# Palladium Hydrogen Purifier

*PS7-PD1-70*

*Rev.A*

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## FOREWORD

This operation manual provides the information required to operate the MegaTorr® Palladium Hydrogen Purifier. This manual is not intended to provide servicing instructions to the user. The MegaTorr® purifier should be operated only by personnel who are familiar with the procedures required for safe operation. It is strongly recommended that the factory be consulted before any maintenance or repairs are attempted.

**WARNING: Improper installation, operation, or service of the MegaTorr purifier can cause fire and electrocution.**

**CAUTION: Entegris does not provide any external fire protection for it's purification products. External fire protection is site specific and the exclusive responsibility of the end user.**

**CAUTION: This purifier is designed to purify hydrogen only. Do not allow the process material to come into contact with gases other than hydrogen or the recommended purge gases; this could cause permanent damage to the purifier.**

**CAUTION: The purifier must have electrical power, instrument air pressure, and applicable gas pressure for proper operation. If proper electrical power, instrument air pressure, and applicable gas pressure are not supplied, the purifier could be permanently damaged and the factory warranty will be void.**

### EXPLANATION: CDS/SPECIFICATION

#### SPECIFICATION

Provides the interface information (size, weight, connections) as well as the general configuration parameters (voltage types) and options available (filter, pressure transducers). These specifications are general and must be used with the customer data sheet for an accurate understanding of your purifier.

#### CDS / CUSTOMER DATA SHEET

Provides the exact configuration of your specific purifier as purchased. The customer data sheet identifies: operating voltage, options as ordered, and other project specific information; it may include drawings and/or photographs of your purifier as ordered from Entegris.

## SPECIFICATION

MICROCONTAMINATION CONTROL

# Palladium Hydrogen Gas Purifier

*PS7-PD1-10 through PS7-PD1-70*

The MegaTorr® palladium hydrogen gas purifiers use a micro-channel palladium membrane process to provide ultra-high purity (UHP) hydrogen for semiconductor applications. Outlet impurity levels for all impurities including $O_2$, CO, $CO_2$, $H_2O$, $CH_4$, He, Ar, and $N_2$ are reduced to sub parts per billion (ppb) levels.

Hydrogen is fed into the system via the $H_2$ inlet connection. The gas flows into palladium (Pd) cells, which allow only pure hydrogen to diffuse through the membranes to the pure side. The purified gas then flows to the outlet connection. The Pd cells operate at 400°C, and trapped impurities are vented through the bleed gas line. A nitrogen purge system is included to purge the purifier at startup and during any shutdown.

## SAFETY FEATURES

- **Hydrogen sensor:** Placed inside the cabinet to detect hydrogen and give a control system alert.
- **Emergency stop button (EMO):** Provides immediate shutdown of heater power.
- **High temperature hardware interlock**: For over-temperature protection independent of the control system.

## STANDARD FEATURES

- Microprocessor PLC
- 5.7" color touch screen human machine interface (HMI)
- Nitrogen purge system
- Bleed gas vent line
- Leak test connections
- Inlet and outlet pressure transducers
- Electric gas preheater with heat exchanger
- Closed-loop temperature controls
- Alarm and gas relay customer connections
- Vented cabinet purge with low airflow warning
- Ground fault equipment protection (GFEP)
- Data storage
- Separate control power
- Purifier hold down brackets

## OPTIONAL EQUIPMENT

- **Deoxo pre-purifier** for inlet hydrogen with >100 ppm $O_2$
- **Inlet mass flow meter** provides process gas flow rate and total flow indication
- **Auto or manual bypass** allows process gas flow to bypass the PD cell.
- **MODBUS® Data communication port** provides operation data output.
- **Z-purge of electrical bay** for safety compliance in certain operating environments.

## APPLICATIONS

- Semiconductor
- Flat panel display
- LED/Compound semiconductor
- Fiber optic
- Research
- Solar
- Fuel cell

## SPECIFICATION (CONTINUED)

| Model | Typical flow at 260 psig inlet, 80 psig outlet pressure |
|---|---|
| PS7-PD1-10 ~ 30* | 7.0 $Nm^3/hr$ – 21.0 $Nm^3/hr$ |
| PS7-PD1-40 ~ 70* | 28.0 $Nm^3/hr$ – 49.0 $Nm^3/hr$ |

**Standard models available in sizes 10, 20, 30, 40, 55, and 70*

*$Nm^3$ defined at normal conditions of 20°C and 1 atm.*

### PRODUCT SPECIFICATIONS (FOR ALL MODELS)

| | | |
|---|---|---|
| **Gas purified** | Hydrogen | |
| **Inlet requirements** | $H_2$: 4.0N inlet purity*,<br>20 micron max particle size | |
| | **Temperature** | 0° – 35°C (32° – 95°F) |
| | **Pressure** | 3.8 barg (55 psig) minimum<br>20.7 barg (300 psig) maximum<br>Customer must provide inlet overpressure protection at no greater than 22.8 barg (330 psig) |
| **Instrument air** | Clean, dry air or nitrogen filtered to 10 µm | |
| | **Pressure** | 6.6 barg (95 psig) minimum<br>9.7 barg (140 psig) maximum |
| **Optional Z-purge (uses instrument air supply)** | Clean, dry air or nitrogen filtered to 10 µm | |
| | **Pressure** | 6.6 barg (95 psig) minimum<br>9.7 barg (140 psig) maximum |
| **Nitrogen purge** | 99.95% or better, 5 - 20 slpm | |
| | **Pressure** | 5 barg (72 psig) minimum<br>6.8 barg (98 psig) maximum |
| **Helium leak test input pressure** | Minimum 10 psig greater than $N_2$ pressure<br>Maximum 13.79 barg (200 psig) | |
| **Impurities removed** | $H_2O$, $O_2$, CO, $CO_2$, $N_2$, $CH_4$**, NMHC, He, and Ar<br>to <1 ppb* | |
| **Inlet particle filtration** | 0.5 micron (standard) | |
| **Maximum allowable differential pressure** | <12.4 bard (180 psid) | |
| **Operating temperature (nominal)** | Palladium cell at 400°C (752°F) | |
| **Applicable codes and standards** | ASME Pressure Vessel Standards Section VIII<br>US National Electric Code<br>CE Marking (must be specified on order) | |

**Consult factory for non-standard inlet or outlet purity requirements. Analytical specification certified at greater than 10% of the maximum flow (NMHC, He, and Ar removal is guaranteed but not measured).*

***Tested to < 10ppb at the factory, < 1 ppb outlet purity achieved after suitable conditioning.*

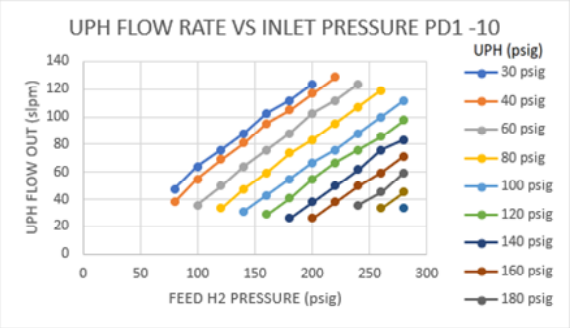
## SPECIFICATION (CONTINUED)

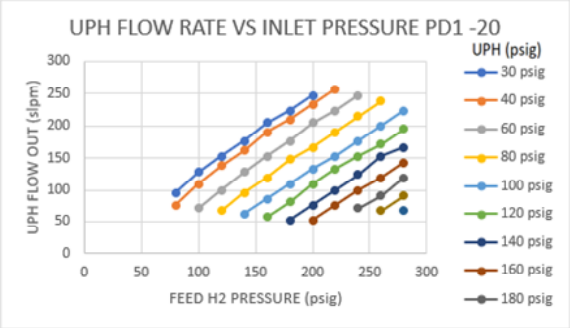
| | |
|---|---|
| **Purifier model** | PS7-PD1-10 ~ 70 |
| **Dimensions** | **Height** 999 mm (~39.3")<br>**Width** 762 mm (~30.0")<br>**Depth 483** mm (~19.0")<br>**Weight** <300 Kg (<660 lbs) |
| **Purifier clearance** | 1 meter (~3 feet) in front of purifier |
| **Mechanical connections** | **Feed inlet** 1/2" FVCR |
| | **Purified outlet** 1/2" FVCR |
| | **Bleed gas outlet vent** 1/4" FVCR<br>**Nitrogen purge inlet** 1/4" MVCR<br>**Cabinet vent** 4" duct<br>**Pneumatic inlet** 3/8" FNPT |
| **Bleed gas vent temperature** | Ambient air +30°C (+54°F) |
| **Bleed gas vent flow rate** | 2% of maximum rated flow |
| **Main power** | 3600 W |
| | 208 or 230 VAC, 1 phase, 50/60 hZ |
| **Separate control power** | 120 or 230 VAC, 1 phase, 50/60 Hz, Power consumption: 0.1 kW |
| **Cabinet ventilation** | 260$Nm^3$/hr (150 scfm) (at facilities vacuum – 0.2" $H_2O$) |
| **Installation** | Indoor, non-classified area, ambient temperature 5° – 35°C (41° – 95°F) |

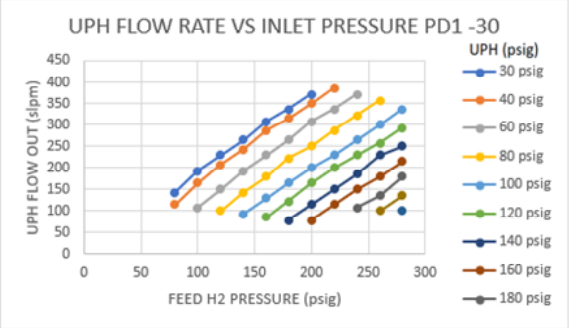
## SPECIFICATION (CONTINUED)

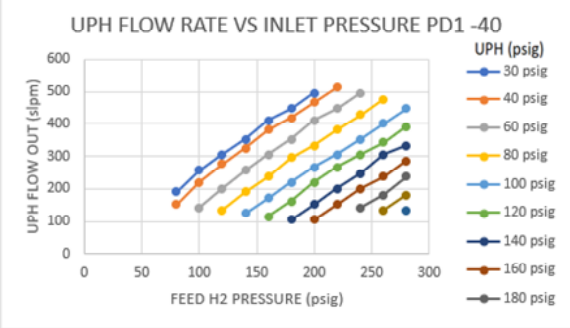
### FLOW RATE

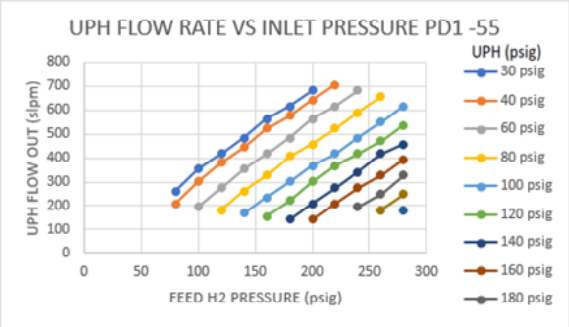
This is an estimate of maximum flow conditions. Actual minimum flow conditions may be slightly above or below the estimates shown.

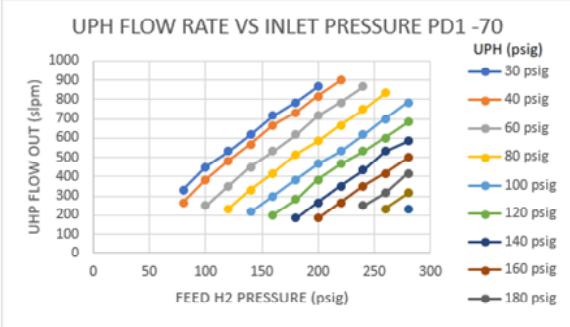



### FOR MORE INFORMATION

Please call your Regional Customer Service Center today to learn what Entegris can do for you. Visit entegris.com and select the Contact Us link to find the customer service center nearest you.

### TERMS AND CONDITIONS OF SALE

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www.entegris.com

## CUSTOMER DATA SHEET

Entegris

MICROCONTAMINATION CONTROL

# PS7-PD1-70
# CUSTOMER DATA SHEET (CDS)

## PS7-PD1 Series Palladium Membrane Hydrogen Purifier

| | | | |
|---|---|---|---|
| Model Number: | PS7-PD1-70-1 | CDS Date & Revision: | 6 January 2021<br>Rev. A |
| Quantity & Gas Type: | One (1) Unit for H2 | Project Name: | 1221 |
| Customer Name: | | S/O Number: | 2252886 |
| Location: | Indianapolis, IN | Forecast Number(s): | E1578 |
| Contact: | | Quote Number: | 20467912 |
| P.O. Number: | 40526990-1 | Serial Number(s): | |

| | **Entegris Approval** |
|---|---|
| **Reference Specification: S110-1025_F** | **NH** |

**Main Power Option**

| **Select Main Power** | **Entegris Approval** |
|---|---|
| ☒ **208 VAC, Single Phase, 50/60 Hz, 3 wire with ground**<br>☐ 230 VAC, Single Phase, 50/60 Hz | **NH** |

## CUSTOMER DATA SHEET (CONTINUED)

| Operating Conditions | | | Entegris Approval |
|---|---|---|---|
| Max Flow Rate: 300 slpm | Inlet Pressure: 9.3 barA | Outlet Pressure: 5 barA | NH |

| Standard Options | Required? | Entegris Approval |
|---|---|---|
| MODBUS Data Communications Port (Ethernet Output) | YES | NH |
| Separate Control Power (120 VAC, 1 phase) | YES | NH |
| Deoxo Pre-Purifier | YES | NH |

| Non-Standard Requirements | Entegris Approval |
|---|---|
| | |
| | |

## CUSTOMER DATA SHEET (CONTINUED)

| Analytical Specifications based on Typical 4.0N (99.99%) Inlet Purity | | | |
|---|---|---|---|
| **Impurity** | **Entegris Standard Outlets** | **Non-standard Outlets** | **Entegris Approval** |
| $H_2O$ | < 1.0 ppb | -- | **SV** |
| $O_2$ | < 1.0 ppb | -- | **SV** |
| CO | < 1.0 ppb | -- | **SV** |
| $CO_2$ | < 1.0 ppb | -- | **SV** |
| $N_2$ | < 1.0 ppb | -- | **SV** |
| $Ch_4$ | < 1.0 ppb | -- | **SV** |
| NMHC | < 1.0 ppb | -- | **SV** |
| He | < 1.0 ppb | -- | **SV** |
| Ar | < 1.0 ppb | -- | **SV** |
| Max # of Particles | 1 ppcf | -- | -- |
| Particle Size | @ 0.1 µm | -- | -- |

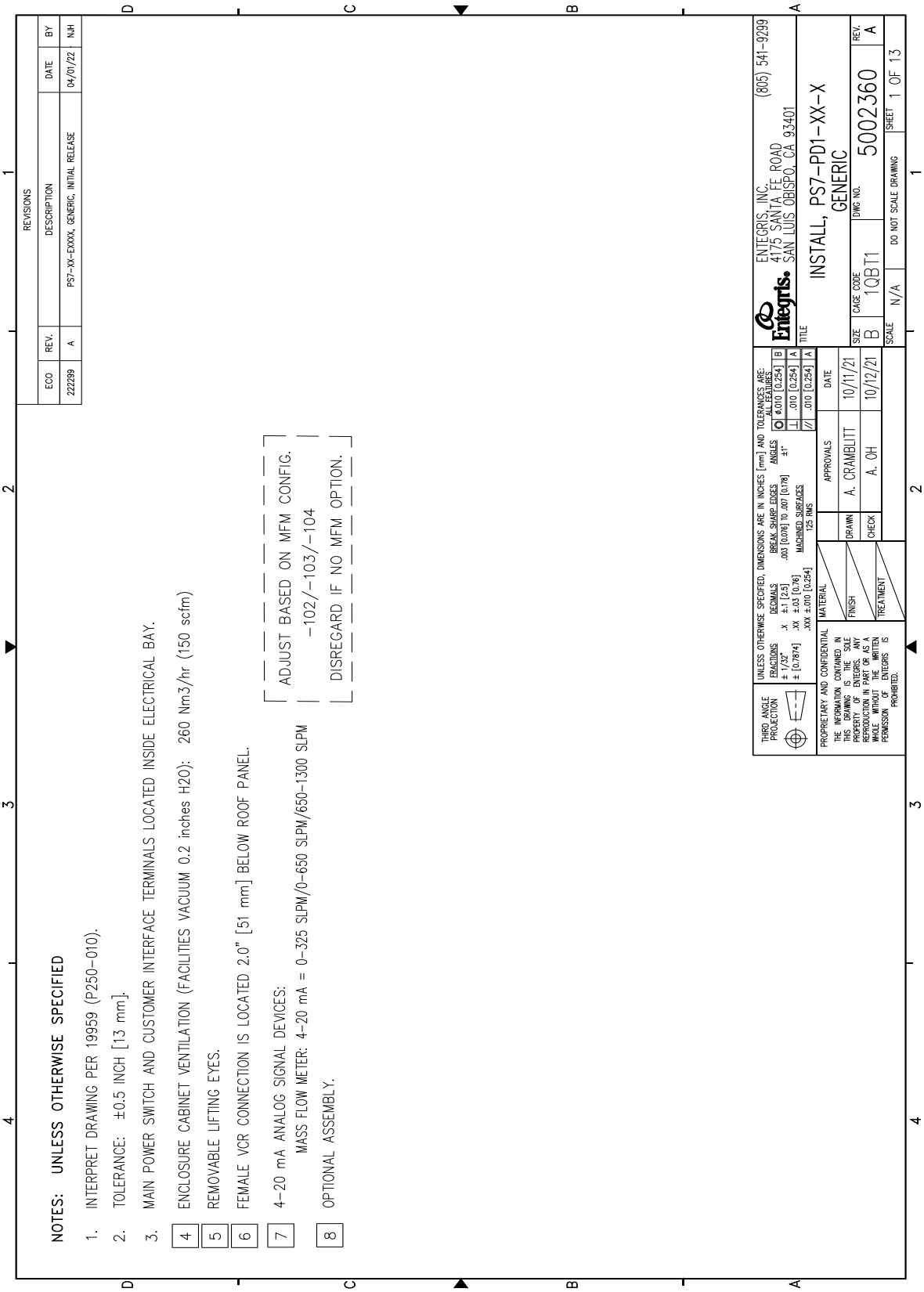
| **Documentation Requirements** | **Entegris Approval** |
|---|---|
| Quality Documentation Package<br><br>Provide email version (PDF format) to Matt Goerss of Andon seven days after shipment. | **BC** |
| Product Manual<br><br>Provide email version (PDF format) to Matt Goerss of Andon seven days after shipment. | **NH** |

