

**SPECIFICATIONS - DETAILED PROVISIONS**  
**Section 16950 - Custom Control Panels**

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**SECTION 16950  
CUSTOM CONTROL PANELS**

**PART 1 - GENERAL**

**1.01 DESCRIPTION**

Contractor shall furnish and install custom control panels as specified herein, shown on the Drawings, and where specified in other Specification Sections.

- A. Custom control panels include, but are not limited to, Unit Control Panels (UCPs), Local Control Panels (LCPs), and Programmable Logic Controllers (PLCs). Custom control panels include control panels designed and supplied by equipment manufacturers as part of packaged equipment and equipment systems.
- B. The Instrumentation and Control Subcontractor (per Section 17005) shall design or review design of custom control panels and coordinate the interface between custom control panels, MCCs, other control panels, instrumentation, and District's SCADA system (including remote telemetry units, RTUs).

**1.02 RELATED WORK SPECIFIED ELSEWHERE**

- A. The Contract Documents are a single integrated document, and as such all Divisions and Sections apply. It is the responsibility of the Contractor and its Subcontractors to review all sections to ensure a complete and coordinated project.
- B. Related Specification Sections include, but are not limited to, the following:
  - 1. Sections of the Specifications specifying equipment and/or systems requiring electrical power and/or control.
  - 2. Division 16 – Electrical
  - 3. Division 17 – Instrumentation and Controls

**1.03 SUBMITTALS**

All submittals shall be in accordance with the General Conditions and requirements specified herein.

A. Shop Drawings

Contractor shall prepare and submit complete and organized information, drawings, and technical data for all equipment and components. All drawings shall be legible and reduced to a maximum size of 11" x 17" for inclusion within the submittal. Shop drawings shall include, but not be limited to, the following:

1. Detailed Bill of Materials for all control panel hardware, and associated materials and components, listing: manufacturer's name, quantity, description, size, and catalog/part number.
2. Complete documentation for all control panel equipment and associated components, including: manufacturer's product literature, specifications, performance capabilities, features and accessories, dimensions and weights, illustrations, and data in sufficient detail to demonstrate compliance with Specification requirements. Manufacturer's literature and data shall be marked to clearly delineate all applicable information and crossing out all inapplicable information.
3. Control panel fabrication drawings (plan view, and interior and exterior elevation views) with all equipment and components clearly shown, dimensioned, and labeled. Drawings shall show the equipment and component assembly, clearances, and locations for conduits/conductors and anchor bolts. Devices shall be identified with the same marking as used on the schematic diagrams. The drawings shall include a detailed layout of all door mounted pilot devices and instruments.
4. Enclosure construction, NEMA Type, and type and gauge of materials.
5. Detailed descriptions of control panel equipment, equipment installation requirements, and heat dissipations.
6. System configuration with power circuit single line diagrams, grounding circuits, circuit breakers, and fuses.
7. Control schematics, ladder diagrams, and interconnection drawings (see Part 1.03.B herein) for additional requirements.
8. Nameplate data including the nameplate material, heights of letter and inscriptions.
9. Spare parts list as specified in this Section.

10. Manufacturer's installation instructions including receiving, handling, and storage requirements.

B. Control Diagrams

1. Schematic diagrams shall show the equipment serial number, the purchaser's drawing number, purchase order number, or similar identification which will indicate the particular equipment to which the diagrams apply.
2. Diagrams shall show all equipment and components in the electrical system including internal wiring of subassemblies. Diagrams shall clearly identify internal and external devices, and all remote contacts and signals. Show all interconnections between power sources and device elements of a particular system or equipment, and all interlocks with other equipment/systems in a manner that fully indicates the circuit function and operation. Show all panel terminal block identification numbers and all wire numbers. Show all intermediate terminations between field elements and panels. Diagrams of subassemblies may be furnished on separate sheets.
3. Identify each device by a unique number or number-letter combination.
4. Conductor Identification: Identify each conductor by a unique number, letter, or number-letter combination. Consecutive numbering is preferred. Each conductor shall have the same identification at all terminals and tie points. All conductors connected to the same terminal or tie point shall have the same identification. Where multi conductor cable is used, a color code may be used to supplement the above identification. Where color coded multi conductor cable is used for wiring identical components, such as limit switches, the color code used shall be consistent and charted on related diagrams.
5. Provide a schematic diagram for each electrical system. The schematic diagram shall be drawn between vertical lines which represent the source of control power. Show control devices between these lines. Show actuating coils of control devices on the right-hand side. Show contacts between the coils and the left vertical line.
  - a. Where the internal wiring diagrams of subassemblies are furnished on separate sheets, they shall be shown as a rectangle in the schematic diagram with all external points identified and cross-referenced to the separate sheets of the control circuit. Show coils and contacts internal to the subassemblies in the rectangle connected to their terminal points.
  - b. For clarity, show control device symbols in the order in which the controls are positioned on the diagram.

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- c. Use a cross-referencing system in conjunction with each relay coil so that associated contacts may be readily located on the diagram. Where a relay contact appears on a sheet separate from the one on which the coil is shown, describe the purpose of the contact on the same sheet.
- d. Show all spare contacts.
- e. Show limit, pressure, level, flow, temperature, and similar switch symbols on the schematic diagram with all utilities turned off (electric power, air, gas, oil, water, lubrication, etc.) and with the equipment at its normal starting position.
- f. Show contacts of multiple contact devices (e.g., selector switches and pushbuttons) on the line of the schematic diagram where they are connected in a circuit. Indicate a mechanical connection between the multiple contacts by a dotted line or arrow.
- g. Additional charts or diagrams may be used to indicate the position of multiple contact devices such as limit, pressure, level, and selector switches.
- h. Show the purpose or function of all switches adjacent to the symbols.
- i. Show the purpose or function of controls such as relays, starters, contactors, solenoids, subassemblies, and timers on the diagram adjacent to their respective symbols. Show the number of positions of the solenoid valve adjacent to the valve solenoid symbol.

