SECTION 16160

CABINETS AND ENCLOSURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this Specification is to provide details of cabinets and enclosures for non-hazardous indoor and outdoor locations, which will protect internal equipment from environmental conditions existing in the areas in which the enclosures are to be installed. Also, it is the intent of this Specification to provide consistency between enclosures supplied under different sections of this Contract.

1.2 QUALITY ASSURANCE

A. Supply cabinets and enclosures in accordance with the following:
   1. Underwriter's Laboratory, Inc. listed.
   2. National Electrical Manufacturers Association Standard 250-1991.
   3. American National Standards Institute.
   4. National Electrical Code.

B. Cabinets and enclosures supplied under this Section shall conform to the requirements of Specification Section 16010 Paragraph 1.2, "Quality Assurance".

C. Stock cabinets and enclosures shall be manufactured by Hoffman Engineering Company or equivalent. Custom fabricated enclosures shall be equal in quality, appearance and performance to stock enclosures. All enclosures shall be subject to the review of the Engineer.

1.3 RELATED WORK

A. Additional details for panels and enclosures for process equipment are provided in the individual specification sections in Division 11.

B. Additional details for panels and enclosures for instrumentation are provided in Section 13440.

C. Miscellaneous panel and enclosure auxiliary equipment, such as lights, switches, fuses, etc. are contained in Section 16050.

1.4 REFERENCES

A. ASTM C1777 - Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.

B. ASTM D149 - Test Methods for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

C. ASTM D256 - Test Methods for Impact Resistance of Plastics and Electrical Insulating Materials.

D. ASTM A495 - Test Method for High-Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.

E. ASTM D570 - Test Method for Water Absorption of Plastics.

F. ASTM D638 - Test Method for Tensile Properties of Plastic.

G. ASTM D648 - Test Method for Deflection Temperature of Plastics Under Flexural Load.
H. ASTM D790 - Test Method of Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
I. ASTM D792 - Test Method for Specific Gravity (Relative Density) and Density of Plastic Placement by Displacement.
J. UL94 - Flammability Rating.

1.5 SUBMITTALS TO THE ENGINEER

A. Submit shop drawings in accordance with General Conditions and as indicated herein. Shop drawings shall be submitted for all cabinets and enclosures to be provided under various sections of the Contract.
B. Shop drawings shall be checked by the Contractor for compliance with the Contract Documents. Verify that all enclosures to be furnished will fit into available space, will maintain specified clearances, and conform to the NEMA ratings of the areas in which they are to be installed.
C. Shop drawings shall consist of the following:
    1. Project name and location.
    2. Contractor's name.
    3. List of equipment being submitted together with proposed manufacturers, types and catalog numbers.
    4. Scale or dimensioned enclosure drawings and standard catalog cut sheets where applicable.
    5. Enclosure NEMA ratings, required clearances, etc.
    6. Provide a specific statement noting that the enclosure/panel furnished will fit in the space provided.
    7. Listing of all accessories to be furnished.
    8. Wiring diagrams for such items as panel lights, duplex receptacles, panel heaters, cooling fans, etc. where applicable.
    9. Provide heating requirement calculations for all exterior panels and panels located in unheated spaces, and cooling requirement calculations for heat dissipation from panels containing VFD's and other heat generating equipment as necessary.
    10. Submit all control panel faceplate arrangements for review and acceptance.

1.6 DELIVERY, STORAGE AND HANDLING

A. Coordinate delivery of control cabinets and enclosures with the project schedule.
B. Exercise care during loading, transporting, unloading, and handling of cabinets and enclosures to prevent damage. Check for defects or damage to enclosures upon arrival at construction site.
C. Store cabinets and enclosures on the construction site in areas which will afford protection from the weather, as well as excessive condensation and construction dust and debris.

D. Replace or repair, to the satisfaction of the Engineer, any cabinets and enclosures which are defective or have been damaged during installation, at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. NEMA classifications for panels and enclosures shall be as noted on Drawing E-1, unless otherwise specifically called out within the Specifications.
   2. Panels and enclosures shall be furnished factory-wired and tested with all equipment and appurtenances mounted thereon.
   3. Panels larger than 36 inches in any dimension shall not be wall mounted.
   4. Provide two doors if panel is larger than 36 inches wide.
   5. Refer to the drawings for minimum control panel faceplate requirements. In the absence of specific details, faceplates shall be arranged in a manner to provide a neat and workable panel.
   6. Panel front-mounted pilot lights, selector switches, push buttons, and appurtenances shall be provided in accordance with Section 16900.

