INSTRUCTION MANUAL

Level-Lance™ MULTI-POINT ON/OFF LEVEL DETECTOR Model 5400A

We do our level best

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INSTRUCTION MANUAL NUMBER

909GF282

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1. DESCRIPTION

1.1 GENERAL DESCRIPTION:

The ROBERTSHAW Level-Lance Model 5400A is a microprocessor based, multi-point On-Off capacitance type level detection system. Utilizing the Pulse Frequency Modulation (PFM) method of signal transmission ensures that accuracy, repeatability and longevity are enhanced over level systems using conventional analog transmission schemes. The PFM transmitter, normally mounted directly on the sensing probe, requires no calibration or adjustments of any kind. The control unit can be mounted up to one mile from the PFM transmitter without requiring any special type of interconnecting wire or cable. Two wires are all that is required. The PFM transmitter does not require any primary power because it receives its operating power from the control unit over the same two wires used to transmit the level signal.

The PFM transmitter is also designed to provide electrostatic protection at the probe input. It transmits a frequency modulated pulse signal to the microprocessor based control unit. The variation in the frequency of the pulse is proportional to the product level on the sensing probe. The microprocessor in the control unit receives the pulse and processes it to extract the level information. The microprocessor then compares this level information to the "AUTO-SET" calibration data stored in the non-volatile memory. When the level data coincides with this previously stored data, the appropriate output relay is either activated or deactivated, to give the desired control action. The total system design has been optimized to yield the highest possible levels of both EMI and RFI rejection.

The Model 5400A Level-Lance is calibrated by means of the "AUTO-SET" feature. This feature permits all calibration of the unit to be done by the simple act of pushing a button.

The Model 5400A Level-Lance is designed with plug-in type relay output modules to allow for easy configuration changes. Relay outputs can be added or removed in the field by the user. The control unit has the capability of having up to four relay output modules installed. The PFM input is optically coupled for better noise immunity.

Each relay output can be individually configured for:

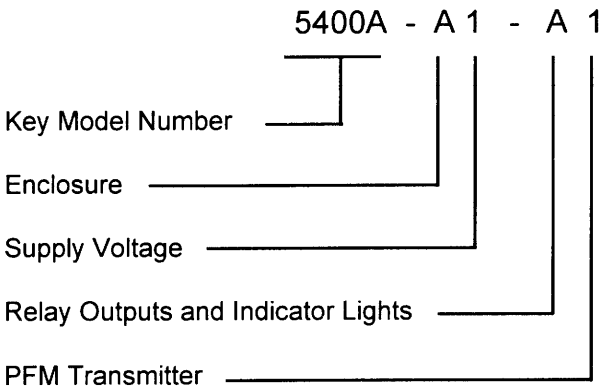
A) Fixed minimum or adjustable differential (deadband).
B) High or Low level fail safe.
C) Adjustable time delay.

These selections are made by means of miniature selector switches located on the individual relay output modules. All relay output module functions are totally independent of other relay output modules.

An additional switch located on the main (microprocessor) board allows for selection of the overall operating mode as follows:

A) Normal operation.
B) Load sharing. This mode permits the sequential operation of two to four pumps or motors, alternated or rotated to prolong their life.
C) Test (self diagnostics). LED's indicate transmitter (PFM) or receiver (RCVR) failure or calibration (CAL) error.

1.2 MODEL IDENTIFICATION:



KEY MODEL NUMBER

Designation	Description
5400A	Multiple output microprocessor based On-Off level controller and PFM Transmitter.

TABLE 1 - ENCLOSURE

Designation	Description
A	NEMA 4, Raintight, Steel
B	NEMA 4X, Raintight, Fiberglass
C	NEMA 4X, Raintight, Stainless Steel
D	NEMA 7CD & 9EFG, Explosion Proof, Cast Aluminum

TABLE 2 - SUPPLY VOLTAGE

Designation	Description
1	18 - 30 VDC
2	120/240 VAC, ± 10%, 50/60 Hz

TABLE 3 - RELAY OUTPUTS

Designation	Description
A	One Relay Output w/o Indicator light
B	Two Relay Outputs w/o Indicator lights
C	Three Relay Outputs w/o Indicator lights
D	Four Relay Outputs w/o Indicator lights
E	One Relay Output with Indicator light
F	Two Relay Outputs with Indicator lights
G	Three Relay Outputs with Indicator lights
H	Four Relay Outputs with Indicator Lights

TABLE 4 - PFM TRANSMITTER

Designation	Description
0	None - Controller Only
1	Standard PFM Transmitter, Probe Mounted, NEMA 4
2*	Standard PFM Transmitter, Remote Mounted, NEMA 4
3	Standard PFM Transmitter. Probe Mounted, NEMA 4X
4*	Standard PFM Transmitter, Remote Mounted, NEMA 4X

* Maximum distance between probe and remote mounted PFM Transmitter is 15 feet. Installation requires coaxial cable, conduit and conduit outlet box listed under ACCESSORIES.

1.3 ACCESSORIES:

Part Number	Description
032KC190-XX*	Conduit with 1/2" NPT connections, flexible, liquid tight, general purpose
032KC600-XX*	Coax cable
032KC650-XX*	Coax cable with general purpose conduit
032KC700-XX*	Coax cable with NEMA 4 conduit outlet box**
032KC710-XX*	Coax cable with general purpose conduit and NEMA 4 conduit outlet box
032KC720-02	Coax cable, 2 ft long, with explosion proof conduit and NEMA 4 conduit outlet box**
032KC720-05	Coax cable, 5 ft long, with explosion proof conduit and NEMA 4 conduit outlet box**
032KC720-08	Coax cable, 8 ft long, with explosion proof conduit and NEMA 4 conduit outlet box**
032KC720-10	Coax cable, 10 ft long, with explosion proof conduit and NEMA 4 conduit outlet box**
032KC800-XX*	Coax cable with NEMA 4X epoxy painted conduit outlet box**
032KC810-XX*	Coax cable with general purpose conduit and NEMA 4X epoxy painted conduit outlet box
032KC820-02	Coax cable, 2 ft long, with explosion proof conduit and NEMA 4X epoxy painted conduit outlet box**
032KC820-05	Coax cable, 5 ft long, with explosion proof conduit and NEMA 4X epoxy painted conduit outlet box**
032KC820-08	Coax cable, 8 ft long, with explosion proof conduit and NEMA 4X epoxy painted conduit outlet box**
032KC820-10	Coax cable, 10 ft long, with explosion proof conduit and NEMA 4X epoxy painted conduit outlet box**
032KC900-XX*	Coax cable with NEMA 4X stainless steel conduit outlet box**
032KC910-XX*	Coax cable with general purpose conduit and NEMA 4X stainless steel conduit outlet box
032KC920-02	Coax cable, 2 ft long, with explosion proof conduit and NEMA 4X stainless steel conduit outlet box**
032KC920-05	Coax cable, 5 ft long, with explosion proof conduit and NEMA 4X stainless steel conduit outlet box**
032KC920-08	Coax cable, 8 ft long, with explosion proof conduit and NEMA 4X stainless steel conduit outlet box**
032KC920-10	Coax cable, 10 ft long, with explosion proof conduit and NEMA 4X stainless steel conduit outlet box**
909SD029**	Conduit outlet box, NEMA 4
909SD029-50**	Conduit outlet box, NEMA 4X, epoxy painted
909SD029-51**	Conduit outlet box, NEMA 4X, stainless steel

* Substitute the desired cable length, in feet, for "XX" to complete Cable Part Number.
Maximum cable length is 15 feet.
Coax cable is Teflon insulated, maximum temperature 350° F, with terminations for attachment to probe and PFM Transmitter.