C. Operation and Maintenance Manual

Contractor shall submit a detailed Operation and Maintenance (O&M) Manual for all custom control panels specified herein and shown on the Drawings. The O&M Manual shall be provided in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein.

The O&M Manual shall include, but not be limited to, the following:

- 1. Equipment Performance Data and Drawings
  - a. Detailed Bill of Materials for all control panel equipment and components, listing: manufacturer's name, quantity, description, size, range, and model/part number.

- b. Manufacturer's product literature, specifications, performance capabilities, features and accessories, and illustrations.
- c. Manufacturer's data and drawings showing dimensions, physical configurations, installation and mounting details, and wiring schematics.
- d. Control ladder diagrams and wiring schematics. Loop diagrams for each monitoring and/or control loop.

2. Installation and Operation Requirements

- a. Complete, detailed installation and operation instructions for all control panel equipment and components.

3. Service and Maintenance Data

- a. Service and maintenance data shall include all information and instructions required by District's personnel to keep the control panel and all associated components functioning properly under the full range of operating conditions.
- b. Explanation with illustrations as necessary for each service and maintenance task.
- c. Recommended schedule of service and maintenance tasks.
- d. Troubleshooting instructions.
- e. List of maintenance tools and equipment.
- f. Recommended spare parts list.
- g. Names, addresses and phone numbers of all manufacturers and manufacturer's local service representatives.

D. Final O&M Manual

Upon successful completion of startup and initial operation, Contractor shall submit a Final O&M Manual in accordance with the requirements of the District's General Conditions, Specification Section 01430, and as specified herein. In addition to the O&M Manual requirements specified above, the Final O&M Manual shall be supplemented with the as-built drawings (including all field changes) for all control panel wiring and loop diagrams.

#### 1.04 DESIGN AND GENERAL REQUIREMENTS

##### A. Power for Control Panels and Interconnected Devices

1. All control panels shall be supplied with 480 VAC, 3-phase, 240 VAC Single Phase or 120 VAC Single Phase 60 Hz. power, as shown on the Drawings. All control panels shall be designed to minimize sources of control power (foreign power) from other panels.
2. Each control panel shall have a flange mounted disconnecting circuit breaker operable from the control panel front and interlocked with the enclosure door, to be used to isolate the control panel from the power supply.
3. The panel shall have a nameplate identifying the circuit breaker feeding the panel. Warning labels shall be provided identifying sources of foreign power to be disconnected prior to accessing the control panel.
4. The control voltage within the control panel controls shall be 120 VAC. Where the electrical power supply to the control panel is 240 VAC single phase or 480 VAC 3-phase, as shown on the Drawings, the control panel shall be provided with control power transformers, overcurrent protection, and power supplies to convert supply voltage to utilization voltage.
5. The control panel shall be the source of power for all 120 VAC devices interconnected with the control panel including, but not limited to solenoid valves, instruments, and transmitters both mounted in the control panel and remotely connected to the control panel.

##### B. Enclosure General Requirements

Unless indicated otherwise on the Drawings, or in the individual packaged equipment specification sections, control panels shall comply with the following requirements:

1. Control panels enclosures shall meet, or exceed, area classifications requirements per NEC.
2. Control panel enclosures shall have the following NEMA ratings:
  - a. Enclosures installed indoors shall be rated NEMA 12.
  - b. Enclosures installed outdoors shall be rated NEMA 4X.
  - c. Enclosures installed indoors in wet or corrosive areas shall be rated NEMA 4X.



- d. Enclosures installed indoors in hazardous areas shall be rated NEMA 7.
  - e. Enclosures installed outdoors in hazardous areas shall be rated NEMA 4 and NEMA 7.
3. Control panels shall be either freestanding, pedestal-mounted, wall-mounted, or equipment skid-mounted, as specified in the individual packaged equipment specification sections or indicated on the Drawings.
  4. Internal control components shall be mounted on an internal back-panel.
  5. Each source of foreign control voltage shall be isolated by providing fuses on a separate terminal block, clearly labeled for incoming foreign control voltage.
  6. Discrete outputs from the control panel shall be provided by electrically isolated contacts rated for 5 A (minimum) at 120 VAC. Output isolation shall be provided through interposing relays or PLC relay output cards (if applicable).
  7. Analog inputs and outputs shall be an isolated 4-20 mA 2-wire signal with power supply, power supply pilot light, and fuses.
  8. Programmable Logic Controllers (PLCs) may be supplied in lieu of hardwired relay logic with the District's approval or if specified in the specification section for the specific equipment. The PLC shall be in accordance with Section 17010, Programmable Logic Controller.
  9. All control panel mounted indicating lights, switches, and operator interface devices shall be mounted at least 3 feet above the finished floor elevation, but no more than 6 feet above the finished floor elevation.
  10. Terminals shall be mounted vertical and locations of terminals and wireways shall be coordinated to account for conduit entrances.
  11. Control panels that contain circuit breakers, combination full-voltage motor starters, soft starters, variable frequency drives, or other motor controls shall comply with the requirements Section 16480, Motor Control Centers, Switchboards, and Panelboards, and Section 16160, Variable Frequency Drives.

**1.05 QUALITY ASSURANCE**

A. References

This section contains references and information from the following documents which are made a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

B. Unless specified otherwise, references to documents shall mean the documents in effect at the time of Bid (or on the effective date of the Agreement if there were no bids).

Reference	Title
NFPA 70	National Electrical Code (NEC)
NFPA 70E	Standard for Electrical Safety in the Workplace
NFPA 79	Electrical Standard for Industrial Machinery
NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA ICS 6	Industrial Control and Systems: Enclosures
UL 508A	Industrial Control Panels
UL 698A	Industrial Control Panels Relating to Hazardous (Classified) Locations

Assembly:

1. The assembled panels and individual components shall be Underwriters Laboratory (UL) listed and labeled.
2. Equipment and components shall be UL listed for the proposed purpose.
3. The control panels shall have factory applied UL 508A labels.
4. The intrinsic safety barriers required within a control panel shall be provided per UL 698A with factory applied labels as required by UL.