## CUSTOMER DATA SHEET (CONTINUED)

| Revision Approvals | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| Engineering | **PEM** | | | | | | |
| Contracts | **DS** | | | | | | |
| Analytical | **SV** | | | | | | |
| Quality | **BC** | | | | | | |
| Product Manager | **GZC** | | | | | | |

| | |
|---|---|
| Customer Approval | |

## INSTALLATION DRAWING



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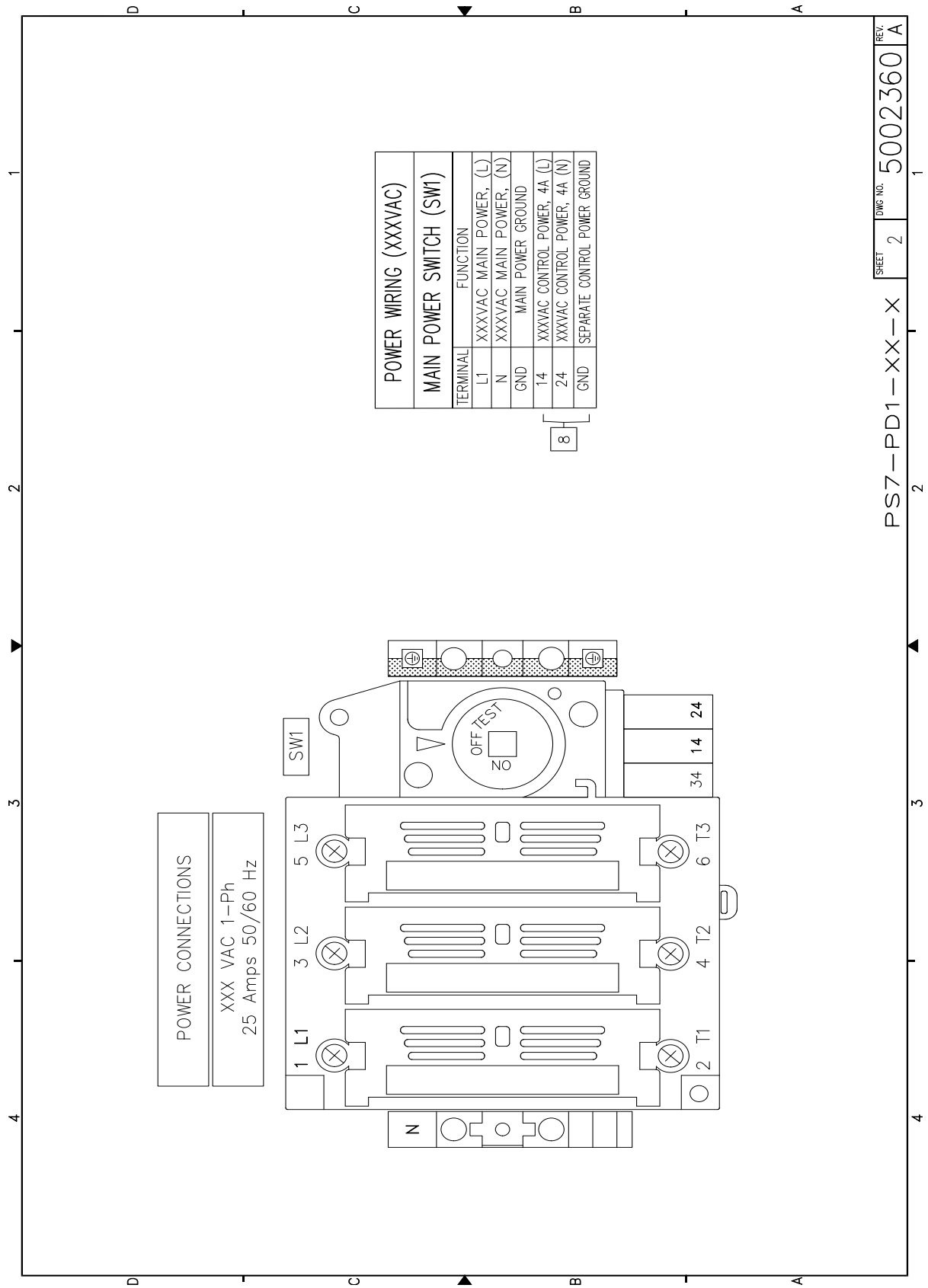

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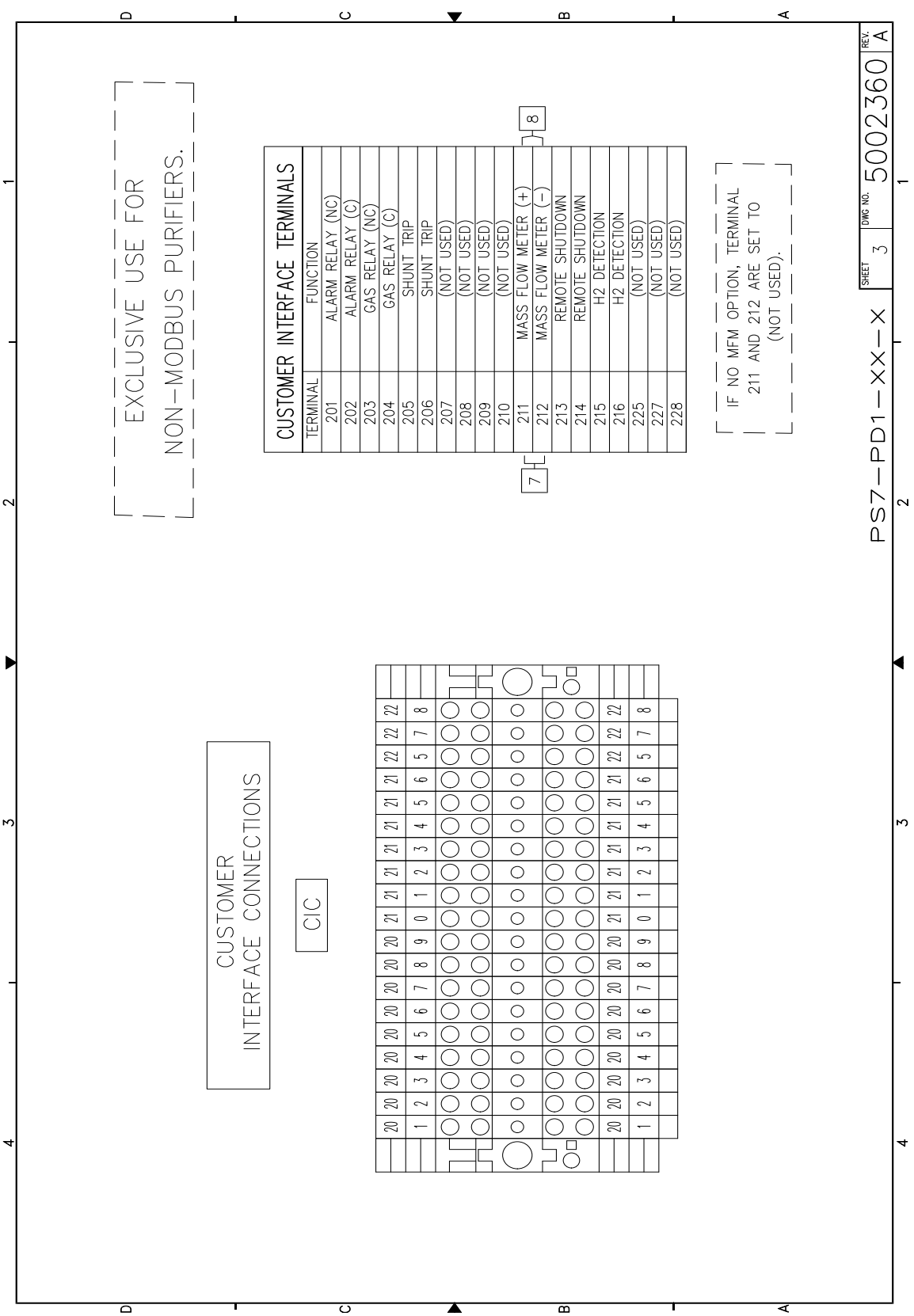

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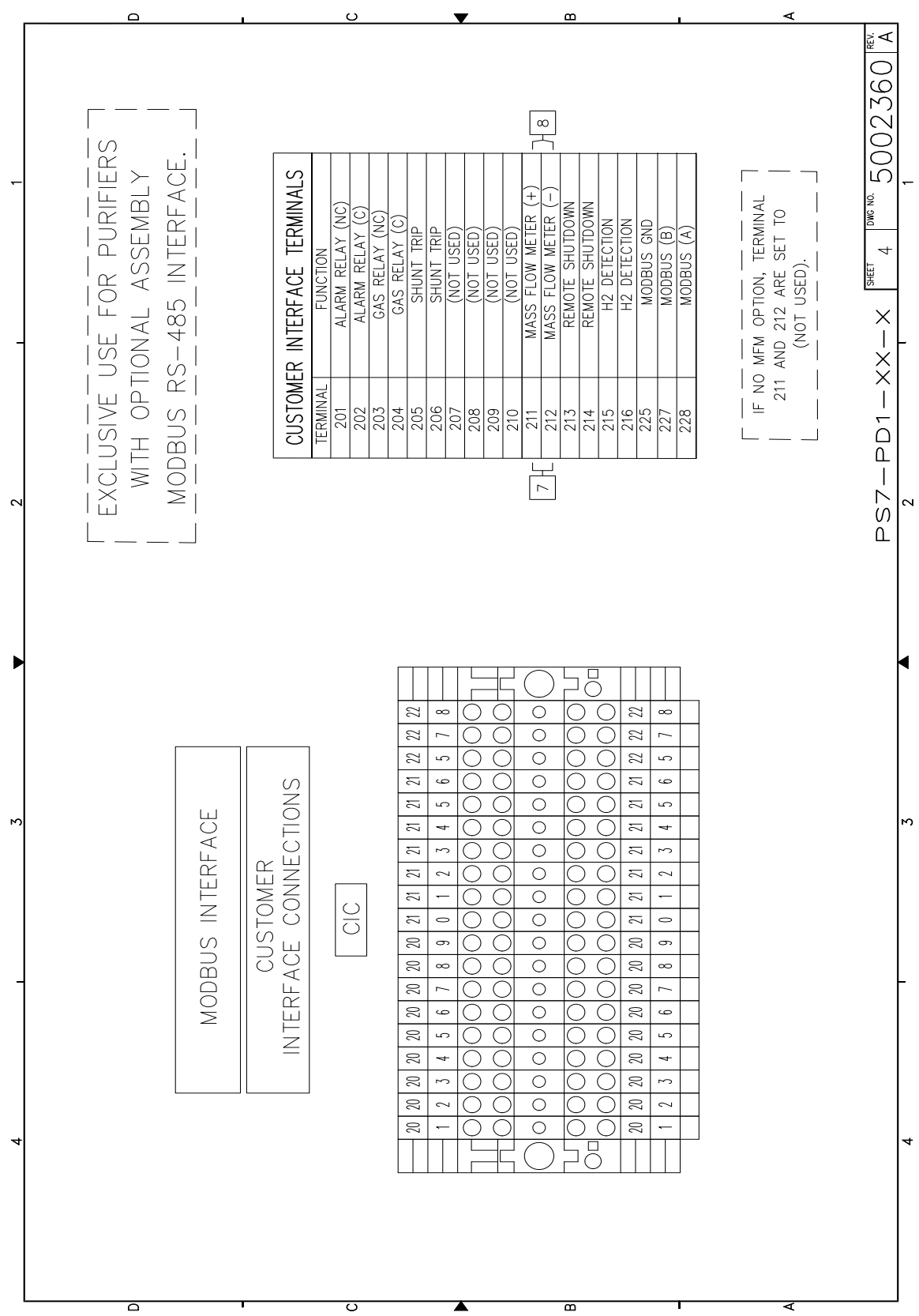

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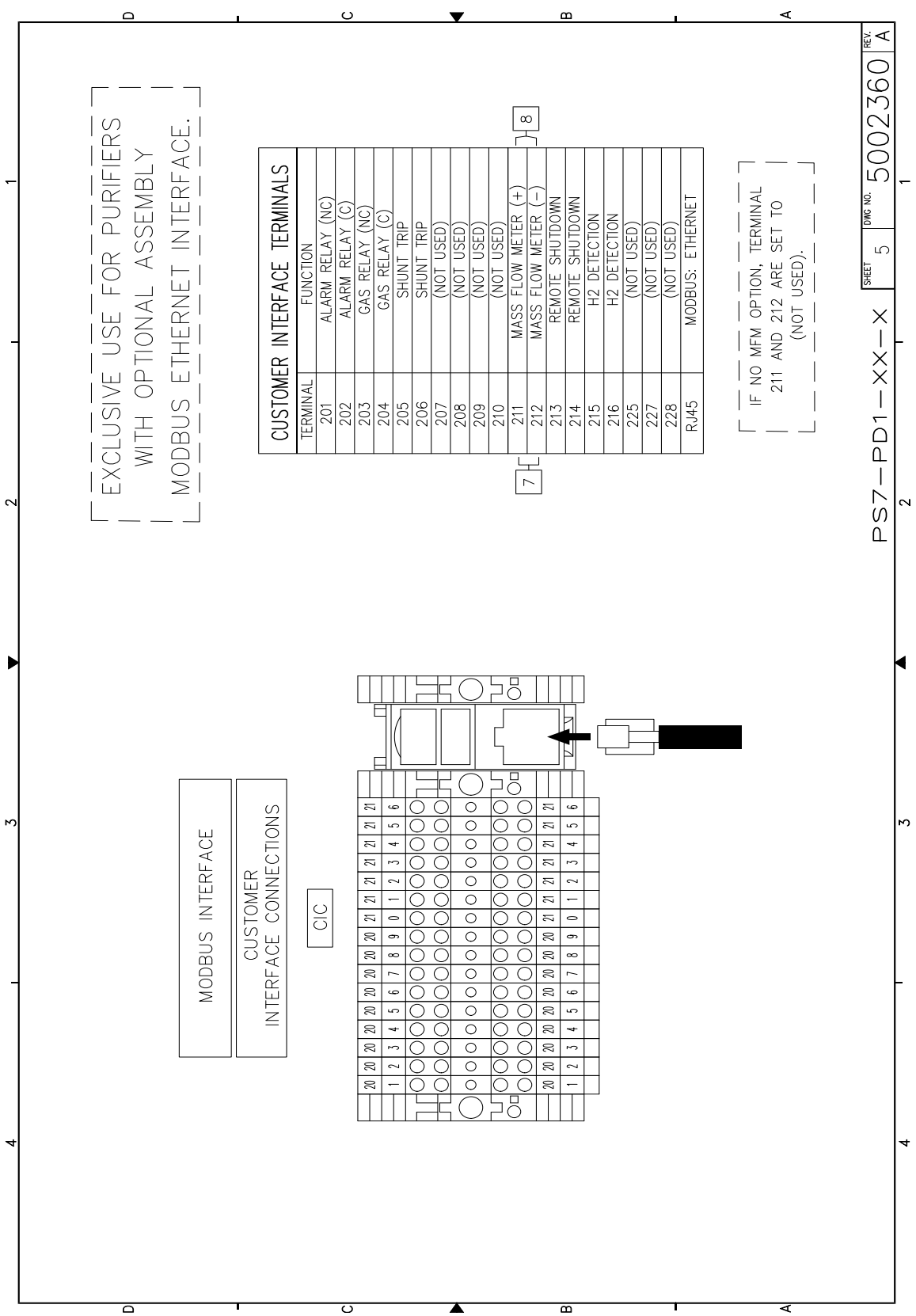

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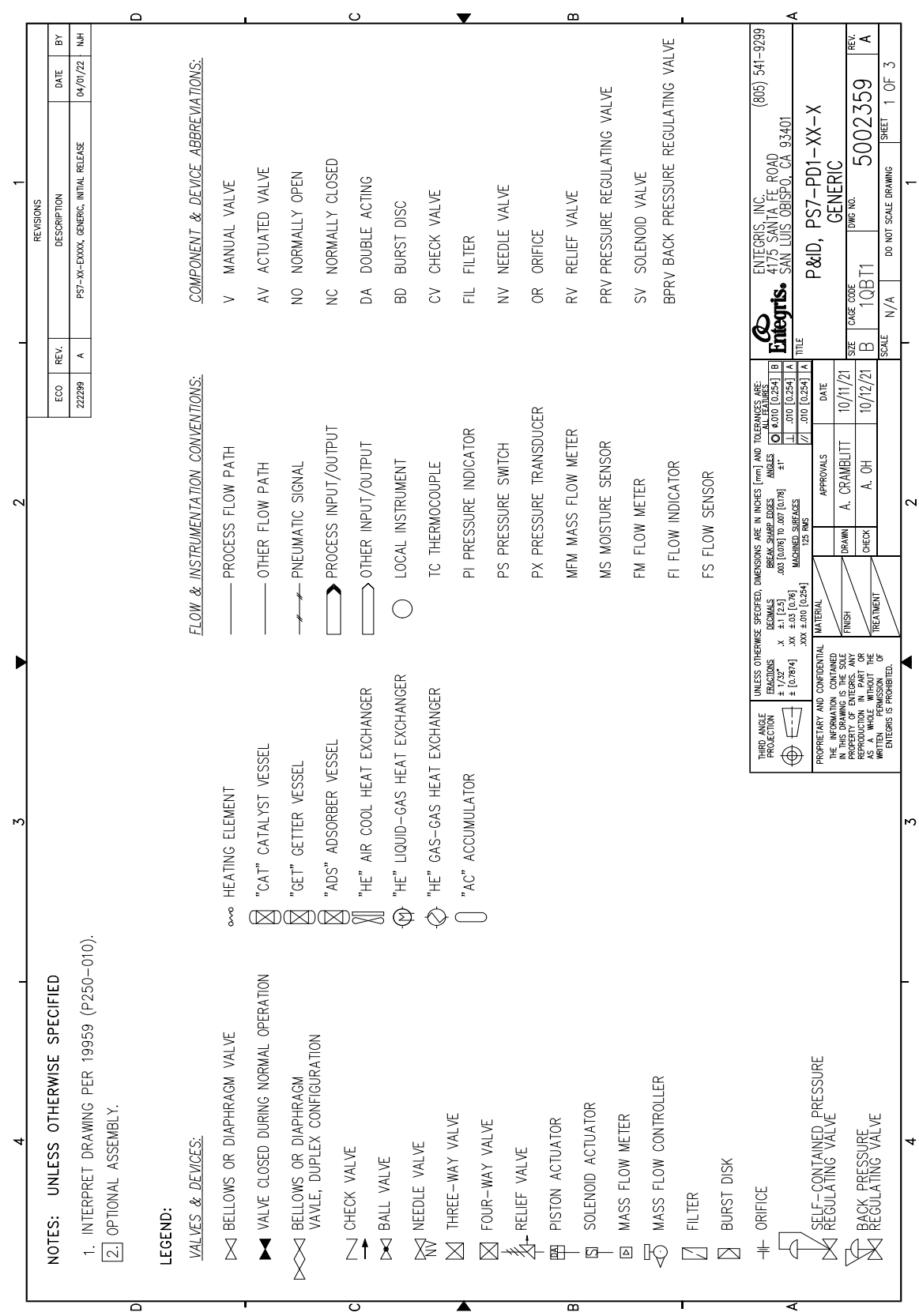