**Conduit outlet boxes are explosion proof.

2. SPECIFICATIONS

2.1 ENVIRONMENTAL:

Operating Temperature ..... -30° to +140° F
(-34° to +60° C)

Storage Temperature ..... -40° to +158° F
(-40° to +70° C)

Relative Humidity ... 0 to 95% (non-condensing)

Vibration ..... ± 2 G, 10 to 200 Hz

Shock ..... 75 G for 11 msec
without permanent damage

2.2 ELECTRICAL/ELECTRONIC:

Supply Voltage
Standard - 120/240 VAC ± 10%, 50/60 Hz
Optional - 18 to 30 VDC

Supply Power
Exp-proof w/lights.... 48 Watts Max
All other models..... 20 Watts Max

Control Range ..... 0 to 3000 pF

Adjustable Differential ..... 2 pF to 100% of
Control Range

Adjustable Time Delay ..... 0 to 99 seconds

Ambient Temperature Effect
± 0.005 pF/deg F or ± 0.01%/deg F,
whichever is greater

Supply Variation Effect .....None

Linearity ..... ± 0.5%

Resolution ..... 0.1 pF

Repeatability ..... ± 0.1 pF

Relay Output
Electro-Mechanical, DPDT
10 A @ 30 VDC,120 VAC, 240 VAC RES;
5 A @ 120 VAC IND;
3 A @ 240 VAC IND;
1/3 HP @ 120 VAC, 240 VAC

Maximum Distance Between Probe and
Transmitter ..... Fifteen (15) feet

Type of Interconnecting Cable
Coaxial, RG-62/U, rated 80° minimum

Maximum Distance Between Transmitter and
Controller ..... One (1) mile

Type of Interconnecting Cable
Two (2) wires, twisted pair in grounded metal conduit or twisted, shielded pair in non-metallic conduit.
14 AWG Maximum rated 80° C minimum

2.3 ENCLOSURE:

Controller
Raintight -
Standard - Polyurethane painted steel, Type 4
Optional - Fiberglass, Type 4X
Optional - Stainless steel, Type 4X
Explosion Proof - Cast aluminum, UL Listed Class I, Group D; Class II, Group E, F & G; Class I, Zone 1, Group IIA
c-UL Listed Class I, Group C & D; Class II, Group E, F & G; Class I, Zone 1, Group IIB

PFM Transmitter
Raintight -
Standard - Polyurethane painted cast aluminum, Type 4
Optional - Gray epoxy painted cast aluminum, Type 4X

2.4 WEIGHTS(approximate):

Controller, steel ..... 20 lbs (9.07 kg)
Controller, fiberglass ..... 12 lbs (5.44 kg)
Controller, stainless steel .....21 lbs (9.53 kg)
Controller, explosion proof .... 51 lbs. (23.13 kg)
PFM Transmitter .....2.8 lbs. (1.27 kg)

2.5 INTRINSIC SAFETY:

PFM Transmitter and Probe

Without the addition of a barrier

UL Certified for use in the United States as intrinsically safe for Class I, Division 1, Group A, B, C & D; Class II, Division 1, Group E, F & G and Class I, Zone 0, Group IIC hazardous locations when connected as shown on drawing 907GA826. Maximum distance between controller and PFM transmitter is 333 feet.

c-UL Certified for use in Canada as intrinsically safe for Class I, Division 1, Group C & D; Class II, Division 1, Group E, F & G and Class I, Zone 0, Group IIB hazardous locations when connected as shown on drawing 907GA826. Maximum distance between controller and PFM transmitter is 1000 feet (305 M).

With an added barrier

UL and c-UL Certified as intrinsically safe for Class I, Division 1, Group A, B, C & D; Class II, Division 1, Group E, F & G and Class I, Zone 0, Group IIC hazardous locations when connected as shown on drawing 907GA811 found in the PFM transmitter instruction manual. Maximum distance between barrier and PFM transmitter is determined by the specifications of the interconnecting cable as specified on drawing 907GA811. Maximum distance between the controller and the PFM transmitter is one mile.

Note: Intrinsic safety ratings specified above apply only when using the standard 900GA336 series PFM transmitter normally supplied with the instrument. When employing a different PFM transmitter, refer to the instruction manual supplied with that PFM transmitter for the intrinsic safety ratings.

2.6 AGENCY CERTIFICATIONS:

UL Listed ..... File E164999
c-UL Listed ..... File E164999

Note: Agency Certifications apply only when using the standard 900GA336 series PFM transmitter normally supplied with the instrument.

3. INSTALLATION

3.1 GENERAL

Examine the instrument for possible shipping damages.

> IMPORTANT
> If for any reason it is determined that parts should be returned to the factory, please notify the nearest ROBERTSHAW sales representative prior to shipment. Each unit must be properly packaged to prevent damage. ROBERTSHAW assumes no responsibility for equipment damaged in shipment due to improper packaging.

Choose the mounting location in accordance with good instrument practice, avoiding extremes of temperature, humidity and vibration. (See SPECIFICATIONS, section 2.)

3.2 PROBE MOUNTING

ROBERTSHAW probes are purchased separately in a variety of sizes and types for specific applications involving liquids and granular materials. Insulated probes are used for liquid solutions or liquid interface detection where only one of two liquids is electrically conductive. Bare type probes can be used on non-conductive products only.

> CAUTION
> When installing an insulated probe, care should be taken to prevent accidental puncture of the probe insulation.

Non-flanged probes should be installed so that the face of the packing gland is flush (or nearly flush) with the vessel wall. Flanged probes should be installed with a proper mating flange.

When installing the probe in a nozzle, recess, or open end well, a sheathed probe should be used, with the sheath length equal to the nozzle, recess, or well length. A sheath on the sensing probe has the effect of deadening that section of the probe so condensate or product build-up will not affect the instrument or the desired set point.

Vertical mounted probes can be installed in either the top or the bottom of the vessel. If the probe must be installed in the side of the vessel (horizontally), it must be bent so that the detection points desired are along the vertical portion of the probe. Most probes can be bent in the field but care must be taken in order not to damage the probe or the insulation on the probe. If a bent probe is required, it is recommended that it be ordered from the factory already bent. With either vertically mounted or horizontally mounted (bent) probes, all desired detection points must be along the vertical portion of the probe.

3.3 INSTRUMENT MOUNTING

See Figures 1, 2 and 3 for controller mounting dimensions. Refer to PFM transmitter instruction manual for PFM mounting dimensions.

3.3.1 Control Unit

The Model 5400A Level-Lance control unit can be oriented in any direction and is designed to be mounted remotely from the sensing probe and PFM transmitter. The Pulse Frequency Modulation (PFM) transmitter is normally mounted directly on the sensing probe, but as an option may be mounted remotely from the sensing probe using a coaxial cable listed in the ACCESSORIES table (see section 1.3).

The control unit should normally be mounted in the factory supplied enclosure. However, if utilization of the factory supplied enclosure is not possible, make certain that the electronic chassis assembly is properly shielded from electrical interference caused by devices such as motor starters, relays, etc.

> WARNING
> Not utilizing the factory supplied enclosure will violate agency certifications and the integrity of the intrinsically safe circuit.

3.3.2 PFM Transmitter

Refer to the PFM transmitter instruction manual for mounting instructions.

3.4 ELECTRICAL CONNECTIONS

All electrical connections should be made in accordance with Figure 5 and the PFM transmitter instruction manual. See SPECIFICATIONS (section 2) for relay contact ratings. The unit must be grounded for proper operation.

For an intrinsically safe PFM transmitter and probe installation when using the 900GA336 series PFM transmitter normally supplied with the instrument, also refer to drawing 907GA826 (figure 4). If interconnecting cable lengths between the transmitter and controller are to exceed those specified on drawing 907GA826, refer to drawing 907GA811 found in the PFM instruction manual and install the appropriate barrier. When employing a different PFM transmitter, refer to the instruction manual supplied with that PFM transmitter and install the appropriate barrier.

> NOTE
> Tighten field wiring terminal screws to five (5) pound-inches (0.56 N/m).

3.4.1 Interconnection Cable

The PFM transmitter is normally mounted directly on the probe assembly and is connected to the Level-Lance control unit using two wires (color coded, twisted pair cable is recommended) in grounded metal conduit with no power lines present. Otherwise, shielded, twisted pair cable must be used for this connection. Terminals GND (-) and SIG (+) on the PFM transmitter should be connected to the corresponding terminals on the PFM input board of the Level-Lance control unit.

> WARNING
> Seal fittings must be installed in all explosion-proof installations.

