

**ADDENDUM 1
TO THE CONTRACT PROVISIONS AND CONTRACT PLANS**

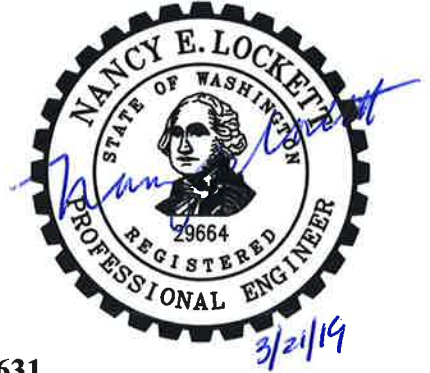
FOR

**CITY OF LONG BEACH
REGIONAL BIOSOLIDS FACILITY**

G&O #18522

ISSUED THIS DATE: THURSDAY, MARCH 21, 2019

**BID OPENING: 2:00 PM (LOCAL TIME) ON
TUESDAY, APRIL 9, 2019
CITY OF LONG BEACH
115 BOLSTAD AVENUE WEST
LONG BEACH, WASHINGTON 98631**



Bidder shall acknowledge receipt of this Addendum on Page P-4 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 CALL FOR BIDS

ITEM 1:

Page CB-2, Call for Bids

ADD the following before the last paragraph:

“A Prebid Conference is scheduled for Thursday, March 28, 2019. The conference will begin at the Wastewater Treatment Facility, 313 6th Street NE, Long Beach, Washington 98631 at 2:00 p.m. (local time). Prospective bidders are encouraged to participate. No other site visits shall be allowed.”

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

ITEM 1:

ADD the attached New Specification Section 16910 – PLC Hardware and Software Procurement

ITEM 2:

ADD the attached New Specification Section 16940 – Control Panels

SECTION 16910

PLC HARDWARE AND SOFTWARE PROCUREMENT

PART 1 GENERAL

1.1 SCOPE

The work specified in this Section consists of hardware and software procurement of Programmable Logic Controllers (PLCs) and Operator Interface Units (OIUs).

Programming is by others and is not part of this contract.

1.2 RELATED WORKS SPECIFIED ELSEWHERE

<u>Section</u>	<u>Item</u>
01300	Submittals
16050	Basic Electrical Materials and Methods

1.3 REFERENCES

<u>Reference</u>	<u>Title</u>
NEMA	National Electrical Manufacturers Association
ICS-1	General Standards for Industrial Control and Systems
ICS-1.1	Safety Guidelines for the Application, Installation and Maintenance of Solid State Control
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

1.4 SYSTEM DESCRIPTION

A. HARDWARE AND SOFTWARE REQUIREMENTS

1. The system includes racks, central processing units (CPUs), input/output (I/O) modules, communication modules, power supplies, OIUs, and associated accessory items to provide a complete and functional process control system for the facility.
2. The system includes development and application software required by the PLC and OIU hardware to provide complete operation functionality for the facility.

B. PERFORMANCE REQUIREMENTS

1. The installed system is capable of performing the functional and operational algorithms required for control of the process.

1.5 DEFINITIONS

Reference specification 16050.

1.6 SUBMITTALS

- A. Submit under the provisions of Specification Section 01300.

B. PRODUCT DATA

1. Submit an electronic version of the manufacturer's data sheets for hardware components including specific model numbers for each device and size of memory provided in each CPU.
2. Submit an electronic version of the manufacturer's installation and user's manuals.
3. If required by the software manufacturer provide a "runtime" license of the software to the Owner and provide copies of the license agreement to the Owner.

C. OPERATION AND MAINTENANCE MANUALS

1. Provide specific information including:
 - a. An electronic version of the manufacturer's published operation and maintenance manual, user's manual, and troubleshooting guide.
 - b. Information for obtaining assistance and troubleshooting, parts ordering information, and field service personnel requests.

1.7 QUALITY ASSURANCE

A. QUALIFICATIONS

Programmer must have testing hardware and sufficient programming experience to demonstrate operational functionality per Section 2 herein.

1.8 EXTRA MATERIALS

Reference Specification Section 16050 for spare parts.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the requirements, provide products by the following manufacturers:

1. Allen Bradley Company.

2.2 EQUIPMENT

A. Conform to NEMA ICS 1.1 for installation and application of the PLC system.

2.3 COMPONENTS

Hardware is referenced against Allen Bradley PLC products. The PLC CPU, I/O, OIU, and communication cards shall be provided with the latest version of firmware.