C. Factory Testing

Prior to shipment, the manufacturer shall test the functional operation of the control panels as specified in Part 3.01 herein.

D. Environmental Sustainability

1. All indoor and outdoor panels and instrument enclosures shall be suitable for operation in the ambient conditions associated with the locations designated in the Contract Documents.
2. Unless specified otherwise, heating, cooling and dehumidifying devices shall be provided in order to maintain all instrumentation components to within a range equal to 20 percent above the minimum and 20 percent below the maximum of the rated environmental operating ranges. All required power wiring and temperature controls shall be provided for these devices.
3. Enclosures suitable for the designated environment shall be furnished.
4. All control panels and instrumentation enclosures in hazardous areas shall be suitable for use in the particular hazardous or classified location in which it is to be installed.

**1.06 DELIVERY, STORAGE, AND HANDLING**

A. Delivery

All control panels shall be crated for shipment using heavy framework and skids:

1. Each panel shall further be cushioned satisfactorily to protect the finish of the instruments and panel during shipment.
2. All instruments, which are shipped with the panel, shall further have suitable shipping stops and cushioning material installed in a manner to protect instrument parts, which could be damaged due to mechanical shock during shipment.
3. Large panel units and/or panel units weighing over 100 lbs. shall be provided with removable lifting lugs to facilitate handling.

B. Storage and Handling

Control panels shall be stored and handled in accordance with the manufacturer's instructions and requirements and in a manner to protect the panel from the elements. Panels shall be handled in a manner to protect the components and enclosures.

## **PART 2 - PRODUCTS**

### **2.01 MANUFACTURERS**

- A. Control panel enclosures shall be standard manufactured enclosures, whenever possible, and shall be as manufactured by Hoffman Engineering, Rittal, Stalin, or equal.
- B. Dimensions
  - 1. The Instrumentation and Control Subcontractor (ICS) and/or manufacturer of the packaged equipment system shall be responsible to design and size all panel enclosures based upon:
    - a. Available space in area, as indicated on the Drawings.
    - b. Equipment and device requirements for components located within the control panel enclosure.
  - 2. The size of the control panel enclosures as indicated on the Drawings is based on preliminary, non-certified, information and as such these sizes are to be used as a general guideline.
  - 3. A narrow or wide panel enclosure shall be provided if necessary to accommodate the available space. A larger enclosure shall be provided if necessary to accommodate the equipment, devices, and appurtenances located within the panel.

### **2.02 MANUFACTURED ENCLOSURES**

- A. Type NEMA 1 and NEMA 12 Enclosures for Indoor Installation
  - 1. Unless specified otherwise, enclosures rated NEMA 12 shall be provided for all indoor panels located in dry, non-corrosive areas. Where panels are located in dry, non-corrosive areas and are required to be ventilated for cooling (fan or non-fan cooled), enclosures shall be rated NEMA 1 gasketed.
  - 2. NEMA 1 gasketed enclosures shall be designed to house electrical controls, terminals, and instruments and shall provide protection from dust and dirt.
  - 3. NEMA 12 enclosures shall be designed to house electrical controls, terminals, and instruments, and shall provide protection from dust, dirt, and oil.

4. Enclosure minimum construction requirements shall be as follows:
  - a. Seams continuously welded and ground smooth.
  - b. Door and body stiffeners as needed to make a rigid enclosure.
  - c. Heavy gauge continuous hinge.
  - d. Rolled lip around 3 sides of the door and all sides of the enclosure opening to prevent migration of liquids and contaminants into enclosure.
  - e. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.
  - f. Interior back panel held in place by collar studs welded to enclosure. Back panel shall be full size, constructed of 10 gauge steel with stiffeners as required. Provide split back panel where specified or indicated on the Drawings.
  - g. Door window where specified or indicated on the Drawings:
    - i) Safety plate glass.
    - ii) Held in place by rubber locking seal.
    - iii) Sized to allow full view of alphanumeric display, operator interface, PLC Human-Machine Interface (HMI), etc.
  - h. Door panel cutouts for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges. Reinforce around cutouts with steel angles or flat bars for large panel cutouts such as for HMIs and for pilot device groupings where the removed metal exceeds 50 percent of the available metal in an area bound by a 3-inch envelope around said pilot devices.
  - i. Finish for NEMA 1 and NEMA 12 Enclosures
    - i) All steel parts shall be provided with UL listed acrylic/alkyd baked enamel paint finish or TGIC powder coat, except plated parts used for ground connections. All painted parts shall undergo a multi-stage treatment process, followed by the finishing paint coat.

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- ii) Pre-treatment shall include:
  - a) Hot alkaline cleaner to remove grease and oil.
  - b) Iron phosphate treatment to improve adhesion and corrosion resistance
- iii) The paint shall be applied using an electro-deposition process to ensure a uniform paint coat with high adhesion.
- iv) The standard paint finish shall be tested to UL 50 per ASTM B117 (5% ASTM Salt Spray) with no greater than 0.125 inch loss of paint from a scribed line.
- v) Paint color for enclosures shall be #49 medium light gray or #61 dark gray per ANSI Standard Z55.1 (60-70 gloss) on all exterior surfaces, unless specified otherwise. All unit interior surfaces shall be painted white for better visibility inside the unit.
- vi) Panels that are in the same room as motor control centers switchboards, etc. shall be of the same color as the motor control center or switchboards so that the control panel blends into the lineup.
- j. Manufacturer's standard gauge steel.
- k. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.
- l. Print pocket inside door which shall be furnished with final as-built wiring diagrams and all applicable manufacturer warranties.
- m. Heating and cooling per Part 1.05.D and Part 2.04 herein.
- n. Heavy duty lifting eyes for all free standing panels.
- o. Free standing, wall mount, or with floor stands or legs as indicated on the Drawings.
- p. With flange mounted, disconnect for incoming power.
- q. Hinges: steel piano-type running full length of doors.

