

SECTION 16920 CONTROL PANELS

PART 1 GENERAL

1.1 DESCRIPTION

- A. Section Includes: Design standards and manufacturing requirements for control panels and enclosures.

1.2 REFERENCES

- A. Underwriters Laboratory UL508A – Safety Standards for Industrial Control Panels
- B. National Electric Code Section 409 – Industrial Control Panels
- C. NEMA 250-2008 – Enclosures for Electrical Equipment

1.3 QUALITY ASSURANCE

- A. Include components shown on contract drawings and accessories and hardware not shown but necessary to meet manufacturer recommendations and/or WSSC specifications.
- B. Equipment: Installed following manufacturer's recommendations. Follow manufacturer's installation manuals for guidance and details not shown on contract drawings.

1.4 SUBMITTALS

- A. Submit for review following Section 01330. Drawings: AutoCAD format and may be electronically transmitted.
 - 1. Power distribution wiring diagram.
 - 2. Back panel and subpanel layouts showing location of panel-mounted equipment.
 - 3. Enclosure elevation drawing showing location of externally mounted equipment.
 - 4. Enclosure assembly diagram if applicable.
 - 5. Complete bill of materials.

PART 2 MATERIALS

2.1 ENCLOSURES

- A. NEMA Rating: Follow standards for NEMA type indicated on drawings or as specified herein.

1. NEMA Type 12 dust-tight:
 - a. Provided for indoor controlled environment locations as shown on drawings. Provide continuous gasket around door opening.
 - b. Phosphate coating for rust proofing and white enamel panel interior finish.
 - 1) Exterior finish: Hoffman custom paint color #RAL7021 (T014) or ANSI-61 gray powder coat.
 - 2) Enclosures requiring legs: Paint color to match enclosure.
2. NEMA Type 4 watertight and dust-tight: Provided for indoor or outdoor locations as shown on Drawings.
3. NEMA Type 4X corrosion resistant: Provided for indoor and outdoor locations as shown on Drawings.
- a. Door clamps and hinge pins: Stainless steel.
4. NEMA-rated enclosures for PLC and Remote I/O panels: Hoffman Brand or equal.

B. General.

1. Designed for connection to 120VAC branch circuits. Equipment that requires higher voltage sources, e.g. VFDs and uV reactor controls: Supplied in separate enclosures.
2. Enclosures that contain interlocked control circuits or circuit supplied from external power source which cannot be de-energized by panel disconnect: Furnish with following warning label;
CAUTION: THIS EQUIPMENT MAY HAVE MORE THAN ONE POWER SOURCE OR IS INTERLOCKED WITH OTHER EQUIPMENT.
3. Mounted outdoors or in unheated areas: Provide internal condensation and freezing protection with thermostat control.
4. Contain incandescent or LED light package equipped with manually operated switch. At least one GFCI-type duplex utility outlet: Provided on control panel.
5. Fully enclosed units with front and/or rear access doors, designed to fit in space available, as specified in contract drawings.
6. Enclosures which contain PLC processor and communication modules: Equipped with door-mounted factory window kits to enable viewing of status LEDs.
7. Vapor-phase protective corrosion inhibitors.
 - a. Inhibitor: Activated upon shipment to site.
 - b. Panels:
 - 1) Do not store with inhibitors inactive.
 - 2) Cover to reduce ventilation and prolong inhibitor life, if necessary.
 - c. Approved Manufacturers:
 - 1) Hoffman A-HC15E.
 - 2) 10E.
 - 3) Or Equal.
 8. Front door-mounted nameplate that identifies panel inside, e.g., PLC-D, CHEM RIO-4.
- a. Nameplates.

- 1) As shown on contract drawings or listed in specifications.
- 2) Laminated plastic having black letters on white background and attached using stainless steel screws.
 9. Print pocket.
- a. Mounted inside door.
- b. Include one copy of relevant as-built drawings prior to shipment.
 10. Factory back panels for mounting control panel components and equipment.
- a. Side panels may be used to increase amount of available panel space.
- b. 24 inch deep or greater that contain back panel: Supplied with studs for future installation of full length side panels on both sides of enclosure.
 11. Sufficient structural reinforcements to limit vibration and prevent distortion or damage to panel and components during shipment, installation and operation.