A. CENTRAL PROCESSOR UNIT (CPU)

Allen Bradley P/N 1769-L24ER, no exceptions.

Memory:	0.75 MB
Ethernet Ports:	2 ports (single address) + 1 USB
Ethernet I/P Nodes:	8
Modules supported:	4

B. ANALOG INPUT/OUTPUT (I/O) MODULES

Provide modules as defined in the PLC I/O tables in the Plans.

1. Analog Input Cards

Type 1:

Allen Bradley P/N 1769-IF4I:

Channels:	4
Input Type:	4-20 mA
Resolution:	16 bit or +/-15 bit
Differential?	Yes
Isolated?	Yes

2. Analog Output Cards

Type 1:

Allen Bradley P/N 1769-OF4CI:

Channels:	4
Input Type:	4-20 mA
Resolution:	16 bit
Differential?	Yes
Isolated?	Yes

C. DIGITAL INPUT/OUTPUT (I/O) MODULES

Provide modules as defined in the PLC I/O tables in the Plans.

1. Digital Input Cards

Type 1:

Allen Bradley P/N 1769-IQ16, no exceptions:

Input Channels:	16
Input Voltage:	24 VDC
Signal Polarity:	Sinking/Sourcing (configure card for sourcing; +24VDC = true)

2. Digital Output Cards

Type 1:

Allen Bradley P/N 1769-OB16, no exceptions:

Output Channels:	16
Output Voltage:	24 VDC
Signal Polarity:	Sourcing

D. POWER SUPPLY UNITS

1. For racks using separate power supplies, use the largest power supply available for that specific rack.

Allen Bradley P/N 1769-PB4, no exceptions:

Input Voltage:	24 VDC
5 VDC Ampacity:	4 Amps
24 VDC Ampacity:	2 Amps

E. OPERATOR INTERFACE UNIT

1. Provide Operator Interface Units suitable for installation through the control panel door. Every operator interface unit shall meet the following requirements.
 - a. Provide a 15-incg Maple Systems HMI P/N 5150XL, no exceptions.
 - b. Shall not degrade the environmental rating of the enclosure to which it is installed. For outdoor applications, the OIU shall be provided with a permanently mounted weatherproof cover viewable with the cover closed.
 - c. Shall have a display screen that is 15 inch minimum (measured diagonally).
 - d. Shall be provided with a power supply if required to operate from the same power source as the PLC.

2.4 ACCESSORIES

Provide all accessories required, whether indicated or not, for a complete PLC control system to accomplish the requirements of the Plans and Specifications.

2.5 SOURCE QUALITY CONTROL

A. SHOP TEST

1. Submit a shop test plan indicating how the test will be conducted, and how equipment operation will be verified.

2. Provide a shop test after factory assembly of the PLC control panel and prior to shipment including the following:
 - a. Conduct a burn-in period (minimum of 2 days) where the system is powered continuously and checked for proper operation and operating temperature.
 - b. Provide sufficient PLC programming to demonstrate PLC I/O testing. Include a PC with sufficient software tools to allow visual demonstration of each digital/analog input status/value and be capable of forcing digital and analog outputs. Coordinate effort with PLC programmer if required.
 - c. Utilize dummy I/Os to verify proper operation.
 - d. Demonstrate that all PLC hardware is fully functional.
 - e. Allow for Owner and/or Engineer representatives to witness the shop test. Provide a minimum of 15 days notice prior to test.
 - f. Do not ship the system prior to successful completion of this testing.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install PLC control system in accordance with manufacturer's written instructions.
- B. Test, verify and demonstrate access to and functionality of PLC system.

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

SECTION 16940
CONTROL PANELS

PART 1 GENERAL

1.1 SCOPE

The work specified in this Section includes control panels [10 CP 01].

1.2 RELATED WORKS SPECIFIED ELSEWHERE

<u>Section</u>	<u>Item</u>
01300	Submittals
16910	Programmable Logic Controller (PLC) Hardware
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, and etc.
2. 120 VAC or 24 VDC device power to control devices such as PLCs, radios, network switches, and 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), and etc.