- r. Copper ground bus bar 1/4-inch x 1-inch with solderless connectors for all equipment grounds.
- s. Bonding and grounding kit, including all cable and mounting hardware required to ground equipment to the door and body of the enclosure.

B. Type NEMA 4X Enclosures for Outdoor and Indoor (Wet or Corrosive Locations) Installation

1. Unless specified otherwise, enclosures rated NEMA 4X shall be provided for all outdoor panels and indoor panels located in wet, corrosive areas.
2. NEMA 4X enclosures shall be designed to house electrical controls, terminals, and instruments and shall provide protection from dust, dirt, oil, water, and corrosion.
3. In general, NEMA 4X enclosures shall be constructed of stainless steel. NEMA 4X enclosures constructed of non-metallic fiberglass reinforced polyester resin shall be provided only where specifically indicated on the Drawings or specified in individual specification sections for packaged equipment systems.
4. Minimum construction requirements for stainless steel enclosures shall be as follows:
  - a. Type 316 stainless steel, 14-gauge minimum.
  - b. Seams continuously welded and ground smooth.
  - c. Door and body stiffeners as needed to make a rigid enclosure.
  - d. Heavy gauge continuous hinge.
  - e. Rolled lip around three sides of the door and all sides of the enclosure opening to prevent migration of liquids and contaminants into enclosure.
  - f. Oil-resistant gasket attached to door with oil-resistant adhesive. Gasket to seal against roll lip on the enclosure opening.
  - g. Interior back panel held in place by collar studs welded to enclosure. Back panel shall be full size, constructed of 10 gauge steel with stiffeners as required. Provide split back panel where specified or indicated on the Drawings.

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- h. Unless specified otherwise or indicated otherwise on the Drawings, panels shall be provided with interior swing-out door for:
  - i) Mounting switches, lights, devices, and HMIs.
  - ii) A window shall be provided in the exterior door for view of interior lights, devices, and instruments if indicated on the Drawings.
- i. Door panel cutouts (exterior and swing-out doors) for instruments, devices, and windows shall be cut, punched, or drilled and smoothly finished with rounded edges. Reinforce around cutouts with steel angles or flat bars for large panel cutouts such as for HMIs and for pilot device groupings where the removed metal exceeds 50 percent of the available metal in an area bound by 3-inch envelope around said pilot devices.
- j. Door window where specified or indicated on the Drawings:
  - i) Safety plate glass.
  - ii) Held in place by rubber locking seal.
  - iii) Sized to allow full view of alphanumeric display, operator interface, PLC Human-Machine Interface (HMI), etc.
- k. Finish:
  - i) Stainless steel surfaces shall be unpainted and provided with a brushed finished.
  - ii) Interior steel parts shall be finished per Part 2.02.A.4.i herein. Finish paint color shall be white (60-70 gloss).
- l. Each door to have a three-point latching mechanism and padlocking handle with rollers on the ends of the latch rods.
- m. Print pocket inside door which shall be furnished with final as-built wiring diagrams and all applicable manufacturer warranties.
- n. Heating and cooling per Part 1.05.D and Part 2.04 herein.
- o. Heavy duty lifting eyes for all free standing panels.



- p. Free standing, wall mount, or with floor stands or legs as indicated on the Drawings.
  - q. With flange mounted, disconnect for incoming power.
  - r. Hinges: steel piano-type running full length of doors.
  - s. Copper ground bus bar 1/4-inch x 1-inch with solderless connectors for all equipment grounds.
  - t. Bonding and grounding kit, including all cable and mounting hardware required to ground equipment to the door and body of the enclosure.
5. Minimum construction requirements for non-metallic enclosures shall be as follows:
- a. Shall meet the applicable requirements herein for stainless steel enclosures plus the following additional requirements.
  - b. Non-metallic enclosures shall be molded fiberglass reinforced polyester resin with plate steel reinforcing on the sides, top, and bottom. The fiberglass reinforced polyester resin shall meet the following minimum standards:
    - i) Minimum flexural strength of 29,000 psi per ASTM D790.
    - ii) Maximum water absorption of 0.07% per ASTM D570.
    - iii) Minimum tensile strength of 17,500 psi per ASTM D651.
    - iv) Heat distortion at 400°F per ASTM D648.
    - v) Minimum specific gravity of 1.35 per ASTM D792.
    - vi) Minimum dielectric strength of 400 V/mil per ASTM D149.
    - vii) Minimum arc resistance of 180 seconds per ASTM D495.
    - viii) Flammability of 94V-O per ASTM D3801 and UL-94.
  - c. All seams shall be sealed.
  - d. Hinges shall be constructed of fiberglass with no exposed metal parts.

- e. No exposed metal parts, except for captive stainless steel door screws which shall be replaceable.
- f. Provisions for mounting panels shall be an integral part of the enclosure whether by way of internal mounting channels welded to the interior or by way of spot-welded collar studs.
- g. Panel exterior gelcoat shall be UV light resistant and shall be light gray in color.
- h. Each panel shall be provided with a stainless steel door hasp suitable for padlocking.
- i. Enclosure mounting panels shall be constructed of 1/4" thick (minimum) aluminum plate with rounded corners and no sharp edges. Aluminum shall be provided with a uniform brushed finish.

### **2.03 ENCLOSURE LIGHTS AND RECEPTACLES**

- A. Each control panel shall be provided with LED lighting fixtures of sufficient size and quantity to provide 50 foot-candles of illumination within the panel. The lighting fixtures shall be horizontal LED tube type fixtures and shall be mounted to the top of the enclosure. The light fixtures shall be wired to a UL-approved switch mounted inside the panel.
- B. Each control panel shall be provided with a duplex, 120VAC, 15A, 3-wire grounded GFCI type convenience receptacle.
- C. The light fixture(s) and receptacle shall be provided with power by a control transformer in the panel or by a separate 120 VAC circuit, if indicated on the Drawings.

