ADDENDUM 1
TO THE CONTRACT PROVISIONS AND CONTRACT PLANS

FOR

MASON COUNTY PUD NO. 1
BAY EAST IRON AND MANGANESE TREATMENT

G&O #23522

ISSUED THIS DATE: THURSDAY, MAY 21, 2026

BID SUBMITTAL: 3:30 P.M. (LOCAL TIME) ON MONDAY, JUNE 1, 2026
MASON COUNTY PUD NO. 1
21971 NORTH HIGHWAY 101
SHELTON, WASHINGTON 98584

Bidder shall acknowledge receipt of this Addendum on Page P-5 of the Proposal.

TO PROSPECTIVE BIDDERS:

The attention of all prospective bidders on the above project is directed to the following additions and modifications to the Contract Provisions and Contract Plans.

I. ADDITIONS, MODIFICATIONS, AND/OR DELETIONS TO THE TECHNICAL SPECIFICATIONS

ITEM 1:

Page iii, Table of Contents

Under Division 16, Electrical, **ADD** the following:

"16940 Control Panels ..... 16940-1"

ITEM 2:

Page 16050-20, Specification Section 16050-3.8, EXTRA MATERIALS

ADD the following at the end of the section:

"C. CONTROL PANELS (ASSOCIATED CSI SECTION – 16940)

The following quantities cover all control panels fabricated by the fabrication shop (quantities are not per panel).

1. DIN-rail Fused Terminals

Provide five spare DIN-rail fused terminals of each type and rating.

2. DIN-rail Feed-Through Terminals

   Provide five spare DIN-rail feed-through terminals of each type, color, and rating.

3. Power Fuses (line power)

   Provide three spare power fuses of each type and rating.

4. Control Power Fuses

   Provide 10 percent (minimum of two) spare control power fuses of each type and rating.

   Provide one control fuse puller.

5. PLC I/O Fuses

   Provide 10 percent (minimum of two packets of five fuses each) spare control fuses of each type, voltage, and rating. Fuse ampacity should be clearly shown or marked.

6. PLC Buffer Relays

   Provide 10 percent (minimum of four) spare PLC buffer relays of each type, style, and rating.

7. Control and Timing Relays

   Provide 10 percent (minimum of four) spare control and timing relays of each type, style, and rating.

8. Control and Timing Relay Sockets

   Provide two spare control and timing relay sockets of each type, style, and rating.

9. Intrinsically Safe Barriers

   Provide one spare intrinsically safe barrier each type, style, and rating.

10. Ethernet Switches

    Provide one spare Ethernet switch of each type.

11. Relay/Solenoid Surge Protective Devices

    Provide two spare Metal Oxide Varistors (MOVs) for AC relays and solenoids and two spare diodes for DC relays and solenoids.

12. Provide a single latching plastic container with a printed label adhered to the lid stating, “CONTROL PANEL SPARE PARTS.”

D. PLC PROCUREMENT (ASSOCIATED CSI SECTION – 16910)

1. Provide 10 percent (minimum of one) boxed spares of each PLC I/O module, communications module, power supply, and CPU module used in this contract.

2. Provide a single latching plastic container with a printed label adhered to the lid stating, “PLC SPARE PARTS.””

ITEM 3:

Page 16910-1, Specification Section 16910-1.1, SCOPE

DELETE the last line and **REPLACE** with the following:

“PLC programming is described in Section 13451.”

ITEM 4:

ADD the attached New Specification Section 16940 – Control Panels.

SECTION 16940

CONTROL PANELS

PART 1 GENERAL

1.1 SCOPE

The work specified in this Section includes PLC control panel [01 CP 01].

1.2 RELATED WORKS SPECIFIED ELSEWHERE

Section	Item
01300	Submittals
16910	PLC Hardware and Software Procurement
Division 16	Electrical

1.3 DEFINITIONS

A. CONTROL PANELS

Reference Section 16050.

B. CONTROL POWER

Control power is considered electrical power at either 120 VAC or 24 VDC that powers control or instrumentation devices. Control power circuits are less than 150 VAC and less than or equal to 20 Amps.

Examples:

1. 120 VAC or 24 VDC device power to instruments such as flow meters, chlorine analyzers, dissolved oxygen transmitters, etc.

2. 120 VAC or 24 VDC device power to control devices such as PLCs, radios, network switches, etc.

3. 120 VAC power to control devices such as motor operated valves, metering pumps (even when through dedicated receptacles), lighting circuits (controlled within a lighting control panel), etc.

1.4 REFERENCES

Reference	Title
NEMA	National Electrical Manufacturers Association
ICS-1	General Standards for Industrial Control and Systems
ICS-4	Terminal Blocks for Industrial Use
ICS-6	Enclosures for Industrial Controls and Systems
Publication No. 250	Enclosures for Electrical Equipment (1000 V maximum)
NFPA	National Fire Protection Association
NEC	National Electric Code
JIC-EMP-1	Joint Industrial Council

1.5 SYSTEM DESCRIPTION

A. CONTROL PANELS

1. Reference Section 16050, Definitions.

2. Control panels shall be fabricated similar to those shown on the Plans. With the exception of the discrete and analog I/O terminal blocks, the exact dimensions and component layout is not critical.

3. The system includes new control panels for control of process equipment. Some of the control panels are provided under Division 16. Some panels are provided under other Divisions with equipment specified in those Divisions. Control panels, whether provided under Division 16 or other Divisions, shall meet the requirements of this Section.

1.6 SUBMITTALS

A. SHOP DRAWINGS

1. See Section 01300.

2. Dimensioned or to-scale panel layout drawings.

3. Materials of construction.

4. Drawings showing conduit and wiring access locations.

5. Elementary wiring diagrams and terminal block drawings, differentiating between panel and field wiring.

6. Bill of Materials describing the reference name or number, quantity, complete English language description, manufacturer, model number, local supplier, and wiring or piping reference. Information shall include manufacturer name, catalog descriptions, wiring and piping diagrams, dimensional plans, anchoring details, installation instruction, and test results.

7. Loop diagrams with all components connected per ISA standards.

8. Nameplate text.

9. Heat calculations and relationship to enclosure fan, heater, air conditioner.

10. UPS system loading and resulting back-up run time.

B. OPERATION AND MAINTENANCE MANUALS

1. See Section 01300.

2. Provide manufacturer's operating and maintenance manuals for each device or item provided.

3. Recommended spare parts stocking list.

C. CONTRACTOR CERTIFICATION

1. If the submitted panel(s) are to be labelled and listed with an agency other than UL, submit proof of certification as a panel shop by that agency. For UL listed panels, the Contractor fabricating panels shall submit proof of certification as a UL 508A and/or UL 698A (if required) panel shop upon request.

1.7 QUALITY ASSURANCE

A. Make shop drawings available prior to placement of conduits in slabs to ensure placement is coordinated with panel access locations.

B. Test panels prior to shipment to project site.

1. The entire assembled panel shall be tested to be free from grounds and shorts.

2. Controllers, circuits, and interlocks shall be rung out and tested to assure that they function correctly before the panel is shipped.

Prior to placement of conduit feeds, assure approved control panel layouts are available.

C. Panels supplied under this Section are provided by a single manufacturer.

D. Provide panels labeled by a recognized testing laboratory acceptable to the State of Washington Department of Labor and Industries meeting the requirements of Article 409 of the NEC.

E. Revise all drawings upon completion of the work to show "as shipped" condition of the panel.

1.8 STORAGE AND HANDLING

A. After completion of shop assembly and testing, enclose panels in heavy-duty polyethylene envelopes or secured sheeting to provide complete protection from dust and moisture. Place dehumidifiers inside the polyethylene covering.

B. Skid-mount the equipment for final transport. Show shipping weight on shipping tags, together with instructions for unloading, transporting, storing, and handling on job site.

1.9 EXTRA MATERIALS

Reference Specification Section 16050 for spare parts.

PART 2 PRODUCTS, MATERIALS

2.1 CONTROL PANEL ENCLOSURES

A. ENCLOSURE BODIES

Control panel enclosures are factory listed and labeled enclosures fabricated of stretcher leveled steel welded into a rigid, self-supporting structure. Control panels shall be completely enclosed, welded construction, self-supporting, and gasketed dust tight.

1. Panels mounted outdoors or in below-ground vaults shall be NEMA 4X 316L stainless steel.

Exception:

- *Unless indicated otherwise in the Plans.*

2. Panels mounted indoors shall be NEMA 1 gasketed.

Exception:

- *Unless indicated otherwise in the Plans.*

B. HINGES AND HINGE PINS

1. Provide full length (continuous) piano hinges rated for 1.5 times the weight of the door plus all door-mounted instruments.

2. Hinges shall be welded to all surfaces and shall match the metallurgy of the enclosure.

3. Hinge pins shall be 316L stainless steel on all panels.

C. MOUNTING FEET

If called for, mounting feet shall be the height indicated on the Plans and shall be made of the same material as the enclosure body that it supports.

2.2 CONTROL PANEL POWER DEVICES

A. FUSES

1. Power Circuit Fusing

Reference Specification 16410, Enclosed Switches, Fuses, and Circuit Breakers.

2. Control Power Fusing

Control power fuses are FRN for ratings above 10 amperes and FNQ for 10 amperes and below. FRN fuses are mounted in phenolic blocks with a fuse puller mounted adjacent to them. FNQ fuse holders are DIN-rail mounted type, 12A, 300 V minimum, hinged to disconnect and replace fuse, with blown fuse indicating light. Label all fuseholders with fuse identification number and fuse size and type. Provide five spare fuses of each type and size in each panel. Provide box mounted on panel interior marked "SPARE FUSES" to hold the spares.