1.4 REFERENCES

<u>Reference</u>	<u>Title</u>
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.
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 508 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 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.

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 #BSPM1120S2G or equal.

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.

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.

b. 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.

c. 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.

- d. 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.

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. 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 indicators. Relays shall be IDEC, P&B/Tyco or equal.

2. 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.

3. 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. 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.

F. 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.

G. 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:

- *Ethernet switch [08 ESW 01] shall be 10/100 MB, 120 VAC powered, desktop, 5-port, unmanaged, commercial grade.*
- *Non-DIN-rail acceptable if over 16 channels.*

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, and 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 so 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 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.).

D. 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.

E. 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.
6. Panel material, penetrations, and 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. 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 insure 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. 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 the additional stainless steel shelving.

C. 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.

D. 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.

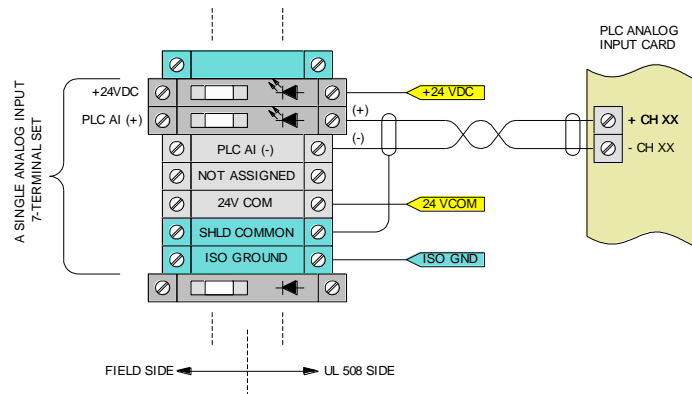
E. FIELD CONNECTIONS TO PLC I/O

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.

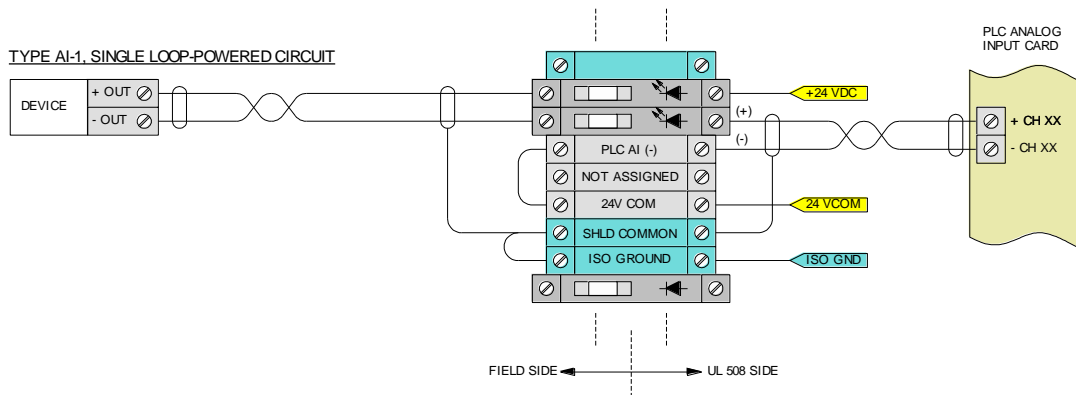
No additional 24 VDC fusing is to be provided.

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

2. Analog Input, 7-Terminal Connection Methods

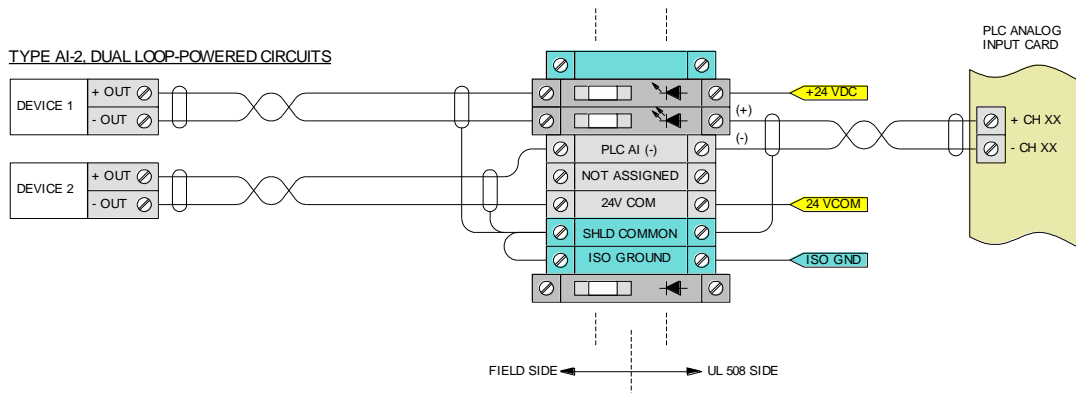
- a. Field Connection **TYPE AI-1**, connection to a single loop-powered field device