C. Free-Standing Steel Enclosures

1. Single door: 12-gauge sheet steel.
2. Multiple door: 10-gauge steel.
3. Back panels and side panels: Minimum 12-gauge steel.
4. Full size back panels: Equipped with stiffeners and heavy duty supports as needed to ensure rigidity.
5. Exterior welds: Ground and sanded to smooth finish free of burrs.
6. Surface: Free of ridges, nuts, bolt heads, and similar protrusions.
7. Removable lifting lugs on top of enclosure designed to facilitate rigging and lifting of enclosure during installation.
- a. Plugs: Provided to fill the lifting ring holes after installation is complete.
 8. Full-length door with handle-operated three point latch for front or rear access. Certain installations may require lockable door handles.
 9. Floor stands or foot kits, when required, as shown on panel drawings.
 10. Provide steel stiffeners as necessary to prevent deflection of back panels and doors due to heavy panel-mounted or door-mounted components.
- a. Stiffener: Minimum 0.25 inches deep by 1 inch wide tack welded to back of the panel or door.

D. Wall-Mounted Steel Enclosures

1. 14-gauge steel.
2. Back panels and side panels: Minimum 12-gauge steel.
3. Doors: Equipped with rubber gaskets and continuous hinges.
4. Enclosures: Equipped with 2-point latching door handles.
- a. In wet or corrosive environments screw clamps may be required around perimeter of door to ensure tight seal.
- b. Certain installations may require lockable door handles.

2.2 PANEL WIRING AND TERMINATIONS

- A. Designed, manufactured and tested following latest standards listed herein.
- B. Back panel and side panel wire bundles.
 - 1. Run inside Panduit-style wire duct to facilitate tracing of circuits.
 - 2. Exposed wire bundles connecting door-mounted devices and side panels to back panel are allowed.
 - 3. Fastened down at suitable intervals, not to exceed 12 inches in length.
- C. Segregate AC control power and I/O wiring, and DC control power and I/O wiring within panel as much as possible.
 - 1. Group wires and cables according to function. Run in separate wire ducts and/or bundles.
 - 2. Keep analog signals (4-20 mA and 0-10V) as far away from AC control power and I/O wiring as possible.
- D. Use flexible stranded copper wiring.
 - 1. No solid conductor wire is permitted.
- E. 120VAC and 24VDC wiring in panel: Type MTW, rated for operation at 600V at conductor temperatures not to exceed 90 deg. C.
- F. Analog I/O and Instrumentation cable: No. 18 AWG, twisted, shielded single pair, instrumentation cable with minimum of six twists per foot and including continuous foil shield with drain wire. PVC-coated and rated for operation at 300V at conductor temperatures not to exceed 90 deg. C.
 - 1. Individual Pair Shield: 1.35 mil, double-faced aluminum/synthetic polymer overlapped for 100% coverage.
 - 2. Outer Jacket: 45-mil nominal thickness.
 - 3. Dimension: 0.31 inch nominal OD.
 - 4. Conductors:
 - a. Bare soft annealed copper, Class B, 7-strand concentric, following ASTM B8.
 - b. 20 AWG, 7-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Pair conductors: Color-code Red (+), Black (-).
- G. Minimum wire conductor sizing: Follow UL 508A standards for industrial control panels:
 - AC line side power: No smaller than 14 AWG.
 - AC line and control circuits: No smaller than 16 AWG.
 - DC line, load and control circuits: No smaller than 16 AWG.
 - Analog signal wiring: No smaller than 20 AWG.

H. Panel wiring: Color coded as follows:

BLACK	AC line, load and control circuits operating at line voltage.
WHITE	AC neutral
RED	AC control circuits at line voltage which are controlled by a relay contact or other control element
BLUE	DC, line load and control circuits
BLUE WITH WHITE STRIPE	DC common or 0VDC
YELLOW	Interlocked control circuits or any circuit supplied from external power source which cannot be de-energized by control panel disconnect.
GREEN	Equipment grounding conductors with or without yellow stripe.

I. Analog and instrumentation conductors: Color coded as follows:

1. RED: Positive (+)
2. BLACK: Negative (-)

J. Wire:

1. Run in continuous lengths from screw terminal to screw terminal.
2. Provide wire service loops to simplify removal of panel components.
3. Do not splice wiring.
4. Identified at both ends with white machine printed, sleeve-type labels.

a. Hand lettered wire labels are not allowed.

K. Wire numbering: Consistent with nomenclature used in sample drawings.

1. All PLC I/O module wiring: Numbered according to I/O point base/slot/point assignments.

L. 120 VAC Discrete Inputs: The Control panel will provide 120VAC to field equipment for signaling purposes only.

2. Wires: Red.
3. Field equipment: Equipped with 120VAC rated dry contacts and shall operate the dry contacts. All Emergency Stop and other alarm

Inputs shall be wired Failed-Safe (normally closed), where the de-energized circuit represents an alarm.