3. PLC I/O Field Connection Fusing

   a. 24 VDC Fusing

      i. Fuses for 24 VDC circuits shall be 5 x 20 mm, glass body, fast acting, 250 VAC, sized by the integrator unless specifically called in the Plans or Specifications.

      ii. Fuse holders for 24 VDC circuits shall be DIN-rail mounted type, provided in fusible terminal blocks, for 5 x 20 mm fuses, black, hinged to open, 10-57 VAC/VDC, with red LED blown fuse indicators, 30 AWG - #12 AWG, 15A.

   b. 120 VAC Fusing

      i. Fuses for 120 VAC circuits shall be 1/4" x 1-1/4", glass body, time-delay, 250 VAC, sized by the integrator unless specifically called in the Plans or Specifications.

      ii. Fuse holders for 120 VAC circuits shall be DIN-rail mounted type, provided in fusible terminal blocks, for 1/4" x 1-1/4" fuses, black, 100-300 VAC, with neon blown fuse indicators, #30 AWG - #12 AWG, 15A.

B. CIRCUIT BREAKERS

1. Power Circuit Breakers

   Reference Specification 16410, Enclosed Switches, Fuses, and Circuit Breakers.

2. Control Power Circuit Breakers

   Control power circuit breakers shall be DIN-rail mounted type, miniature, 240 VAC, single pole, 10 kAIC (minimum) @ 240 VAC, “C” curve (inductive) trip characteristics, 1,500 VAC dielectric strength (minimum), #14 to #12 AWG 75 degrees C line and load screw terminals, UL 489, CSA 22.2 No. 5.1; Allen Bradley Bulletin 1492-SPU Series A or equal.

C. DISCONNECT SWITCHES AND ACTUATORS

1. For Power Circuits > 30 Amps

Reference Specification 16410, Enclosed Switches, Fuses, and Circuit Breakers.

2. For Power Circuits <= 30 Amps

a. For Single Phase Circuits

Load disconnect switches shall be 2-position, OFF-ON, 90 degree, 600 VAC, 20 A or 32 A rating, single pole, front door installation; Allen Bradley 194L-E **aa**-1751 or equal, where **aa** = 20 for 20 A unit and **aa** = 32 for 32 A unit.

Associated switch actuators shall be OFF-ON, 90 degree, front/door installation, IP66 rated, 22.5 mm central hole mount, square, red/yellow handle with padlock provision, 48 mm x 48 mm; Allen Bradley 194L-HC4L-175I or equal.

b. For Three Phase Circuits

Load disconnect switches shall be 2-position, OFF-ON, 90-degree, 600 VAC, 20 A or 32 A rating, 4-pole, front door installation; Allen Bradley 194L-E **aa**-1754 or equal, where **aa** = 20 for a 20 A unit and **aa** = 32 for a 32 A unit.

Load disconnect switch actuators shall be OFF-ON, 90-degree, front/door installation, IP66 rated, 22.5 mm central hole mount, square, grey/black handle with padlock provision, 64 mm x 64 mm; Allen Bradley 194L-HC6E-175I or equal.

When being used as a 3 PH motor safety disconnect switch, reference Specification 16410, Enclosed Switches, Fuses, and Circuit Breakers.

D. SURGE PROTECTIVE DEVICES

1. For Power Circuits > 150 VAC and > 30 A

Reference Specification 16280, Surge Protective Devices.

2. For Control Power Circuits

Control power SPDs shall protect L-N, L-G and N-G and have a minimum peak surge current of 40kA, shall have terminals that accept a #12 AWG conductor, shall be rated for the voltage shown in the Plans, shall be listed, and shall have a terminal configuration with separate Line, Neutral, and Ground connections.

Control power SPDs shall meet Mil-Std-220 for maximum EMI/RFI attenuation.

Control power SPDs shall be DIN-rail mounted, 1-inch wide maximum.

Control power SPDs shall be Cooper Bossman #BSPMA1_S2GR or equal.

3. For Telecommunications

All incoming phone and internet services shall be provided with surge protection.

a. Intermatic IG2TM or equal for twisted pair copper.

b. Intermatic IG4TM or equal for coaxial cable.

E. UPS SYSTEMS

1. 24 VDC UPS Systems

24 VDC UPS Systems shall include the 24 VDC power supplies, the converters, batteries, and redundancy modules as described herein. Each of these devices shall be DIN-rail mounted, industrial rated, packaged, and listed. Custom-built circuits boards and loose electronic devices shall not be allowed. Provide a minimum of 30 minutes of backup time or that shown on the Plans, whichever is the greater.

a. A single 24 VDC UPS system shall include, as a minimum, the following devices:

i. 1x 24 VDC Power Supply;

ii. 1x 24/12 VDC UPS Controller;

iii. 1x 12 VDC Backup Battery.

b. A dual (paralleled) 24 VDC UPS systems shall include, as a minimum, the following devices:

i. 2x 24 VDC Power Supplies;

ii. 2x 24/12 VDC UPS Controllers;

iii. 2x 12 VDC Backup Batteries;

iv. 1x 24 VDC DC Redundancy Module.

The minimum DC UPS system shall be capable of providing 10 Amps at 24 VDC continuously. The specifications listed below are for a minimum system. Increase the system ampacity as called on the Plans.

c. 24 VDC Power Supplies

24 VDC power supplies shall be 120 VAC input, 24 VDC output, 10 A minimum, with +/- 1 percent voltage regulation from no-load to full-load. Process power supplies shall be sized by the integrator and increased in size as required. Provide the power supply sizing calculations with the product submittal.

i. 10 A: PULS #QS10.241 or equal.

d. 24 VDC UPS Controllers

DC UPS controllers shall be 24-28 VDC normal input, 12 VDC battery input with a 24 VDC, 10 A output (minimum) and a 12 VDC, 5 A output, with indicating LEDs. The unit shall monitor the battery and provide a dry contact output to indicate that the battery should be replaced.

i. 24 VDC @ 10 A, 12 VDC @ 5A: PULS #UB10.245 or equal.

e. 12 VDC Backup Batteries

Batteries shall be fully sealed gel type. Batteries shall be rated for 12 Ah (minimum) and rated to operate between -40 degrees C to 60 degrees C.

f. DC Redundancy Module

DC Redundancy Modules provide parallel connectivity of two separate 24 VDC systems and are required on all dual 24 VDC supply systems.

Provide DC Redundancy module, 24 VDC/24 VDC input, 24 VDC output, 20 Amp; PULS YR2.DIODE or equal.

F. POWER MONITOR UNITS (PMU)

Power monitor unit shall be of the same manufacturer as the PLC. 3 phase power monitor units shall be complete with the following:

1. Current Transformers (CTs)

Mechanical and thermal ratings of transformers shall be coordinated with that of the equipment in which they are mounted. Basic impulse level shall be 10 kV and accuracy class shall be 0.3 for B-0.1, B-0.2, and B-0.5 burdens. A clearly visible nameplate shall give complete transformer characteristics.

Three independent current transformers shall be provided with 5 ampere secondary current at the primary current ratio indicated.

a. For new installations, provide doughnut style current transformers.

b. For existing installations, provide split core style current transformers.

2. Potential Transformers (PTs)

Potential transformers shall only be allowed for PMUs connected to circuits > 600 VAC. For < 600 VAC, provide PMUs that connect directly to the measured bus.

3. Fusing

   Provide all required fusing and fuse blocks.

4. The Power Monitor Unit

   The PMU shall have the following features and functions.

   a. Front panel mountable.

   b. Powered from the unit's PTs or directly off of the measured bus. A separate power source shall not be required.

   c. LED display or an LCD backlit display.

   d. Capable of transmitting measured data over the network type that is used by the PLC/HMI systems. All hardware and software shall be included to provide a complete and functional network interface.

5. Measurement Capabilities

   The PMU shall measure and transmit the following:

   - RMS Voltage line-to-line and line-to-neutral for all three phases with an accuracy of +/-0.3 percent of full scale.
   - RMS current per phase with an accuracy of +/-0.3 percent of full scale.
   - Real power (in kW), 3 Phase total with an accuracy of +/-0.6 percent of full scale.
   - Apparent power (in kVA), 3 Phase total with an accuracy of +/-0.6 percent of full scale.
   - Reactive power (in kVAR), 3 Phase total with an accuracy of +/-0.6 percent of full scale.
   - Power Factor (PF) with an accuracy of +/-1.0 percent of full scale.
   - Frequency in Hertz with an accuracy of +/-0.2 percent of full scale.

- Voltage Total Harmonic Distortion in Percent to the 31st harmonic.
- Current Total Harmonic Distortion in Percent to the 31st harmonic.
- RMS Average Current.
- RMS Average Voltage.
- kW-Hours.
- kVAR-hours.
- Peak Average kW with date/time stamp.
- Peak Average kVA with date/time stamp.
- Peak Average kVAR with date/time stamp.
- Peak kW Demand with date/time stamp.
- Peak kVAR Demand with date/time stamp.
- Peak Maximum Current for each phase with date/time stamp.
- Peak Maximum Voltage for each phase with date/time stamp.
- Peak Minimum Voltage for each phase with date/time stamp.

6. Annunciation

The PMU shall provide an instantaneous dry contact Form C alarm that transitions under any selectable combination of the following conditions:

- Phase Loss.
- Phase Reversal.
- Phase Imbalance (with adjustable setpoint and time delay).

- Overvoltage (with adjustable setpoint and time delay).
- Undervoltage (with adjustable setpoint and time delay).
- Overcurrent (with adjustable setpoint and time delay).