The optional remote mounted PFM transmitter can be installed up to a maximum distance of fifteen feet (4.6 m) from the probe. The interconnection wiring from the sensing probe to the remote mounted PFM transmitter must be high temperature Teflon insulated coaxial cable (see section 1.3).

> NOTE
> Polyethylene dielectric coaxial cable is not recommended for remote mounted PFM applications due to its poorer temperature stability.

The outer shield of the coaxial cable should be connected between GND on the remote PFM transmitter and the ground screw in the probe conduit outlet box. The center conductor of the cable should be connected between PROBE on the remote PFM transmitter and the probe rod inside the conduit outlet box.

3.4.2 Relay Contact Terminals

When switching inductive loads such as relay and solenoids coils, motors, valves, etc, the arc suppression network should be installed across or parallel with the load to prevent the interference generated by arcing contacts.

3.4.3 Power Connections

Connect power supply to the appropriate terminals as shown in figure 5. Before applying power to the circuit board (for AC units), position the power supply selector on the left side of the board for the power level to be used (120 or 240 VOLTS AC).

Control units with indicating lights that are mounted in an explosion proof enclosure must employ lamps having a voltage rating equal to the supply input voltage. DC units are supplied with 24 V lamps installed. AC units are supplied with 120 V lamps installed and 220 V lamps supplied loose. Before applying power to the instrument change lamps if necessary.

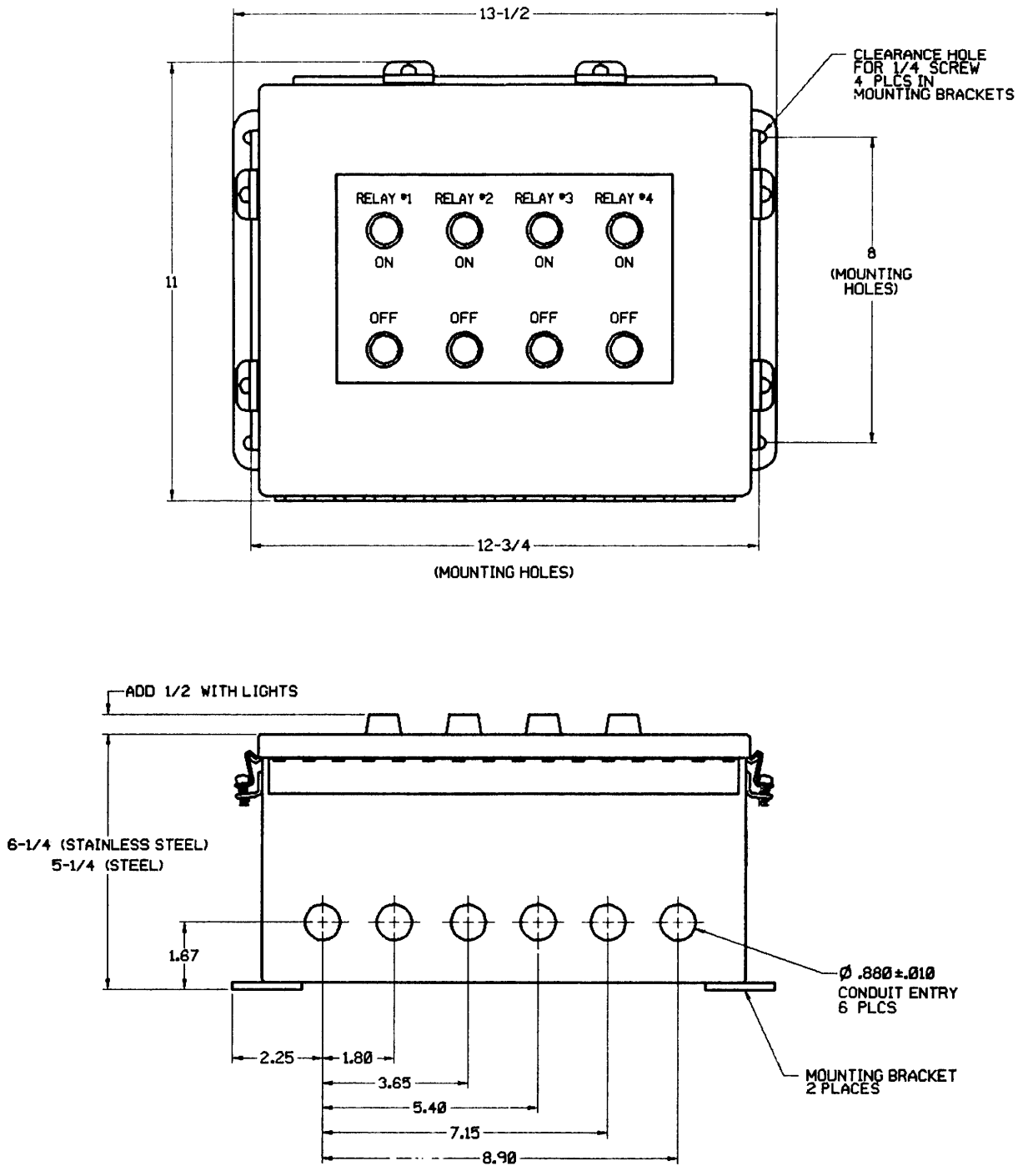


Figure 1
NEMA 4 Painted Steel Enclosure and
NEMA 4X, Corrosion Resistant, Stainless Steel Enclosure