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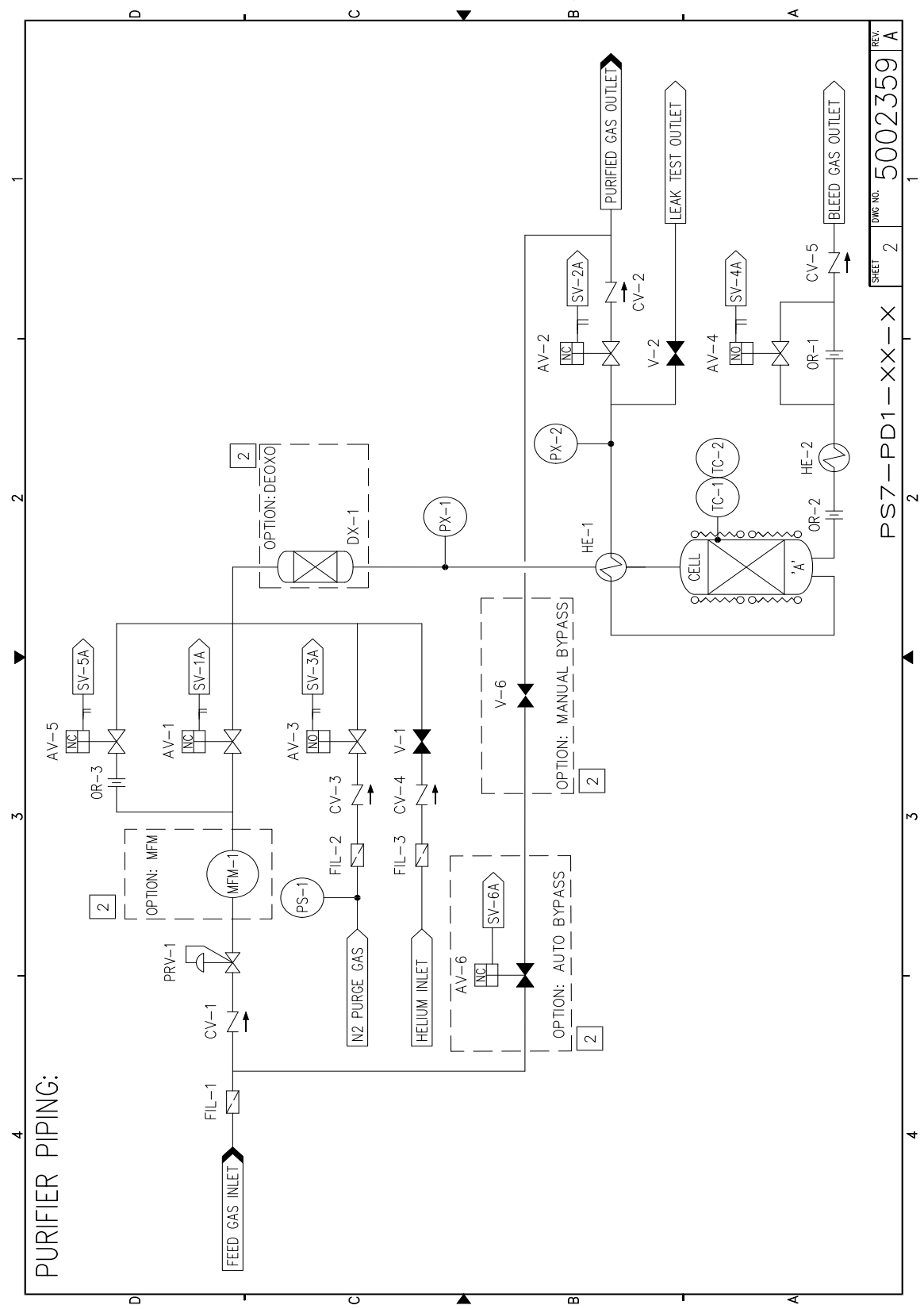

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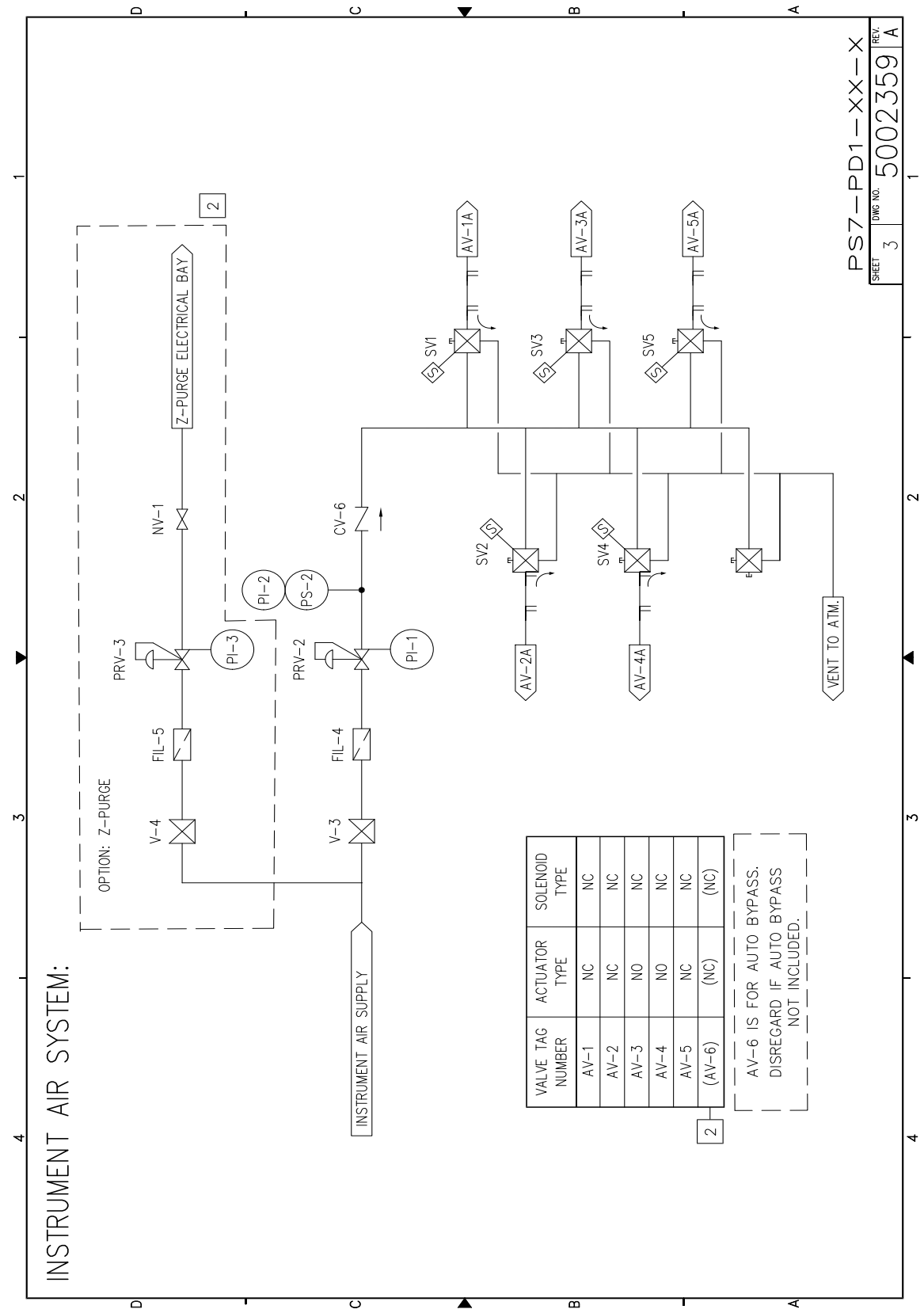


| REVISIONS | | | | |
|---|---|---|---|---|
| ECO | REV. | DESCRIPTION | DATE | BY |
| 222580 | A | INITIAL RELEASE | 04/12/22 | LM |
| 226759 | B | FIX TO SV MANIFOLD SHIELD CABLE | 09/09/22 | LM |

NOTES: UNLESS OTHERWISE SPECIFIED

1. INTERPRET DRAWING PER 19959.
2. BOLD WIRING LINES INDICATE BUSSED POWER.
3. ARROWS INDICATE POWER OR SIGNAL DIRECTION. CONTROL SIGNAL CODES AS FOLLOWS:
   AI = ANALOG INPUT DI = DIGITAL INPUT
   TC = THERMOCOUPLE INPUT DO = DIGITAL OUTPUT
4. NUMBERS IN ( ) INDICATE WIRE DESIGNATIONS. WIRES IN { } INDICATE WIRE GAUGE SIZE.

5. REMOTE SHUTDOWN (TRIP) CIRCUIT SHOWN ON SHEET 4.
6. CUSTOMER INTERFACE CONNECTIONS (C.I.C.).
7. SET DIP SWITCH ON TC/AI MODULE (SLOT 2). SEE TABLE 1 ON SHEET 2.

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES [mm] AND TOLERANCES ARE:
FRACTIONS ± 1/32" ± [0.7874] DECIMALS .X ±.1 [2.5] .XX ±.03 [0.76] .XXX ±.010 [0.254] BREAK SHARP EDGES .003 [0.076] TO .007 [0.178] ANGLES ±1°
MACHINED SURFACES 125 RMS
ALL FEATURES: ⌀.010 [0.254] B; ⊥ .010 [0.254] A; // .010 [0.254] A



MATERIAL
FINISH
TREATMENT

| | APPROVALS | DATE |
|---|---|---|
| DRAWN | L. MADAIN | 04/12/22 |
| CHECK | E. ORTIZ | 04/14/22 |

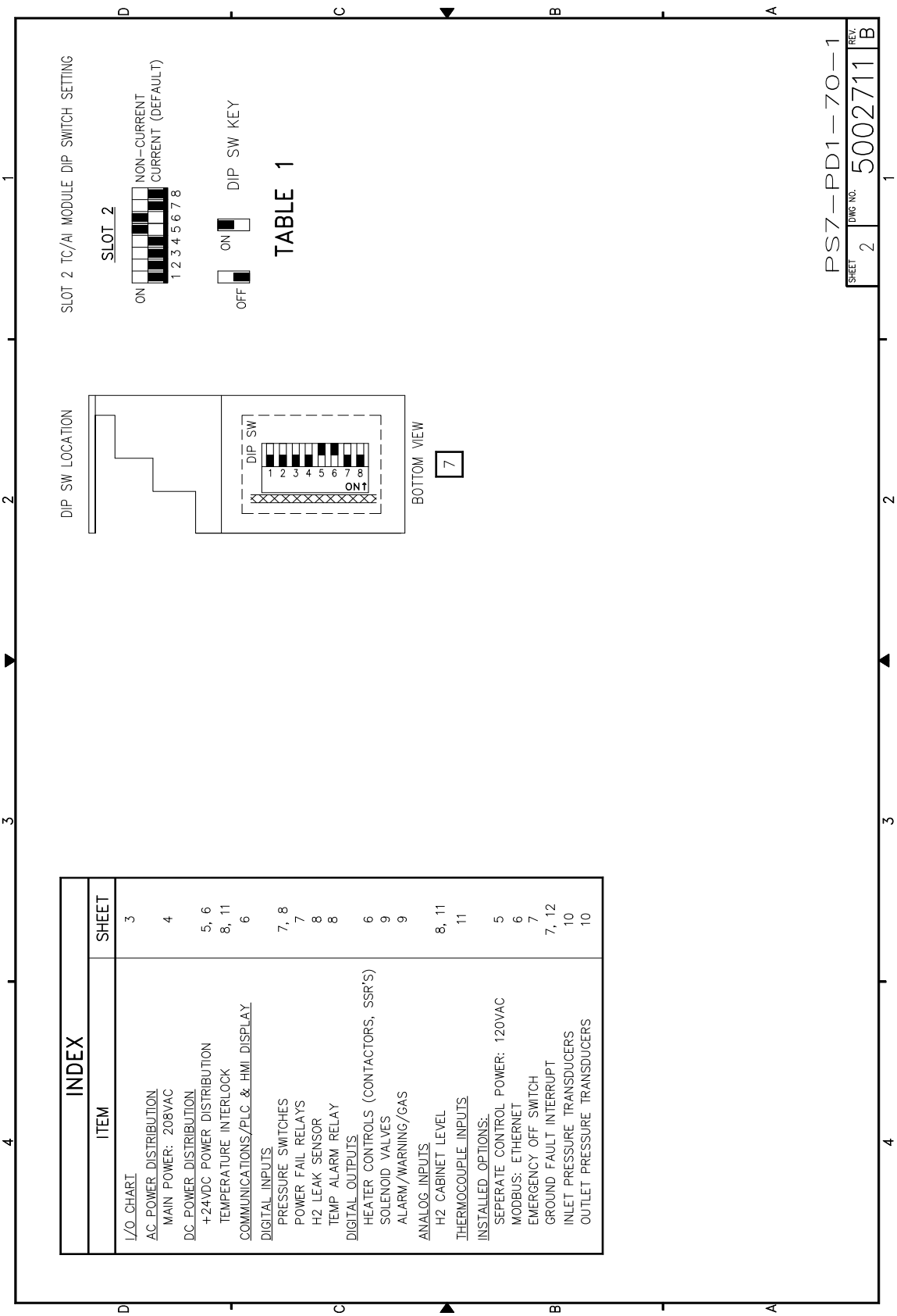
Entegris. ENTEGRIS, INC. (805) 541-9299
4175 SANTA FE ROAD
SAN LUIS OBISPO, CA 93401

TITLE
SCHEMATIC,
PS7-PD1-70-1, 208V

| SIZE | CAGE CODE | DWG NO. | REV. |
|---|---|---|---|
| B | 1QBT1 | 5002711 | B |

SCALE N/A DO NOT SCALE DRAWING SHEET 1 OF 12

## ELECTRICAL SCHEMATIC (CONTINUED)



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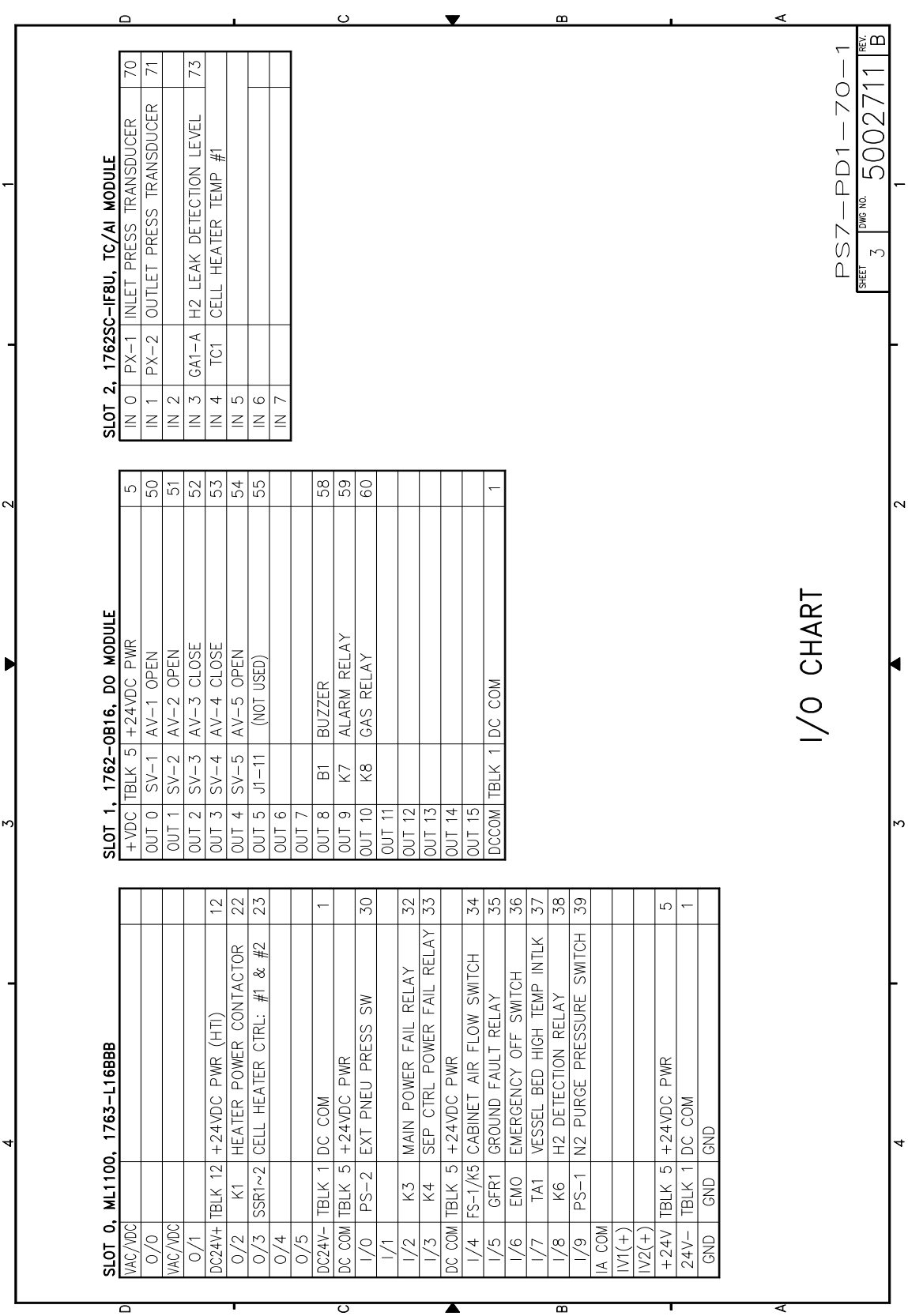

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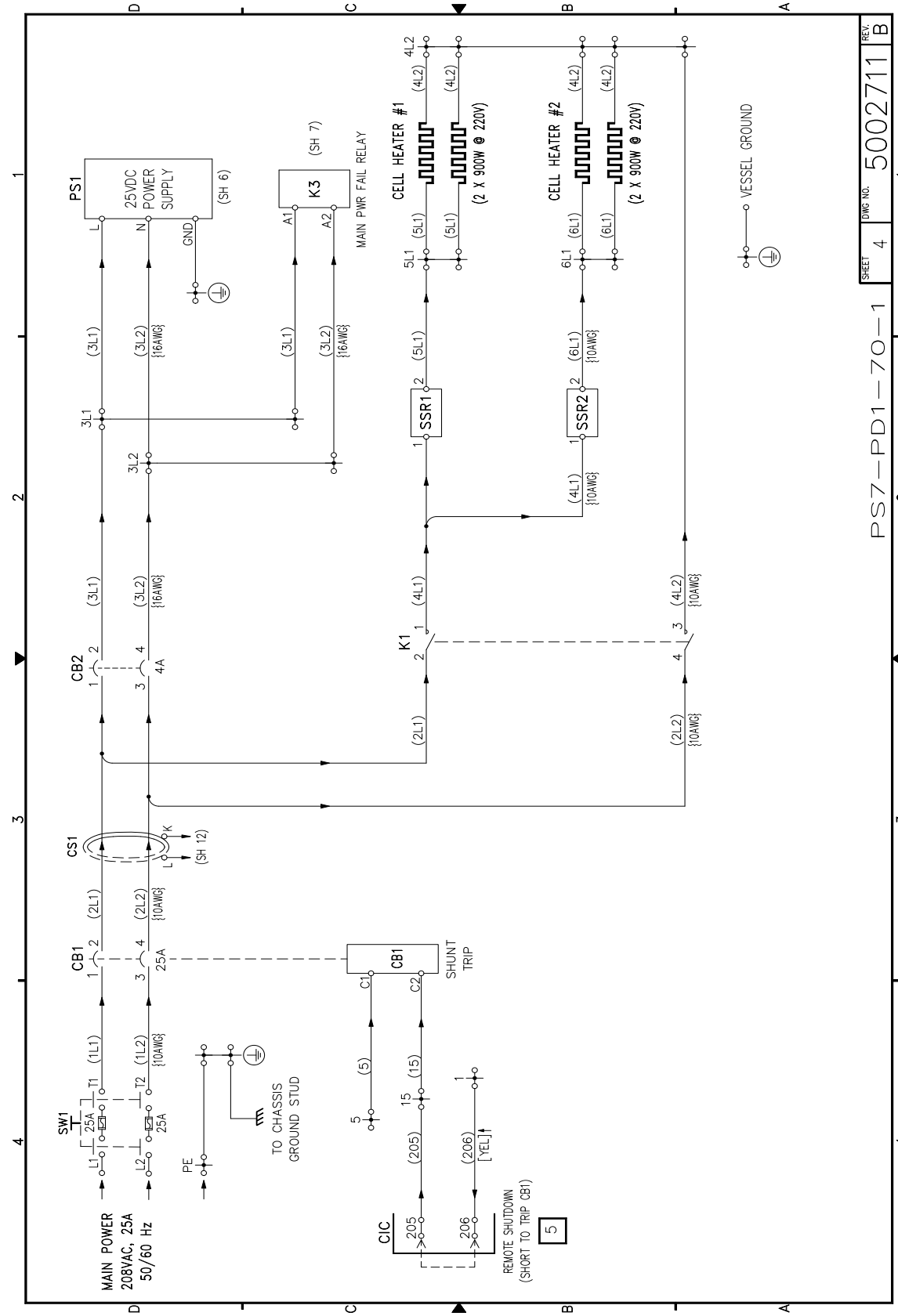