### **2.04 ENCLOSURE HEATING AND VENTILATION**

- A. Control panel enclosures shall be provided with heating and ventilation designed by the manufacturer to meet the following requirements and Part 1.05.D herein.
  - 1. Space heaters shall be provided to prevent condensation. Space heaters shall operate on 120 V, 60 Hz power. Adjustable line voltage thermostats shall be provided for controlling the space heaters.

2. Non-forced air and forced air ventilation cooling shall be provided as required to maintain the required temperature of the housed equipment. Forced air ventilation shall be provided with supply fans mounted at the bottom of each enclosure section. The bottom door fans shall force fresh air into the enclosure to create a positive internal air pressure; and thereby, forcing out dirt and contaminants, and moving warm air out through ventilation louvers mounted at the top of the doors. A line voltage thermostat shall control the fans based on the panel internal temperature. Door interlock switches shall be provided to turn the fans off when the door is opened.
  3. Supply fans shall be provided with air intake openings equipped with fixed louvers and washable aluminum mesh filters.

Ventilation air shall be exhausted through fixed, louvered openings equipped with washable aluminum mesh filters.

Air supply and exhaust openings shall be sized by the control panel manufacturer for the air flow required to maintain the proper inside temperature. All air filters shall be provided with interior door mounted frames allowing easy removal for cleaning.
- B. Where necessary or where specified elsewhere, control panels shall be provided with air conditioning to maintain the required temperature for the housed equipment. Control panel air conditioning units shall be provided in accordance with the following requirements:
1. The air conditioning system shall provide closed-loop cooling and shall be sized by the control panel manufacturer based on: heat generated from all panel equipment and auxiliary components operating at full rated capacity, and said equipment operating under maximum ambient temperature conditions.
  2. Unless specified otherwise, air conditioning unit shall operate on 115 V or 230 V, single phase, 60 hertz power supplied by the control panel.
  3. Air conditioning unit shall be provided with: 16-gauge (minimum) welded steel framework, an efficient and quiet rotary compressor, built-in condensate evaporator, HFC environment friendly refrigerant, and additional corrosion protection for all aluminum, copper, and ferrous metal surfaces.
  4. Air conditioning units for indoor control panels shall be furnished with built-in digital temperature controllers. Air conditioning units for outdoor control panels shall be furnished with remote temperature controllers mounted inside the control panel enclosure in an accessible and visible location.

5. Unless indicated otherwise on the Drawings, the air conditioning unit shall be designed to mount on the side of the control panel enclosure while maintaining NEMA Type 12, 4, or 4X integrity, and shall be furnished with a gasket kit at the interface between the enclosure and air conditioner. Air conditioning units mounted to NEMA Type 4X stainless steel enclosures shall be constructed of stainless steel.
  6. Air conditioning unit shall be constructed to allow easy access for maintenance, including easy pull-out air filters. A minimum of three (3) spare replacement air filters shall be provided with each air conditioning unit.
  7. Air conditioner units shall be UL listed, and shall be as manufactured by Ice Qube, Inc., or equal.
- C. Control power transformers with primary and secondary fuse protection shall be provided as required for proper operation of the enclosure heating and ventilating equipment, unless Drawings show otherwise. Supply voltage shall be 120 VAC and 60 Hz. Separate line voltage thermostats shall be provided for heating and cooling.

## **2.05 CONTROL DEVICES AND COMPONENTS**

### **A. Control Transformers**

If incoming power supply as shown on the Drawings is other than 120 VAC, each control panel shall be provided with a control transformer. Control transformers shall comply with the following requirements:

1. Each control transformer shall be rated 480/120 V or 240V/120V single phase, 2 wire, 60 Hz, and shall conform to the applicable requirements of NEMA ST 1. The transformer shall have adequate volt-ampere capacity for all connected control function loads indicated, plus an additional 20 percent capacity. Transformer capacity shall be increased as required for any additional non-control function loads, such as condensation heaters, ventilation fans, or air conditioning.
2. Each control transformer shall be feed from the load side of the panel or motor controller disconnect. Control transformers rated 480/120 V shall be provided with two primary fuses rated to interrupt 50,000 A (minimum) at 600 V. One transformer secondary lead shall be provided with a time delay, slow-blow fuse rated to interrupt 10,000 A at 250 V, and the other secondary lead shall be grounded. All fuses shall be provided with blown fuse indicators.

Where control circuit power is provided from a source other than a unit transformer (e.g. a lighting panel circuit breaker), the motor controller disconnect shall include an electrical interlock for disconnection of externally powered control circuits.

B. Control Relays

Control relays shall be general purpose, electrically operated, magnetically held, plug-in blade or pin style with DIN rail mountable socket and LED indicator. Control relays shall be UL listed with 10 A rated contacts (thermal continuous current at 120 VAC), and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles and pole arrangement shall be as indicated on the Drawings and as specified herein. Control relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

C. Time Delay Relays

Time delay relays shall be general purpose, multi-range, multi-function plug-in blade or pin style with DIN rail mountable socket and LED indicators (timing and timed out). Time delay relays shall be provided with multiple programmable timing ranges (0.5 sec to 24 hours, minimum) and multiple operating modes. As a minimum, relay operating modes shall include: on-delay, off-delay, repeat cycle off start, repeat cycle on start, and signal on/off delay. Time delay relays shall be UL listed with 5 A rated contacts (thermal continuous current at 120 VAC) non-inductive load, and shall be provided with 120 VAC coils, unless specified otherwise. Number of poles, pole arrangement, and maximum timing adjustment shall be as indicated on the Drawings and as specified herein. Time delay relays shall be as manufactured by Allen-Bradley, IDEC, OMRON, Potter-Brumfield, or equal.

