SOURCE QUALITY CONTROL

- A. Shop Inspections

- 1. Perform visual inspection and verify that overall workmanship is acceptable.
  - 2. Verify that location of panel mounted devices agrees with approved arrangement drawing.
  - 3. Verify that equipment and devices are properly identified with nameplates.
  - 4. Verify that devices, meters, switches, and pushbuttons operate properly.
  - 5. Verify that internal devices and components are securely mounted and properly identified.
  - 6. Verify that internal wiring is neatly bundled, terminations are securely tightened, wires are properly tagged, and wire colors are acceptable.
  - 7. Verify that conduit materials are correct and installed properly.

- B. Shop Tests

- 1. Relays, meters, circuit breakers, switches, and lamps shall be tested in accordance with manufacturer's standard procedures.

2. Wiring tests shall include point-to-point continuity tests and insulation testing. Do not perform megger testing on static devices.
3. Check control circuit function as far as possible by actuating control switches and push buttons and by applying appropriate signals at terminal blocks. Functioning of associated panel devices may be witnessed by Owner and checks made for proper output signals at terminal blocks

## PART 3 EXECUTION

### 3.01 ASSEMBLY

- A. Arrange components to facilitate operations. Control devices shall be ergonomically located and arranged for ambidextrous operation. Where not possible, right-hand operation should be favored.
- B. Make field cutouts for front-of-panel mounted devices within manufacturer's tolerance. Maintain integrity of panel's IEC rating.
  1. Do not make field cutouts on hazardous enclosures, use factory cutouts only.
- C. Mount components securely. Comply with manufacturer's instructions regarding location, torque, and clearance requirements.
- D. The unit manufacturer shall provide all internal wiring, controls, and devices integral with the unit(s) for a complete installation. Unit (s) shall be supplied as a single point electrical connection for the Electrical Installer.
- E. All electrical components shall be permanently identified with nameplates, which shall be engraved to correspond with the designations shown on the Supplier's diagrams and fabrication drawings. All motor starters, contactors, variable frequency controllers, overloads, disconnect switches, circuit breakers, etc. shall be clearly identified and labeled. Warning signs identifying voltages present shall be installed on each enclosure door.
- F. The final decision to accept "or equals" or alternates will be made by the Owner. Substitutions proposed by the Supplier must be submitted in writing with the bid. Approvals will be made in writing at the time that the Contract is awarded. Substitutions proposed after the bid is awarded will not be accepted.
- G. All original documentation related to the construction, testing, calibration of instruments, etc. for the packaged equipment shall be retained for qualification/validation purposes. Copies of this documentation shall be submitted to the Owner.

### 3.02 WIRING

- A. Wire components exactly as shown on Owner approved wiring diagrams. Wires shall be grouped and arranged neatly to facilitate tracing of circuits.
- B. Arrange wiring so instruments or devices may be removed and serviced without disturbing wiring. No wire shall be routed across face or rear of an instrument, junction box, or device in a manner that will prevent opening of covers, removal of equipment, or access to leads, terminals, or instruments.
- C. Group wires in bundles and secured with ultraviolet resistant, nonflammable, nonmetallic wire wraps. Bundles shall be run in an orderly manner and shall be adequately supported.
- D. Bundle low-level signal (20 mA, 5VDC, or less) cables separately and maintain minimum spacing of 150 mm from power and control cables, except where crossing at right angles in control panels. Where such spacing cannot be maintained, provide a fixed, solid, continuous ferrous barrier to separate low-level signal cables from other cable types.
- E. Shielded cables shall not be bundled with non-shielded cables. Provide terminals for shields. Shielded cables are to have jackets and shields intact up to terminals to which conductors are connected. Conductors shall not be bundled with other leads after shields have been removed. Shields shall be grounded at only one end of cable (at source cabinets unless otherwise noted).
- F. Route wires in covered plastic wireways where feasible. Wire fill for wireways containing power wiring shall be in accordance with IEC. Wireways containing signal wiring shall not be more than 60 percent full.
  - 1. Use separate wireways for low level signal wiring.
- G. Group and form wiring into a loop when going from fixed part or panel-to-panel door. Support each end of loop. Length of each loop shall be such that wires will be subjected to no other stresses but torsion.
- H. Where wiring crosses sharp metal edges or hinges, provide protection using grommets or spiral wrap protectors.
- I. Provide service loop in wiring at terminal blocks to allow movement of wiring up or down by four terminals.

## **END OF SECTION**