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

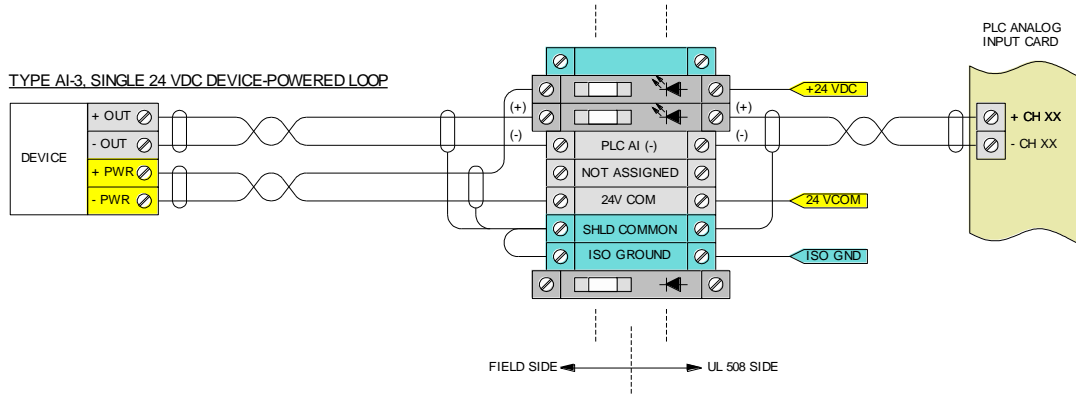
The Figure below shows the method of connecting a PLC analog input to two loop-powered field devices using a 7-terminal standard analog input terminal group.



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

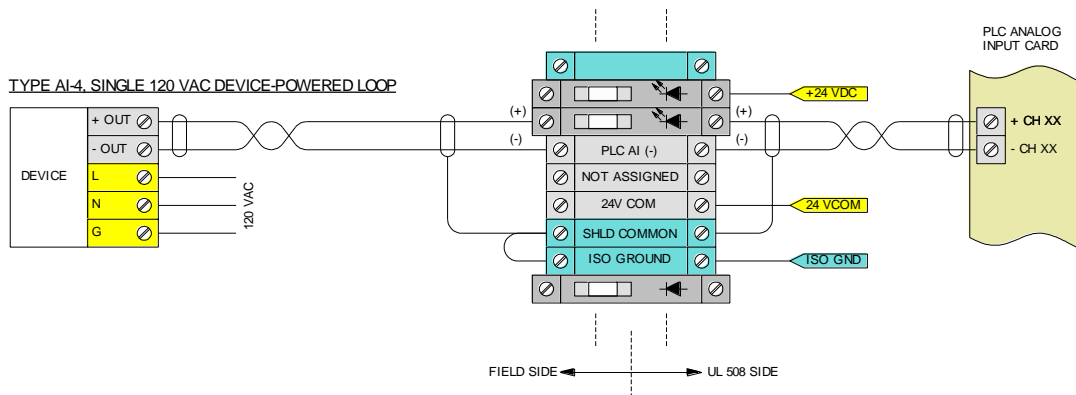
The Figure below shows the method of connecting a PLC analog input to a single 24 VDC device-powered field device

device using a 7-terminal standard analog input terminal group. Device power is provided by the control system power.