D. Elapsed Time Meters

Elapsed time meters shall be electromechanical, NEMA Type 4X rated, with rectangular or round case suitable for flush panel mounting. Each meter shall have 6-digit (minimum) registers with counter numbers at least 3 mm high, and shall be non-resettable. White counter numbers on black backgrounds shall provide hour indication with the last digit in contrasting colors to indicate tenths of an hour. Each meter shall operate on 120 VAC input power. Elapsed time meters shall be as manufactured by Eaton, Honeywell/Hobbs, or equal.

E. Pilot Devices

1. Pilot devices consisting of pushbuttons, selector switches, pilot lights, and incidental items shall be as manufactured by Allen-Bradley, Eaton/Cutler Hammer, or Schneider/Square D (no substitutes).

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2. Pilot devices shall be suitable for mounting on MCCs, switchgear, control panels, and control stations. Pilot devices shall be 30.5 mm, NEMA Type 4/13 with cast metal bases, chrome-plated octagonal mounting nuts, and legend plates.
3. Contact blocks shall have AC contact ratings of NEMA A600, 10 A with silver contacts for corrosion resistance and clear side plates for contact inspection.
4. Pushbuttons and switch knobs shall be heavy duty plastic. Unless indicated otherwise on the Drawings, switch knobs shall be black and pushbuttons shall colors shall be as follows:

<b>Color</b>	<b>Function</b>	<b>Examples</b>
Red	Emergency Stop, Stop, Off	Emergency Stop button, Master Stop button, Stop of one or more motors
Yellow (Amber)	Return, Emergency Return, Intervention (suppress abnormal conditions)	Return of machine to safe position, override other functions previously selected
Green	Start-On	General or machine start. Start of cycle or partial sequence.
Black	No specific function assigned	Permitted to be used for any function except for those listed above.

5. Pilot light devices shall be push-to-test type and shall be provided with LEDs and transformers suitable for operation on 120 VAC power. Pilot light lenses shall be shatter resistant plastic. Unless indicated otherwise on the Drawings, pilot light lens colors shall be as follows:

<b>Color</b>	<b>Function</b>	<b>Examples</b>
Red	Fail or Alarm (abnormal condition requiring immediate attention)	Indication that a protective device has stopped the machine, e.g. overload
Yellow (Amber)	Warning (marginal condition, change or impending change of conditions)	Some value (e.g. pressure) is approaching its permissible limits. Overload permitted for a limited time. Ground fault indication.

<b>Color</b>	<b>Function</b>	<b>Examples</b>
Green	Machine Ready, Machine Running, Safety	Machine ready for operation with all conditions normal. Machine run.
White	Normal Condition, Confirmation	Normal pressure. Control power on.

F. Mounting of Instruments

1. Provide cutouts, and door mount all instrument items indicated on the Drawings or specified to be panel mounted, including any instruments specified to be furnished by other vendors but installed in panel (if applicable).
2. Mount, behind panel doors, other instrument accessory items as required and/or specified.
3. The rear of panel mounted equipment shall be installed with due regard to commissioning adjustments, servicing requirements and cover removal.
4. Spare space shall be kept clear of wiring, etc. to give maximum space for future additions.

G. Door Mounted Device Shield

Provide a clear acrylic glass (Plexiglass) shield to cover back of door mounted devices (lights, switches, OIT, etc.). Plexiglass shield shall be 1/8" thick and shall be mounted to the panel door (outer door and/or inner swing-out door) with 1/4" diameter stainless steel bolts and spacers between back of panel door and Plexiglass shield. Bolts and spacers shall be provided at shield corners and along shield edges as necessary to provide a rigid shield.

H. Terminals and Power Supplies

All terminals and power supplies shall be as manufactured by Phoenix Contact (no substitutes).

1. Provide terminal blocks for all incoming and outgoing control wires. Unless indicated otherwise on the Drawings, mount terminal blocks vertically. Wire and mount terminal blocks so that internal and external wiring do not cross over the terminals. No more than two conductors shall be terminated at each terminal connection.

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2. Field wiring shall terminate on the "field side" of the terminal blocks. Do not connect internal panel wiring to the "field side" of the terminal blocks. Do not connect field wiring to the "panel side" of the terminal block.
3. Unless specified otherwise, all field wiring shall be connected to fused terminal blocks, including input and output terminals to and from PLCs. PLC loop powered analog signals shall be connected to two-level, non-fused terminal blocks.
4. Terminal blocks shall be modular, rail mounted, rated at 20 amperes, 600 volts capable of terminating wire sizes 12 through 24 AWG and constructed of polyamide thermoplastic. Terminal blocks shall be UL listed in accordance with UL 486A and 1059. All current carrying parts shall be made of copper or brass electroplated with tin/lead. Terminal connection shall be a screw clamp pressure plate connection, designed such that the clamping screw does not clamp the screw directly to the wire.
5. Provide symmetrical steel assembly rails, end brackets, jumper bars, and other accessories as required for a complete terminal block assembly.
6. Terminal blocks shall be consecutively numbered from top to bottom with preprinted marking tags. Tags shall be white polyamide and hot printed with black symbols so that the print is permanent.
7. Specific model terminal blocks shall be as follows:
  - a. Phoenix Contact Terminal Block, Single-Level, Non-Fused, Model UK5N
  - b. Phoenix Contact Terminal Block, Two-Level, Non-Fused, Model UKKB5
  - c. Phoenix Contact Terminal Block, Fused, Model UKK5-HESILED
  - d. Phoenix Contact End Cover, Model D-UKKB3/5
  - e. Phoenix Contact Clamp, Model E/UK1.

Alternate model terminal blocks or terminal blocks from other manufacturers are not acceptable.

#### I. Power Supplies

Unless specified otherwise, power supply shall be Phoenix Contact Power Supply AC-DC 24V @ 2A 85-264V In, Enclosed DIN Rail Mount Mini Series, Model 2938730. Alternate model power supplies from other manufacturers are not acceptable.