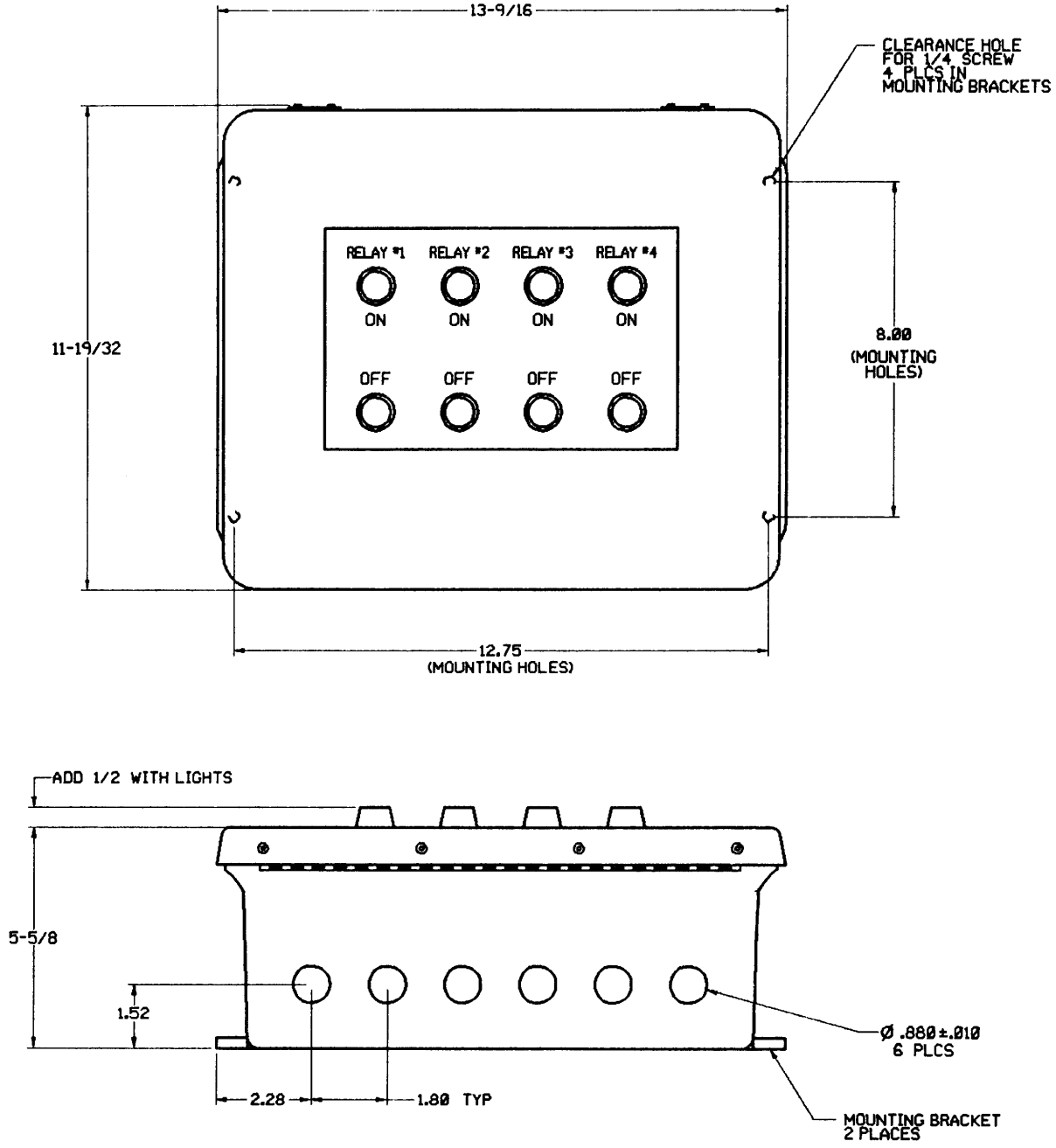


Figure 2
NEMA 4X, Corrosion Resistant, Fiberglass Enclosure

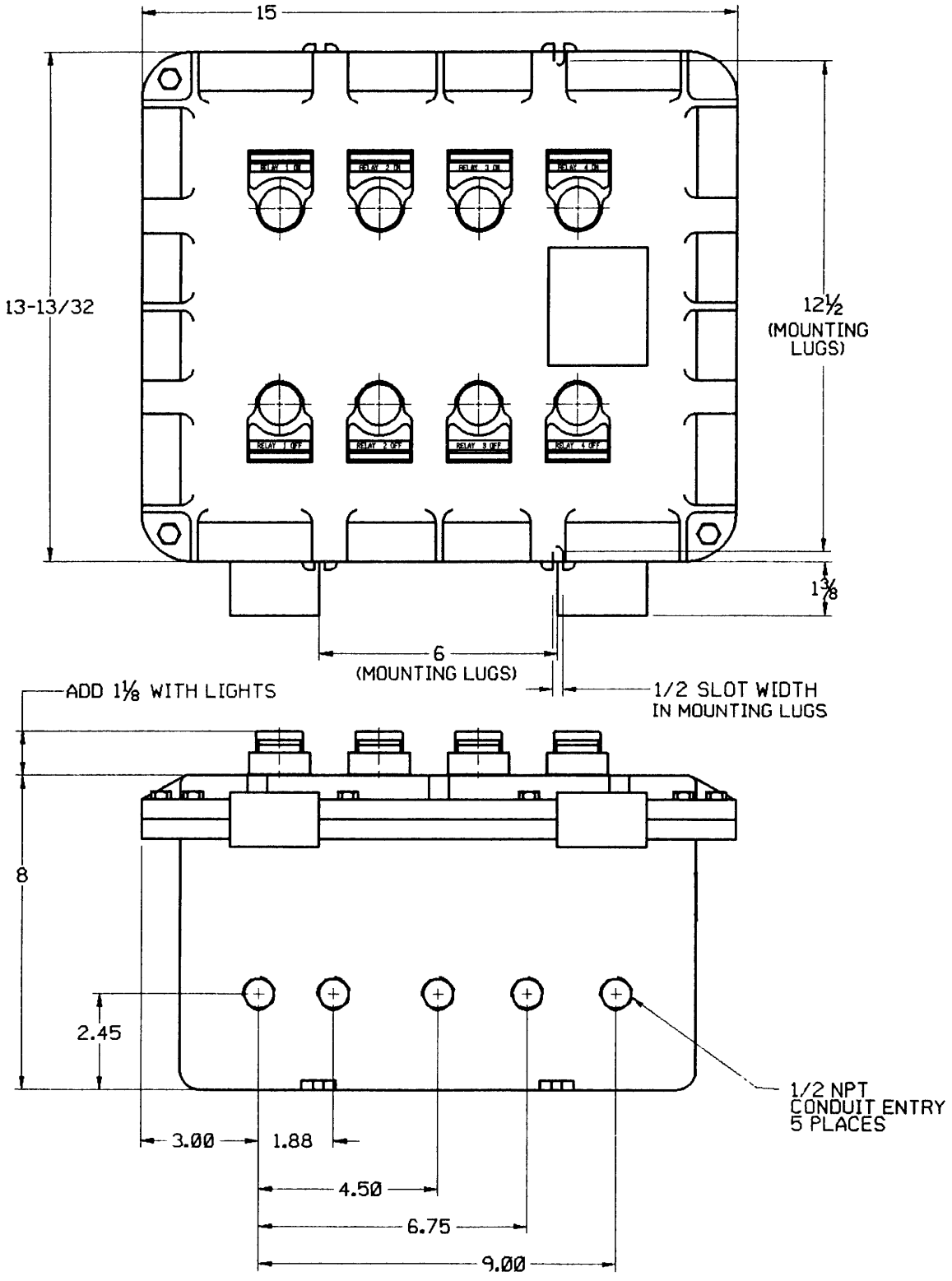


Figure 3
NEMA 7CD and NEMA 9EFG
Explosion-Proof, Cast Aluminum, Enclosure

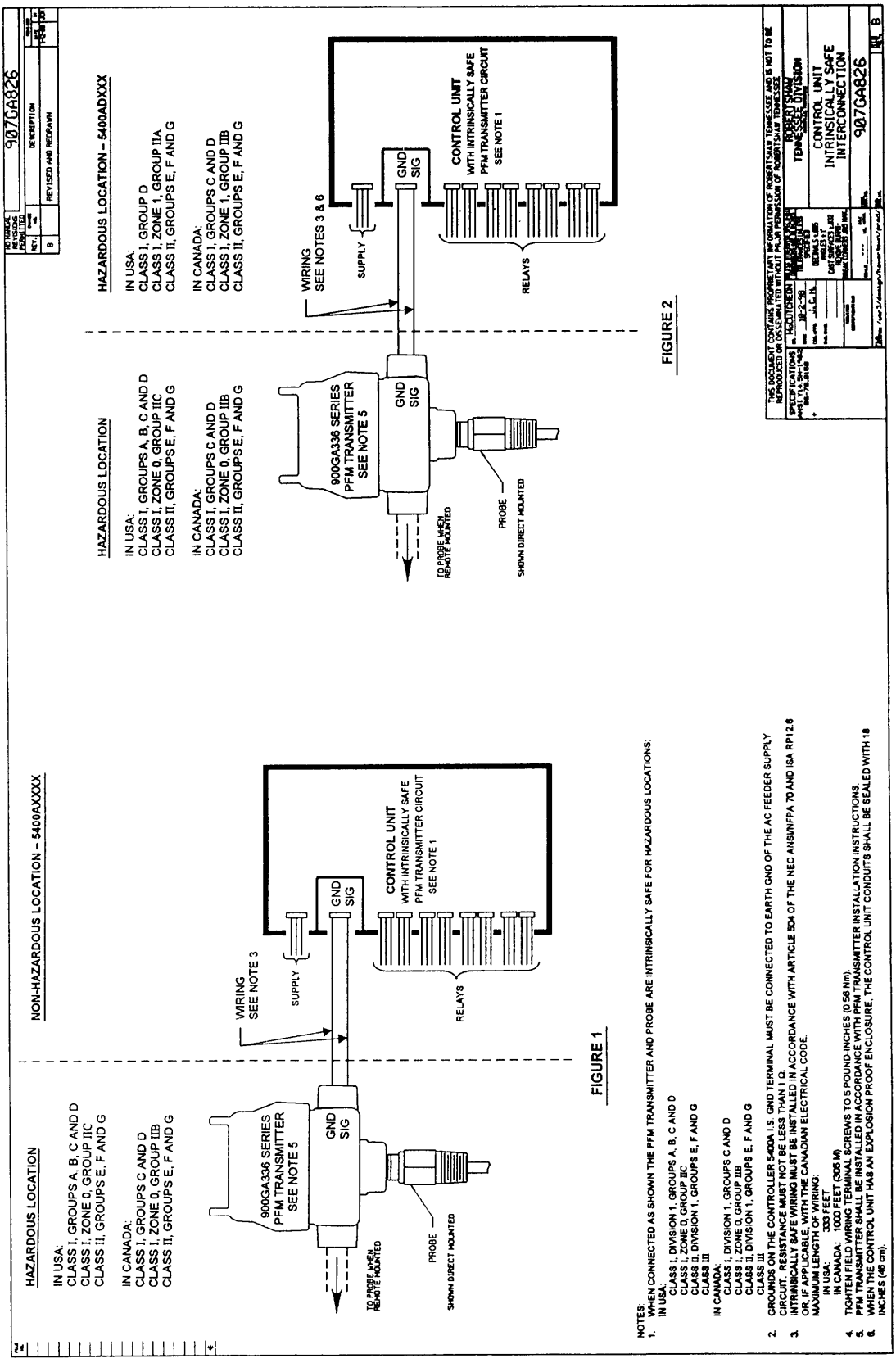
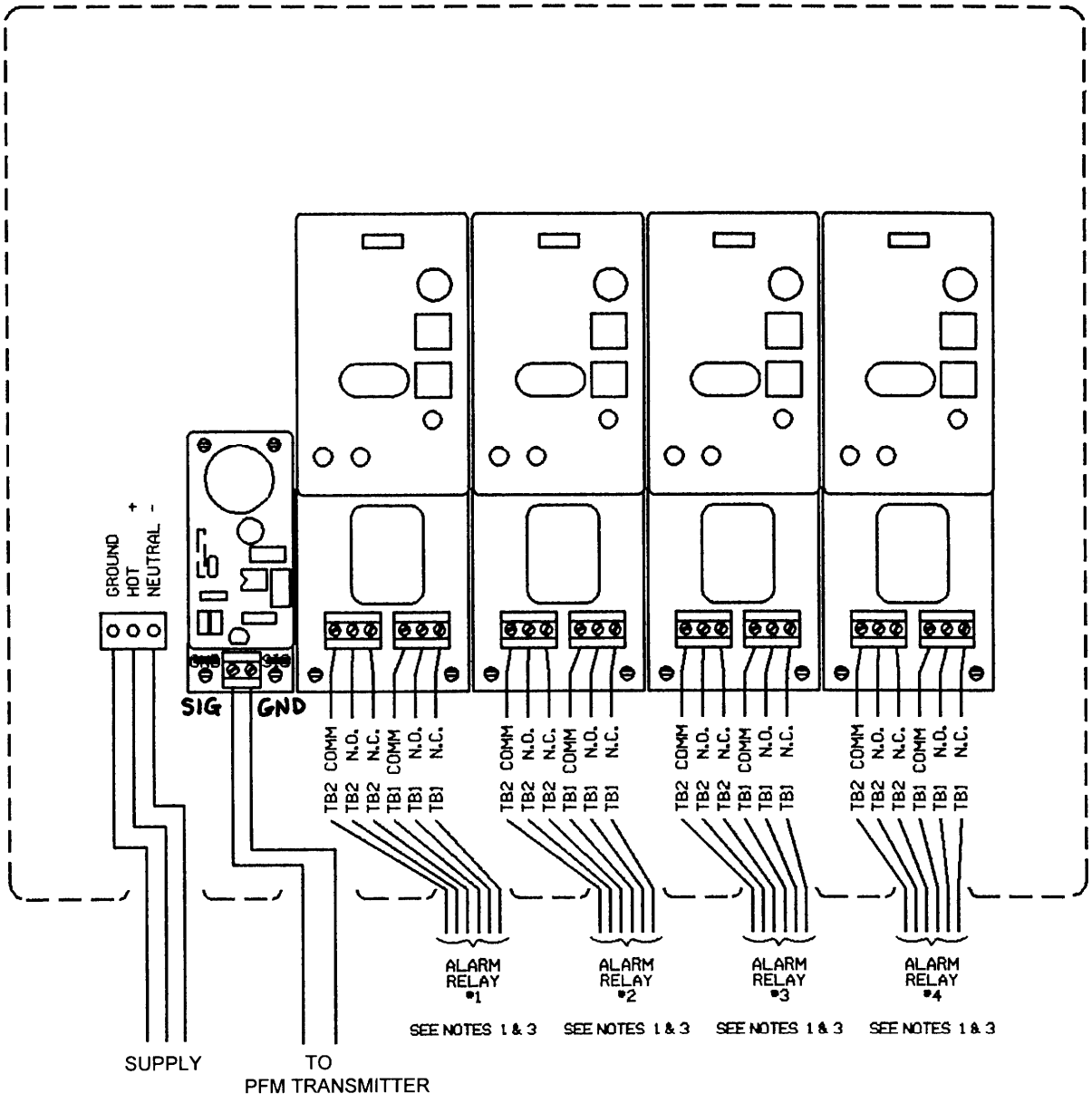


Figure 4
Intrinsic Safety Requirements



NOTES:

1. RELAYS ARE NORMALLY ENERGIZED AND BECOME DE-ENERGIZED WHEN LEVEL OR PROCESS REACHES CONTROL POINT.
2. ON EXPLOSION-PROOF MODELS:
   WHEN INDICATOR LIGHTS ARE SUPPLIED, TB1 ON EACH RELAY BOARD IS USED TO OPERATE ITS RESPECTIVE INDICATOR LIGHT. TB1 IS FACTORY WIRED TO THE INDICATOR LIGHTS.
3. TIGHTEN ALL FIELD WIRING SCREWS TO 5 POUND-INCHES (0.56 N/m).
4. FIELD WIRING TO THE CONTROL UNIT TO BE 14 AWG MAXIMUM, RATED 80° C MINIMUM.

Figure 5
Electrical Connections - Controller

4. HARDWARE SETUP

4.1 PROGRAM SWITCH SELECTION (PROCESSOR BOARD)

The PROGRAM switch bank is located on the main processor board (see figure 6) and allows the user to select the four main programs available in the Model 5400A Level Lance. There are two load-sharing programs, a hardware test program, and the standard deadband operating program. The table below details these settings.

Program Switch Settings

SW #1-1	SW #1-2	Operation
OFF	OFF	Standard
OFF	ON	Test
ON	OFF	Rotate On Low (Load-Sharing)
ON	ON	Rotate On High (Load-Sharing)

NOTE
The program descriptions below refer to mode switch settings and LED indicators located on the individual relay output boards. These settings are described in detail in section 4.2 and shown in figure 6.

4.1.1 Standard Operating Program

The Standard operating mode is where all control points operate with either a fixed or adjustable deadband. The user may select either fail-safe mode and any time delay mode. No load sharing occurs.

4.1.2 Hardware Test Program

The Test program is designed to test control unit hardware (switch inputs and interface IC's) by individual relay board. It is recommended that the user operate the unit in the test program to get familiarized with the operation of the controls and adjustments. It does the following:

1. If the time delays are enabled (switches 1 & 2 of the mode switch, SW3, on the relay board), the test program turns the PFM failure LED on and off at a rate determined by the time delay switches (S1, S2) of the activated relay board. If the delay switches are set to zero or disabled, the LED is operated at every other PFM cycle (approximately 1 second).

2. Relay state is determined by the position of the Fail-Safe switch, with high fail-safe causing the relay to de-energize.