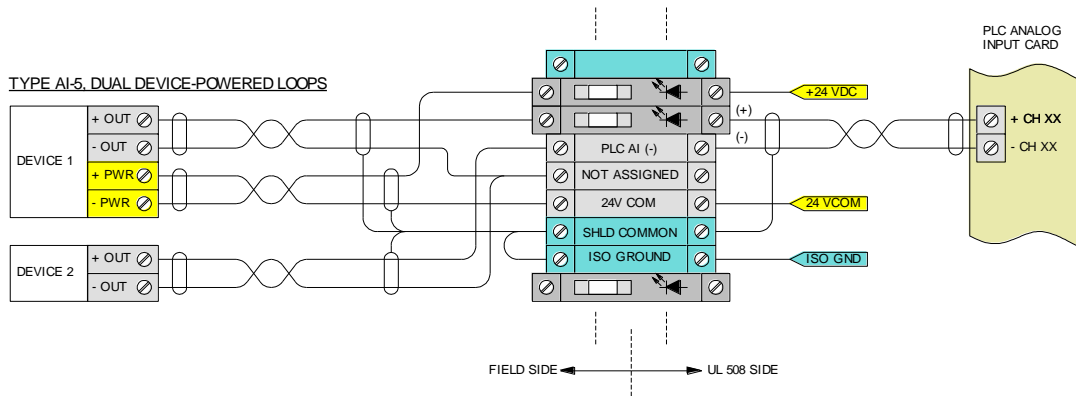
- d. Field Connection **TYPE AI-4**, connection to a single 120 VAC device-powered field device

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.

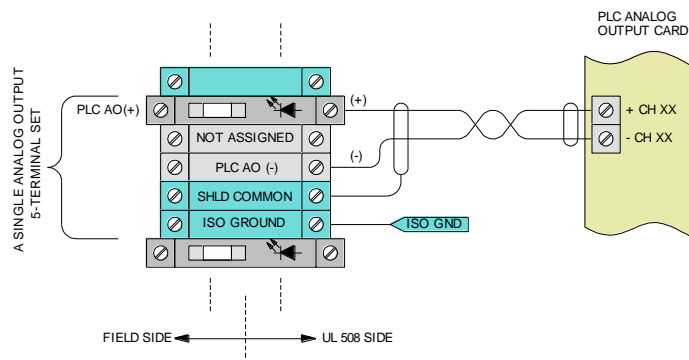


3. Analog Output, Termination and Connectivity

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.

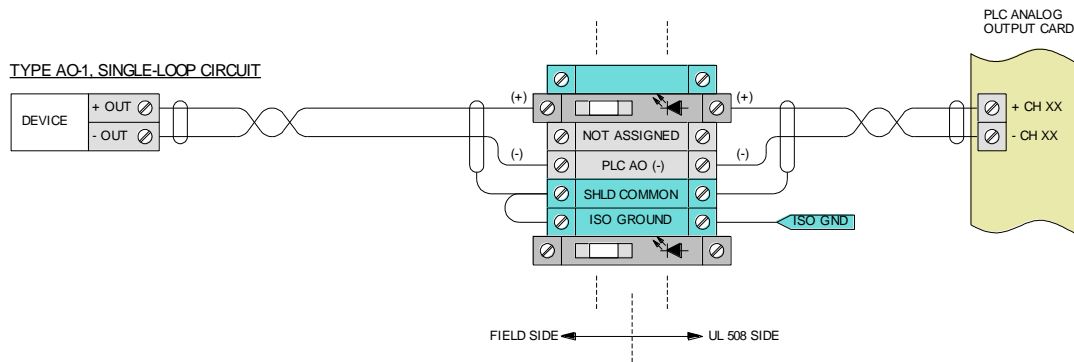
No additional 24 VDC fusing is to be provided.

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

4. Analog Output, 5-Terminal Connection Methods

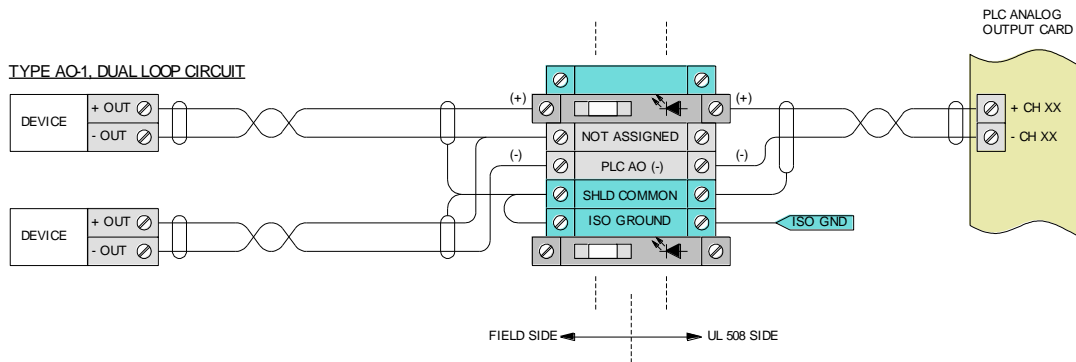
- a. Field Connection **TYPE AO-1**, connection to a single field device