B. General NEMA Class Requirements:
   1. NEMA Type 1 Enclosures
      a. Enclosures shall be sheet steel, 16 gauge for box widths up to and including 18", 14 gauge for box widths of 24", and 12 gauge for box widths of 30" and greater. Enclosures shall have continuously welded seams ground smooth; supplied with or without knockouts; shall have door and body stiffeners where necessary.
      b. Doors shall have continuous piano-type hinges. Latches shall be T-handle or quick-release type only. Latches which require use of tools for access, utilize wing-nuts, etc. will not be acceptable.
      c. Panels/enclosures shall be factory coated inside and out with ANSI 61 gray polyester powder coating over phosphatized surfaces. Where required, enclosures shall be provided with interior panels painted white, for mounting of components.
      d. Panels/enclosures shall be equipped with map pockets, and provisions for locking access doors.
      e. Panels/enclosures shall be essentially of the dimensions shown on the Drawings, or as required to contain the necessary apparatus. Final panel/enclosure dimensions shall provide for easy access to all internal components with ease of maintenance considered. Conflicts with panel sizing and available spacing shall immediately be brought to the attention of the Engineer prior to proceeding.
   2. NEMA Type 3R Enclosures:
      a. Type 3R enclosures shall not be used to house controls or electronics that require heating. See the specific “Special Requirements” for outdoor panels below.

b. Enclosures shall be steel, 16 gauge for box widths up to and including 12", 14 gauge for box widths between 15" and 24", and 12 gauge for box widths of 30" and greater. Free-standing enclosures shall be 12 gauge minimum. Enclosures shall have drip shield top; seam free sides, front, and back; and furnished with knockouts in bottom only. Provide door and body stiffeners where necessary. Large enclosures shall be provided with lifting eyes and, where floor-mounted, with 12-inch floor stands. No floor stands are to be provided for free-standing models.

c. The doors shall have galvanized steel piano-type hinges with stainless steel pins. Latches shall be T-handle or quick-release type only. Latches which require use of tools for access, utilize wing-nuts, etc. will not be acceptable.

d. Panels/enclosures shall be factory coated inside and out with prime and finish coats. Finish coat color to be ANSI 61 gray. Two prime coats shall be applied. Prime coat shall be rust inhibitive primer equal to Koppers Inertol Rustinhibitive Primer 621. Finish coat shall be compatible with prime coat and shall be an alkyd applied in two coats with a minimum dry film thickness of 1.5 mils per coat. Alkyd coating shall be equal to Koppers Glamortex 501 Enamel. Surface preparations shall be in accordance with manufacturer's requirements. Where required, enclosures shall be provided with interior panels painted white, for mounting of components.

e. Panels/enclosures shall be equipped with map pockets, and provisions for locking access doors.

f. Panels/enclosures shall be essentially of the dimensions shown on the Drawings, or as required to contain the necessary apparatus. Final panel/enclosure dimensions shall provide for easy access to all internal components with ease of maintenance considered. Conflicts with panel sizing and available spacing shall immediately be brought to the attention of the Engineer prior to proceeding.

3. NEMA Type 4 Enclosures:

a. Enclosures shall be sheet steel, 16 gauge for box sizes up to and including 24" by 24", 14 gauge for box sizes larger than 24" by 24" up to 60" by 36", and 12 gauge for box sizes greater than 60" by 36". Free-standing enclosures shall be 12 gauge minimum. Enclosures shall have continuously welded seams ground smooth; supplied with no holes or knockouts. Provide with door and body stiffeners as required and with rolled lip around door and enclosure opening. Enclosures to be installed outdoors shall be provided with drip shields. Large enclosures shall be provided with lifting eyes and, where floor-mounted, with 12-inch floor stands. No floor stands are to be provided for free-standing models.

b. The doors shall have stainless steel piano-type hinges with stainless steel pins. Provide oil-resistant door gaskets. Latches shall be T-handle or quick-release type only. Latches which require use of tools for access, utilize wing-nuts, etc. will not be acceptable.