G. PHASE MONITOR RELAYS (PMRS)

1. PMRs shall only be used on 3 phase power systems and shall be compatible with the voltage configuration as shown on the Plans. For 240 VAC 3 phase systems, the high leg shall be phase B.

2. PMRs shall monitor the following conditions and provide the ability to adjust trip values and time delays as described below:

   a. Phase Loss

      i. Trip not adjustable

      ii. Time delay not adjustable, fixed at 100 msec.

   b. Phase Reversal

      i. Trip not adjustable

      ii. Time delay not adjustable, fixed at 100 msec.

   c. Phase Unbalance

      i. Trip adjustable, set at 10 percent

      ii. Time delay not adjustable, fixed at 2 seconds.

   d. Under voltage

      i. Trip adjustable, set at 80 percent of nominal voltage

      ii. Time delay adjustable, set at 5 seconds.

   e. Overvoltage

      i. Trip not adjustable, fixed at 110 percent of nominal voltage

ii. Time delay not adjustable, fixed based on inverse time.

3. PMRs shall be provided with 1x SPDT (Form C) dry isolated contact that transitions when thresholds are exceeded for time delays described above.

4. PMRs shall be: Automation Direct, Prosense, PMRU-1C-480A or equal.

H. MOTOR START COUNTERS/MOTOR RUN TIME (ELAPSED TIME) METERS

When the control panel contains motor starters, start counter and run time meter shall be a combination electromechanical device. Eaton CEC-55PM-406 or equal. Battery backed LCD displays shall not be used. Refer to Specification 16420, Motor Controllers.

I. CURRENT TRANSFORMERS

Current transformers are 1 percent accuracy at burden and lead length as installed. G.E., Midwest, Westinghouse or Hawkeye.

J. AMMETERS

Ammeters are ±2 percent accuracy, 2-1/2-inch size GE, Simpson, Weston, or Crompton.

K. ANALOG CURRENT TRANSMITTERS

Loop powered 4-20 mA solid core current transducer for currents up to 200 A. Hawkeye H721 Series or equal.

2.3 CONTROL PANEL CONTROL DEVICES

A. PILOT LIGHTS

1. Pilot lights shall be heavy duty, Class 9001, Type J, NEMA 4 (watertight) and NEMA 13 (oil-tight), metal collar, push-to-test, multi-segmented LED with red, green, amber, blue, clear, white, or yellow colored caps as shown on the Plans.

a. Allen-Bradley

b. Cutler-Hammer

c. General Electric

d. Siemens

e. Square D

B. PUSH BUTTONS

1. Push buttons shall be heavy duty, Class 9001, Type K, UL Types 4 and 13, NEMA 4 (watertight) and NEMA 13 (oil-tight), metal collar, non-illuminating, with full button guard. Contact block shall be provided with 1 N.O. and 1 N.C. contacts minimum with the ability to stack additional blocks. Provide additional blocks as required.

   Pushbutton actuators may be standard, mushroom head, recessed (flush collar), or deep recessed (deep collar) as required.

   a. Allen-Bradley

   b. Cutler-Hammer

   c. General Electric

   d. Siemens

   e. Square D

C. SELECTOR SWITCHES

1. On-Off Selector Switches

   ON-OFF selector switches shall be Class 9001, Type K, UL types 4 and 13, NEMA 4 (watertight) and NEMA 13 (oil-tight), metal collar, non-illuminating push button contact blocks with 2-position operators and standard knob. Contact block shall be provided with 2 N.O. and 2 N.C. contacts minimum with the ability to stack additional blocks. Provide additional blocks as required.

   The 2-position operator shall be manual rotation to left and manual rotation to right. Two contact block stacks shall be provided. In both contact block stacks, one set of contacts is closed in the left position and open in the right position. In both contact block

stacks, one set of contacts is closed in the right position and open in the left position.

a. Allen-Bradley

b. Cutler-Hammer

c. General Electric

d. Siemens

e. Square D

2. Hand-Off-Auto (HOA) Selector Switches

HOA selector switches shall be Class 9001, Type K, UL types 4 and 13, NEMA 4 (watertight) and NEMA 13 (oil-tight), metal collar, non-illuminating push button contact blocks with 3-position operators and standard knob. Contact block shall be provided with 2 N.O. and 2 N.C. contacts minimum with the ability to stack additional blocks. Provide additional blocks as required.

The 3-position operator shall be manual rotation to left and right from center and manual return back to center. Two contact block stacks shall be provided. In both contact block stacks, one set of contacts is closed in the left position and open in the center and right positions. In both contact block stacks, one set of contacts is closed in the right position and open in the center and left positions.

a. Allen-Bradley

b. Cutler-Hammer

c. General Electric

d. Siemens

e. Square D

3. Reset-Off-On Selector Switches

RESET-OFF-ON selector switches shall be Class 9001, Type K, UL types 4 and 13, NEMA 4 (watertight) and NEMA 13 (oil-tight), metal collar, non-illuminating push button contact

blocks with 3-position operators and standard knob. Contact block shall be provided with 2 N.O. and 2 N.C. contacts minimum with the ability to stack additional blocks. Provide additional blocks as required.

The 3-position operator shall be manual rotation to left and right from center, spring return from left to center and manual return from right to center. Two contact block stacks shall be provided. In both contact block stacks, one set of contacts is closed in the left position and open in the center and right positions. In both contact block stacks, one set of contacts is closed in the right position and open in the center and left positions.

a. Allen-Bradley

b. Cutler-Hammer

c. General Electric

d. Siemens

e. Square D

D. RELAYS

Regardless of the technology of a relay's control (from simple to programmable), the relay's output technology shall be the electro-mechanical type. Electronic outputs (triacs, thyristors, transistors, etc.) shall not be allowed.

Exceptions:

- *Unless specifically shown otherwise on the Plans.*
- *Unless approved in writing by the Engineer.*

1. Contactor relays

Contactor relays for switching 120 VAC power circuits including, but not limited to, lighting, solenoid valves, and small motors shall be electro-mechanical machine tool, heavy-duty type, NEMA rated, with 120 VAC/24 VDC coils and double-break contacts rated at 20 A at 250 VAC. Equip relays with surge suppressers. IEC rated relays are not permitted.

2. Control relays

   Control relays for logic control circuits shall be permitted to be miniature "ice cube" type DPDT or 4PDT with 24V or 110-120V AC/DC coils with a mechanical life of 20 million operations minimum and an electrical life of 1 million operations minimum at 1 amp. The dielectric strength between the coil and contacts shall be 2,000 VAC for 1 minute. Contacts shall be rated at 10A at 250 VAC, 10A at 30 VDC. Relays shall have a maximum pickup and release time of 25 milliseconds and a minimum drop voltage of 30 percent of the rated voltage. Relays shall include non-polarized LED coil indictors. Relays shall be IDEC, P&B/Tyco or equal.

3. Alternating relays

   Alternating relays shall have 24 VDC or 120 VAC coils as required for the application.

   a. Duplex Alternating Relays

      2-state alternating relays shall be DPDT with the transition between states occurring on loss of power to the coil.

   b. Triplex Alternating Relays

      Triplex alternating relays shall operate on 3 switch inputs, with the loads falling out in the reverse order of their pull-up. Relays shall be octal socket type with 120 VAC or 24 VDC coils. Contacts shall be rated at 3 A at 24/120 VAC with a full load electrical life of 100,000 operations and a mechanical life of 10,000,000 operations.

      Relays that operate with a first-on, first-off control sequence shall not be allowed.

      Macromatic (Triplexor Only), #ATP120A1 (120 VAC coil) or #APT024A1 (24 VDC coil) or equal.

4. Time delay relays

   Time delay relays shall be electronic, programmable, multifunction type with a minimum of two Form C (DPDT) contacts rated at 10 A into resistive loads. Timers shall have a selectable timing range

from 0.05 seconds to 999 hours. The following features shall be provided on the front of the timer for easy and clear adjustability:

a. Function selection (type of delay function);

b. Time setting (3 digits);

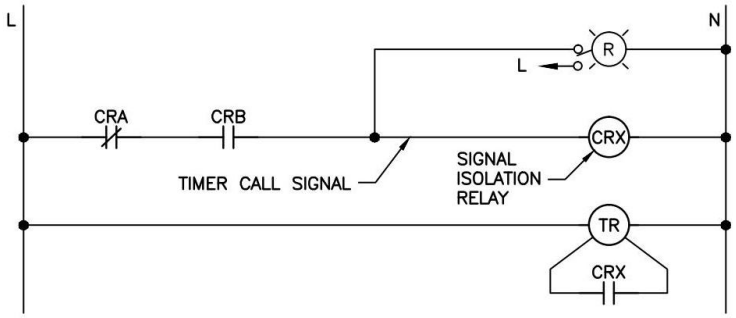
c. Timing range (seconds, minutes, hours);

d. Table showing the selectable functions;

e. LED indicator that indicates timing mode and time out condition.

On-delay timers (TDAE, Time Delay After Energization) shall be 8-pin octal socket style with 120 VAC or 24 VDC coils; Macromatic #TD-70222 and #TD-70228 respectively.

Off-delay timers (TDAD, Time Delay After De-energization) shall be 11-pin socket style with 120 VAC or 24 VDC coils, requiring an isolated trigger (see figure below); Macromatic #TD-71622 and #TD-71628, respectively.



5. PLC 24 VDC Output Buffer Relays

PLC 24 VDC output buffer relays shall be miniature DIN-rail DPDT type with silver-nickel alloy contacts rated at 8 amps @ 250 VAC/30 VDC (resistive load), 4 amps @ 250 VAC/30 VDC (inductive load), and 100,000 operations at full rated load with a dielectric strength between contacts of 1,000 VAC for 1 minute.