4. For each dry contact, a pair of wires shall be installed and landed from the Control panel to the dry contact.
 - a. One wire shall be hot (+) the other shall be used to return power back to the Control when the dry contact is closed.
 - b. Both wires shall be continuous home-runs from field equipment panel to Control panel with NO intermediate terminations or splices.
 - c. A sample drawing will be provided and followed.
- M. 120 VAC or 24VDC Relay Outputs: The Control panel will be Supplied with 120VAC or 24 VDC control power from the field equipment for control purposes only.
 1. Wires: Yellow to indicate foreign voltage.
 2. Control Discrete Output card will provide a dry contact to switch power on and off. Each dry contact will only have one function and serve only one piece of field equipment (for example, a single dry contact cannot be used to turn on a pump and used to illuminate a panel light).
 3. For each dry contact, a pair of wires shall be installed and landed from the Control panel to the field equipment.
 - a. One wire shall be hot (+) the other shall be used to return power back to the field equipment when the dry contact is closed.
 - b. De-energizing field equipment shall consequently de-energize the 120VAC or 24VDC control power.
 - c. Both wires: Continuous home-runs from field equipment panel to Control panel with NO intermediate terminations or splices.
 - d. A sample drawing will be provided and followed.
 4. In general, the current for Allen Bradley 1756 output modules shall not exceed 2 Amps and never exceed the manufacturer's limitations. The A-B relay output module (1756-OW16I) used on Control panels does not have on board fusing, therefore one of the 2 terminals provided for field connections, typically the line side, shall be equipped with a 2A rated fast blow fuse.
 5. In general, the current for CTI output modules shall not exceed 5 Amps and never exceed the manufacturer's limitations. The CTI relay output module (#2534) used on Control panels is equipped with on board fusing; therefore standard thru terminals may be used for field connections.

2.3 TERMINAL BLOCKS

- A. Factory assembled on standard 35mm din rail mounted on standoffs to provide easy access to terminal screws.
 1. Prefabricated terminal strips are not allowed.
- B. Screw type with pressure plate (compressor type) requiring no lugs on connecting wires.
 1. Rated for wire size 12 AWG or smaller.
 2. Rated for 600 volt service.
 3. Cage clamp style terminals are not allowed.

- C. Furnished with engraved plastic markers displaying wire numbers or alphanumeric designation shown on drawings and/or on the I/O point list.
 - 1. If connected to PLC I/O modules: Numbered according to I/O point base/slot/point assignments.
- D. Reserve one side of each terminal block assembly for incoming field wiring.
 - 1. Common connections and jumpers required for internal wiring on field side of terminal is not allowed.
 - 2. No more than two wires terminated at any single screw terminal.
- E. Through terminals and fuse terminals ganged together to create common voltage buses: Utilize internal screw jumpers.
 - 1. Wire jumpers and comb jumpers are not allowed.
- F. I/O module points, including unused spares: Connected to terminal blocks.
 - 1. Terminal block assemblies for power distribution: Include minimum 25 percent spare fuse terminals, connected to AC or DC bus via internal jumpers.
- G. Fused terminal blocks.
 - 1. Follow typical wiring diagrams for power distribution and I/O modules.
 - 2. Required for overcurrent protection of analog input modules and discrete output modules not equipped with internal fuses or protected by interposing relays.
 - 3. Provided with blown-fuse indicator and fast-acting, 5 x 20mm fuses, unless approved otherwise.
 - 4. Cross section not greater than 8mm.
- H. Terminal block assemblies for analog input and output channels.
 - 1. Include ground terminals that connect directly to panel ground through din rail.
 - 2. Ground terminals: Green and yellow in color.
- I. Feed through terminal blocks: High density with cross section not greater than 2.5mm.
- J. Approved Manufacturer.
 - 1. Weidmuller brand
 - 2. Or equal.

<u>Terminal Type</u>	<u>Wiedmuller Cat. No.</u>
Analog input (+), fused	WSI6
Analog input (-)	WDU2.5

Analog input shield	WPE2.5
Analog output (+)	WDU2.5
Analog output (-)	WDU2.5
Analog output shield	WPE2.5
Discrete input	WDK2.5*
Discrete output	WDU2.5
Digital output, fused	WSI6
All others	WDU2.5 or WSI6

*Note: Discrete input terminal block assemblies require 2-tier terminals. The top tier is used for the individual inputs. The terminals on the bottom tier are ganged together using internal screw jumpers to form a voltage bus for wetting of field contacts.