c Panels/enclosures shall be factory coated inside and out with prime and finish coats. Finish coat color to be ANSI 61 gray. Two prime coats shall be applied. Primer shall be rust inhibitive primer equal to Koppers Inertol Rustinhibitive Primer 621. Finish coat shall be compatible with prime coat and shall be an alkyd applied in two coats with a minimum dry film thickness of 1.5 mils per coat. Alkyd coating shall be equal to Koppers Glamortex 501 Enamel. Surface preparations shall be in accordance with manufacturer's requirements. Where required, enclosures shall be provided with interior panels painted white, for mounting of components.

d. Panels/enclosures shall be equipped with map pockets, and provisions for locking access doors.

e. Panels/enclosures shall be essentially of the dimensions shown on the Drawings, or as required to contain the necessary apparatus. Final panel/enclosure dimensions shall provide for easy access to all internal components with ease of maintenance considered. Conflicts with panel sizing and available spacing shall immediately be brought to the attention of the Engineer prior to proceeding.

4. NEMA Type 4X Enclosures:

a. Type 4X enclosures shall be stainless steel, aluminum, or fiberglass-reinforced polyester (FRP). No other metals or plastics will be allowed.

1) Type 304 stainless steel enclosures shall be 16 gauge for box sizes up to and including 24" by 24", 14 gauge for box sizes larger than 24" by 24" up to 36" width, and 12 gauge for box widths greater than 36 inches. Free-standing enclosures shall be 12 gauge minimum.

2) Aluminum enclosures shall be type 5052 H-32 aluminum, minimum 0.080-inch thick.

3) Fiberglass enclosures shall have the following properties:

a)	Thermal Conductivity (ASTM C177)	2.0 BTU in/hr - ft^2/Degree F
b)	Dielectric Strength (ASTM D149)	375 VPM
c)	Notched IZOD Impact (ASTM D256)	12 Ft. lb/in.
d)	Arc Resistance (ASTM D495)	180 Seconds
e)	Water Absorption (ASTM D570)	0.30 Percent
f)	Tensile Strength (ASTM D638)	8,000 PSI
g)	Heat Deflection (ASTM D648)	395 Degree F - 264 PSI
h)	Flexural Strength (ASTM D790)	18,000 PSI

i) Service Temperature Range -31 Degrees F to 266 Degrees F

b. Metal enclosures shall have continuously welded seams ground smooth. Fiberglass cabinet and enclosures shall be thermoset polyester reinforced with fiberglass. Cabinet and enclosure bodies, covers, doors and backs shall be by the compression, injection or open molding process. Finish for fiberglass cabinets and enclosures shall be light gray inside and outside.
c. Enclosures shall be supplied with no holes or knockouts; shall have door and body stiffeners where necessary; rolled lip around door and enclosure opening.
d. Enclosures to be installed outdoors shall be provided with drip shields. Large enclosures shall be provided with lifting eyes and, where floor-mounted, with 12-inch floor stands. No floor stands are to be provided for free-standing models.
e. The doors shall have piano-type hinges with stainless steel pins. Provide oil-resistant door gaskets. All enclosure hinges, clamps, etc. shall be stainless steel or fiberglass as appropriate. Latches shall be T-handle or quick-release type only. Latches which require use of tools for access, utilize wing-nuts, etc. will not be acceptable.
f. Enclosures/panels shall be provided unpainted, with metal enclosures having a smooth brushed finish. Where required, enclosures shall be provided with interior panels painted white, for mounting of components.
g Panels/enclosures shall be equipped with map pockets, and provisions for locking access doors.
h. Panels/enclosures shall be essentially of the dimensions shown on the Drawings, or as required to contain the necessary apparatus. Final panel/enclosure dimensions shall provide for easy access to all internal components with ease of maintenance considered. Conflicts with panel sizing and available spacing shall immediately be brought to the attention of the Engineer prior to proceeding.

5. NEMA Type 12 Enclosures:
   a. Enclosures shall be sheet steel, 16 gauge for box sizes up to and including 24" by 24", 14 gauge for box sizes larger than 24" by 24" up to 60" by 36", and 12 gauge for box sizes greater than 60" by 36". Free-standing enclosures shall be 12 gauge minimum. Enclosures shall have continuously welded seams ground smooth; supplied with no holes or knockouts; shall have door and body stiffeners where necessary; rolled lip around door and enclosure opening. Enclosures to be installed in areas with the potential for dripping liquids shall be provided with drip shields. Large enclosures shall be provided with lifting eyes and, where floor-mounted, with 12-inch floor stands. No floor stands are required for free-standing units.
   b. The doors shall have continuous piano-type hinges. Provide oil-resistant door gaskets. Latches shall be T-handle or quick-release type only.