3. Operates the CAL LED whenever the CAL pushbutton switches are used.

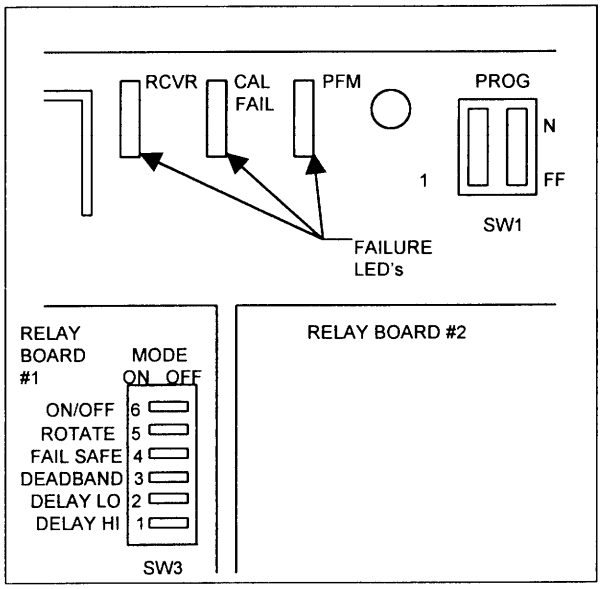


Figure 6
Program Switch & Failure LED's

The relay board being tested must be turned on (miniature switch #6 on the relay board mode switch bank SW3) to be tested. If more than one relay board is turned on, the lowest number active relay board will be tested. For example, if relays 2, 3 and 4 are on, then relay board #2 will be tested. The PFM failure LED on the main processor board will be operated based on relay #2 time delay. The CAL LED's on all relay boards will turn ON only when relay #2 pushbutton CAL switches are depressed. The following table gives examples of which relay will be tested for a certain combination of ON/OFF switch settings. As can be seen from the table, of the relay boards that are turned ON, the left-most board will be tested.

Test Program Setup

Switch #6 of SW3				Relay Board Under Test
Relay Board #1	Relay Board #2	Relay Board #3	Relay Board #4	
ON	ON	ON	ON	#1
ON	OFF	OFF	ON	#1
OFF	ON	OFF	ON	#2
OFF	OFF	ON	ON	#3
OFF	OFF	OFF	ON	#4

4.1.2.1 Relay Board Checkout

Once the appropriate relay has been selected (see above) and the test program has been selected with the program switch on the microprocessor board, the relay circuit can be tested. If relay #1 has been selected, the depressing the CAL pushbutton switches on relay board #1 should cause the CAL LED's to turn ON. Miniature switch #4 of the Mode switch, SW3, on relay board #1 should operate the relay state. When miniature switch #4 is OFF the relay should de-energize, the red alarm LED should be ON, and the green normal LED should be OFF. When miniature switch #4 is ON the relay should energize, the red alarm LED should be OFF, and the green normal LED should be ON. The time delay can be tested by turning ON miniature switch #1 and/or #2 and setting the time delay rotary switches to the desired time delay. The PFM LED should then turn OFF and ON with the delay that has been selected. The relay board should be replaced if it does not perform as described here.

4.1.3 Lead-Lag (Load-Sharing) Program

4.1.3.1 General Description

Lead-Lag operation permits the sequence of operation of two to four pumps or motors to be alternated or rotated to prolong their life. Two, three, or four relays may be used in this mode of operation. If two relays are used (to alternate sequence of operation), relays #1 and #2 must be used. If three relays are to be used (to rotate sequence of operation), relays #1, #2, and #3 must be used. In the Lead-Lag (load sharing) mode, the calibrated HIGH or LOW level control points are rotated (or alternated in the case of two relays) one relay position when the condition to cause rotation occurs. For example, if three relays are used in load sharing, the initial condition is where calibrated control points for relay #1 would be active on relay #1, calibrated control points for relay #2 would be active on relay #2, and calibrated control points for relay #3 would be active on relay #3. After the first rotation occurred, calibrated control points for relay #3 would be active on relay #2, calibrated control points for relay #2 would be active on relay #1, and calibrated control points for relay #1 would be active on relay #3. On the next rotation, the calibrated control points would shift again in the same way.

The position of the miniature switches on the PROGRAM switch bank determines the condition at which rotation of control points occurs.

4.1.3.2 Lead-Lag Calibration

> NOTE
> If two relays are used for load sharing (i.e. relay #1 and relay #2), relay #3 and relay #4 can operate independently with fixed or adjustable deadband. If three relays are used for load sharing, relay #4 can operate independently with fixed or adjustable deadband.

On the PROGRAM switch bank, if switch #1 is ON and switch #2 is OFF (Rotate On Low), rotation of control points occur after the level reaches the LOW level control point of any of the load sharing relays and returns to normal. If both switch #1 and switch #2 are ON (Rotate On High), rotation of control points occur after the level reaches the HIGH level control point of any of the load sharing relays and then returns to normal. To restate, when load-sharing is selected on the PROGRAM switch and one or more alarms are detected on any of the relays being rotated, rotation of control points occur when all rotated relays return to the normal condition (energized).

4.2 RELAY BOARD SETUP

4.2.1 Relay Selection

The Model 5400A comes with two, three, or four relays. If desired, each relay (or any combination of relays) can be disabled, meaning that it will not be operated. The desired relays can be activated by moving miniature switch #6 on the Mode Switch bank, SW3, of each relay board to ON. This switch is labeled "ON/OFF" on the relay board cover. This 6 position switch bank is located in the upper right hand corner of the board above the pushbutton calibrate switches.

4.2.2 Load-Sharing Selection

The Model 5400A allows the user to select which of the relays present are to be rotated in a load-sharing scheme. This is done by setting miniature switch #5 of the Mode Switch bank, SW3, to the ON position for the relays to be rotated. This switch is labeled "ROTATE" on the relay board cover.

4.2.3 Fail-Safe Mode Selection

The Model 5400A is designed with field-setable switches to allow for fail-safe relay operation upon loss of electrical power or certain other component failures. The switch position #4 (labeled FAIL-SAFE) on the Mode Switch bank, SW3, of each relay is used for this purpose. When miniature switch #4 is in the ON position, the corresponding relay is set for HIGH LEVEL FAIL-SAFE operation and when switch #4 is in the OFF position, it is set for LOW LEVEL FAIL-SAFE operation.

> NOTE
> Each output relay is independent of all the other relays so the mode selection and calibration must be performed for each individual relay board.

Set the appropriate switch for each relay in the desired position based on the definitions below.

> NOTE
> The red display LED above each relay will be "ON" when the relay is de-energized and the green display LED above each relay will be "ON" when the relay is energized.

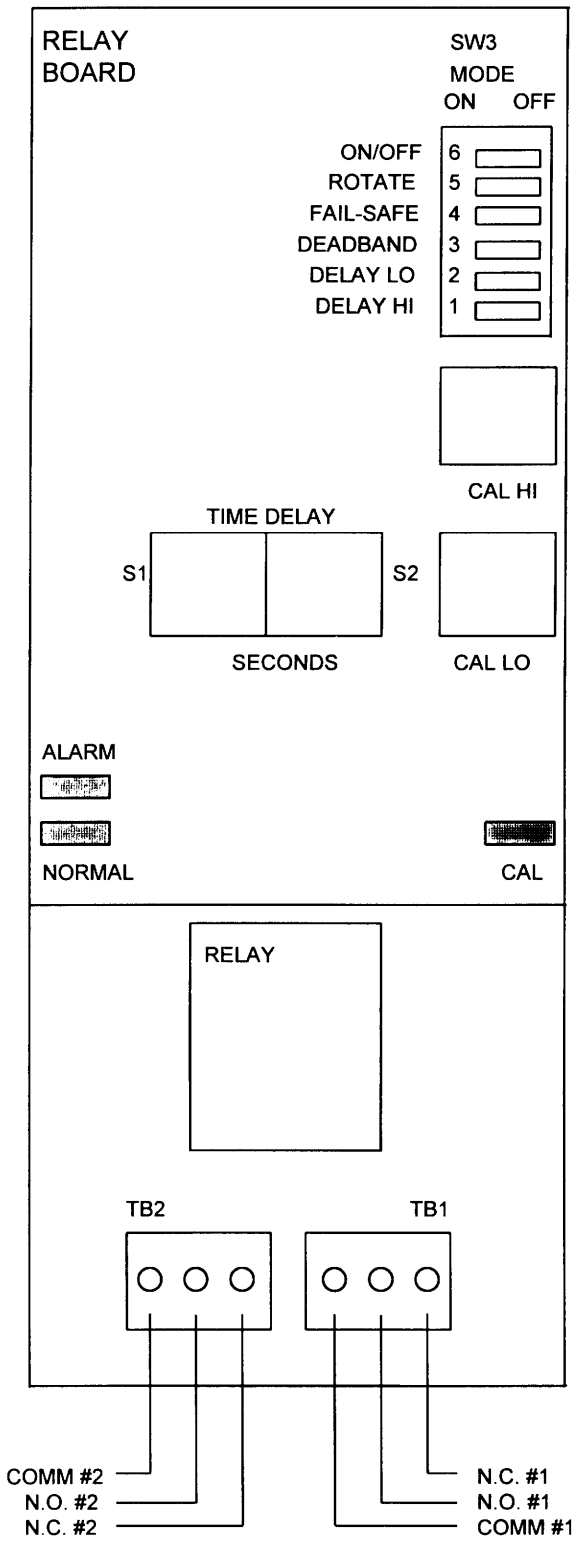


Figure 7
Relay Board Switch Settings

Applications for HIGH LEVEL detection should use the HIGH LEVEL FAIL-SAFE mode. In this mode, an increasing level (or capacitance) causes the control relay to de-energize and turn the red alarm LED "ON" when the HIGH LEVEL control point of the instrument is reached. Thus, the loss of electrical power or other system failure would also cause the control relay to de-energize. For example, this mode would be used to prevent overfilling a vessel.