The relay coil shall be 24 VDC, with a mechanical life of 50 million operations and a dielectric strength between the coil and contacts of 5,000 VAC for 1 minute. Relays shall have a maximum pickup time of 15 milliseconds and release time of

10 milliseconds and a minimum drop voltage of 10 percent of the rated voltage.

Relays shall include a non-polarized LED coil indicator.

Relays shall include a DIN-rail mounting socket, 0.625-inch wide maximum with finger-safe screw terminals and replacement locking lever. DPDT relays and sockets shall be stackable at 0.625 inch.

Relays shall be IDEC RJ2S-CL-D24 or exact equal.
Sockets shall be IDEC SJ2S-07L or exact equal.

6. PLC 120 VAC - to - 24 VDC Input Buffer Relays

PLC 120 VAC input buffer relays shall be miniature DIN-rail DPDT type with silver-nickel alloy contacts rated at 8 amps @ 250 VAC/30 VDC (resistive load), 4 amps @ 250 VAC/30 VDC (inductive load), and 200,000 operations at full rated load with a dielectric strength between contacts of 1,000 VAC for 1 minute.

The relay coil shall be 120 VAC, with a mechanical life of 30 million operations and a dielectric strength between the coil and contacts of 5,000 VAC for 1 minute. Relays shall have a maximum pickup time of 15 milliseconds and release time of 10 milliseconds and a minimum drop voltage of 30 percent of the rated voltage.

Relays shall include a non-polarized LED coil indicator.

Relays shall include a DIN-rail mounting socket, 0.625-inch wide maximum with finger-safe screw terminals and replacement locking lever. DPDT relays and sockets shall be stackable at 0.625 inch.

Relays shall be IDEC RJ2S-CL-A120 or exact equal.
Sockets shall be IDEC SJ2S-07L or exact equal.

E. LEVEL INDICATOR/SETPOINT CONTROLLERS (LICs)

For processes using setpoint controllers for level control, such as wet wells and reservoirs, the following specifications shall apply.

1. 120 VAC or 24 VDC power (as shown on the Plans).

2. 4-20 mA or 0-10 VDC analog input (as shown on the Plans).

3. 16-point scaling for non-linear processes.

4. Four setpoint outputs, each with its own separate “SET” and “RESET” setoints.

5. Panel mount configuration.

6. LICs shall be Red Lion PAXP Process Input Panel Meters with PAXCDS Quad Setpoint Relay Output Card or equivalent.

F. THERMAL SETPOINT CONTROLLERS/TRANSMITTERS

1. Motor Winding Temperature Monitoring and Alarming Thermal Setpoint Controllers shall be:

   a. 2-wire, 3-wire, and 4-wire Ni100 and Pt100 RTD compatible;

   b. B, E J, K, N, R, S, T (ITS 90/IEC 584), L (DIN 43710) thermocouple compatible;

   c. Provide a linearized 4-20 mA isolated output;

   d. Provide an adjustable over- and under- temp Form A, 250 VAC, 500 VA (2 A) output contact;

   e. Provide line monitoring for sensor wire-break and short circuit;

   f. Capable of operating between 20 and 250 VAC input power;

   g. Provide galvanic separation of input circuits, output circuits, and power supply;

   h. Provide no more than 0.2 mA of sensor current;

   i. Provide galvanic separation of input circuits, output circuits, and power supply;

   j. Turck Interface Module, Ex-Temperature Measuring Amplifier, 1-Channle; Part Number IM34-12EX-RI or equal.

G. INTRINSICALLY SAFE BARRIERS

1. Intrinsically Safe Barriers, Analog (ISBAs)

   a. ISBAs shall be single-channel, 4-20 mA input, 2-wire, 4-20 mA output, loop powered with an ungrounded field circuit; R. Stahl P/N 9002/13-280-110-001, no exceptions.

   b. ISBAs shall provide electrical isolation between the input circuit, the output circuit, and the supply voltage.

   c. ISBAs shall transfer 4-20 mA or 0-10 VDC input signals without attenuation (1:1 throughput).

2. Intrinsically Safe Barriers, Digital (ISBDs)

   a. ISBDs shall be contact input, 2-channel, 2 x SPST, 2 Amp rated output (configurable N.O. or N.C.), universal supply voltage 20-250 VAC/20 – 125 VDC, UL-913 listed: Turck IM1-22Ex-R, PR Electronics 5202B2 or equivalent.

   b. ISBDs shall provide electrical isolation between the input circuit, the output circuit, and the supply voltage.

   c. ISBDs shall have programming switches to select if the output will operate in normally closed, normally open, or short circuit/wire break modes (fault detection mode). Disable the wire-break and short-circuit monitoring when using mechanical contacts as the input.

   d. ISBDs shall have an LED on the front cover to indicate the switching status of the digital device.

H. ETHERNET SWITCHES

Ethernet switches shall be industrial grade, 10/100 MB, DIN-rail mounted type, 24 VDC powered, 8-port; N-Tron 300 series or equal.

Exceptions:

- *If the requirement shown on the Plans is greater than 8 ports, then provide the higher value.*

- *Non-DIN-rail is acceptable if over 16 channels.*

I. AUTODIALERS

Autodialers shall be 8 channel, 8 phone number, with dial-out capability for power failure and low battery and shall include 20-hour internal backup batteries. The device shall operate at 12 VDC and include a 120 VAC to 12 VDC wall plug power supply.

Exception:

- *Provide 8 channel input or the number of channels as shown on the Plans, whichever is the greater.*

Antx Dialog Scout, or equal.

2.4 CONTROL PANEL ANCILLARY DEVICES

A. RECEPTACLES MOUNTED IN CONTROL PANELS

120 VAC power to convenience and device receptacle in control panels shall not be derived from the same panelboard circuit as that used for process control devices (PLC, flow meters, autodialers, DC power supplies, etc.).

1. Convenience Receptacles

Convenience receptacles in control panels are not dedicated and are intended for providing 120 VAC convenience power for non-motor-operated equipment.

Convenience receptacles shall be GFCI, 15 Amp, 125 VAC, duplex, white, in a DIN-rail mount, cast aluminum box. Stamped steel boxes shall not be used.

2. Device Receptacles

Device receptacles are dedicated for communication and control devices operating within the control panel on a continuous basis. These include devices with 120 VAC power packs like VPNs, Fiber-To-Voice Converters, Data-To-Voice Converters, etc.

Device receptacles shall be non-GFCI, 15 Amp, 125 VAC, duplex, white, in a DIN-rail mount, cast aluminum box. Stamped steel boxes shall not be used.

On Communication Patch Panels, these receptacle circuits can be extended with surge- and load-protected power strips.

3. Combination Port

The combination port shall consist of a simplex 120 VAC receptacle and a Category 5e ethernet port mounted on a single bulkhead.

The simplex receptacle shall have a placard stating “For Computer Use Only” along with the current rating. The current rating shall not be less than 3 A. If the receptacle rating is less than 15 A, the combination port shall have an integrated circuit breaker, operable without opening the enclosure, allowing the receptacle to be wired to an ordinary 15 A circuit.

The Category 5e ethernet port shall be a female RJ-45 connector, allowing an operator to connect a computer to the PLC over ethernet without opening the enclosure.

The bulkhead shall be a listed assembly. The bulkhead shall be installed in a manner that preserves the environmental rating of the enclosure. The bulkhead shall have a hinged cover that protects the combination port when not in use.

B. PANEL LIGHTING

For all panels designated on the Plans, provide an LED lighting package, under cabinet style, hardwired, 120 VAC, with integral door-activated ON/OFF switch.

120 VAC power to the panel light shall not be derived from the same Panelboard circuit as that used for process control devices (PLC, flow meters, autodialers, DC power supplies, etc.).

C. PANEL HEATER

Provide a panel heater with thermostat in each outdoor control panel and all panels designated on the Plans. Each heater shall include a DIN-rail mounted disconnect breaker and associated feedthrough and grounding terminals for connection to external 120 VAC line, neutral, and ground conductors. The heater and thermostat shall be prewired to these terminals and breakers.

The wattages shown below are minimum values. The Contractor shall size the panel heaters based on enclosure size, internal load heat generation, minimum operating temperature of devices in the enclosures, and minimum ambient temperature. Contractor shall include panel heating calculations with control panel submittals.

For panels with a front surface area greater than 11 square feet, provide a touch-safe, 550 watt minimum, 120 VAC panel heater with integral thermostat.

120 VAC power to panel heaters shall not be derived from the same Panelboard circuit as that used for process control devices (PLC, flow meters, autodialers, DC power supplies, etc.).

D. PANEL AIR CONDITIONING UNITS

Provide control panel air conditioners where specifically called out on the Plans. Size the AC unit to maintain an operating temperature below the specification of that device within the panel with the lowest "maximum allowed temperature." Present calculations to Engineering during Submittal.

E. PANEL COOLING FANS

Provide a panel cooling system in enclosures that contain motor starters, drives, PLCs, RTUs, and other electronic devices that can generate heat and have maximum operating temperature limits unless specifically shown otherwise in the Plans. The panel cooling system shall include one or more fans with a thermostat as a minimum. The cooling system shall be sufficiently sized to maintain an internal enclosure temperature below the maximum operating temperature of all internal devices.

Provide a thermostat for cooling, N.O. contact, adjustable setpoint range 32 to 140 degrees F, 15 Amp-rated contact at 120 VAC.