Latches which require use of tools for access, utilize wing-nuts, etc. will not be acceptable.

c. Panels/enclosures shall be coated inside and out with ANSI 61 gray over phosphatized surfaces. Where required, enclosures shall be provided with interior panels painted white, for mounting of components.

d. Panels/enclosures shall be equipped with map pockets, and provisions for locking access doors.

e. Panels/enclosures shall be essentially of the dimensions shown on the Drawings, or as required to contain the necessary apparatus. Final panel/enclosure dimensions shall provide for easy access to all internal components with ease of maintenance considered. Conflicts with panel sizing and available spacing shall immediately be brought to the attention of the Engineer prior to proceeding.

C. Nameplate/Identification:

1. All panels/enclosures, and all contained equipment/instrumentation shall be provided with a nameplate providing identification of the unit. Identification wording shall be as noted on the drawings. In the absence of specific identification of name tag wording, provide general descriptive information of unit function.
2. Enclosure/panel exterior name tags shall be of rigid laminated plastic. Lettering shall be 5/16 inch high, white letters on a black background. Interior name tags can be identical to exterior name tags in quality, or can be stamped stainless steel tags.
3. Name tags shall be mounted below panel mounted items (interior and exterior as appropriate).

D. Control Panel Wiring:

1. All wiring shall conform to the latest requirements of NEC and all local requirements.
2. All control wires internal to panels shall be minimum No. 14 AWG. Wires carrying line voltage shall be minimum No. 12 AWG. All conductors shall be copper. Wire in close proximity to heating devices shall be Type AVA UL approved. All wiring shall be run in PVC wiring channels and bundled with nylon cable ties.
3. Bundles of wires must be secured to the panel structure every 8 inches minimum. All interior wiring will be point to point with no splices. All wiring from and to panels shall be through terminals located in the panel.
4. Shielded wire shall be separated from other wires and equipment with suitable barriers and with terminal blocks for continuous shield grounding to the connecting cables.
5. Intrinsically safe wiring shall be separated by barriers from all other wiring.
6. Wires to the front of panel devices shall be looped, extra flexible and bundled.
7. All wires shall be marked at both ends with numbers by self-sticking wire markers or with slip-on style plastic markers. Color coding shall include the following:

Red wires - Interior control circuits

Yellow wires - Interlocks powered from external sources (foreign voltages)
Blue wires - DC voltages
Orange wires - 120V alarm, instrumentation, telemetering
See Section 16010 for additional color coding.

8. Terminals shall be arranged in alphabetic and numeric order in columns on removable subplates. A maximum of two connections shall be made to each side of a terminal, including jumpers. Provide an additional 20 percent spare terminals with the following minimum requirements:
   Power terminals - 2 spares
   Control terminals - 10 spares
9. Provide ground terminal for each panel.
10. All control panels shall be provided with spare mountings for additional relays. Number of spare mountings will correspond to 5% of the total number of relays within each panel, with a minimum of one (1) spare mounting.
11. All control panels shall be provided with an appropriately sized surge arrester to protect panel internals. Surge arrester shall be equal to Square D Model SP3650 in quality and appropriately sized for function.
12. All control panels will be suitable for use with 120V, 1 phase power. The panels shall be equipped with an internal power supply fuse and disconnect switch. Fuse blocks will be provided as required to allow a separate fuse for each piece of equipment within the panel requiring power.
13. Provide complete wiring diagrams for all control panels.
14. All wiring entering and leaving control panels shall be terminated on field terminal blocks and labeled.

E. Special Requirements:
   1. Outdoor Control Panels/Panels in Unheated Spaces
      a. When components requiring a minimum temperature in which to operate, such as solid state devices, are to be installed inside the enclosure, the enclosure shall be NEMA 4 minimum, or 4X where specifically called for, or required. The enclosures shall be insulated and heated. Insulate the inside of all exterior surfaces with 1 inch thick rigid fiberglass insulation board having a maximum thermal conductivity ("k" value) of 0.35 BTU-in/hr-ft^2-^{O}F. The insulation shall be finished with manufacturer's standard all service jacket. Coverings containing foil will not be acceptable.
      b. Enclosures shall be equipped with a built-in heater and adjustable thermostat. Heater shall be sized to maintain 40^{O}F (or higher if required) inside panel with an outside ambient temperature of –30^{O}F and a 15 MPH wind. The heater shall include a fan to circulate the air within the enclosure to prevent hot spots. Thermostat shall measure air temperature, not surface temperature. Heater shall be similar to Hoffman Engineering Co. series D-AH.
      c. Provide strip heater with thermostat for condensation control.
      d. Provide heating requirement calculations for review and acceptance.
   2. All Instrument and Control Panels