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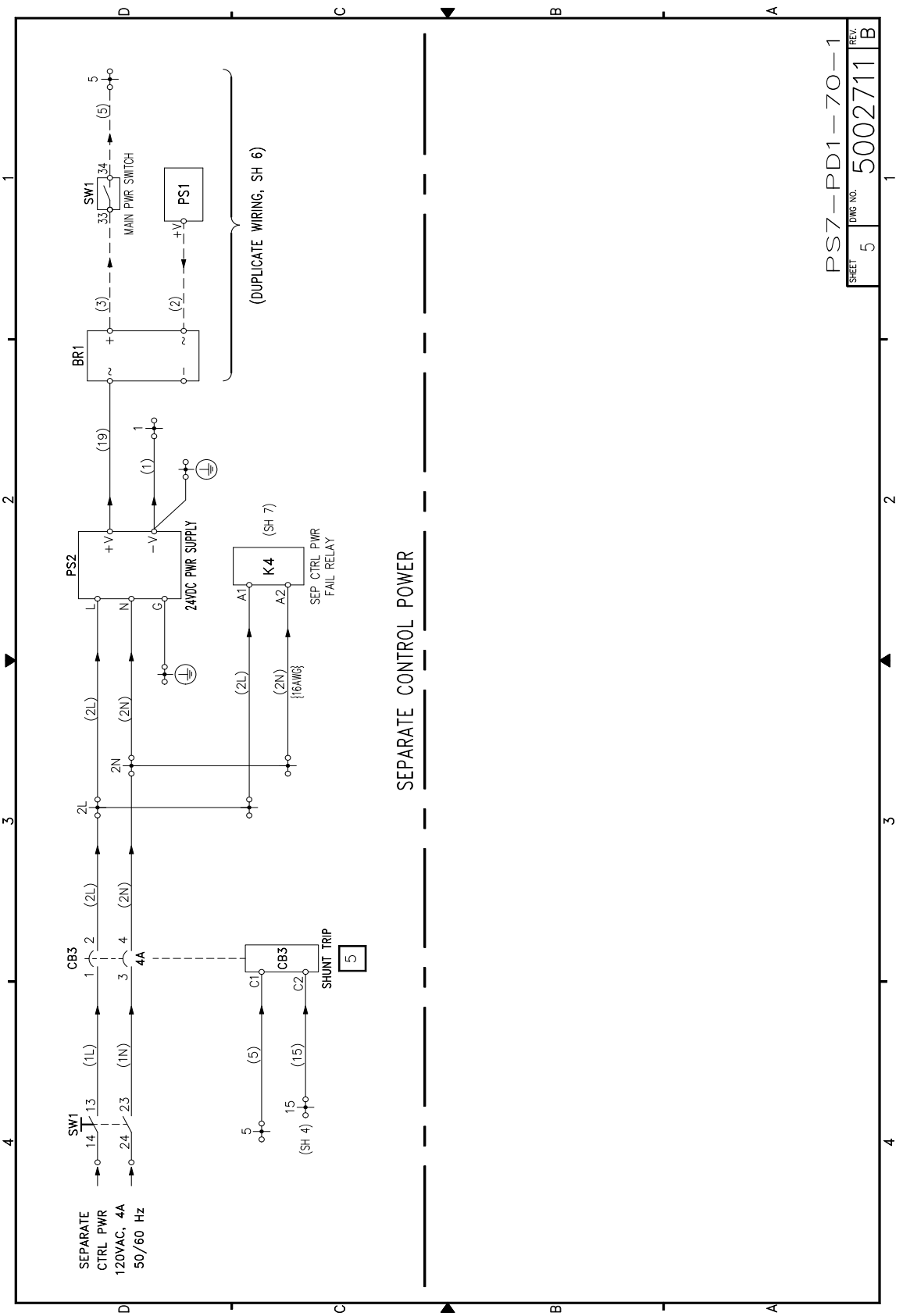

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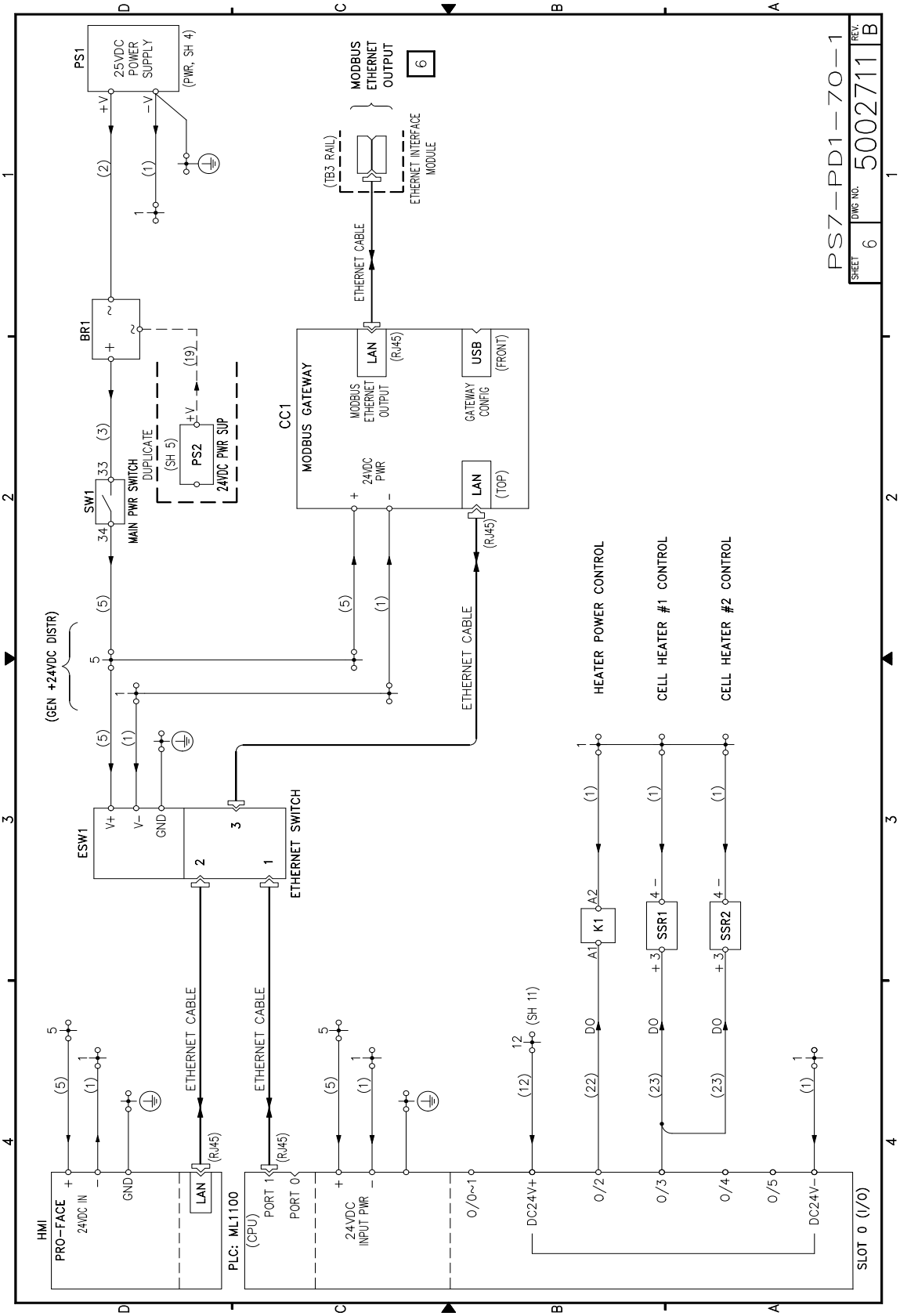

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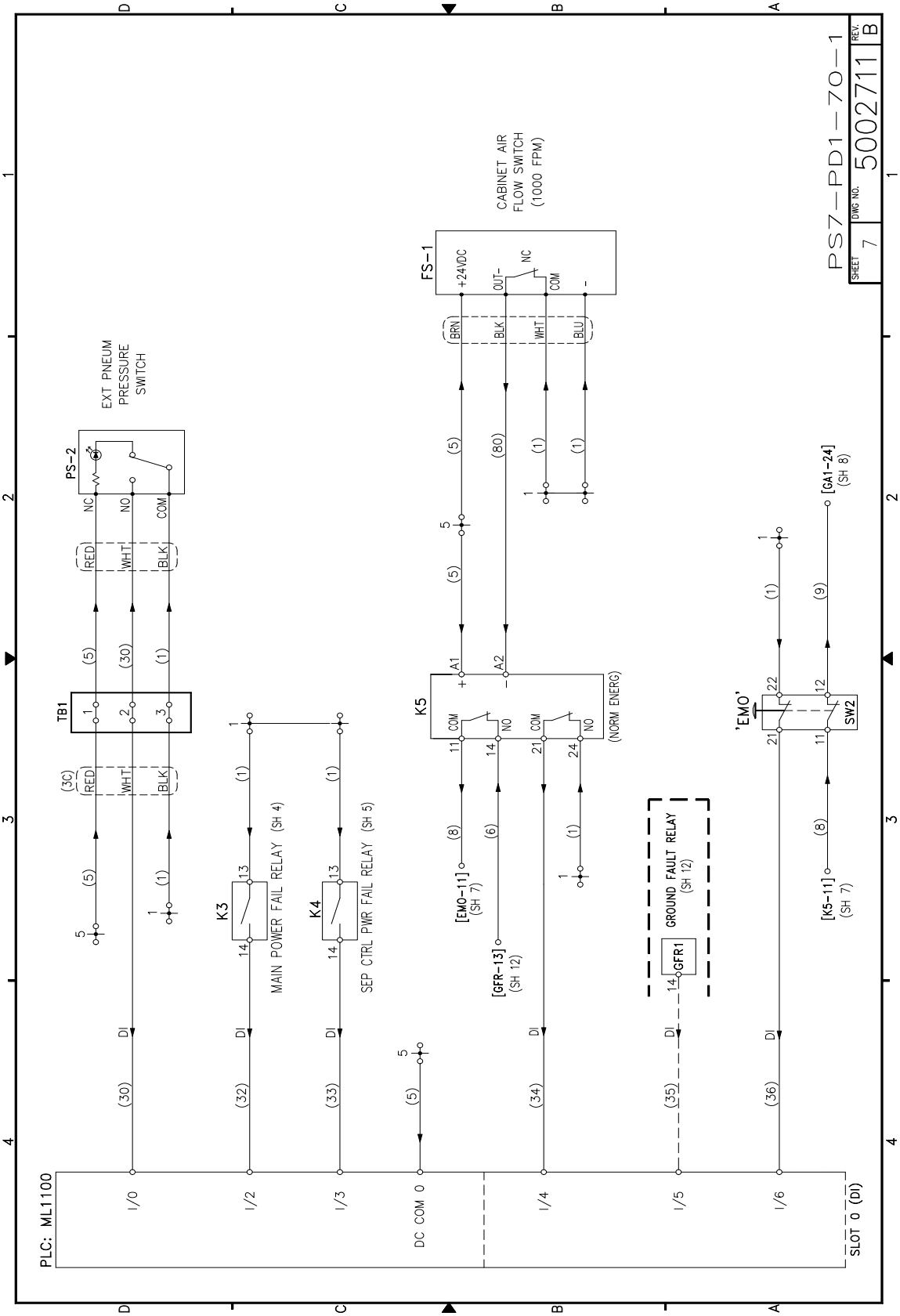

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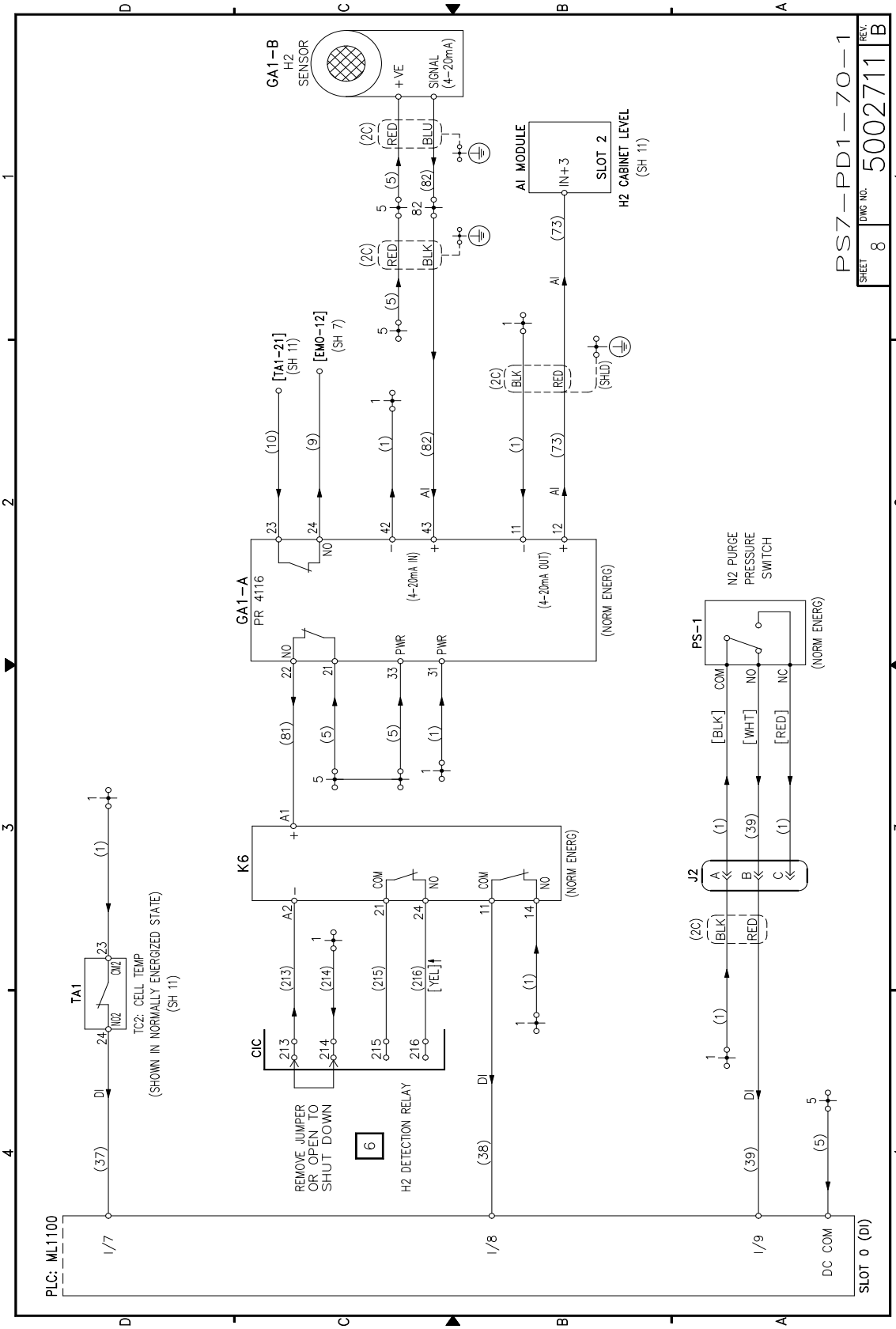

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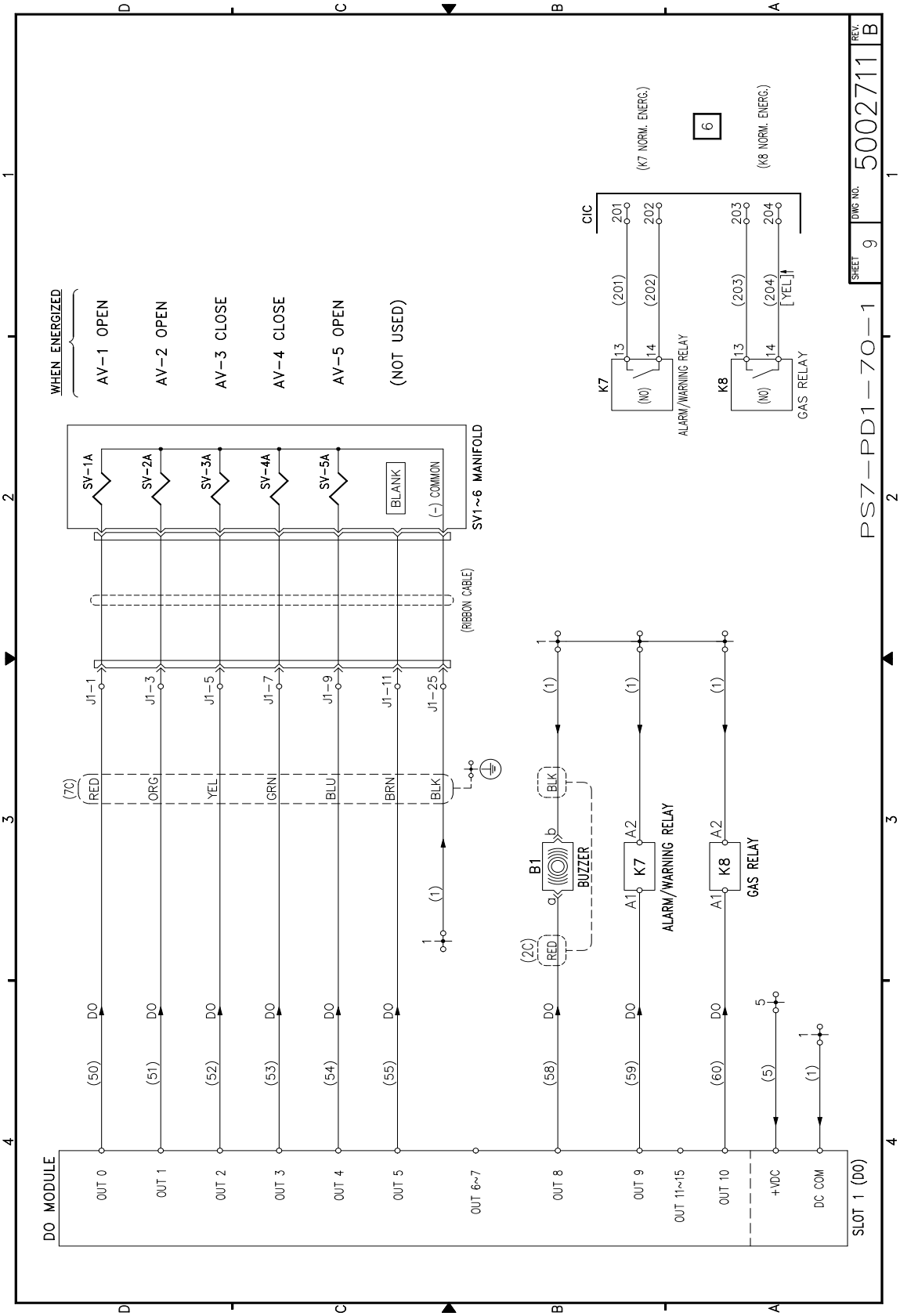