## 2.06 MARKERS AND NAMEPLATES

### A. Markers

Each signal, control, alarm, and indicating circuit conductor connected to a given electrical point shall be designated by a single unique number, which shall be shown on all manufacturer shop drawings. These numbers shall be marked on all conductors at every terminal. Conductor markers shall be pre-printed white identification tags with clear heat shrinkable tubing. Heat shrinking of the identification tags and clear tubing shall be in accordance with manufacturer's specifications.

1. Conductor identification tags shall be in accordance with the following requirements:
  - a. The conductor identification tags shall consist of heat shrinkable flame retarded identification sleeves that fit tightly over the conductor or cable to be marked. Identification sleeves shall be made of a seamless cross-linked polyolefin with a 3 to 1 shrink ratio.
  - b. The conductor identification tag system shall be UL recognized to Standard 224, MIL-M-81531. Identification tags shall be smear resistant prior to shrinking and achieve a permanent mark when shrunk, without the need for permatizing equipment. Identification marks shall be legible after 20 eraser rubs and 30 solvent brush strokes.
  - c. Identification sleeves shall be seamless. Sleeves shall be resistant to common industrial fluids including Freon TF, Isopropyl Alcohol and Ethylene Glycol. Identification sleeves shall have a temperature range of -30°C to 105°C and a dielectric strength of 500 V/mil minute. The identification sleeves shall be suitable for indoor or outdoor use. The conductor identification tag system shall be as manufactured by Raychem/Kroy Cable Marking, or Brady-Permasleeve White Polyolefin (B-342), or equal. Heat shrinkable thermoplastic tags are not acceptable.
2. The conductor identification sleeves shall be provided with heat shrink clear tubing in accordance with the following:
  - a. To provide a long-term permanent marker in high ambient temperatures, a translucent (clear) shrink tube shall be placed over each wire marker (extending past both edges of adhesive wire marker) and heat shrunk.

- b. The clear tube shall be suitable for high temperature performance, abrasion resistance and cut-through resistance and resistant to chemicals and solvents. The clear tubing shall meet the high temperature performance that meets or exceeds military industrial standards: MIL-1-23053, Test C, with UL VW-1 ratings. Operating temperature range shall be -55°C to 175°C. Product shall be Kynar as manufactured by Raychem, or equal.

B. Nameplates

1. Plainly and permanently identify control and power devices using the same identification as shown on the schematic diagrams. Show identification for devices inside the enclosure on a nameplate adjacent to, not on, the device.
  - a. Exception No. 1: Where the size or location of the devices make individual identification impractical, such as on electronic assemblies, use group identification.
  - b. Exception No. 2: Where panel layouts do not permit the mounting of identification nameplates adjacent to components, such as relays, place the permanent relay identification on the relay where it is plainly visible, and provide a second identification on the top of the panel wireway cover directly below the relay. Identify the wireway covers to show their proper location.
2. Identification nameplates for devices mounted inside and outside the control enclosure shall be one of the following:
  - a. Laminated phenolic for engraving stock; a minimum of 0.062 inch thick with black background and white lettering. Fasten nameplates with stainless steel drive screws, or the equivalent. Use permanent adhesives for attaching nameplates to wireway covers.
  - b. Stainless steel; a minimum of 0.031 inch thick for engraving stock or 0.012 inch thick for embossing stock. Fasten nameplates with stainless steel drive screws, or the equivalent.

## 2.07 WIRING METHODS

- A. Panel wiring shall be neatly contained in panel wireways, including incoming and outgoing field control wiring. Provide separate wireways for internal wiring and field wiring. Panelways shall be colored white for 240 VAC circuits and colored light gray for 120 VAC, restricted slot design, with matching snap on overs. Provide panelways with mounting holes and nylon "push" rivets for mounting. Panelways material shall be PVC or noryl. Panelways shall be as manufactured by Panduit, or equal.
- B. Provide minimum 2 inches of clearance between panelway and wire terminations to allow for clear viewing of wire identification marking.
- C. Wiring run to control devices on the front door shall be tied together at short intervals and secured to the inside front door with Panduit adhesive mounts. Mounts shall be Clincher adjustable releasable clamp type for wire bundles 0.69 inch in diameter or smaller, or AM2-C mounts with Uni-Ty releasable nylon cable ties for bundles larger than 0.69 inch in diameter. Mounts shall be attached to front panel with Eastman 910 adhesive, or equal.
- D. Signal and Control Circuit Wiring
  - 1. Wire type and sizing:
    - a. Conductor shall be flexible stranded copper machine tool wire.
    - b. These shall be UL listed Type MTW flexible or Type SIS and shall be rated 600 volts.
    - c. Wires for instrument signal circuits and alarm input circuits shall be No. 14 AWG, minimum.
    - d. Wires connecting to PLC wiring arms shall be multiconductor No. 16 AWG, minimum.
    - e. All other wires, including shielded cables, shall be No. 16 AWG, minimum. Shielded cables shall be used for analog signals.
    - f. Wire insulation colors shall be as follows:
      - i) Control Wiring
        - a) PLC Inputs (Status) DI = Blue
        - b) PLC Outputs DO = Brown
        - c) 12VDC Positive = Red

- d) 12VDC Negative = Black
- e) 24VDC Positive = Yellow
- f) 24VDC Negative = Blue
- g) 120 VAC Positive = Red
- h) 120 VAC Negative = White
- i) 120VAC Switch Leg = Do not use Black, Red or Blue
- j) 480 VAC Switch Leg = Do not use Brown, Orange or Yellow

ii) Power Wiring

- a) 480 VAC A-Phase = Brown, B-Phase = Orange, C-Phase = Yellow
- b) 120/208/240 VAC A-Phase = Black, B-Phase = Red, C-Phase = Blue
- c) Phase tape with colors is acceptable
- d) Foreign Power = Yellow

Note: Match existing wiring when appropriate.