a. All instrument and control enclosures shall have the proper NEMA rating for the areas in which they will be installed, as specified above. All front-mounted instruments and devices shall be installed in such a way as to maintain the NEMA rating of the enclosure.
b. Instrument and control panels which are to be installed outdoors shall have a hinged dead front with a separate inside hinged door (NEMA 1). All control devices and main circuit breaker operating handle shall be mounted through the inner door. The main circuit breaker shall have a lock arrangement that prevents the inner door from being opened when the breaker is in the on position. Where required, the outer door shall have transparent window(s) to allow viewing of instruments or controls while maintaining the NEMA rating. The panels shall be mounted as shown on the Drawings.
c. Panels shall be supplied with GFI duplex convenience outlet and 100-watt panel light with on-off switch. Outlet and panel light shall be connected to 120 volt power supply so as to not disconnect control, instrumentation, or PLC power in the event that the GFI outlet should trip.

3. Special Cooling Requirements
   a. Enclosures which contain Variable Frequency Drives or other heat-producing equipment shall be provided with modifications and/or accessories designed to dissipate excess heat and allow for proper equipment cooling, while maintaining the enclosure NEMA rating. Following are several accessories which may be used, depending upon the ambient temperature and NEMA rating of the area.
      1) Cooling fans with dust filters, for NEMA 1 enclosures.
      2) Heat exchangers with circulating fans and filters, for NEMA 12 enclosures.
      3) Air conditioners, for NEMA 12 enclosures in areas with high ambient temperatures.
   b. Provide heat dissipation calculations and cooling method proposal for review and acceptance. Design ambient air temperature shall be 95^{o}F.
4. Mounting of Exterior Panels/Enclosure
   a. Securely mount panels/enclosures on 4"-diameter Schedule 40 galvanized pipe(s) as shown on the Drawings.
   b. All fasteners shall be hot dipped galvanized. No cut edges after galvanizing or cadmium plated hardware will be permitted.

F. Spare Parts/Materials:
1. Provide 1 gallon of paint for each enclosure/panel topcoat color utilized.
2. Provide the following spare parts for <u>each</u> panel/enclosure provided. Spare parts shall be contained in the panel/enclosure in such a manner as to permit accessibility and prevent accidental damage.
   a. Provide 10 of each lamp type.
   b. Provide one of each type relay.
   c. Provide one control switch and/or push-button of each type.
   d. Provide 10 fuses of each type and size.

e. Provide 1 of each color and type light lense.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All interconnecting wiring between panels, unless specifically detailed otherwise, shall be by the electrical trade regardless of source of the panel itself.

B. Install enclosures in locations as shown on the Drawings. Large enclosures shall be secured to floor or equipment pad. Small enclosures may be supported on walls using metal framing channels or similar hardware to provide a minimum 1/2 inch air space between enclosure and wall.

1. All framing channels and mounting hardware for NEMA 3R and NEMA 4 enclosures shall be galvanized steel.
2. All framing channels and mounting hardware for NEMA 4X enclosures shall be stainless steel.

C. Mounting heights shall be as shown on the contract drawings or the tops placed a maximum of 72 inches above finished floor or platform when the elevation is not shown.

D. Provide special protection for all devices and terminal blocks when cutting, drilling, and/or installing any device in the control panel.

3.2 TESTS

A. Testing of the enclosures themselves is not required. However, all equipment and controls which are mounted in or on the enclosures shall be tested as specified in applicable sections of DIVISIONS 11, 13, 14, 15 and 16.

3.3 CLEANING

A. Do not allow excess debris to accumulate inside enclosures during the course of construction.

B. Upon completion of the work, remove all debris and surplus materials from inside enclosures and leave them clean.

C. Clean all enclosure surfaces and touch up any scratched or damaged areas to the satisfaction of the Engineer.

END OF SECTION