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

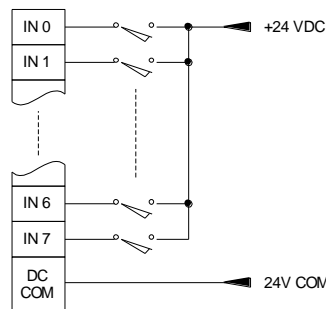
The Figure below shows the method of connecting a PLC analog output to two field devices using a 5-terminal standard analog output terminal group. These devices can be loop-powered or device powered.



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.

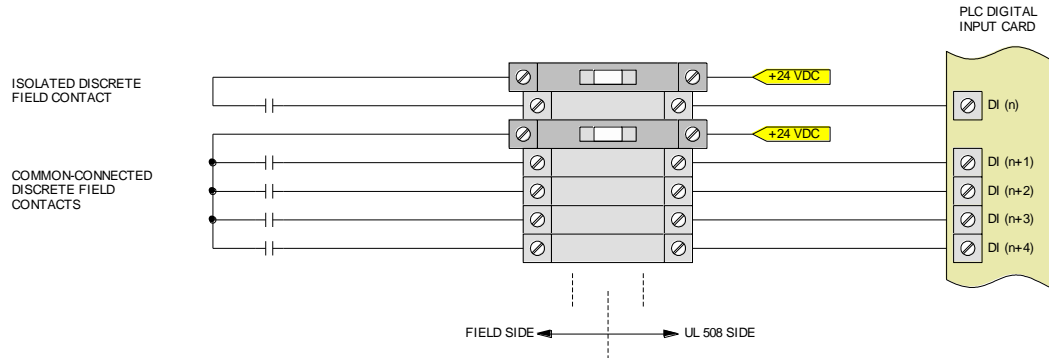
Fuses shall be 0.5 Amp.

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

c. Digital Input Connection Methods

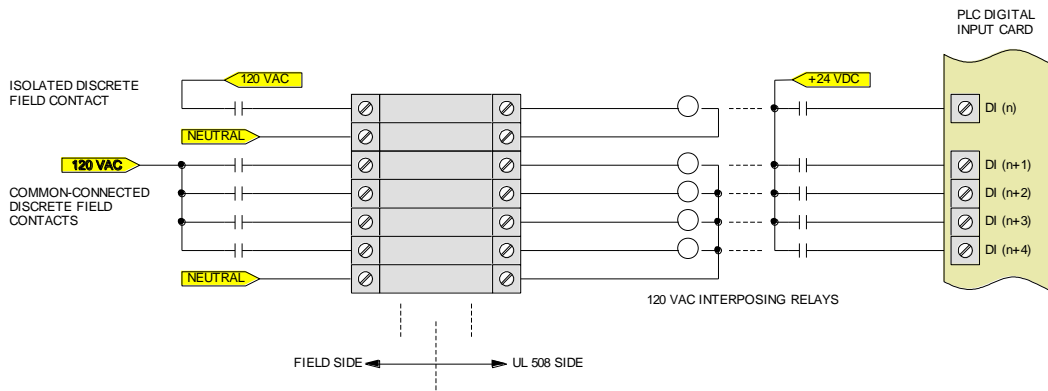
i. Connections to “Dry” Field Contacts

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.