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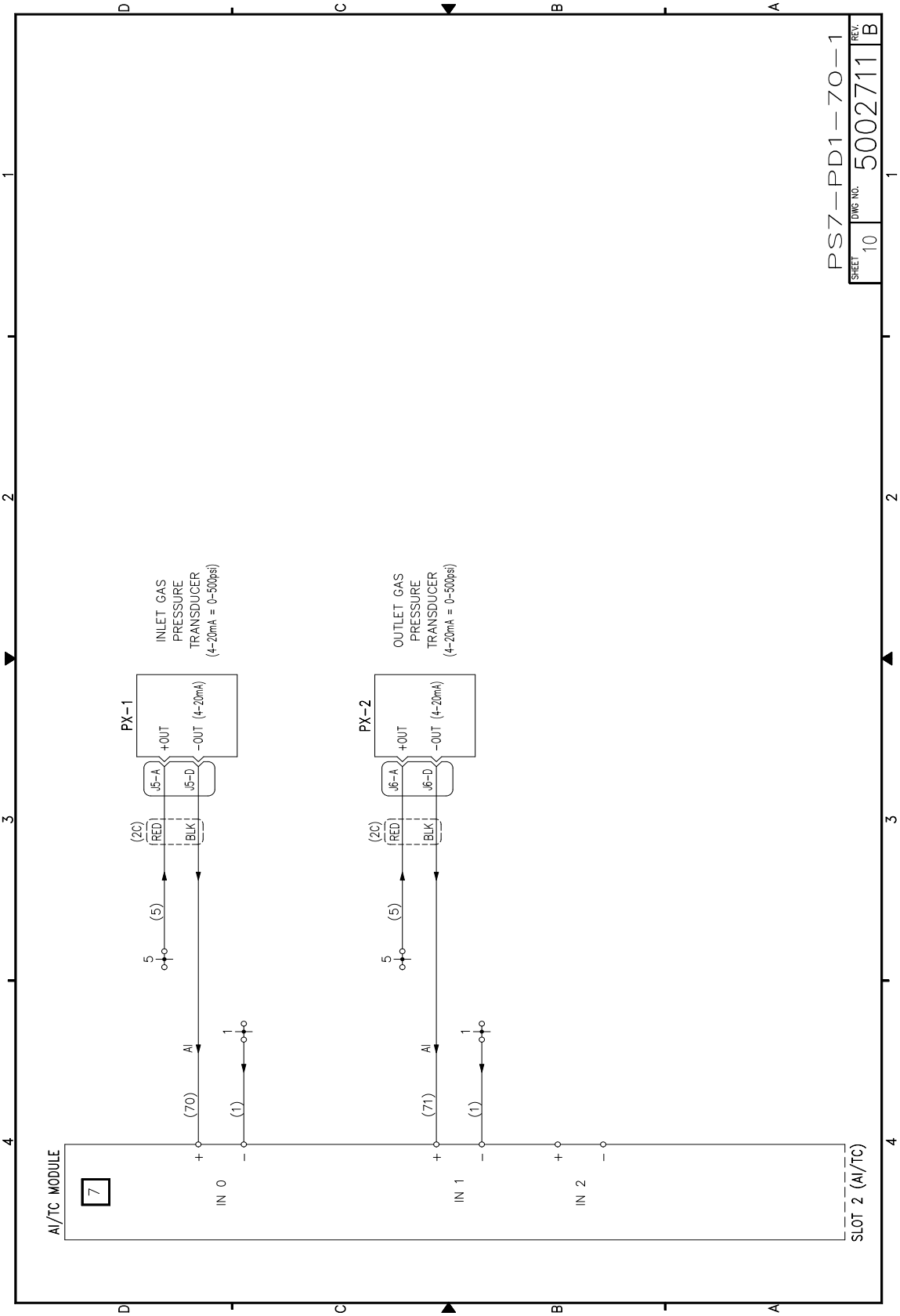

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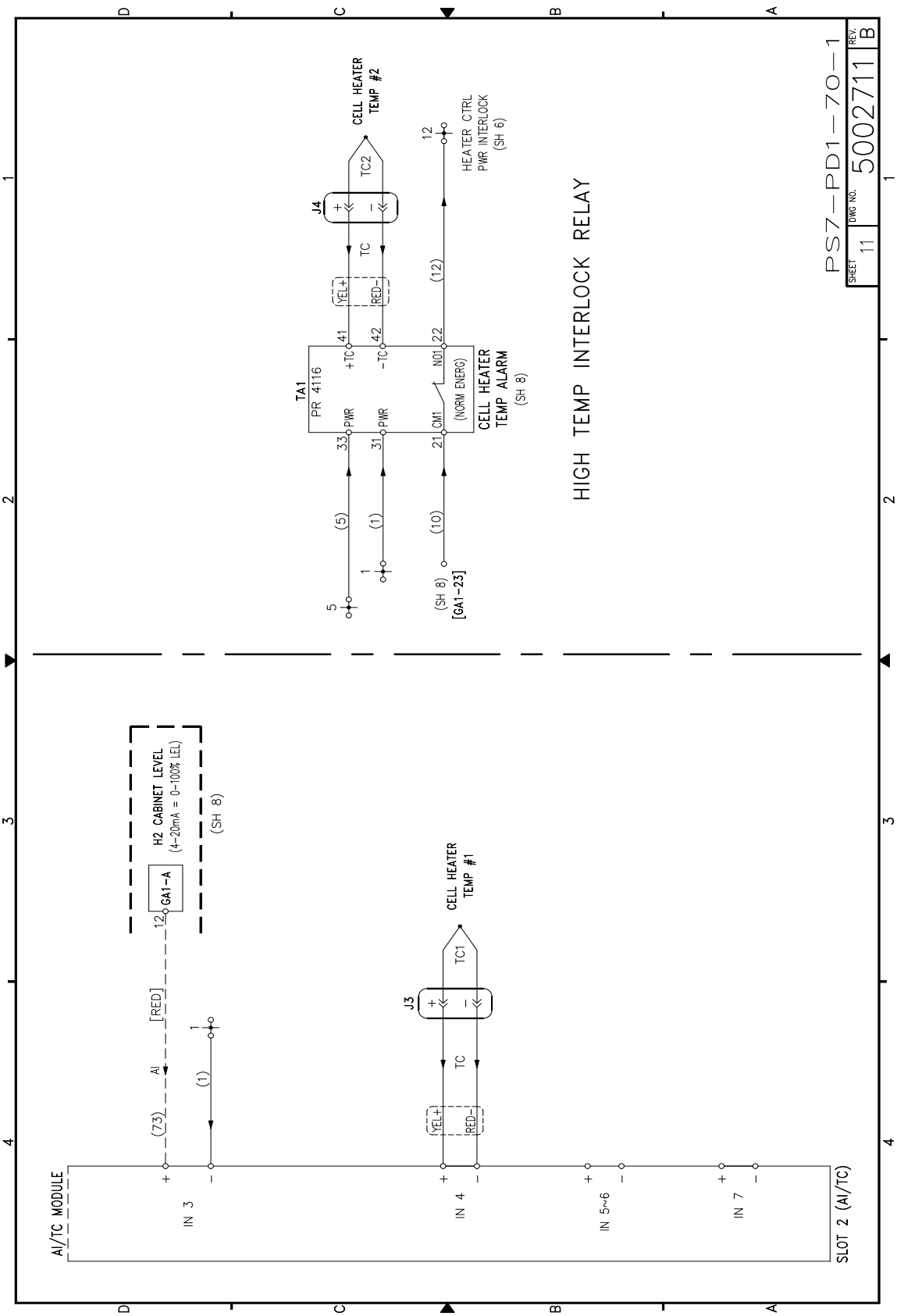

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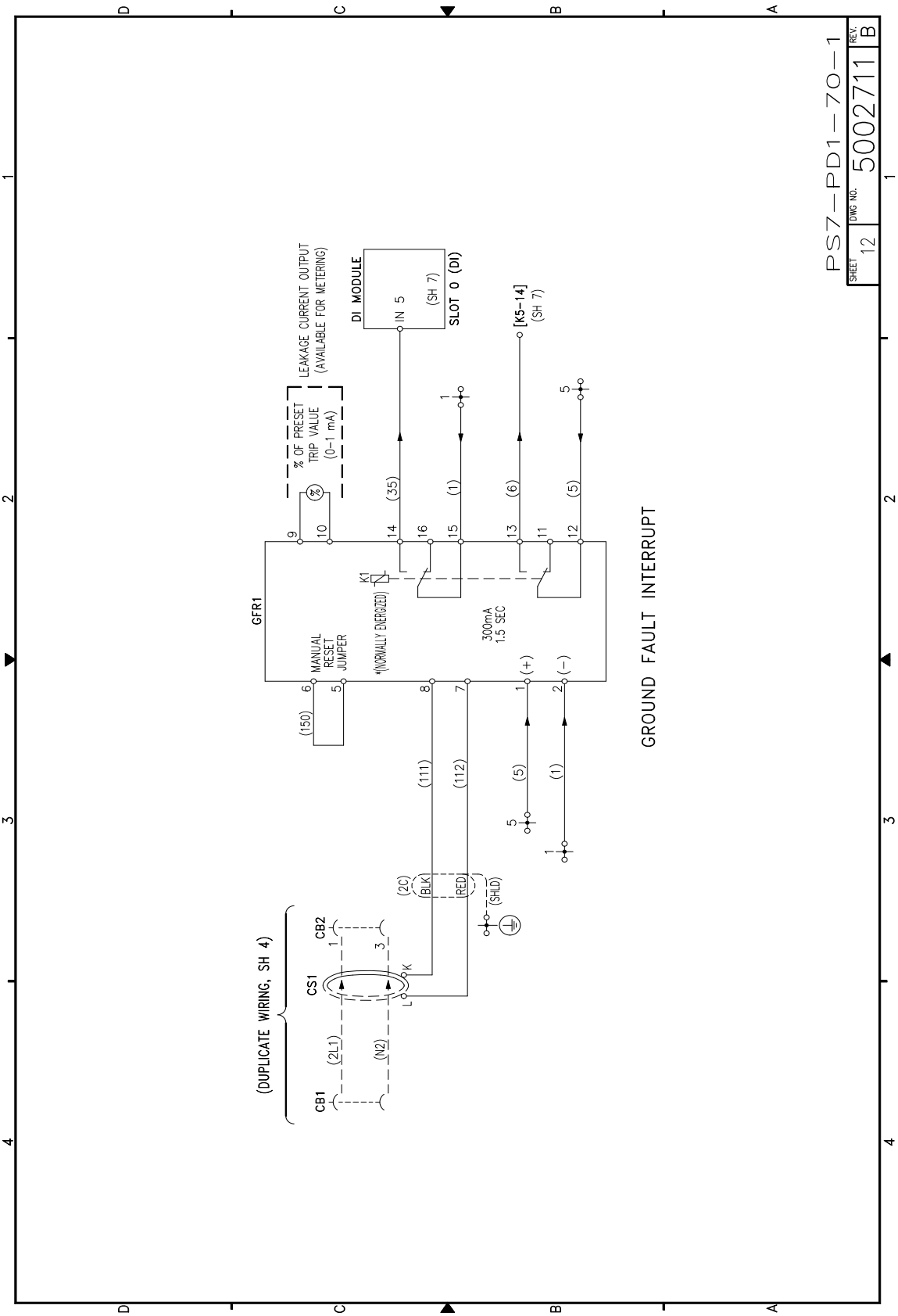
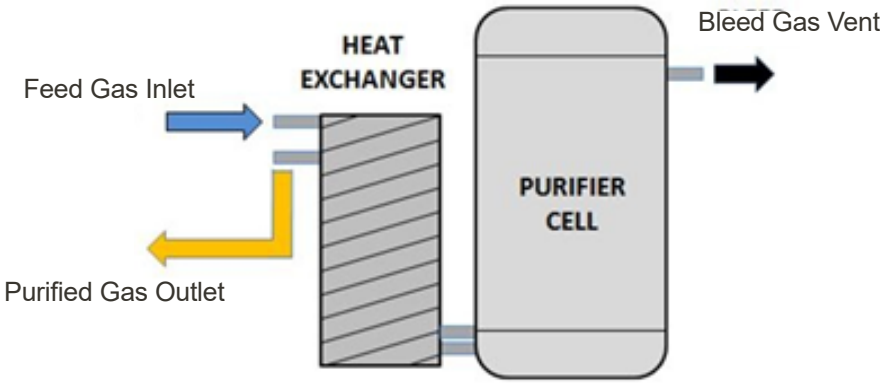


## PRINCIPLE OF OPERATION

Entegris Palladium hydrogen purifiers are all based on a palladium membrane capable of purifying hydrogen to very high levels (up to 99.9999999% purity). Palladium (Pd) hydrogen purifiers operate on the principle of diffusion to purify hydrogen. The palladium membrane absorbs hydrogen molecules onto its surface, where each hydrogen molecule dissociates into two hydrogen atoms. Each hydrogen atom loses its electron to the palladium membrane and diffuses through the palladium lattice as a proton. The protons recombine with two electrons on the far side of the lattice to form a hydrogen molecule that is desorbed from the palladium membrane. The partial pressure of hydrogen on each side of the palladium membrane determines the direction and flow rate of hydrogen across the membrane. Hydrogen diffuses across the membrane from the feed gas inlet (higher hydrogen partial pressure) to the purified gas outlet (low partial pressure). Because of this process, impurities on the purified gas side of the membrane are typically less than 1 part per billion.

When a palladium membrane purifier is shut-down, it is important to remove all of the hydrogen in the purifier before the palladium membrane cools below 300°C. When the palladium membrane temperature drops, the diffusion rate decreases and hydrogen can remain absorbed within the lattice of the palladium membrane. This can cause hydrogen embrittlement and can irreparably damage the purifier. All (Entegris palladium hydrogen purifiers have the nitrogen purge feature included, which will automatically prevent this potential issue from occurring.

The figure below shows the basic gas flow diagram for a single cell:




*(Flow diagram for illustrative purposes only)*

Internally, the purifier has two main chambers: the 'feed gas inlet' and the 'purified gas outlet' (or UPH, Ultra Pure Hydrogen). The feed gas inlet, is where the purge gas or the incoming hydrogen are fed to the system. The purified gas outlet side contains only the ultra-pure hydrogen that permeates from the feed side. A third side, called the bleed gas vent line, exhausts some hydrogen and the contaminants which are not able to penetrate the palladium membrane.

## OPERATING PRECAUTIONS

It is recommended that the palladium hydrogen purifier be operated at all times in accordance with recognized, safe practices for hydrogen-handling equipment. When using hydrogen, be well aware of the properties of the gas. For example, hydrogen:

- Is combustible at concentrations between 4% and 75% in air.
- Detonates at concentrations between 18% and 59% in air.
- Has an auto ignition threshold (in air) of 500°C.
- Will be ignited with an electrical discharge exceeding the energy equivalent to 200 mA at 24 VDC.

Please consult your qualified safety personnel for required safe operating procedures and practices. The following general safety precautions are recommended:

- Use only grounded electrical connections.
- Do not operate instruments in the presence of fugitive hydrogen.
- Permit only qualified and trained personnel to make component replacements.
- Always disconnect electrical power before removing unit cover.
- Allow time for hot internal surfaces to cool.
- Avoid the use of spark producing electrical equipment near the purifier cell.
- Operate the unit only in a well-ventilated area that is equipped with hydrogen detection instrumentation, an alarm system, and a fire protection system that meets the criteria of NFPA 30.
- Post 'No Smoking' signs in areas where hydrogen can be present.

Exposure to hydrogen feed-gas streams of unknown quality is inadvisable and may result in damage to the membrane. In particular, ensure that corrosive contaminates such as halogens and halides are absent from the feed-gas stream. Do not allow sulfur compounds or unsaturated hydrocarbons in the feed gas as these compounds will poison the surface of the palladium alloy membrane.

Gases such as $N_2$, CO, $CO_2$, $H_2O$, $NH_3$, and $CH_4$ are not harmful to the palladium membrane but will reduce the transfer rate by reducing the hydrogen partial pressure. Specifically, it is known that large amounts of oils, organic compounds, solvents, greases, pipe compounds, and fitting lubricants (particularly those containing lead) will decrease the capacity of the hydrogen purifier. Mercury, lead, zinc and iron salts should also be excluded from coming in contact with the palladium alloy tubes.

**Oxygen Content:**

Oxygen in a concentration greater than 1,000 ppm, although not a surface poison, may cause damage to the palladium membranes from excessive heat. If the gas stream contains > 1,000 ppm oxygen please contact the Entegris Pure Gas factory for information about an upstream de-oxo pre-purifier to convert the oxygen to moisture (503 media).

## REVERSE PRESSURIZATION:

Hydrogen diffuses through palladium in a direction determined by the pressure gradient. To produce ultra pure hydrogen you must have a higher pressure on the feed gas inlet side of the palladium cell than on the purified gas outlet side. Reverse pressurization occurs when the purified gas outlet pressure exceeds the feed gas inlet pressure and a differential of greater than 15 to 25 PSI, this can damage the palladium membranes and void the warranty.

⚠ **WARNING: Do not allow the purified gas outlet pressure or bleed gas vent to exceed 15 psi over the feed gas inlet or nitrogen purge inlet.**

## TEMPERATURE CYCLING:

To maintain optimum performance of your Palladium Hydrogen Purifier, it is recommended to minimize the number of cycles between operating temperature and room temperature. The system performs best when operating temperature is sustained.

## UN-PACKING AND INSTALLATION

**CAUTION: Follow installation instructions precisely for safe and reliable operation. Complete all welding before installing and facilitating electrical equipment to prevent damage to the electronic control system.**

**CAUTION: Stop installation immediately if you encounter any inconsistencies with these instructions. Close all manual valves and call the factory. Do not continue installation without direction from Entegris customer service.**

**CAUTION: Entegris recommends that a field service engineer complete the installation procedures and perform purifier start-up after electrical connections are made.**

**CAUTION: It is the customer's responsibility to ensure that this purifier is installed with an appropriately sized full flow pressure relief system external to the purifier.**

### Un-packing

**CAUTION: Use extreme care in handling the enclosure since the purifier will be damaged if it is tipped on its side or dropped.**

For safety and purity, the purifier is shipped purged with nitrogen.

Carefully off-load the purifier crate with appropriate equipment. Inspect the crate for any exterior damage. Take particular care to watch for moisture, crushing, denting, or any other external signs of shipping damage. After removing the crate and plastic inspect the shock watch and trip meters located inside the electrical cabinet.