Cooling fans shall be configured to exhaust air. Vents shall be provided for supply air. Layout fans and vents in such a manner as to:

1. Maximize cooling of critical components;

2. Minimize air flow restriction;

3. Eliminate entry of water or dust particles into the enclosure.

Provide vent covers over fan and vent openings to eliminate rain and moderate washdown for all outdoor panels and all panels so designated on the Plans

Provide a “washdown filter” fan set, capable of eliminating sprayed water entry, stainless steel, 120 VAC, 310 CFM, 3.8 Amps max., 18" x 10" x 5".

120 VAC power to panel fans shall not be derived from the same panelboard circuit as that used for process control devices (PLC, flow meters, autodialers, DC power supplies, etc.).

F. TERMINAL BLOCKS

1. For Power Circuits > 30 Amps

   Terminations for power circuits greater than 150 V to ground or greater than 30 A shall be made using 600 VAC, listed, screw type, Power Distribution Blocks.

2. For Non-Fused Control, Instrumentation, and Power Circuits < 30 VDC, < 150 VAC, and <= 30 Amps

   Provide standard feed-through DIN-rail type IEC terminal blocks, single circuit, screw terminal type, #22 - #10 AWG, rated 600 V AC/DC at 30 A, white or grey; Allen Bradley Bulletin 1492-J4 series or equal.

   Exceptions:

   - *For equipment/chassis grounded circuits*

     Provide DIN-rail type IEC grounding blocks, single circuit, screw terminal type, #22 - #10 AWG, rated 600 V AC/DC at 30 A, green/yellow in color; Allen Bradley Bulletin 1492- WG6 or equal. These ground blocks shall be inherently connected to the din rail.

   - *For instrumentation cable shield terminations (reference Section 3.1.E)*

     Provide standard feed-through DIN-rail type IEC terminal blocks, single circuit, screw terminal type, #22 - #10 AWG, rated 600 V AC/DC at 30 A, blue; Allen Bradley Bulletin 1492-J4-B or equal.

5. Terminals used for digital and analog I/O field connections shall be grouped as shown in Section 3.1.E, FABRICATION, FIELD CONNECTIONS TO PLC I/O.

G. PANEL WIRING PRODUCTS

1. Power Circuit Wiring; Reference Specification 16120.

2. Control Circuit Wiring; Reference Specification 16120.

3. Analog PLC I/O Wiring

Signal cables connected completely inside control panels between analog input and output field terminal groupings and their associated PLC analog cards shall be #22 AWG, stranded, tinned copper, twisted pair, 300 V, 100 percent overall foil shielded cable with #22 AWG tinned copper drain wire; Belden #8451 or equal.

2.5 CONTROL PANEL ACCESSORIES

A. PANEL NAMEPLATES AND IDENTIFICATION

1. Identify each item on the control panel with rectangular nameplates.

2. Provide nameplates of rigid phenolic plastic laminate with engraved lettering or engraved metal plate with filled lettering. Use black background with white lettering.

3. Minimum letter height is 1/2 inch for instrument description and 1/4-inch height for instrument tag number.

4. Provide each panel with a 2-inch by 10-inch (minimum) nameplate with 1-inch-high lettering with panel identification.

5. Abbreviations are not permitted unless approved by the Owner or specifically shown on the nameplates, schedules, or plans.

6. Install nameplates plumb and parallel to the lines of doors or structure to which they are attached. Attach to the sheet metal structure by a thin coat of adhesive and sheet metal screws. Make adhesive and screw applications in such a manner as to avoid nameplate buckling or distortion due to use of excessive adhesive or over tightening of screws.

PART 3 INSTALLATION

3.1 FABRICATION

A. GENERAL

1. Control panels are factory or shop fabricated units completely assembled, wired, and tested before shipment to the job site.

2. Panel construction, in general, meets JIC EMP-1 standards and applicable NEMA and IEEE standards.

   Exception:

   - *Where open penetrations are required, such as for fans and vents, the NEMA rating of the panel may be modified to meet the intent of the design and fit the environment of the application. Verify the change of a panel's NEMA rating with the Engineer.*

3. The panels shall be constructed in accordance with Article 409 of the NEC and electrical testing laboratory standards and shall be so labeled (the standards of a recognized electrical testing laboratory).

4. Size panels for enclosed equipment and available space for mounting of panel or as shown on the Plans.

5. Panels shall be descaled, cleaned, and primed in preparation for painting. Painting shall consist of one coat of flat white enamel in the interior and two coats of hard finish exterior enamel, gray in color. Paint shall be suitable for field touch-up. Spare paint (1 quart) shall be provided for touch-up purposes.

   Exceptions:

   - *If the panel is to be used in eastern Washington, then the final outer coating shall be high gloss white.*

   - *Unless shown otherwise in the Plans stainless steel enclosures shall not be painted.*

6. Panel material, penetrations, etc. shall be verified for proper operation in their intended locations. Issues and concerns shall be brought to the attention of the Engineer prior to fabrication within or on the panel.

B. FREE-STANDING PANELS

1. Welded construction

2. Completely enclosed, self-supporting, and gasketed dust-tight.

3. Seams and corners welded and ground smooth.

4. Furnish doors with keyed alike locking handles and three point catch.

5. Provide each panel with lifting eyebolts. Furnish stainless steel base channels.

6. Slotted bolt holes in base, 1-1/2 long for field adjustment.

C. COMPONENT INSTALLATION

1. Minimize welding to panel fronts and avoid distortion of panel metal.

2. Reinforce around areas of the enclosure weakened by openings or mounting of heavy equipment/components.

3. Accurately and cleanly cut or nibble cutouts and finish free of sharp edges or burrs. Make cutouts plumb, level, and on-line vertically or horizontally within 1/32 of an inch where components are in rows or columns.

4. Provide minimum 1-5/8-inches spacing between horizontal rows of externally mounted components; 1-1/2 inches minimum between vertical columns of components.

5. The distance from the bottom row of components to the floor shall be not less than 36 inches, unless specifically shown as less. In general, all indicating lights, pushbuttons, etc., shall be mounted in accordance with the sequence of operation from left to right and top to bottom.

6. Provide minimum 1/4-inch spacing between components mounted on the panel sub-plate, Provide minimum spacing between the component and the wire duct of 1-1/2 inches above, and 1 inch below.

7. Components mounted in the interior shall be fastened to an interior subpanel using machine screws plus adhesive to ensure vibration-free attachment.

8. Interior component mounting and wiring shall be grouped as much as possible by function and then by component type. Interiors shall be so arranged that control relays, terminal blocks, fuses, etc., can be replaced or added without disturbing adjacent components.

9. AC UPS systems and associated batteries shall be mounted on a shelf specifically sized and braced for the UPS system. This rack shall assure that the UPS system is not resting on the bottom of the Control Panel and that no part of the UPS system blocks, or in any other way interferes with devices, terminals, or wireways that are not specifically a part of the UPS system. The shelf shall have a raised lip around all sides that are not in contact with a wall. The bottom of the shelf shall be at least 4 inches above the bottom of the enclosure (this provides a free flow of cables and conductors from conduits entering the bottom of the panel). Straps shall be provided to secure the UPS to the shelf.

   If insufficient room is available on the panel's backplane, then mount the shelf to the inside of the door. When mounted on the door, secure all cables to the door in such a manner that assures:

   a. Highly reliable secured connections to the UPS (not affected by movement of the door),

   b. Free and unencumbered door movement,

   c. Door movement does not stress the cables.

10. Open batteries provided to support DC UPS systems shall be mounted on 316L stainless steel shelves and provided with non-conducting bracing straps to firmly hold the battery in place. The shelves shall have a raised lip around all sides that are not in contact with a wall. The bottom of the shelf shall be at least 4 inches above the bottom of the enclosure.

    Batteries provided with manufacturer's mounting systems do not require additional stainless steel shelving.

D. PANEL WIRING METHODS

1. Provide panel wiring sizes and colors per Specification 16120.

2. Provide PLC analog and digital input and output circuit field terminations and wiring methods per Section 3.1.E.

3. Field wiring terminations to control panel terminal strips shall be connected as shown on the Plans. Cable shields or "drain" wires shall be terminated as per manufacturer's recommendations.

4. Provide a chassis-connected equipment ground bus at the bottom of PLC control panels.

5. Provide an isolated ground bus, dedicated solely for analog shield connections, adjacent to the equipment ground bus. Provide a separate and dedicated #10 AWG minimum, green-insulated ground wire from the Panelboard ground bus to the isolated ground bus.

6. Provide raceways for panel wiring.

    a. Size raceways per the requirements of NEC.

    b. Provide panel wireways between each row of components, and adjacent to each terminal strip.

    c. Wireways are a minimum of 1-inch wide and 3-inches deep with removable snap-on covers and perforated walls for easy wire entrance. Wireways shall be constructed of non-metallic materials with a voltage insulation in excess of the maximum voltage carried therein Panduit type LG, Panel Channel or equal

7. Run wires neatly in wiring duct tied and bundled with tie wraps or similar materials.

8. Provide wire bending space per NEMA ICS 6.

9. Label wiring within the panel with wire numbers using the same number on both ends of the wire. Identify each wire termination, including long jumpers, with wire markers. Arrange wire labels to permit reading of identification when installed.

10. Connect wiring internal to the panel to one side, leaving the opposite side for field terminations. Connect no more than two wires to any one control terminal point.

11. Arrange wiring inside the panel to separate instrumentation cables, conductors, and terminals at least 12 inches from 120 VAC power and control circuits.

12. Connect electrical equipment grounds to the chassis grounding bus.

13. Provide necessary power supplies for control equipment.

E. WIRE TERMINATION METHODS

1. Power conductors terminated on Power Distribution Blocks shall be covered with the block manufacturer's transparent cover and a caution sticker stating the voltage and available bolted fault current.