2.4 PANEL MOUNTED DEVICES

A. Analog signals.

1. Sent to and received from the field: 4-20mA
2. Analog I/O modules: Configured for 4-20mA signals.
3. Include signal converters necessary to make Control panel compatible with field equipment on panel.

B. Panel and enclosure.

1. Equipped with ground lugs for connection to external ground.
2. Screw terminal-type ground bus bolted to back panel: Provided for grounding electrical equipment and instrumentation.

C. Instruments, pilot devices or operator panel mounted on outside of enclosure:

1. Suitable for flush mounting.
2. Match the NEMA rating of enclosure.
3. Located between 30" and 62" from floor.

D. Panel mounted devices:

1. Mounted on din rail whenever possible
 - a. Din rail segments: Extended to include unused panel space.
 2. Designed to facilitate removal and maintenance of equipment after installation.
3. Identified by markers placed adjacent to, but not on, given device.
4. Markers:

- a. Display device tagnames and/or descriptive names.
 - 1) Engraved plastic nameplates or labels printed with indelible ink. Hand lettered markers are not allowed.

2.5 PILOT DEVICES

- A. Selector switches, pushbuttons, and indicating lights: Heavy duty, oil-tight, 30mm, NEMA 13-rated.
- B. Selector switches and pushbuttons.
 - 1. Supplied with operator mechanisms, appropriate number of contact blocks, and any necessary legend plates bearing pertinent information.
 - 2. Contact block terminals: Labeled for identification purposes and contain no less than one single-pole, double-throw contact.
 - 3. Contact blocks: Heavy duty type rated for 10A breaking current at 120V.
- C. Stop and emergency stop pushbuttons: Red in color unless approved otherwise.
 - 1. Other pushbuttons: Black unless approved otherwise.
- D. Pushbuttons.
 - 1. Operation: Momentary.
 - 2. Switch operation for local-remote, auto-manual, and computer-manual selection: Maintained in all positions.
 - 3. Provided with flush head bezels.
- E. Spring return selector switches: Required where indicated on Contract drawings.
- F. The following color code shall be used for the lenses of all indicating lights:

<u>FUNCTION</u>	<u>COLOR</u>	<u>FUNCTION</u>	<u>COLOR</u>
ON	Red	HIGH	White
OFF	Green	AUTOMATIC	White
CLOSED	Green	MANUAL	Blue
OPEN	Red	LOCAL	Blue
LOW	White	REMOTE	White
FAIL	White	POWER ON	White
TRIPPED	White		
- G. Indicating lights: Push-to-test LED-type, rated for 120V operation.
- H. Selector switches, pushbuttons, and indicating lights: Allen-Bradley Series 800, Siemens Class 52, or equal.

2.6 INTERPOSING RELAYS

- A. Used in conjunction with discrete inputs when field equipment being monitored is not compatible with 120VAC.
- B. Discrete outputs: Energize interposing relays interlocked with field control circuits, unless approved otherwise.
 - 1. Relays.
 - a. Coils rated to match field equipment.
 - b. Contacts rated for no less than 5A.
 - c. Only one Form C contact per relay.
 - d. LEDs to indicate when coil is energized.
 - e. Manual override switches for testing.
 - f. Turck/Releco type C12-A21X or equal.
- C. Provide surge suppressors on DC operated relay coils to reduce high transient voltage generated when circuit to operating coil is opened.
- D. May be required when using unfused PLC relay output modules.

2.7 POWER DISTRIBUTION

- A. Control panels: Furnished with two 120VAC, 20A-rated circuits.
 - 1. Line filtered circuit for powering the PLC, relay outputs, field contacts for digital inputs, 24VDC power supply, instrumentation, etc.
 - 2. Panels that contain the PLC processor and communication modules: Furnished with 120V receptacle on line filtered circuit for powering transceiver.
 - 3. Auxiliary circuit for powering enclosure lights and utility receptacle.
- B. Provide master disconnect switch and auxiliary branch circuit protectors (miniature circuit breakers).
 - 1. Circuit breakers: Used on AC inputs to power supplies and auxiliary circuits.
 - 2. Provide fused terminal blocks for 24VDC-powered devices and for connecting power to bottom tier of digital input terminal block assemblies.
- C. Input terminals, branch circuit protectors, and fuse terminals: Mounted on din rail and grouped according to function.
 - 1. Fuse terminals for digital input terminal block assemblies: Mounted next to digital input terminals.
- D. Auxiliary Branch Circuit Protectors: Siemens Series SY with trip characteristic C, or equal.