Immediately notify Entegris customer service of any shipping damage. Remove all shipping brackets (identified with red hang tags) and packing foam.

### Space/Environmental Requirements

Maintain a minimum of 1 meter (~ 40 inches) of space in front of the purifier. Purifier must be installed indoors in a non-classified area. The electrical cabinet and purifier in general are not resistant to wind, extreme temperatures, moisture, or rain. Install the purifier under the following conditions: winds less than 5 kph, ambient temperatures 5°C to 35°C, relative humidity under 80%, and no precipitation.

**WARNING: Do not remove any caps until you have connected instrument air and prepared the purifier for gas connections. Do not remove any caps or open any valves until instructed to do so.**

## Installation

### Start-up Inspection

The following checklist should be followed exactly prior to start-up. All mating process lines shall be purged and atmosphere free, prior to connecting and tightening any external VCR connections. Ensure that the following connections have been made.

⚠ **CAUTION: Follow uhp component handling procedures precisely to maintain factory performance specifications. Do not expose the purifier connections or internal piping surface to any hydrocarbons, fingerprint oils, or moisture.**

### Instrument Air: Pneumatic Air or Nitrogen

The pneumatic supply must be connected first to protect the system. Confirm pneumatic supply is on and pressure is between 95 and 140 psig. After connecting the pneumatic supply, open the pneumatic inlet valve (V-3) and verify the correct pressure at the pressure gauge (Pi-1 and Pi-2). The line should not be restricted. The connection is a ⅜" female NPT brass female union.

⚠ **CAUTION: if the pressure gauge does not indicate the correct pressure, do not proceed. You cannot continue the installation without pneumatic pressure available.**

### Z-Purge (if equipped)

Is pulled from Instrument Air or Nitrogen (which is already connected). Adjust PRV-2 (if adjustment is necessary) until pressure on 'Z-purge Pressure' Gauge is between 0.3 and 0.7 inches W.C.

### Nitrogen Purge Inlet

Confirm the nitrogen is 99.95% purity and the pressure is between 72 and 98 psig. The connection is a ¼" male VCR bulkhead fitting.

### Feed Gas Inlet and Purified Gas Outlet

The purifier is shipped pressurized with inert gas and the inlet/outlet connections are capped. Adhere to all UHP (Ultra High Purity) procedures during this installation. Completely purge the inlet and outlet gas connections prior to and during connection. The inlet/outlet connections are female VCR bulkheads (see installation drawing for sizes)

⚠ **CAUTION: This purifier is for the purification of HYDROGEN only. Do not use this purifier for any other gases. If the incorrect gas is used, the purifier may be permanently damaged.**

⚠ **WARNING: Hydrogen is extremely flammable and potentially explosive in air. Exercise extreme caution when working with hydrogen. Lel of hydrogen is 4% of volume in air.**

### Bleed Gas Vent Outlet

Connect the vent line to a facility vent line that is compatible with the process gas. Do not connect the vent line to any other line that can create back pressure. It is recommended to install a ⅓ psi check valve (outside of the purifier) to protect against back streaming contaminates. The connection is a ¼" female VCR bulkhead fitting.

**WARNING: Do not obstruct the bleed gas vent, otherwise the performance of the system will decrease and it can cause irreparable damage to the cell.**

### Cabinet Exhaust (Cabinet Ventilation)

Connect the 4" cabinet vent duct to the facility exhaust line. Maintain a flow & vacuum of 260 $Nm^3/hr$ (150 scfm, at Facilities Vacuum, 0.2 inches $H_2O$) during setup and operation.

### Electrical Connections

**WARNING: Do not apply electrical power to the purifier until all pneumatic and gas connections have been completed. Only qualified personnel should install electrical power. Electrical power should meet all applicable codes.**

The customer is responsible for the electrical power supply connections to the purifier. Refer to the installation drawing for more information on electrical power.

- Main Power. Confirm the correct voltage is supplied to SW1 (main power switch terminals).
- Optional Separate Control Power (if equipped). Confirm the correct voltage is supplied to SW1 (control power switch terminals).

Customer Interface Connections (if used)

**CAUTION: Make sure electrical power is off and power to the circuit is interrupted by a circuit breaker before working in the electrical cabinet.**

The customer interface connections provide status signals to the customer. The terminal blocks are located on the upper right DIN rail of the electrical panel inside the electrical cabinet. The customer is responsible for installing the customer interface connections. Refer to the installation drawing for terminal functions.

No access holes are provided for the customer interface connections. The customer may choose the type and size of connection to conform with all applicable local codes and regulations.

## EMERGENCY OFF BUTTON (EMO)

The emergency off button provides a way of shutting down the purifier quickly and safely. Depressing the button will place the system in offline mode. All hydrogen valves will close and the system will open all nitrogen purge valves.

To place the purifier back online after depressing the emergency off button, twist and pull the button until it remains in the "out" position. Insure the main power switch is in the "on" position and select "Restart" from the HMI.

The purifier can now be started up, by pressing the 'start' button.

See 'Main HMI Operation' section for more information.

If any alarms or warning are present, then review section on alarms and warnings and/or contact Entegris Pure Gas for more information.

## MODBUS ADDRESSING

The following default parameters have been established for communication port configuration and may be changed by the operator in the "Special Controls" menu.

Baud = 9600 bps  Parity = Even  Data Bits= 8  Stop Bits = 1  Protocol = RTU (not ASCII)

**Register Addressing**

| R | Name | Description | Format | Units |
|---|---|---|---|---|
| 0 | A_PURIFY_DAY.ACC | Total days in purification | | |
| 1 | A_PURIFY_HR.ACC | Current purify hours (resets at 24) | | |
| 2 | A_PURIFY_MIN.ACC | Current purify minutes (resets at 60) | | |
| 3 | A_PURIFY_TM.ACC | Current purify seconds (resets at 60) | | |
| 4 | A_N2_PURGE_MIN.ACC | Total minutes in current N2 Purge | | |
| 5 | H2_LEAK_RESET_MIN.ACC | Minutes left until H2 Leak Alarm reenabled | | |
| 6 | H2_LEAK_RESET_SEC.ACC | Seconds left until H2 Leak Alarm reenabled (resets at 60) | | |
| 7 | CELL_A_STATE | Sequence step number | | |
| 8 | A_INLET_PX_PSIA | PX1 - Inlet gas pressure | XXX.X | psia |
| 9 | A_OUTLET_PX_PSIA | PX2 - Outlet gas pressure | XXX.X | psia |
| 10 | A_MFM_CUM_HR | MFM - Mass flow meter reading | XXXX | cuM/hr |
| 11 | H2_LEVEL_PERCENT | HC1 - H2 sensor level reading | XXX | % |
| 12 | A_TEMP | TC1 - Cell wall temperature | XXX.X | °C |
| 13 | ELEC_CAB_PX_WC | DPT1 - Electrical Cabinet Pressure | XX.XX | in. WC |
| 14 | CELL_FLOW_TOTAL_CUM | Total flow (Low 16 bits of 32-bit value) | XXXX | cuM |
| 15 | CELL_FLOW_TOTAL_CUM | Total flow (High 16 bits of 32-bit value) | XXXX | cuM |
| 16 | PREHEATER_SP | Preheater PID set point | XXX.X | °C |
| 17 | PREHEATER_PV | Preheater PID process variable | XXX.X | °C |
| 18 | CELL_A_PH_PID.CVP | Preheater control output | XXX | % |
| 19 | MOISTURE_SENSOR | High moiture sensor | XXX | % |

## COIL ADDRESSING

| Modbus | Name | Description |
|---|---|---|
| 640 | MB_HEARTBEAT_ON/EN | Flashing bit to indicate values are updating |
| 641 | SYSTEM_IN_ALARM | System alarm |
| 642 | CELL_A_IN_ALARM | Cell alarm |
| 643 | SYSTEM_IN_WARNING | System warning |
| 644 | CELL_A_IN_WARNING | Cell warning |
| 645 | EMO_ACTIVE | Emergency stop is active |
| 646 | SYSTEM_ONLINE | Cell is purifying |
| 647 | CELL_STANDBY | Cell is in Standby |
| 648 | A_IN_HOT_TEST | Cell is in hot helium leak test |
| 649 | A_IN_COLD_TEST | Cell is in cold helium leak test |
| 656 | A_H2_INLET_OPEN | AV1 OPEN - H2 inlet valve |
| 657 | A_H2_OUTLET_OPEN | AV2 OPEN - H2 outlet valve |
| 658 | A_N2_INLET_CLOSE | AV3 CLOSE - N2 inlet valve |
| 659 | A_BLEED_CLOSE | AV4 CLOSE - Bleed valve |
| 660 | A_EQUALIZE_OPEN | AV5 OPEN - Equalize valve |
| 661 | A_BYPASS_CLOSE | AV6 CLOSE - Bypass valve (option) |
| 664 | ALARM_BUZZER_OUT | Alarm buzzer |
| 665 | ALARM_RELAY | Alarm relay |
| 666 | GAS_RELAY | Gas relay |
| 677 | LP_EXT_PNEU_ALARM | Low external pneumatic pressure alarm |
| 678 | LP_N2_INLET_ALARM | Low Nitrogen inlet pressure alarm |
| 679 | MAIN_PWR_FAIL_ALARM | Main power failure alarm |
| 680 | CTL_PWR_FAIL_ALARM | Control power failure alarm |
| 681 | PLC_FAULT_ALARM | PLC fault alarm |
| 682 | LOW_PLC_BATT_ALARM | Low PLC battery alarm |
| 683 | LOW_AIR_FLOW_ALARM | Low air flow alarm |
| 684 | GFI_FAULT_ALARM | Ground fault interrupt alarm |
| 693 | LP_ELEC_CAB_ALARM | Low electrical cabinet pressure alarm (Z-Purge alarm) |
| 694 | OPEN_DPT1_ALARM | Open differential pressure trasnmitter alarm |
| 696 | H2_LEVEL_ALARM | High Hydrogen level alarm |
| 697 | H2_LEAK_ALARM | Hydrogen leak alarm |
| 698 | OPEN_GA1_ALARM | Open Hydrogen sensor alarm |
| 699 | MOIST_SENSOR_ALARM | Moisture sensor alarm |
| 704 | A_HT_PURIFY_ALARM | High temperature on purify cell alarm |
| 705 | A_LT_PURIFY_ALARM | Low temperature on purify cell alarm |
| 706 | A_PH_FAULT_ALARM | Cell preheater failed to heat alarm |
| 707 | A_OPEN_TC_ALARM | Open thermocouple on Cell wall |
| 708 | A_HTI_ALARM | High temperature heater interlock alarm |
| 709 | A_HI_DUTY_ALARM | High duty cycle alarm |
| 710 | A_LO_DUTY_ALARM | Low duty cycle alarm |
| 711 | A_LP_INLET_GAS_ALM | Low inlet gas pressure alarm |
| 712 | A_LP_OUTLET_GAS_ALM | Low outlet gas pressure alarm |
| 713 | A_LP_DROP_GAS_ALM | Low gas pressure drop alarm |
| 714 | A_HP_INLET_GAS_ALM | High inlet gas pressure alarm |
| 715 | A_HP_OUTLET_GAS_ALM | High outlet gas pressure alarm |
| 716 | A_HP_DROP_GAS_ALM | High gas pressure drop alarm |
| 717 | A_OPEN_PX_IN_ALARM | Open inlet pressure transducer |

## COIL ADDRESSING-CONTINUED

| Modbus | Name | Description |
|---|---|---|
| 718 | A_OPEN_PX_OUT_ALARM | Open outlet pressure transducer |
| 741 | LP_EXT_PNEU_WARN | Low external pneumatic pressure warning (Z-Purge warning) |
| 742 | LP_N2_INLET_WARN | Low Nitrogen inlet pressure warning |
| 743 | MAIN_PWR_FAIL_WARN | Main power failure warning |
| 744 | CTL_PWR_FAIL_WARN | Control power failure warning |
| 745 | PLC_FAULT_WARN | PLC fault warning |
| 746 | LOW_PLC_BATT_WARN | Low PLC battery warning |
| 747 | LOW_AIR_FLOW_WARN | Low air flow warning |
| 748 | GFI_FAULT_WARN | Ground fault interrupt warning |
| 752 | H2_LEAK_ALM_DISABLED | H2 Leak alarm disabled warning |
| 753 | MODBUS_ERROR | Modbus gateway communication error warning |
| 754 | MFM_CONFIG | Mass flow meter configuration |
| 757 | LP_ELEC_CAB_WARN | Low electrical cabinet pressure warning |
| 758 | OPEN_DPT1_WARN | Open differential pressure trasnmitter warning |
| 760 | H2_LEVEL_WARN | High Hydrogen level warning |
| 761 | H2_LEAK_WARN | Hydrogen leak warning |
| 762 | OPEN_GA1_WARN | Open Hydrogen sensor warning |
| 763 | MOIST_SENSOR_WARN | Moisture sensor warning |
| 765 | POWER_LOSS | Power loss during processing warning |
| 768 | A_HT_PURIFY_WARN | High temperature on purify cell warning |
| 769 | A_LT_PURIFY_WARN | Low temperature on purify cell warning |
| 770 | A_PH_FAULT_WARN | Cell preheater failed to heat warning |
| 771 | A_OPEN_TC_WARN | Open thermocouple on Cell wall warning |
| 772 | A_HTI_WARN | High temperature heater interlock warning |
| 773 | A_HI_DUTY_WARN | High duty cycle warning |
| 774 | A_LO_DUTY_WARN | Low duty cycle warning |
| 775 | A_LP_INLET_GAS_WARN | Low inlet gas pressure warning |
| 776 | A_LP_OUTLET_GAS_WRN | Low outlet gas pressure warning |
| 777 | A_LP_DROP_GAS_WARN | Low gas pressure drop warning |
| 778 | A_HP_INLET_GAS_WARN | High inlet gas pressure warning |
| 779 | A_HP_OUTLET_GAS_WRN | High outlet gas pressure warning |
| 780 | A_HP_DROP_GAS_WARN | High gas pressure drop warning |
| 781 | A_OPEN_PX_IN_WARN | Open inlet pressure transducer |
| 782 | A_OPEN_PX_OUT_WARN | Open outlet pressure transducer |

## MODES OF OPERATION

There are six different modes of operation (offline, heating, pressurize, purify, standby, shutdown). The 'startup' consists of taking the purifier from offline to purify modes.

Offline

In the offline mode, nitrogen gas is used to purge the 'feed gas inlet' side and is exhausted through the 'bleed gas outlet' vent line. The nitrogen will not permeate through the palladium membrane, so there is no flow out of the 'purified gas outlet'.

Heating

During heating the system is heated up to 400°C. The purifier has a fail-safe control system that monitors the entire process. Nitrogen is still being purged through the cell.

Equalize/Pressurize

Once the cell has reached operating temperature, the feed gas is switched to hydrogen and the cell is brought up to operating pressure with the 'purified gas outlet' closed. Depending on the cell capacity and electrical specifications, the equalize and pressurize processes may take approximately 45 minutes.

Purify

During purify the cell is at temperature and feed hydrogen travels through the cell. Impurities and some hydrogen travel out the bleed gas vent. Purified hydrogen travels out the purified gas outlet.

⚠ **WARNING: Do not obstruct the bleed gas vent, otherwise the performance of the system will decrease and it can cause irreparable damage to the cell.**

Note on the Boost Bleed function: During a boost bleed cycle in purify mode; hydrogen flow out of the bleed gas vent line will be higher (~8% of maximum flow) than the standard mode (~2% of maximum flow). The boost bleed valve will remain open for 5 minutes, and then it will automatically close and return to the regular bleed rate. This step is used to purge the inlet side of the cell from impurities.

Stand by

The Standby mode is accessible to the operator through the HMI > Special Controls > Manual Controls page. This will close the purified gas outlet valve while keeping the feed gas inlet valve open. The heaters will stay energized and the Palladium cell remains at operating temperature; this mode is used for short term shutdowns only. The system will continue to bleed hydrogen gas at a rate of ~2%.

Shutdown

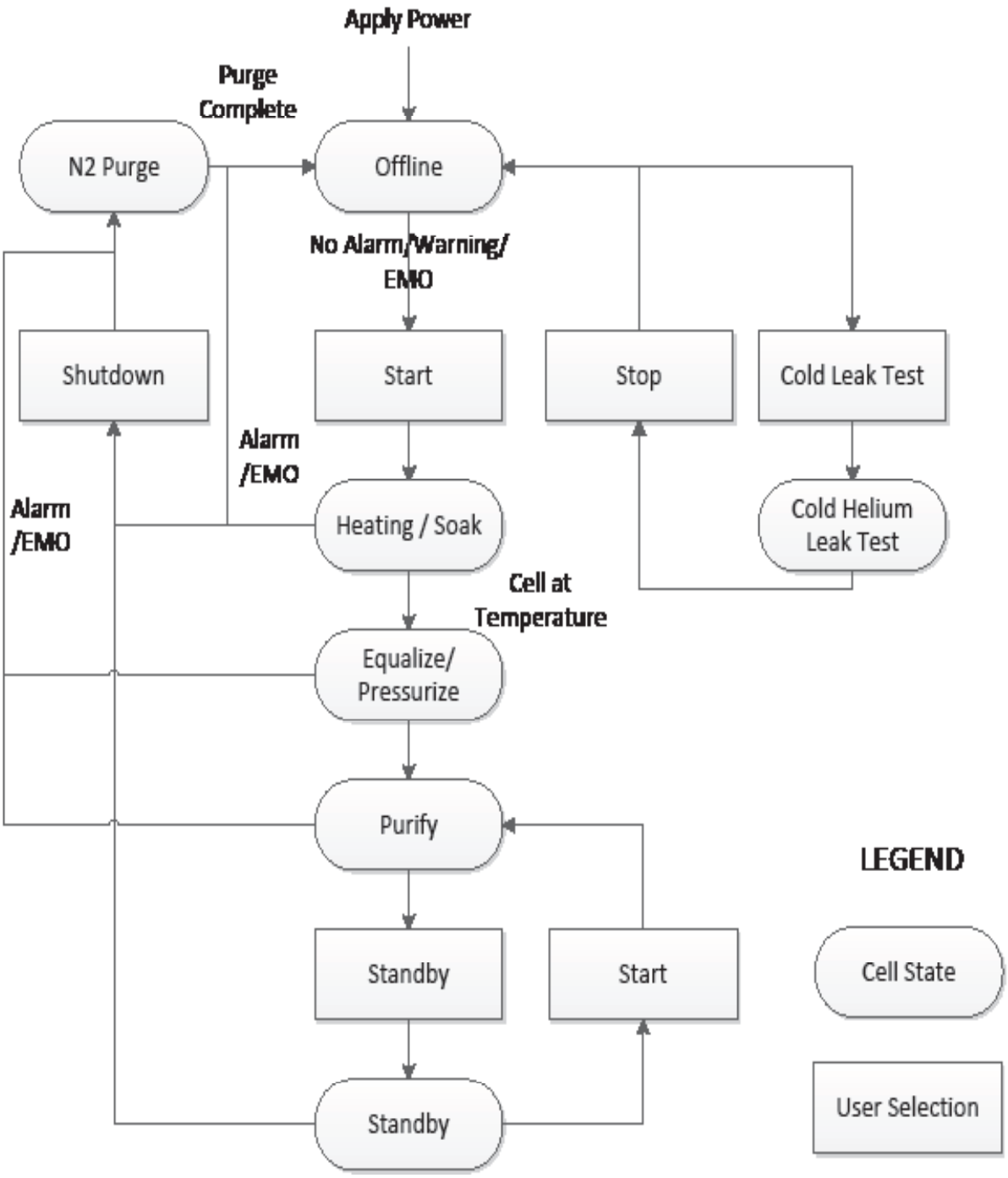
All hydrogen must exit the purifier before shutting down the system. In shutdown mode, the unit vents the hydrogen contained inside the purifier through the bleed gas vent line and then uses the nitrogen purge gas to eliminate all remaining hydrogen inside the cell. It takes 15 to 25 minutes to completely eliminate hydrogen from the purifier. The heater power will stay engaged for 15 minutes during this purge sequence. The cell may take between 6-12 hours to reach room temperature. During this process it is critical that the purge gas leaves the cell, so the bleed line must not be obstructed.