2. Terminate one end of all instrumentation cable shields to blue isolated-ground terminals (reference Section 2.4.E).

3. Provide fused terminals as shown on the Plans or defined herein. Reference Section 2.2 for materials

4. Terminals used for 4-20 mA analog input and output circuits shall be grouped as shown herein. This grouping shall be provided for each analog input and output connected to a PLC, whether assigned or unassigned (spare).

5. Provide terminal strips for the termination of panel wiring not directly connected to panel mounted devices.

6. Terminals shall facilitate wire sizes as follows:

   a. 120 VAC applications: Wire size 12 AWG and smaller.

   b. Other: Wire size 14 AWG and smaller.

7. Tag each I/O terminal to indicate tag number of the connected device or wire.

8. Provide 20 percent excess terminals (minimum) for future expansion.

9. Provide a minimum of 1.5 inches between terminal strips and wireways or between terminal strips.

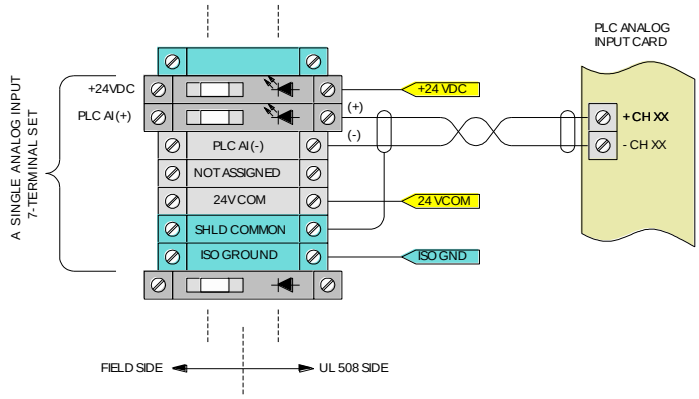
F. FIELD CONNECTIONS TO PLC I/O

1. Analog Input, Termination and Connectivity

Each 4-20 mA PLC analog input shall be connected to a 7-terminal grouping as shown below and as detailed on the Analog Loop Diagrams on the Plans whether the input channel is assigned or unassigned (spare) and whether the input is single-ended, differential, or isolated. No chassis-grounded terminals shall be used. Reference table below.

7-Terminal Analog Input Grouping, Terminal Assignments

Internal Panel Connections	Clarification	Terminal Type and Color
+24VDC	+ 24 VDC Power	Fused, Black
PLC AI (+)	PLC Analog Input, +	Fused, Black
PLC AI (-)	PLC Analog Input, -	Feedthrough, Gray
NOT ASSIGNED	2-Device Connection	Feedthrough, Gray
24VCOM	24 V Common	Feedthrough, Gray
SHLD COMMON	Shield Common	Feedthrough, Blue
ISO GROUND	Isolated Ground	Feedthrough, Blue



All connections on the UL 508 side are the same, regardless of the type of field connection.

Bundle all analog input terminal groups in the same sequence as the analog input cards and channels.

Maintain a minimum of 12 inches between analog terminal groups and AC power circuits.

The shields shall be connected at the terminal block-end only. Shields shall not be connected at the PLC cards.

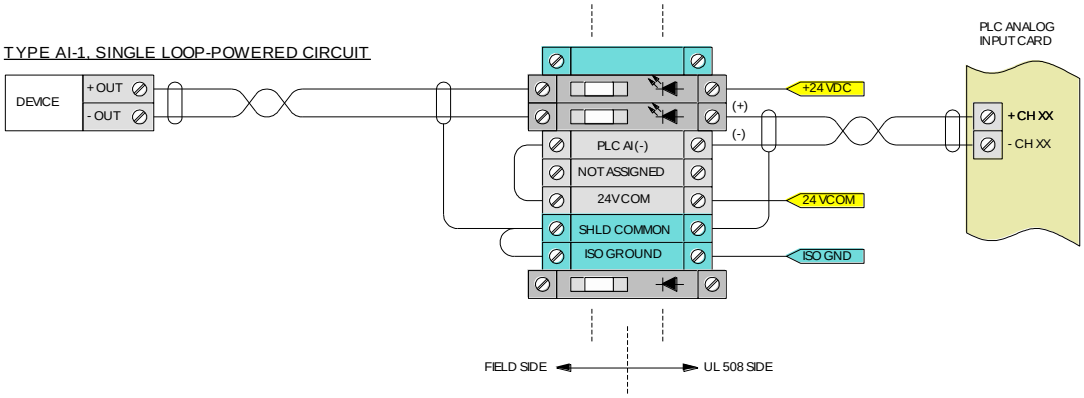
No additional 24 VDC fusing is to be provided.

For cable type between terminal groupings and analog input PLC cards, reference Section 2.4.F.

2. Analog Input, 7-Terminal Connection Methods

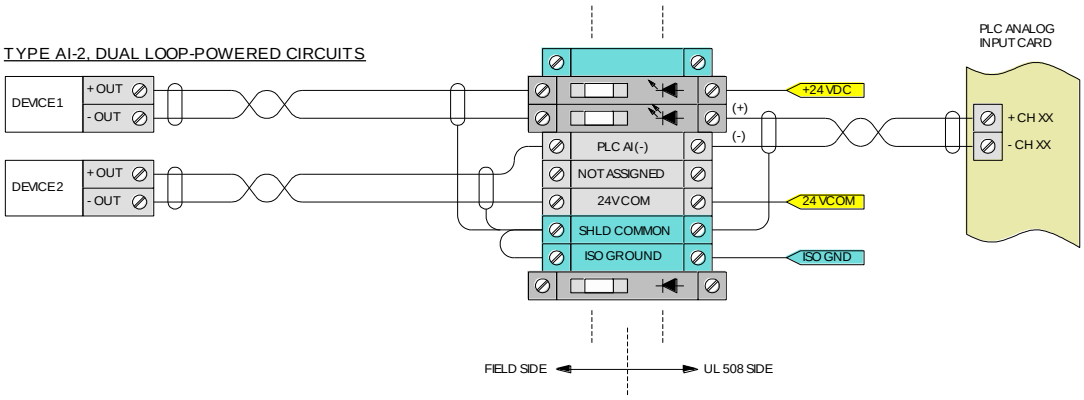
a. Field Connection **TYPE AI-1**, connection to a single loop-powered field device

The Figure below shows the method of connecting a PLC analog input to a single loop-powered field device using a 7-terminal standard analog input terminal group.



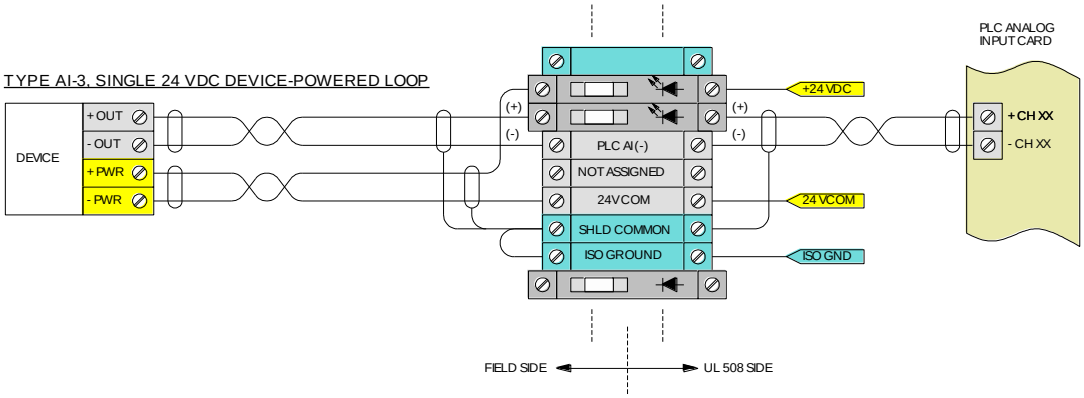
b. Field Connection **TYPE AI-2**, connection to two loop-powered field devices

The Figure below shows the method of connecting a PLC analog input to two loop-powered field devices using a 7-terminal standard analog input terminal group.



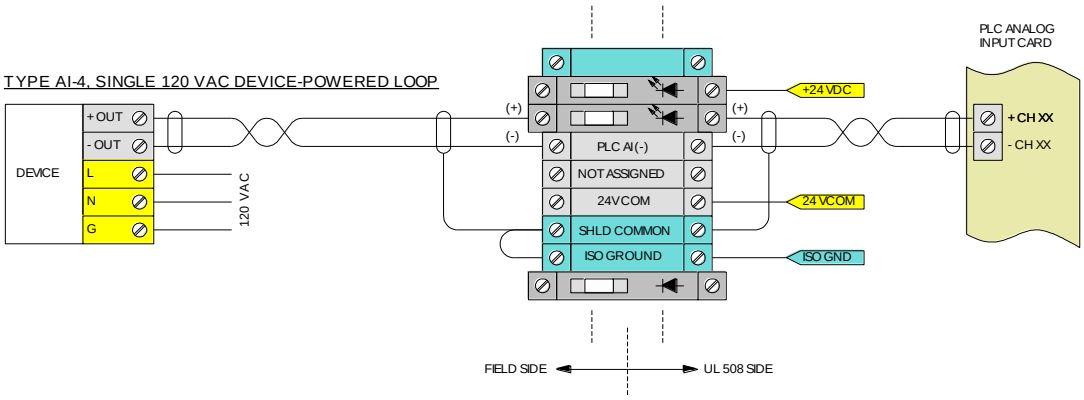
c. Field Connection **TYPE AI-3**, connection to a single 24 VDC device-powered field device

The Figure below shows the method of connecting a PLC analog input to a single 24 VDC device-powered field device using a 7-terminal standard analog input terminal group. Device power is provided by the control system power.