**2.08 SPARE PARTS**

- A. All spare parts shall be of the same material and workmanship, shall meet the same requirements, and shall be interchangeable with the corresponding original parts furnished. Spare parts shall be properly packaged for shipment and storage, and shall be labeled with the manufacturer's part number(s).
- B. As a minimum, Contractor shall furnish the following spare parts:
  - 1. Five (5) fuses of each type and size for single-phase power (including control power).
  - 2. Two (2) indicating light assemblies for each type of pilot light.
  - 3. One (1) control relay of each type and rating.
  - 4. One (1) time delay relay of each type and rating.
- C. Where control panels operate on 3 phase power and/or are equipped with motor starting equipment and components, Contractor shall furnish the following additional spare parts:
  - 1. Three (3) fuses of each type and size for three-phase power.

2. Two (2) complete sets of 3-pole stationary and moving contact assemblies for each size AC contactor.
3. Two (2) operating coils for each size AC contactor.
4. One (1) contactor auxiliary contact of each type.
5. Three (3) contactor overload relays of each type and rating, each relay with a complete set of contact blocks.
6. One (1) spare set of heater elements for each heater rating provided.

### **PART 3 - EXECUTION**

#### **3.01 FACTORY TESTS**

Prior to shipment, each control panel shall be inspected and tested for correct operation by the manufacturer. Each circuit shall be tested for continuity, short circuits, and fault grounds. The functional operation of the control panel shall be tested, including operation of all input and output (I/O) points, control devices, and motor controls. Temporary connections shall be provided between control panels and other system components. Subsequent testing of the system shall include, but not be limited to, programming of the PLC and operator interfaces. PLC system shall be programmed as required.

##### **A. Initial Testing**

Initial testing of the control panel shall include configuration of the PLC and its communications equipment (where PLC is provided) energizing each digital I/O and simulating each analog I/O using a loop simulator and calibrator. Circuits not energized shall be tested for continuity. Energized circuits shall be tested through all components from the terminal blocks in the control panel to the control devices and hardware I/O memory locations in the PLC. Testing of the control system shall be considered completed after control system operation has been successfully simulated at least four (4) times.

An I/O checklist shall be provided for all points in the control panel. The checklist shall include, for each point, the tag name of the point, a description of the point, comments, date and time of the test, and a signature line for the person performing the test. Where a PLC is provided, each digital point set and reset shall be shown. Verification of all analog points shall be shown at 0%, 25%, 50%, and 100% of range. The checklist shall be submitted to District.

B. District-Witnessed Factory Testing

District shall have the option of witnessing the functional shop test. Contractor shall notify District at least three (3) weeks prior to the scheduled functional shop test.

After completion of initial testing, the subsequent testing shall be conducted for inspection by District. All control functions and all status and alarm monitoring and indication shall be demonstrated under simulated operating conditions. Simulating equipment shall be provided and wired into the control system for this testing. The system shall be revised, modified, and adjusted as required by District during the testing period. Testing shall continue for the time period required by District to observe and verify any revisions and shall continue to District's satisfaction. Where panel is equipped with a PLC, the PLC and HMI programs shall be loaded and fully tested in the factory. All hardware, instruments, and software shall be provided as necessary to perform the testing.

**3.02 SITE TESTS**

A. General

Control panel shall be tested with all field wiring connected. All adjustable set points and time delays shall be set as required. Operation of control panel and field devices shall be checked to verify correct operation. All required adjustments shall be made as required for correct operation.

B. Specific Field Verifications

The following specific field verifications shall be performed:

1. Panel control circuits are grounded with one (1) terminal of each load device connected to the grounded conductor.
2. Panel signal and control wiring are separated and installed in separate wireways with barriers between the power wiring and the signal and control wiring.
3. Panel is connected to the facility grounding system as specified.
4. Panel tops of wall-mounted panels are mounted at the same elevation (unless noted otherwise).
5. Panel inner door contains a copy of the as-built elementary and wiring diagrams.
6. Panel inner door contains copies of all applicable equipment warranties.

7. Panel inner door contains a drawing holder.
8. Panel as-built shop drawings and applicable equipment warranties are enclosed in a transparent, protective jacket.
9. All panel functions are as specified.

### **3.03 CONTROL PANEL MOUNTING**

#### **A. General**

Control panels shall be field mounted as indicated on the Drawings or on equipment supplied as shown on District-accepted shop drawings.

#### **B. Mounting Requirements**

Unless indicated otherwise on the Drawings or in the specification sections for the packaged equipment systems, control panels shall be mounted as follows:

1. Control panels supported directly by concrete or concrete masonry walls shall be spaced apart not less than 1-5/8" by strut channel between panel and wall. Strut channel shall be attached to the wall as shown on the Drawings. Panels shall be attached to strut channel with stainless steel strut threaded studs, washers, and nuts. Unless specified others, strut stud diameter shall be 1/16" less than the panel mounting holes.
2. Panels shall be mounted to structures or support systems that are free of vibration or shock.
3. Support systems shall not be attached to handrails, process piping, or mechanical equipment, unless indicated on the Drawings.
4. Unless indicated otherwise on the Drawings, materials used for support of control panels shall be constructed of Type 316 stainless steel. Support systems, including panels, shall be designed to prevent deformation greater than 1/8" under the enclosed equipment load and an external load of 200 pounds in any direction.
5. Panels shall be shimmed to precise alignment so doors operate without binding.
6. Floor-mounted cabinets shall be mounted on 3" minimum high concrete housekeeping pads or grouted bases as indicated on the Drawings.

7. Terminals and terminal blocks shall be sprayed with a silicone resin, similar to Dow Corning R-4-3117 conformal coating, after all terminations and testing have been completed.

### **3.04 MANUFACTURER'S SERVICES**

Unless specified otherwise, equipment manufacturer's services shall be provided at the job site for the minimum number of 8-hour work days listed below, travel time excluded:

- A. Two (2) work days to check the installation, calibrate the equipment, supervise start-up, and supervise testing of the system.
- B. One (1) work day to instruct the District's personnel in the operation and maintenance of the equipment.

**END OF SECTION**