⚠ **WARNING: The "bleed gas vent" line of the cell must not be obstructed, closed, or capped during shutdown. This will prevent hydrogen from exiting the purifier before cooling, and may cause irreparable damage to the cell.**

Maintaining the nitrogen supply is critical. The nitrogen supply will ensure that the palladium cell is purged during the heat up and cooling down processes. This will reduce the thermal stress of the palladium membranes. In the event of any electrical or other failure, flowing nitrogen ensures the integrity of the purifier. The gas will pass through the restrictive orifice and the bleed gas vent line.

⚠ **WARNING: Do not disconnect the nitrogen gas supply unless the system has been properly shut down and the cell temperature has reached ambient conditions.**

## MODE OF OPERATION FLOW DIAGRAM:



## MAIN HMI OPERATION

The HMI is a touch screen that provides detailed data, operating conditions and control options.

Note: The screenshots displayed on the following pages are for example only, and the values shown may not reflect the exact configuration of your purifier.

Parameters labeled “psia” indicate pounds per square inch, absolute. Parameters labeled “bara” indicates pressure in bar, absolute.

Parameters in “$Nm^3$” indicate units of Normal cubic meters.

Parameters in “$Nm^3/hr$” indicate units of Normal cubic meters per hour.

Parameters in “slpm” indicate units of standard liters per minute.

**Main Screen**

The Main Screen appears automatically when the main power is turned on. The hydrogen gas path will show in green. The nitrogen gas path will show in blue.

Displayed Items

Status: Indicates an alarm, warning, emergency stop condition, or systems ok.

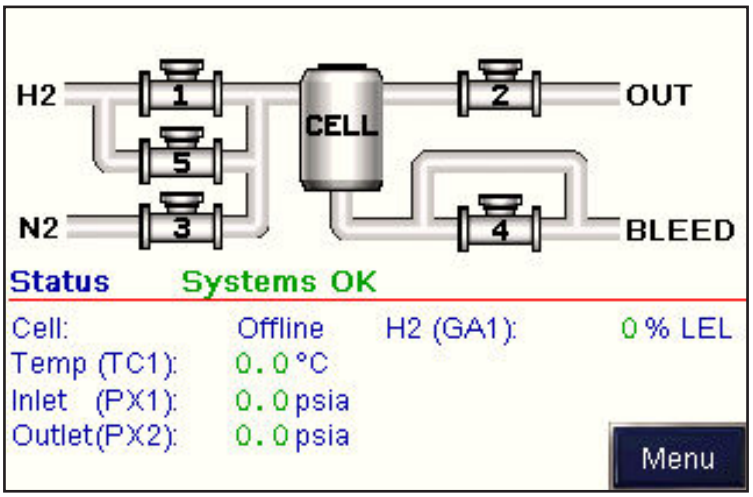
Cell: Indicates the process state of the cell.

Temp: The current temperature of the cell.

Inlet/Outlet: The current pressure on the inlet and outlet of the cell.

H2: The H2 sensor reading.

Flow (MFM): The current and total flow through the purifier. (optional)



## MENU

The Menu button displays the following options: Alarms, Controls, Details, Events, Sequence, Trend, Home

Alarms:

Accesses the Active Alarms screen. This page displays active alarms, warnings, and messages.

Controls: (Special Controls)

Accesses special control screens which allow changes to purifier settings. A password is required to enter these screens.

Details:

Accesses screens which provide in-depth, real-time data on the status of all the purifiers control points, instruments and systems.

Events:

Accesses the Events History screen which displays past events. Each event is identified by a code to the right of the time stamp.

Sequence:

Accesses the Sequence Details screen which outlines all modes of operations, and indicates the current mode (in the sequence).

Trend:

Accesses the heating and inlet/outlet pressures of the purifier cell.

Start:

Will initiate the startup sequence. Some alarms will prevent the purifier from starting, to see more information see the “Alarms & Warnings” section of this document. If there are no active alarms or warnings, the purifier will proceed with startup. Otherwise a message will appear: “An alarm or warning is still present.” In this case, the operator should select the OK button, attempt to resolve the problem, and repeat the start process.

Home:

Returns the user from any screen to the home screen. This replaces the Start button on all screens besides the Main screen.

Menu:

Toggles the visibility of the menu bar.

## ALARMS AND WARNINGS SCREEN

Should an alarm condition occur, the status message "Systems OK" will change to a blinking **Alarm** message and a beeper will sound. A warning (without any alarms) will change the status message to a blinking Warning message.

To acknowledge an alarm or warning, select either the ACCEPT button for a single fault condition, or the ALL button for the entire set. A fault condition can have four states:

Active: The fault condition is currently in effect and has not been accepted by the operator. These faults show in red for alarms, yellow for warnings.

Accepted: The fault banner has been accepted by the operator (by pressing the ACCEPT or ALL button). The condition causing this fault is still occurring or has not been corrected. This fault banner will not clear, but will be displayed in gray.

Inactive: The fault condition has been corrected. The faults will show in white.

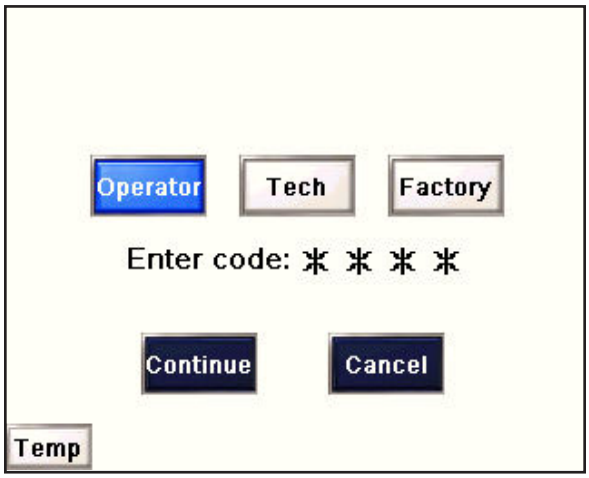
Cleared: Any fault which has been accepted by the operator and has been completely corrected will clear, disappearing from the list. The Alarm History can be referred to later for a history of all alarms and warnings.

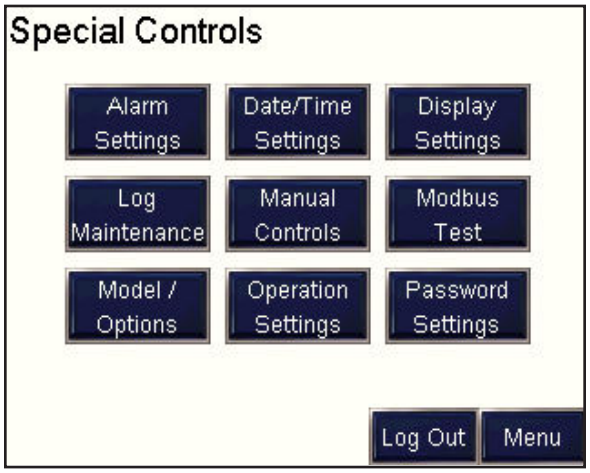
## SPECIAL CONTROLS

Access to the Special Controls screen is limited by a password/login screen. Upon pressing the "Controls" button on the main screen menu, the system login screen will appear. Select "Operator" and enter password (0717) by touching the asterisks to activate the on-screen keypad. Enter password and press continue to access the Controls screen.

Activate any control screen by pressing the blue box (see Special Controls Sub-Screens for further details).

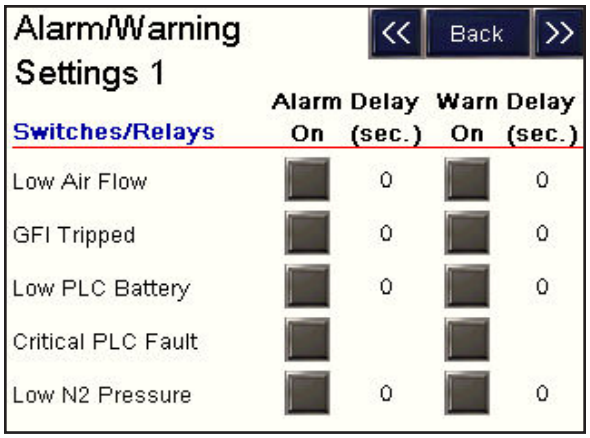
Login privileges expire if no input is received for the set idle time. Idle time can be adjusted in the password settings screen and is preset to 60 minutes at the factory. To prevent unauthorized access, the "Log out" button should be pressed before leaving the purifier unattended.




## ALARMS SETTINGS

The Alarm and Warning Settings screens are used to view and configure the response to a fault condition. The fault can be configured as an alarm, warning, both, or neither. The delay and trip point (where applicable) can be set from these screens as well. The configuration of most alarms is disabled by default (these are grayed out); however some alarms are configurable at Technician level (Displayed in blue. Refer to Alarms and Warnings table for details.) To enable or disable the alarm, press the associated button. To change the delay or trip setting, select the number and enter in a new value.




**TO reset all alarm and warning settings to factory defaults, see the "Model/Options Screen"**

**WHITE buttons indicate that fault is enabled and cannot be changed at current log in level.**

**GREY buttons indicate that fault is not enabled and cannot be changed at current log in level.**

**LIGHT BLUE buttons indicate that the fault is enabled and can be changed at current log in level.**

**DARK BLUE buttons indicate that the fault is not enabled and can be changed at current log in level.**

### DATE/TIME SETTINGS

To set the date/time, press the number you wish to change. Enter the correct value on the keypad and press "Enter" to save your changes. The date/time will immediately update.

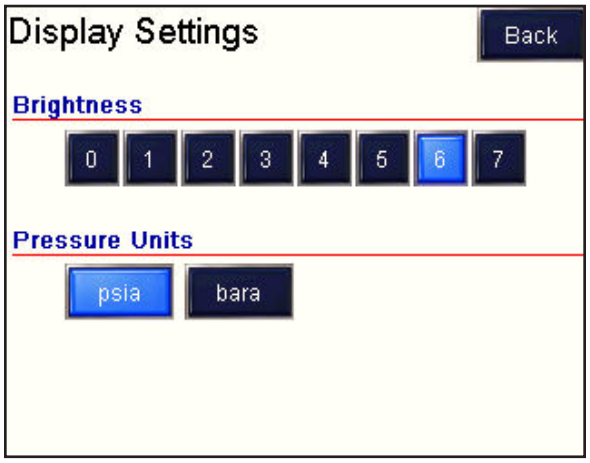

### DISPLAY SETTINGS

Shows the screen brightness level. To change the brightness select the appropriate level.

Pressure Units: Select either psia or bara

NOTE: Pressure units are absolute, NOT gauge.

Flow Units: Select either $Nm^3/hr$ or slpm. (only available with MFM option)




### LOG MAINTENANCE

Display Event Log: Accesses Event History screen which displays past events. (Also accessible by pressing "Events" on the Menu Bar.)

Display Step Log: Displays the past steps, including time and date of transition.

Display Alarm History: Displays the alarm history screen and lists past alarms/warnings, their status, and when the alarm/warning was cleared (if at all).

Download Event Log, Step Log, Alarm History, Trend Data: Used for downloading logs to an external PC. (Usually used for servicing.) Contact Customer Service more information.

## MANUAL CONTROLS

Bleed Purge: This step is used to purge the inlet side of the cell from impurities. The bleed purge opens the bleed valve for 5 minutes, after which the valve will automatically close. The hydrogen flow out of the bleed gas vent line will be higher (~8% of maximum flow) than the standard bleed mode (~2% of maximum flow).

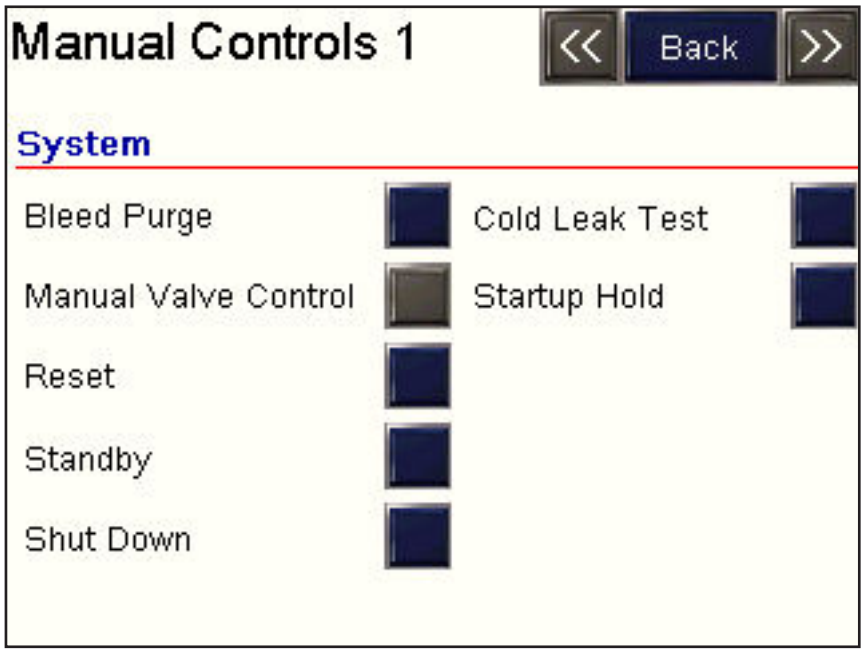
Manual Valve Control: Individual valve control is for qualified Entegris Personnel only.

Reset: Takes the purifier immediately Offline; resets any commands or overrides. This should only be used under the guidance of qualified Entegris Personnel as this may cause damage to the cell. To properly shut down the purifier, use the "Shut Down" command.

Standby: Initiates a Standby request. The purifier must be in start up or already purifying for the command to be recognized. If the purifier is starting up, it will go into Standby once startup is complete. If already purifying, the cell will immediately go into Standby. To disable Standby, press "Start" on the home screen menu; or return to Manual Controls and select "Standby" again.

Shut Down ($N_2$ Purge): Performs a Nitrogen purge to safely take the purifier Offline.

Cold Leak Test: Tests the cell for leaks while in an Offline mode (See Cold Helium Leak Test screen for further details).



### Cold Helium Leak Test

The Cold Helium Leak test is meant for experienced technicians only. All alarms and warnings are disabled during the Cold Leak Test.

**WARNING: Incorrect use of the cold leak test may result in irreparable damage to the purifier.**

The Cold Helium Leak Test is used to test the cell for leaks in a cold state. Three requirements must be met for the Cold Helium Leak Test to begin:

1 - The cell must be Offline

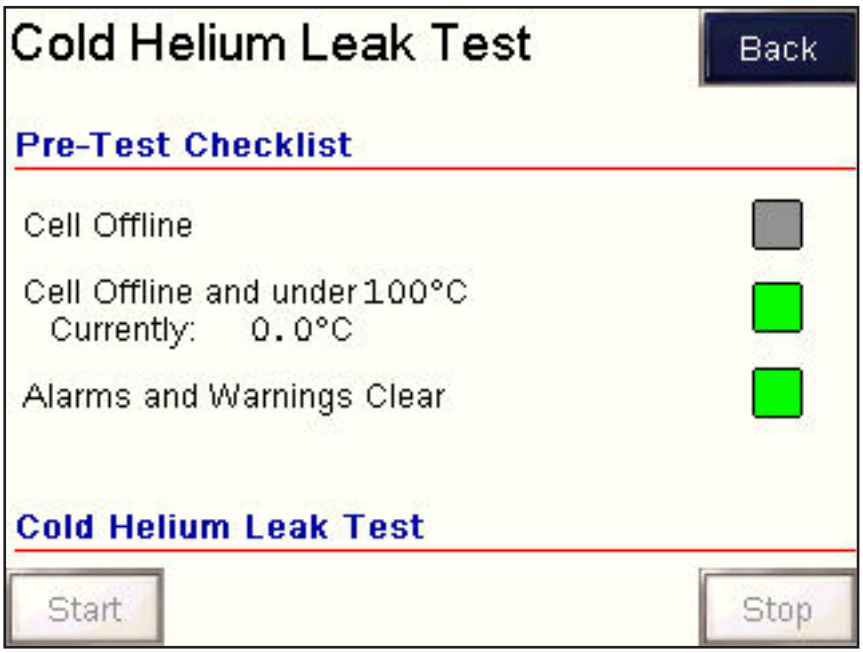
2 - The cell temperature must be less than 100°C

3 – No alarms or warnings are present

Once these requirements are met, the "Start" button will be highlighted in green. Pressing "Start" will bring up a confirmation screen.

**NOTE: All valves are closed during the leak test.**

The "Stop" button will be highlighted in blue while the system is in Cold Helium Leak Test. Pressing "Stop" will bring up a confirmation screen; the system will then go Offline.



### Palladium Cell Leak Test Procedure

All HMI Leak testing criteria must be met before proceeding.

- The outlet side should be evacuated to <1E-7 std cc/sec, this is accomplished by attaching the helium mass spectrometer to valve-2 (V-2) (See P&ID).

*Note : PX-2 should read near 0.0 psia during the initial pump down. During the evacuation process; nitrogen pressure will continue to bleed. Once PX-1 pressure has bled below 20 psia only then shall Helium pressure be applied.*

- Attach helium source to the 'helium inlet' port.
- Open the respective feed valve (V-1).
- Gradually apply helium. Increase pressure to 20 psig.
- Hold test for 30 seconds at this stage.
- Gradually increase pressure to 100 psig.
- Hold test for 30 seconds.
- Watch for an increase in the leak rate, noting any leaks.
- Leak test is complete upon achieving < 1e-7 std cc/sec.
- Close V-2 leak test outlet valve and disconnect the mass spectrometer.
- Close the helium inlet valve (V-1) and disconnect the helium gas source.
- Purge the helium inlet piping up to V-1, using an inert gas source.

*Note: During this test it may be necessary to disconnect and cap off the 'bleed gas outlet' line.*

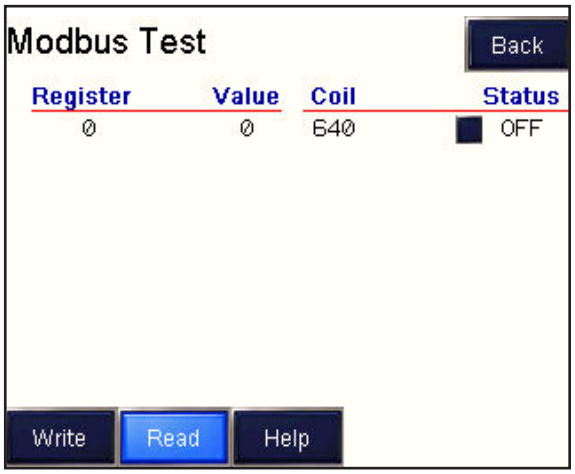
**WARNING: Prior to starting the purifier the bleed gas outlet must not be obstructed. Obstructing the bleed gas outlet may cause irreparable damage to the cell.**

### Modbus Test (Option)

Overriding the MODBUS values will not affect purifier operation.