Applications for LOW LEVEL detection should use the LOW LEVEL FAIL-SAFE mode. In this mode, a decreasing level (or capacitance) causes the control relay to de-energize (red alarm LED "ON") when LOW LEVEL control point of the instrument is reached. Thus, the loss of electrical power or other system failures would also cause the control relay to de-energize. For example, this mode would be used if emptying the vessel below the control point cannot be tolerated.

4.2.4 Deadband Selection

The desired deadband operation (fixed or adjustable) can be selected for each of the individual relays using miniature switch #3 (labeled "DEADBAND") on the Mode Switch bank, SW3, located on each relay circuit board (see figure 7).

Adjustable deadband is normally used only for cyclic operation such as activating a relay element at the upper control point and de-activating it at the lower control point. This feature allows the cyclic control of pumps or valves without the use of external latching relays. Using the procedure in paragraph 5.2, the adjustable deadband can be set to any length within the limits of the instrument and the probe being used. In the HIGH LEVEL FAIL-SAFE mode, the relay will de-energize when the level exceeds the high level control point and energize when the level falls below the low level control point. In the LOW LEVEL FAIL-SAFE mode, the relay will de-energize when the level falls below the low point and energize when the level exceeds the high point.

For applications that do not require cyclic relay action, select fixed deadband operation. In this mode, a 0.1 picofarad fixed deadband is provided to prevent sporadic operation in vessels without turbulence. In vessels with turbulence, the adjustable time delay feature should be used to prevent false operation.

Position miniature switch #3 on the corresponding Mode Switch bank, SW3, in the ON position to select ADJUSTABLE deadband (differential) and in the OFF position to select FIXED deadband for the relay controlled by the switch. The selection of deadband must be made before calibration of the instrument. If it is desired to change the deadband mode for a given relay after calibration is complete, the corresponding miniature switch #3 must be placed in the desired position and recalibrated as described in paragraphs 5.1 and 5.2.

4.2.5 Time Delay Selection

An adjustable time delay can be selected for energizing and/or de-energizing each relay to eliminate false operation due to splashing and/or agitation in the vessel. Time delay operation for each relay is controlled by the position of miniature switches #1 and #2 on the corresponding Mode Switch bank, SW3. Time delay is adjusted by setting rotary switches S1 and S2 on each relay card (see figure 7). The rotary switches (S1, S2) can be found where the card is marked "TIME DELAY". Available delay span is 00 – 99 seconds. S1 controls the "tens" digit and S2 controls the "ones" digit.

If miniature switches #1 and #2 are both in the OFF position, the output relays will operate with no time delay regardless of the time delay switch settings, S1, S2. If time delay is desired at the LOW control point for a decreasing level, then miniature switch #2 should be ON. If time delay is desired at HIGH control point for an increasing level, the miniature switch #1 should be ON. Both delays may be on at the same time.

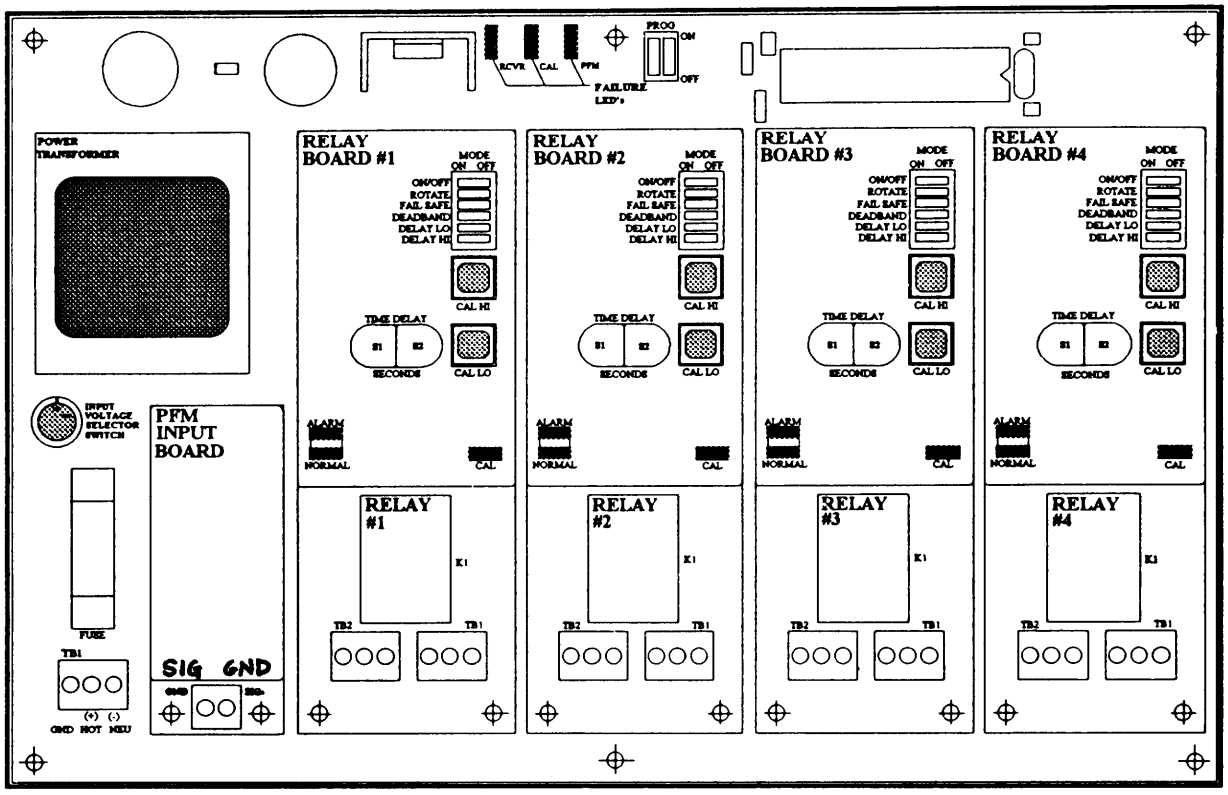


Figure 8
PC Board Locations
(Input & Output)

The following table gives a quick reference summary of the above descriptions.

MODE Switch Usage

Switch Position	Function	
	ON	OFF
6. ON/OFF	Board is active	Board is de-activated
5. ROTATE	Relay is rotated	Relay is not rotated
4. FAIL-SAFE	High Level Fail-Safe (HLFS)	Low Level Fail-Safe (LLFS)
3. DEADBAND	Adjustable	Fixed
2. DELAY LO	Time delay on low is on	Time delay on low is off
1. DELAY HI	Time delay on high is on	Time delay on high is off

5. CALIBRATION OF CONTROL POINTS

There are two calibration procedures: one for fixed deadband operation and one for adjustable deadband operation. The mode of operation must be selected before starting calibration and the relays may be calibrated in any order. Check to see that the following steps have been performed.

a. The switch positions #1 and #2 on the PROGRAM switch on the main processor board have been set to OFF.

b. Relay selection per paragraph 4.2.1.

c. Relay Selection for load sharing per paragraph 4.2.2.

d. Fail-Safe mode selection per paragraph 4.2.3.

e. Deadband selection per paragraph 4.2.4.

f. Time delay attributes have been selected as desired per paragraph 4.2.5 by positioning switches #1 and #2 of SW3 for each relay and adjusting time delay switches (S1, S2).