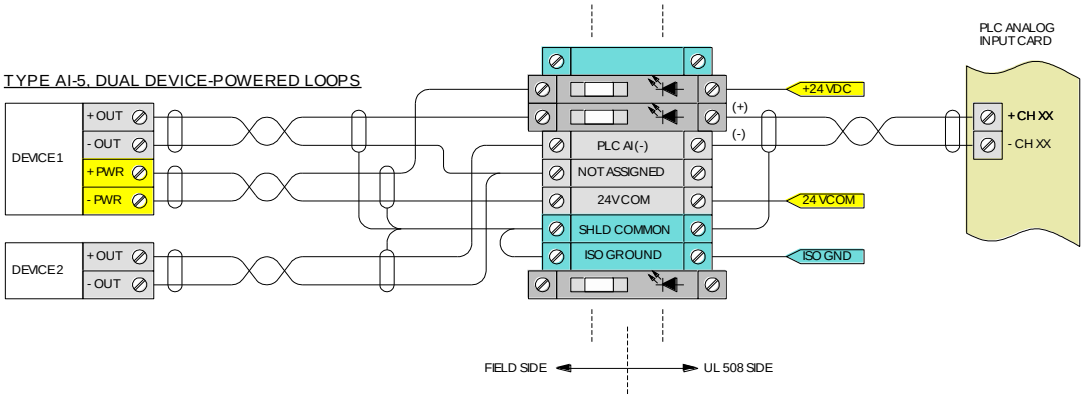
d. Field Connection **TYPE AI-4**, connection to a single 120 VAC device-powered field device

The Figure below shows the method of connecting a PLC analog input to a single 120 VAC device-powered field device using a 7-terminal standard analog input terminal group.



e. Field Connection **TYPE AI-5**, connection to a set of 24 VDC device-powered and loop-powered field devices

The Figure below shows the method of connecting a PLC analog input to two field devices, with at least one requiring 24 VDC device power using a 7-terminal standard analog input terminal group. Device power is provided by the control system power.

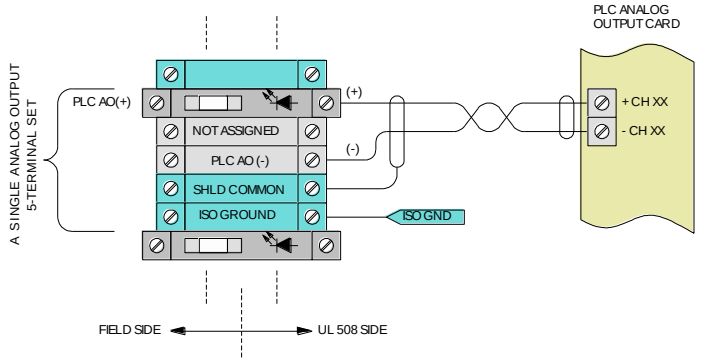


3. Analog Output, Termination and Connectivity

Each 4-20 mA PLC analog output channel shall be connected to a 5-terminal grouping as shown below and as detailed on the Plans whether the input channel is assigned or unassigned and whether the output is isolated or not. No chassis-grounded terminals shall be used. Reference table below.

5-Terminal Analog Input Grouping, Terminal Assignments

Internal Panel Connections	Clarification	Terminal Type and Color
PLC AO(+)	PLC Analog Output, +	Fused, Black
NOT ASSIGNED	2-Device Connection	Feedthrough, Gray
PLC AO(-)	PLC Analog Output, -	Feedthrough, Gray
SHLD COMMON	Shield Common	Feedthrough, Blue
ISO GROUND	Isolated Ground	Feedthrough, Blue



All connections on the UL 508 side are the same, regardless of the type of field connection.

Bundle all analog output terminal groups in the same sequence as the analog output cards and channels.

Maintain a minimum of 12 inches between analog terminal groups and AC power circuits.

The shields shall be connected at the terminal block-end only. Shields shall not be connected at the PLC cards.

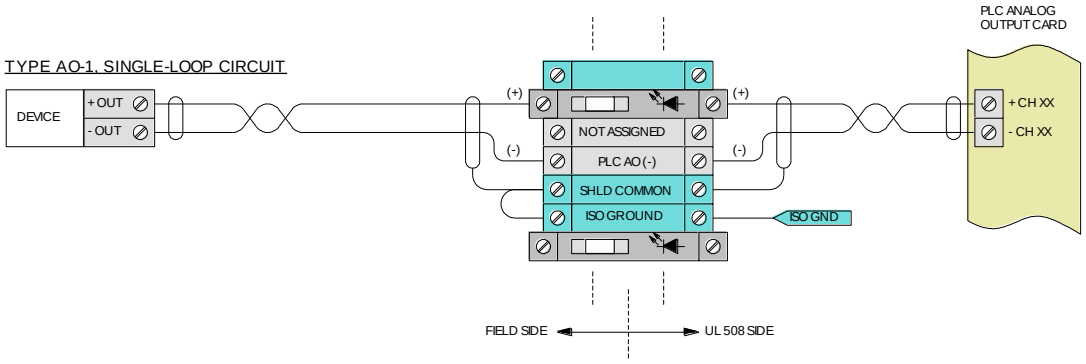
No additional 24 VDC fusing is to be provided.

For cable type between terminal groupings and analog input PLC cards, reference Section 2.4.F.

4. Analog Output, 5-Terminal Connection Methods

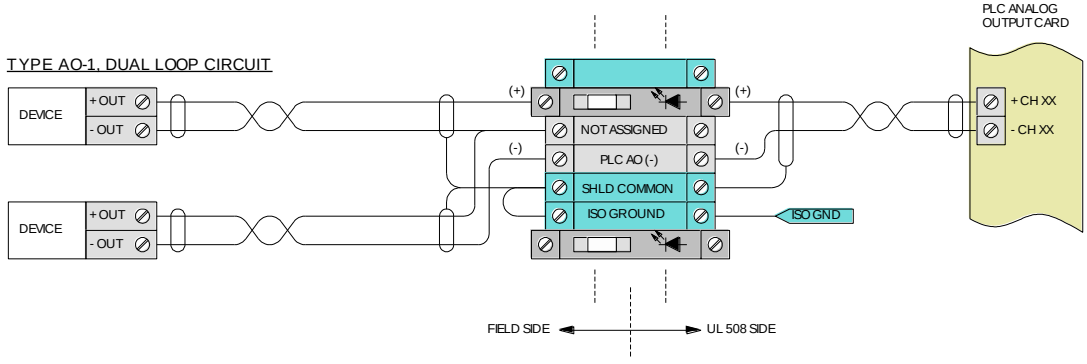
a. Field Connection **TYPE AO-1**, connection to a single field device

The Figure below shows the method of connecting a PLC analog output to a single field device using a 5-terminal standard analog output terminal group.



b. Field Connection **TYPE AO-2**, connection to two field devices

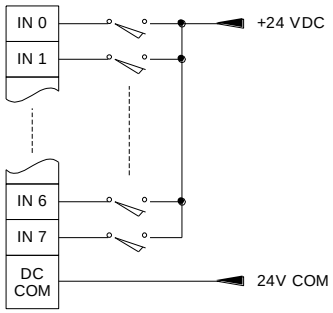
The Figure below shows the method of connecting a PLC analog output to two field devices using a 5-terminal standard analog output terminal group. These devices can be loop-powered or device powered.



5. Digital Input, Termination and Connectivity

a. Digital Input Type

All digital inputs shall be the "sinking" type as shown below. Reference Specification Section 13450, Programmable Logic Controller (PLC) Hardware.



1/2 OF 24 VDC, 16 CHANNEL PLC
DIGITAL SINKING INPUT CIRCUIT

b. Digital Input Fusing to Field Circuits

Provide fusing for each field-connected digital input. A single fuse shall be used for a group of field inputs from a common remote panel providing that the inputs are connected to the same input card. A common fuse shall not be used for separate cards.

Separate fuses shall be provided for field inputs that are not terminated in a common remote panel.

Provide a separate fuse for each set of 4 unassigned (spare) Digital Inputs.

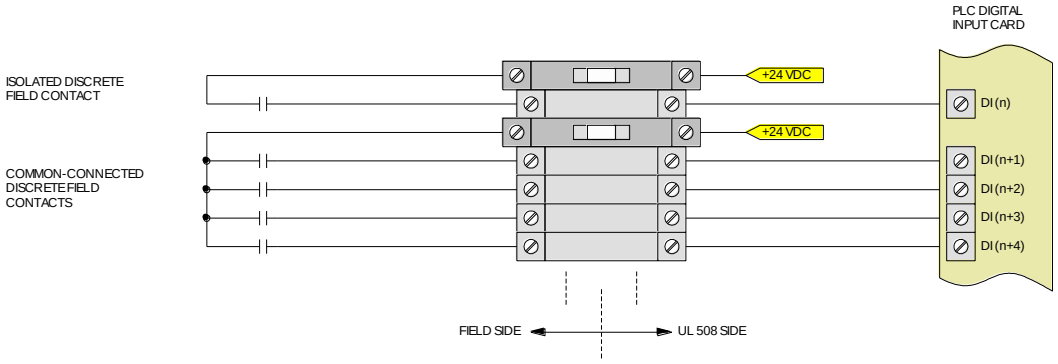
Fuses shall be 0.5 Amp.