To read MODBUS data, press the "Read" button. Enter the Register or Coil address to be read.

To write MODBUS data, press the "Write" button. Enter the Register or Coil address to be changed under "Register" or "Coil" respectively. Enter a number under "Value" or select the box under "Status" to change the output of the respective Register or Coil.




### Model / Options

Purifier: The model size and serial number of the unit

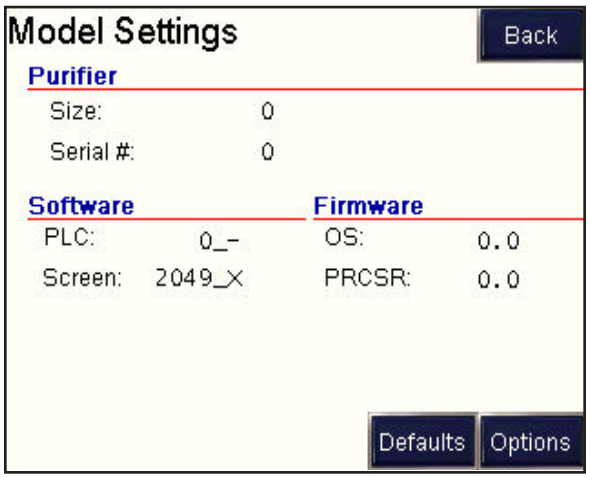
Software: The software number of the PLC and HMI

Firmware: The Operating System Firmware Revision (OS) and Processor Revision (PRCSR)

Scaling: The scaling of the MFM can be adjusted if need be. Log in at Technician level, select the number, and enter in a new value. Only available for purifiers with the MFM option.

Options: View the list of available (gray) and installed (white) software options.

Defaults: Resets all settings to the factory condition.

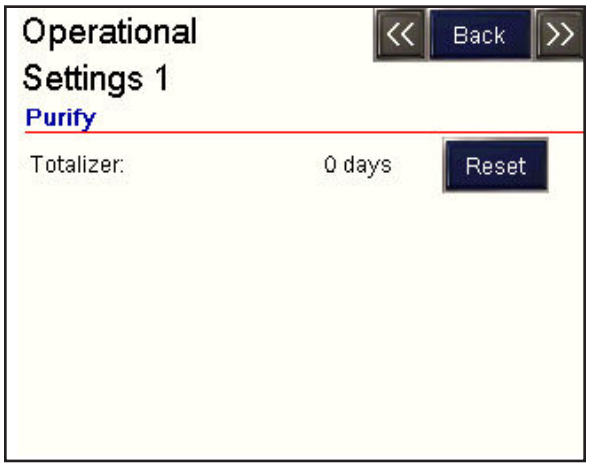



### Operation Settings

Purify: Reset the count of purify days.

Flow: Reset the flow total. Only available on units with the MFM option.

Bypass: Enable or disable the bypass feature. Only available on units with the Autobypass option.

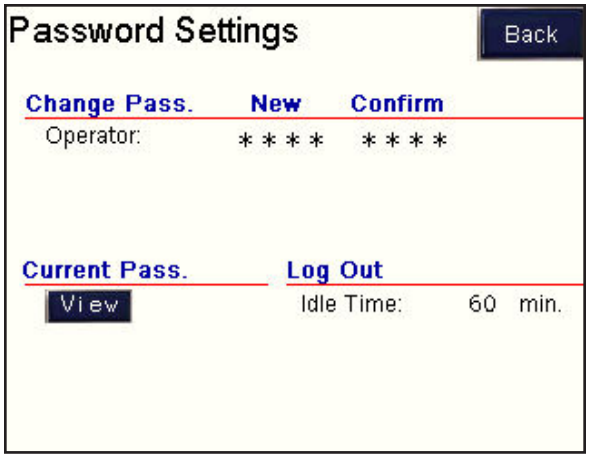


### Password Settings

Change Password: To change the login password, press the asterisks (****) under "New" and enter the new code in the pop-up keypad. Repeat for the "Confirm" field. When the new and confirm codes are identical, the "Apply" button will appear.

Current Password: Press "View" to view current operator password.

Log Out: Press value to change number of minutes before system automatically logs out operator if idle.

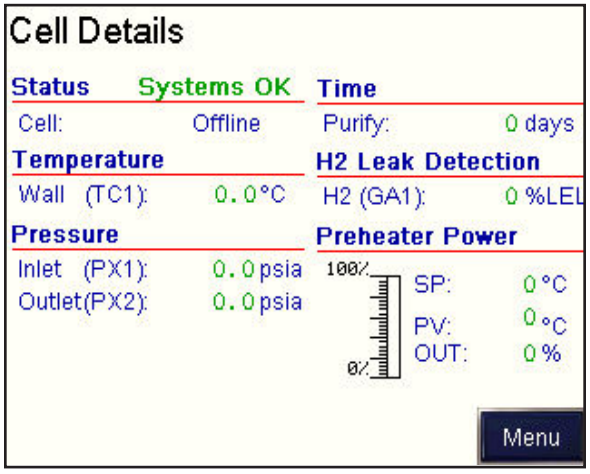



### Cell Details Screen

The Cell Details screen provides in-depth, real-time, operational details of all the purifiers control points, instruments and systems.

The Cell Detail screen indicates the percentage of full power being applied to the heaters. It is not an indication of actual (instrumented) power. It represents the duty cycle of the solid state relay outputs as commanded by the controller.

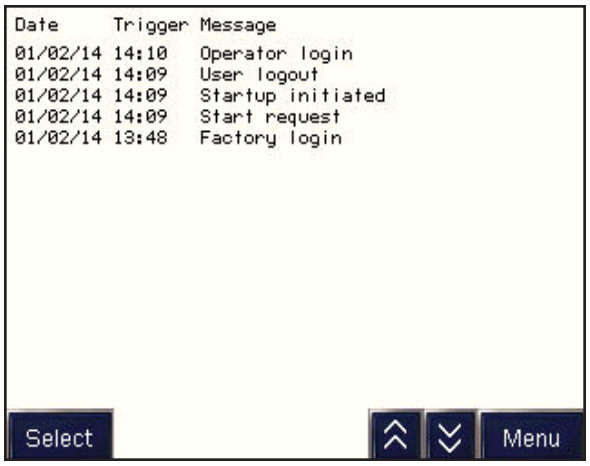
**NOTE: The Cell Details screen can also be accessed by touching the cell on the main screen**




### Event Log

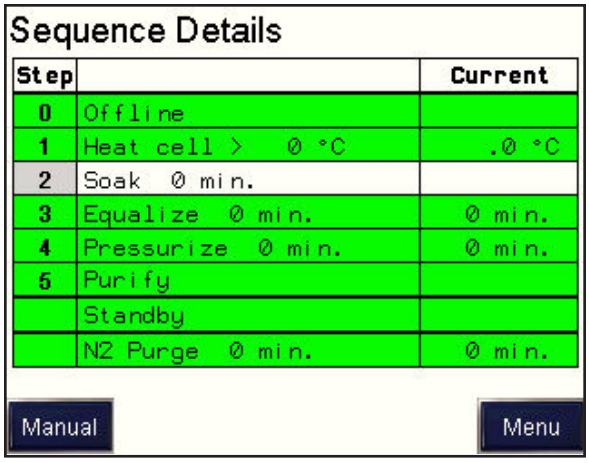
The Events Screen allows the user to review past events. Each event is displayed with a date and time stamp that corresponds to when it occurred.

**NOTE: Press "Select" and use the up and down buttons to scroll through all events.**



### Sequence Details Screen

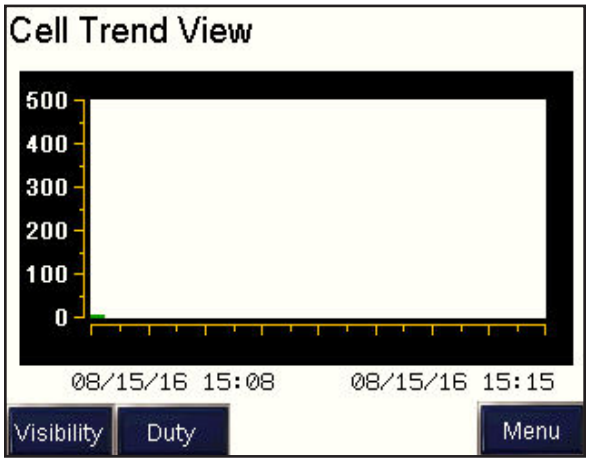
The Sequence Details screen shows all the steps in the cell process and their target set points. The current step is highlighted in green and corresponding current value is displayed on the right. If logged in at Operator level, the "Manual" button will appear, providing a shortcut to the Manual Controls screen.

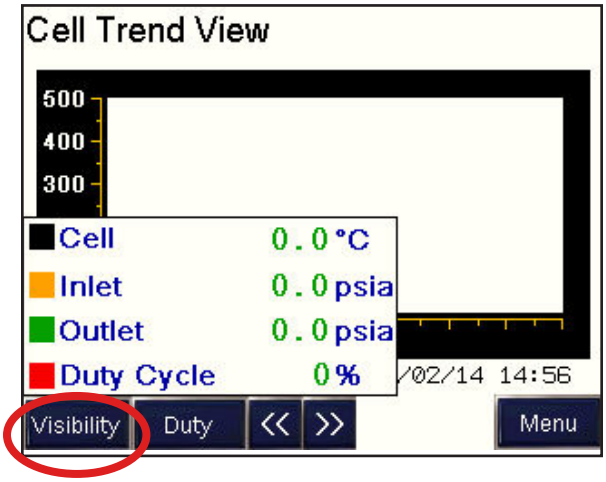



### Trend Data

The Cell Trend screens displays a historical graph of temperature, inlet and outlet pressures, and the duty cycle of the purifier. Pressing the "Visibility" button will bring up a list of recorded variables. Select the squares on the left will toggle the visibility of the selected parameter.

The trend data memory can store up to 10 days of data points; to include temperature, inlet and outlet pressures, and the systems cell duty cycle.



## ALARMS & WARNINGS TABLE

The purifier  continuously monitors its own operational parameters, both for display and to detect any faults. In the event of an alarm or warning, an audible alarm will sound and a message will be displayed on the Alarms screen.  The alarm and warning tables detail the purifiers possible fault states.

Alarms

Alarms not only indicate fault conditions, they also indicate the action that the purifier takes in response to this condition.

System Alarms

These are the most serious type of alarm; the purifiers response is to go to offline or bypass, depending on available options.

Purify Alarms

These alarms indicate a serious condition in a given bed, prompting the purifier to switch beds if possible; if the other bed is not available, the purifier goes to offline or bypass. Purification is an ambient temperature process; the purifying bed must be below a certain temperature.

Catalyst Alarms

These alarms indicate a catalyst bed fault, prompting the purifier to turn off the catalyst heaters and halt oxygen injection.

Regeneration Alarms

These alarms will shut off the regeneration heaters, but will not shut down purification. If a regeneration alarm prevents the completion of  the regeneration cycle at the end of the other bed's purify cycle, a purify alarm may result. Effective regeneration occurs only at an elevated temperature; the regenerating bed must be above a certain temperature for all of the steps in the regeneration cycle to be effective.

Warnings

Warnings are advisory only; the purifier takes no action other than to tell the operator that a fault condition exists. Warnings are the least serious type of reported faults. The faults indicated by a warning can be cured by the operator before they interrupt the purifiers functioning.

## ALARMS

| Screen Message | Description | Device | Settings | Delay | Alarm Enabled | Notes |
|---|---|---|---|---|---|---|
| System | | | | | | |
| LP N2 Inlet | Low Nitrogen inlet pressure | PS-1 | 50 psig | 5 sec. | Always | 4 |
| Emergency Stop | Emergency off switch | EMO | | 0 sec. | Always | 1 |
| H2 Leak | Hydrogen leak | K6 | | 0 sec. | Always (service can disable for 30 min.) | 1,2 |
| PLC Fault | PLC critical error | PLC | | 0 sec. | Always | |
| Cell | | | | | | |
| LP Drop | Low pressure drop across vessel | PX1-PX2 | -15 psi | 5 sec. | Equalize/Pressurize/ Purify/Standby and PX not open | 3 |
| HP Inlet Gas | High inlet gas pressure | PX1 | 345 psia | 5 sec. | Heat/Soak/Equalize/Pressurize/ Purify/Standby and PX1 not open | 3 |
| HP Drop | High pressure drop across vessel | PX1-PX2 | 200 psi | 5 sec. | PX not open | |
| Open Inlet PX1 | Open inlet pressure transducer | PX1 | | 5 sec. | Heat/Soak/Equalize/Pressurize/ Purify/Standby and PX not open | 3 |
| HT Purify | High temperature on purify cell | TC1 | 460°C | 5 sec. | TC1 not open | |
| LT Purify | Low Temperature on purify cell | TC1 | 300°C | 5 sec. | Soak/Equalize/Pressurize/Purify/ Standby | 3 |
| Open TC1 | Open TC on cell wall | TC1 | | 5 sec. | Heat/Soak/Equalize/Pressurize/ Purify/Standby and TC not open | 3 |
| HT Interlock | High temperature interlock | TA1 | 460°C | 5 sec. | Always | 1 |

NOTES:

Cell preheater setpoint = 400°C; rod limit = 475°C

All open analog inputs will cause the reading to display 999.9 [°C,psig,slpm,CuM/hr] or 99.9 [%," WC,bar]

All alarms will cause the system to perform an N2 purge (except during Helium Leak Test)

(1) Heaters will be disabled due to hardware interlock until the device has returned to normal operating conditions

(2) The alarm is configurable at Technician level

(3) The alarm will not clear until the "Start" button is pressed

(4) This is accurate unless Argon Gas is selected as the purge gas. In that case the settings will remain the same but LP AR Inlet will be the message.

## WARNINGS

| Screen Message | Description | Device | Settings | Delay | Warning Enabled | Notes |
|---|---|---|---|---|---|---|
| System | | | | | | |
| LP Elec. Cabinet | Low electrical cabinet pressure (Z-Purge) | DPT1 (option) or ZPC1(option) | 0.1 " WC 0.25" WC | 5 sec. | DPT1 not open | 2 |
| Open DPT1 | Open differential pressure transmitter | DPT1 (option) | | 5 sec. | Always | 2 |
| H2 Level | High Hydrogen level | GA-1 | 10% LEL | 1 sec. | GA-1 not open | 1 |
| Open GA1 | Open Hydrogen sensor | GA-1 | | 10 sec. | Always | 1 |
| LP Extern Pneu | Low external pneumatic pressure | PS-2 | 80 psig | 5 sec. | Always | |
| LP N2 Inlet | Low Nitrogen inlet pressure | PS-1 | 50 psig | 5 sec. | Always | 4 |
| Main Power Fail | Main power failure | K3 | | 5 sec. | Separate control installed | |
| Cntrl Pwr Fail | Separate control power failure | K4 (option) | | 5 sec. | Always | 2 |
| Low Air Flow | Low air flow | FS-1 | 1000 fpm | 5 sec. | Always | 1 |
| GFI Tripped | GFI tripped | GFRI | | 5 sec. | Always | 1 |
| H2 Leak Disabled | H2 Leak Alarm disabled | HC1 | | 0 sec. | Always | |
| MFM Not Config | Mass Flow Meter not configured | MFM (option) | | 180 sec. | Always | |
| Low Screen Battery | Low screen battery | HMI | | 0 sec. | Always | |
| Low PLC battery | Low PLC battery | PLC | | 5 sec. | Always | |
| Screen Comms Error | Screen not communicating | HMI | | 5 sec. | Always | |
| Modbus Error | Modbus not communicating | MODBUS (option) | | 60 sec. | Always | |
| Cell | | | | | | |
| LP Inlet Gas | Low inlet gas pressure | PX1 | 70 psia | 5 sec. | Offline/Heat/Soak/Purify/Standby | 3 |
| LP Outlet Gas | Low outlet gas pressure | PX2 | 35 psia | 5 sec. | Purify | 3 |
| LP Drop | Low pressure drop across vessel | PX1-PX2 | -10 psi | 5 sec. | Equalize/Pressurize/ Purify/Standby and PX not open | 3 |
| HP Inlet Gas | High inlet gas pressure | PX1 | 330 psia | 5 sec. | PX1 not open | 3 |
| HP Outlet Gas | High outlet gas pressure | PX2 | 330 psia | 5 sec. | PX2 not open | |
| HP Drop | High pressure drop across vessel | PX1-PX2 | 190 psi | 5 sec. | PX not open | |
| Open Inlet PX1 | Open inlet pressure transducer | PX1 | | 5 sec. | Offline/Purge and PX not open | 3 |
| Open Outlet PX2 | Open outlet pressure transducer | PX2 | | 5 sec. | Always | |
| HT Purify | High temperature on purify cell | TC1 | 450°C | 5 sec. | TC1 not open | |
| LT Purify | Low Temperature on purify cell | TC1 | 370°C | 5 sec. | Soak/Equalize/Pressurize/Purify/Standby | 3 |
| Preheater Fault | Cell failed to reach temperature | TC1 | 350°C | 3.5 hr. | Heat and not Manual heater ctrl | 3 |
| Open TC1 | Open TC on cell wall | TC1 | | 5 sec. | Offline/Purge and PX not open | 3 |
| High Duty Cycle | High preheater duty cycle | SSR1~2 | 100% | 30 min | Heat/Soak/Equalize/Pressurize/Purify/ Standby/Purge/Hot Test and not Manual heater ctrl | 3 |
| Low Duty Cycle | Low preheater duty cycle | SSR1~2 | 0% | 30 min | Heat/Soak/Equalize/ Pressurize/Purify/Standby and not Manual heater ctrl | 3 |

## MAINTENANCE

This section covers normal maintenance issues. This operator's manual is not intended as a service manual for the purifier. Contact Entegris for purifier repairs or service.

### NORMAL MAINTENANCE

Normal maintenance of the purifier is limited. General cleaning of the purifier is suggested.

### CLEANING

Cleaning should be performed as often as necessary to maintain the purifiers appearance. Dust buildup must be minimized in the electrical compartment.

⚠ **WARNING: Main power switch SW1 must be set to OFF before opening the electrical/electronics portion of the purifier cabinet. Failure to set main power to off before opening the cabinet can result in electrocution, death or severe injury to persons.**

Remove accumulated dust and dirt from the exterior cabinet and internal compartments with pressurized air or a vacuum cleaner. Set main power switch to OFF before opening the electrical/electronics portion of the cabinet.

Wipe dirt, oil, and fingerprints from the operator interface panel using a clean cloth and mild cleaner or solvent. Refer to Screen Cleaning under Special Controls in the Operations section.

⚠ **WARNING: Purifier contains components at elevated temperatures. Allow to cool before performing maintenance.**

### PREVENTATIVE MAINTENANCE

Please refer to Entegris Technical Bulletin T850-000 . This document is available from your local Entegris Field Service Office.

### SPARE PARTS

Please contact your local Entegris Group Field Service Office to request a Spare Parts List.

## CONTACT LIST

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