E. Control Panel Power Supply

1. Provide Control panel with 24VDC power supply rated for either 5A or 10A.
2. Power supplied: Meet or exceed the following specifications;

Input Power:	85 to 132 VACS, 47 to 63 Hz
Minimum Efficiency:	90%
Overload Rating:	150% I (out) rated up to 5 s/min
Protection:	Internally fused, preset current limit
Operating Temp. Range:	0 to 60 deg. C
Mounting:	Din rail mount
Output Voltage:	22.8 to 28V, adjustable
Output Voltage Regulation:	Typical 0.3% V (out)
Ripple and Noise:	<50 mV, pp
Temperature Coefficient:	0.02 percent per degree centigrade
Manufacturer:	Siemens 6EP1333-2AA01 (5A) Siemens 6EP1334-2AA01 (10A) Siemens 6EP1961-3BA20 (Redundancy)

3. Control panels that contain PLC processor:
 - a. Equipped with redundant power supplies and redundancy module that can switch to backup unit in case of failure.
 - 1) Redundancy module status contact: Wired into PLC digital input.

F. Power Line Transient Protection.

1. Provide panels containing solid state electronic equipment with line voltage surge suppressor provided with;
 - a. Surge arrester.
 - b. RFI filter.
 - c. Voltage clamp.
 - d. Terminals for incoming and load wires that shall trip power feed circuit breakers.
 - e. Automatic device reset.
 - f. Din rail mountable.
2. Approved Manufacturers;
 - a. Islatrol brand IE-120.

G. Uninterruptable Power Supply: Ferrups style with MBB bypass transfer switch, quick disconnect cables with twistlock connectors, and caster kit.

H. Exhaust Fan Motor Starter

1. The exhaust fan motor starter shall be across-the-line magnetic type rated in accordance with NEMA standards, sizes and horsepower ratings. The motor starter shall have a 120 volt coil. The motor starter shall be located in the Control Room Exhaust Fan Control Panel. The motor starter shall be furnished with an overload

relay. Provide a heater element in each phase of the relay sized for the motor nameplate full load amps.

2. The exhaust fan motor starter shall be Allen-Bradley Bulletin 509 or Square D Class 8536.

PART 3 EXECUTION

3.1 FACTORY TESTING.

- A. Equipment: Inspected and tested prior to being shipped to field.
- B. Each piece of hardware: Energized and tested to verify components function following manufacturer specifications.
- C. Factory testing: Include integrated system test to demonstrate proper functioning of CPU, local I/O modules, remote I/O network and remote I/O modules. Conduct test using minimally configured system.
- D. Personal computer and software necessary to create PLC hardware configuration for testing: Provided by factory
 1. WSSC will provide CPU rack for testing remote I/O panels upon request.
- E. Test Each I/O point following procedures outlined below. For purposes of factory testing;
 1. "Field terminals" shall mean the terminal blocks on the Control panels meant to receive field wiring
 2. "Console" shall mean the personal computer used to configure PLC and verify I/O test.

Digital Inputs: Jump each digital input field terminal to 120VAC or 24VDC, according to module type. Observe change of state at console.

Digital Outputs: For relay output modules with field connections to both line and load, force each output on at the console and measure the change of state at field terminals with continuity tester. For relay output modules connected to interposing relays on Control panel, verify proper output voltage and operation of interposing relays.

Analog Inputs: Introduce 4 to 20 mA DC signal at field terminal and observe changing value at console. Test response at 4 mA, 12 mA and 20 mA.

Analog Outputs: Force each output at console with values corresponding to 4 mA, 12 mA and 20 mA, and measure results at field terminals.

- F. Provide 5 working days notice prior to starting factory testing. WSSC will typically witness testing, but may waive this requirement on case-by-case basis.
- G. Patent defects in equipment: Repaired or replaced, as required, at no cost to the Commission, until substantial completion.
 - 1. If Latent defects are found notify the Commission immediately.
- H. Any factory modifications to Control panels shall be approved, tested, and documented prior to final acceptance.

3.2 POST TESTING

- A. Submit following documentation within 14 days of finishing factory panel testing.
 - 1. As-built versions of shop drawings listed herein.
 - 2. Fully annotated PLC logic backed up on CD-ROM.
 - 3. OIT configuration, tags and screens backed up CD-ROM.
 - 4. Complete I/O list following Process Control Group format.
- B. Submit final as-shipped drawings prior to shipment for approval and provide one copy within enclosure(s) to be shipped.
- C. Provide for protection, insurance and proper storage of equipment until received and inspected by the owner.
- D. Deliver spare parts for Control panels, as specified in contract drawings and documentation, prior to panel installation.

END OF SECTION

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