Provide a separate gray feedthrough terminal for each digital input channel whether the input channel is assigned or unassigned.

c. Digital Input Connection Methods

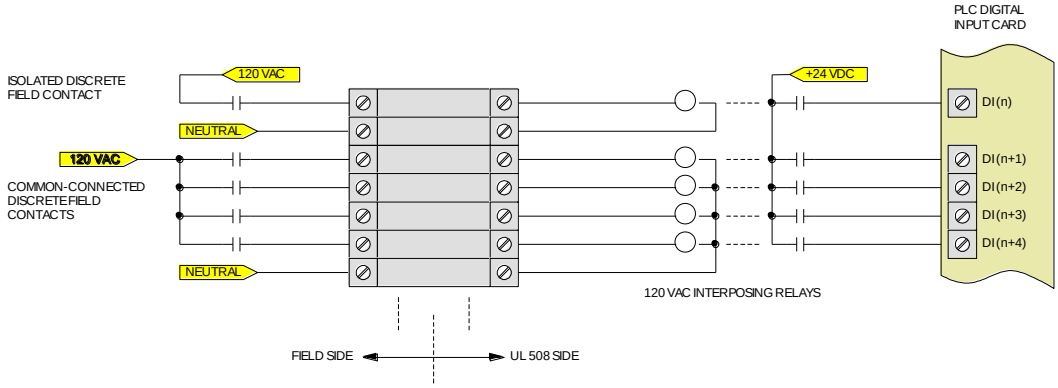
i. Connections to “Dry” Field Contacts

Discrete input field devices with dry Form A or Form B contacts sharing a common cabinet or piece of equipment may be combined into a group sharing a single +24 VDC fused common as shown below.



ii. Connections to “Hot” (wet) 120 VAC Field Circuits

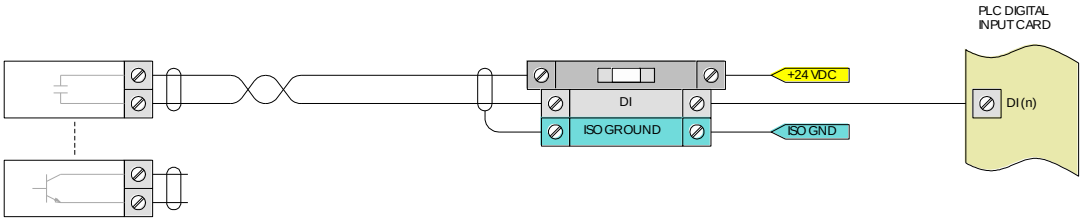
Digital inputs derived from 120 VAC "hot" circuits shall be buffered through interposing relays inside the PLC control panel prior to connection to the 24 VDC Digital Input PLC cards in a manner shown in the Figure below. Reference “PLC 120 VAC - to - 24 VDC Input Buffer Relays” in Section 2.2 for relay product type.



iii. Digital Pulse Inputs

Digital pulse inputs shall be either dry Form A or Form B contacts or active open-collector circuits as

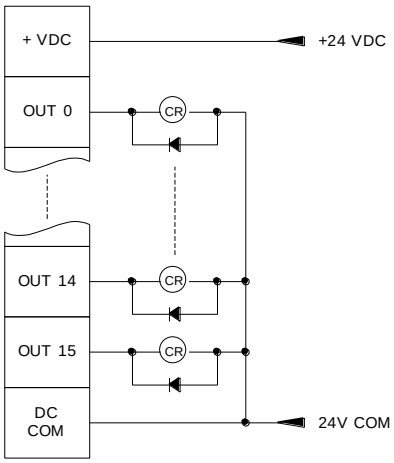
shown in the Figure below. The +24 VDC power shall be provided by the 24 VDC control system power and shall be separately fused.



6. DIGITAL OUTPUT, Termination and Connectivity

a. Digital Output Type

All digital outputs shall be the "sourcing" type as shown below. Reference Specification 13450, Programmable Logic Controller (PLC) Hardware.



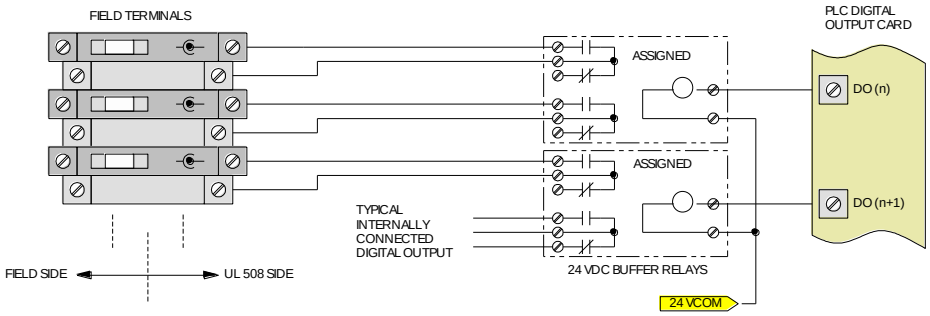
24 VDC, 16 CHANNEL PLC
DIGITAL SOURCING OUTPUT CIRCUIT

b. Digital Output Buffer Relays

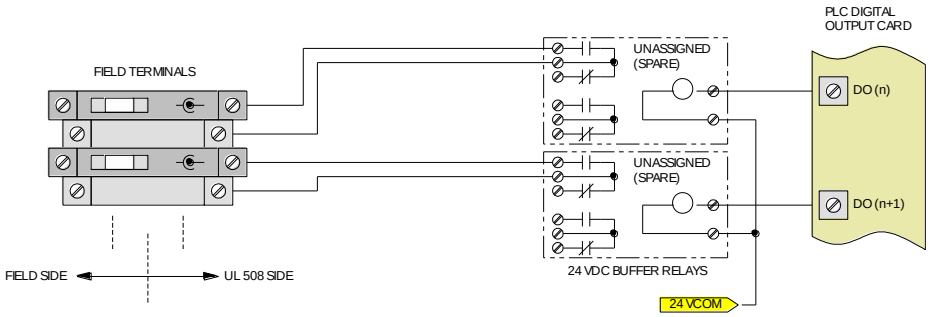
All 24 VDC digital outputs, even if unassigned (spare), shall be buffered through a DPDT (minimum) interposing relay prior to being connected to other internal circuits or field terminals. 4PDT relays shall be provided where shown on wiring diagrams. Reference "PLC 24 VDC Output Buffer Relays" in Part 2 for product type.

Internally connected buffered outputs shall not be fused.

Assigned digital outputs shall be assigned to single or double fused output terminal pairs as shown in the Figure below.



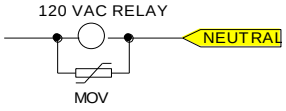
All unassigned digital outputs shall be buffered to a single fused output terminal pair as shown in the Figure below.



G. RELAY COIL SURGE SUPPRESSION

1. 120 VAC Coil Surge Suppression

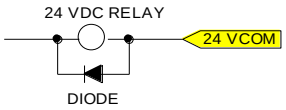
All 120 VAC coils shall be paralleled by a Metal Oxide Varistor (MOV) type surge suppressor as shown in the Figure below. The suppressor shall be connected directly across the relay socket coil terminals with short wire leads.



2. 24 VDC Coil Surge Suppression

All 24 VDC coils shall be paralleled by a reverse-connected shunt diode as shown in the Figure below. The diode shall be connected

directly across the relay socket coil terminals with short wire leads. The diode shall be rated at 1A, 100 PIV minimum.



3.2 SOURCE QUALITY CONTROL

A. Submit a shop test plan indicating how the test will be conducted, and how the system will be verified.

B. Revise all plans upon completion of the work to show the "as shipped" condition of the panel.

C. Allow for the owner and engineer to witness the shop test. Provide a minimum of 15-days' notice prior to the test.

D. Provide a shop test after factory completion and prior to shipment.

1. Test Documentation

   a. Provide a testing procedure and submit to the Engineer at least 1 week prior to the shop test.

   b. Document all required corrections, even those that may be remedied during the shop test.

   c. Issue a copy of the test procedures and necessary corrections to the General Contractor and the Engineer.

   d. Make all necessary corrections before shipping any panels, equipment, or devices to the job site.

   e. Issue a final signed document verifying that each correction has been made.

2. PLC Control Test

   a. Conduct a burn-in period (minimum of 2 days) where the system is operated continuously and checked for proper operation.

b. Utilize simulated I/Os to verify proper operation. Demonstrate the operation of each digital and analog I/O point.

c. Demonstrate compete connectivity and data transfer over the process control network. Verify the operation of all motor starters and remote devices monitored and controlled over the network.

d. Provide a computer and the software required for testing such that the owner may view the simulation of operator entries of field parameters such as set points and alarm values during the test.

3. Relay and Process Controller Test

a. Demonstrate the complete operation of the relay logic, backup logic, process controllers, etc.

4. Motor Starter Test

a. Demonstrate the complete operation of all motor starters. Connect a portable motor to each starter and operate the motor in HAND, OFF, and AUTO modes. Demonstrate the proper operation of all motor safety interlocks.

b. Preprogram all motor starter Human Interface Modules (HIMs) for compliance with motor manufacturer's protection criteria and compliance with the design engineer's control requirements.

5. Other Tests

a. Provide normal operating voltage to all equipment. Demonstrate the operation of all equipment while under power.

b. The entire assembled panel shall be tested to be free from grounds and shorts.

c. Controllers, circuits and interlocks shall be rung out and tested to ensure that they function correctly before the panel is shipped.

3.3 INSTALLATION

A. Install freestanding panels on concrete housekeeping pads.

B. Anchor panels rigidly in place with approved anchorage devices. If mounting details are shown on the Plans, then these methods shall be used.

***** END OF SECTION *****