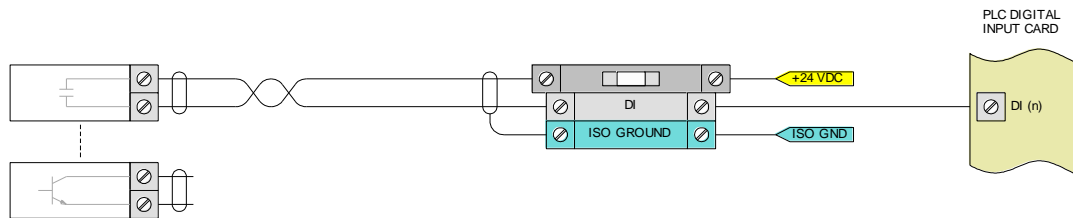
ii. Connections to “Hot” (wet) 120 VAC Field Circuits

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

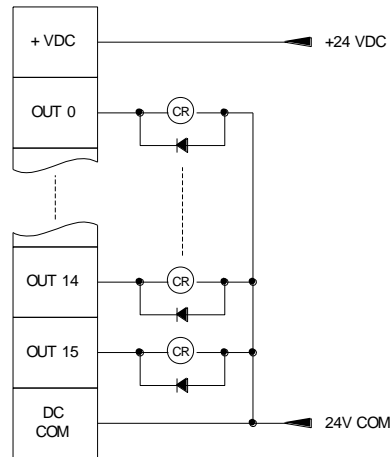
Digital pulse inputs shall be either dry Form A or Form B contacts or active open-collector circuits as shown in the Figure below. The +24 VDC power shall be provided by the 24 VDC control system power and shall be separately fused.



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.



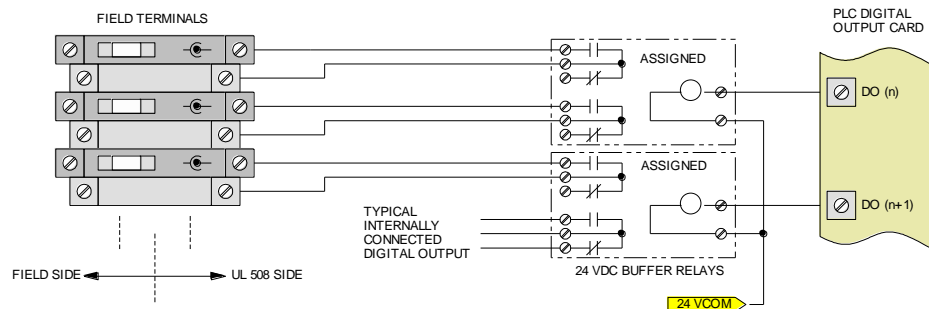
24 VDC, 16 CHANNEL PLC
DIGITAL SOURCING OUTPUT CIRCUIT

b. Digital Output Buffer Relays

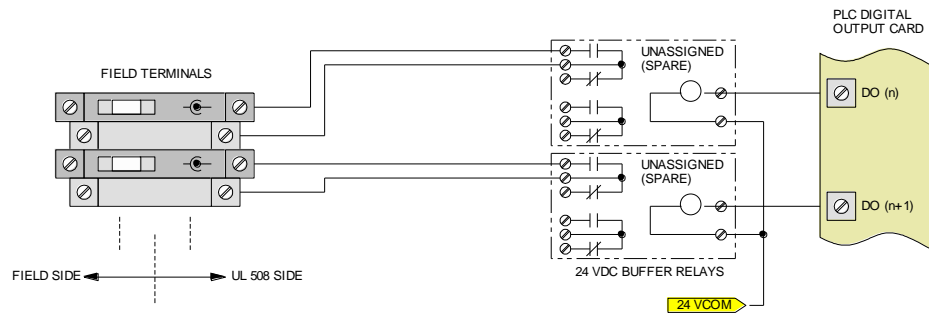
All 24 VDC digital outputs, even if unassigned (spare), shall be buffered through a DPDT (minimum) interposing relay prior to being connected to other internal circuits or field terminals. 4PDT relays shall be provided where shown on wiring diagrams. Reference “PLC 24 VDC Output Buffer Relays” in Part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



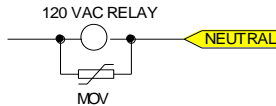
All unassigned digital outputs shall be buffered to a single fused output terminal pair as shown in the Figure below.



F. RELAY COIL SURGE SUPPRESSION

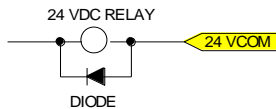
1. 120 VAC Coil Surge Suppression

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 complete 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, and etc.

4. 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 assure that they function correctly before the panel is shipped.

3.3 INSTALLATION

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 *****