Calibration can now be performed. Below are the procedures to calibrate the control points for a single relay.

5.1 FIXED DEADBAND CALIBRATION

a. Bring the level in the vessel to the desired control point.

b. For High Level Fail-Safe (HLFS) locate the CAL HI pushbutton switch on the relay board to be calibrated. For Low Level Fail-Safe (LLFS) locate the CAL LO pushbutton switch on the relay board to be calibrated. Push and hold the appropriate pushbutton until the CAL LED's are illuminated. Release the pushbutton and verify that the CAL LED's are not illuminated.

c. Calibration is now complete for this relay board.

5.2 ADJUSTABLE DEADBAND CALIBRATION

The high and low set points may be calibrated in any order.

a. Bring the level in the vessel to the desired high control point.

b. Locate the CAL HI pushbutton switch, on the relay board to be calibrated. Push and hold it until the CAL LED's are illuminated. Release the pushbutton and verify that the CAL LED's are not illuminated.

c. Lower the level in the vessel to the desired low control point.

d. Locate the CAL LO pushbutton switch, on the relay board to be calibrated. Push and hold it until the CAL LED's are illuminated. Release the pushbutton and verify that the CAL LED's are not illuminated.

e. Calibration is now complete for this relay board.

> NOTE
> Since each relay is independent of all other relays, any or all of the relays may operate in the adjustable deadband mode and there are no restrictions on overlapping the deadbands.

5.3 PROGRAM CALIBRATION

If the unit is to operate in the standard mode, calibration is complete. If load sharing is desired, the program switch on the main processor board must first be set according to the table in Section 3.4.3 and then calibration done in accordance with paragraph 4.1.3.

6. CALIBRATION EXAMPLES

Below are two example applications of the Model 5400A Level Lance. The first characterizes standard operation and the second describes a load-sharing scheme.

6.1 CALIBRATION EXAMPLE #1 STANDARD OPERATION (No load-sharing)

Application: Standard operation of a three relay board model (see figure 9). The control/alarm points, from the bottom of the probe upward, are as follows:

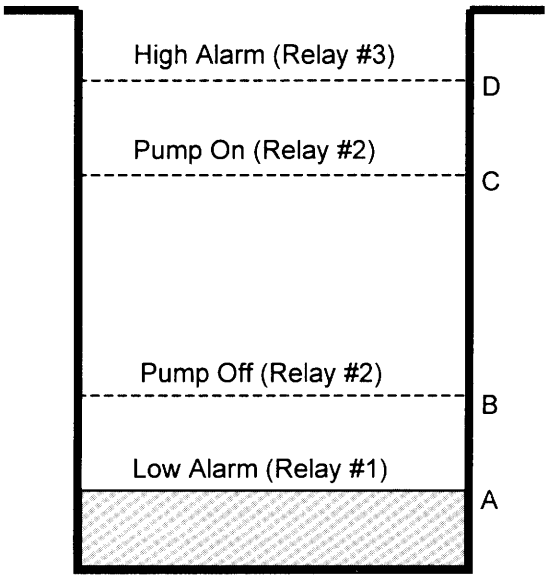


Figure 9
Sample Application
(Standard Operation)

In this application Relay #1, Low Alarm, will operate in the Low Level Fail-Safe (LLFS) mode and Relay #2, Pump On/Off, & Relay #3, High Alarm, will operate in the High Level Fail-Safe (HLFS) mode. Relay #1 & Relay #3 will operate with fixed Deadband and Relay #2 will use adjustable Deadband. No Time Delays will be used.

The actual setup and calibration is accomplished through the following steps:

1. *Power*
   Turn OFF power to the controller.

2. *PROGRAM Switch*
   Place both switches of SW1 (PROG) on the main board in the "OFF" position.

3. *Relay MODE Switches*
   Set the MODE switches on the relay boards as shown in the table below:

Mode Switch	Relay #1	Relay #2	Relay #3
6	ON	ON	ON
5	OFF	OFF	OFF
4	OFF	ON	ON
3	OFF	ON	OFF
2	OFF	OFF	OFF
1	OFF	OFF	OFF

4. *Power*
   Turn ON power to the controller.

5. *Low Alarm (Level "A") Calibration*
   Lower the level in the vessel to the Low Alarm level. Depress and hold the CAL LO pushbutton on relay board #1 until the CAL LED's illuminate. Release the CAL LO pushbutton and verify that the CAL LED's are no longer illuminated.

6. *Pump OFF (Level "B") Calibration*
   Raise the level in the vessel to the point at which you want the pump to turn off. Depress and hold the CAL LO pushbutton on relay board #2 until the CAL LED's illuminate. Release the CAL LO pushbutton and verify that the CAL LED's are no longer illuminated.

7. *Pump ON (Level "C") Calibration*
   Raise the level in the vessel to the point at which you want the pump to turn on. Depress and hold the CAL HI pushbutton on relay #2 until the CAL LED's illuminate. Release the CAL HI pushbutton and verify that the CAL LED's are no longer illuminated.

8. *High Alarm (Level "D") Calibration*
   Raise the level in the vessel to the desired High Alarm point. Depress and hold the CAL HI pushbutton on relay board #3 until the CAL LED's are illuminated. Release the CAL HI pushbutton and verify that the CAL LED's are no longer illuminated.

The calibration procedure is now complete and the Level-Lance is ready for operation.

6.2 CALIBRATION EXAMPLE #2 LOAD-SHARING (Rotate On High)

Application: Load-Sharing operation of a four relay board model (see figure 10). The control/alarm points, from the bottom of the probe upward, are as follows:

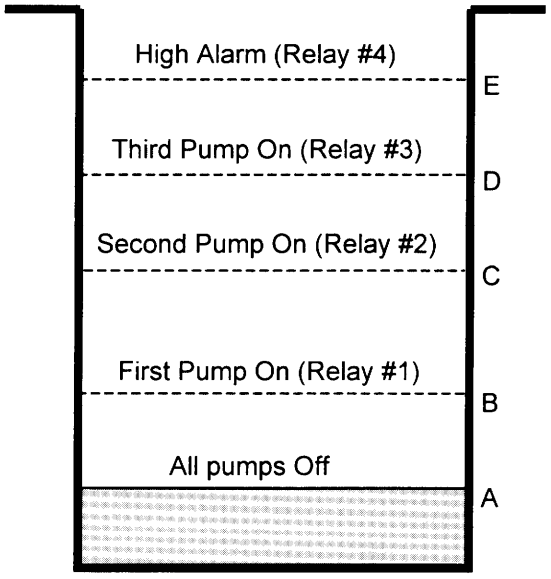


Figure 10
Sample Application
(Load-Sharing Operation)

In this application all relays will operate in the High Level Fail-Safe (HLFS) mode. Relay #1, Relay #2 and Relay #3 will operate with adjustable Deadband, while Relay #4 will have a fixed Deadband. No Time Delays will be used.

The actual setup and calibration is accomplished through the following steps:

1. *Power*
   Turn OFF power to the controller.

2. *PROGRAM switch*
   Place both switch #1 & switch #2 of SW1 (PROG) on the main board in the "ON" position.

3. *Relay MODE Switches*
   Set the MODE switches on the relay boards as shown in table below:

Mode Switch	Relay #1	Relay #2	Relay #3	Relay #4
6	ON	ON	ON	ON
5	ON	ON	ON	OFF
4	ON	ON	ON	ON
3	ON	ON	ON	OFF
2	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF

4. *Power*
   Turn ON power to the controller.

5. *All Pumps Off (Level "A") Calibration*
   Lower the level in the vessel to the All Pumps Off point. Depress and hold the CAL LO pushbutton on relay board #1 until the CAL LED's illuminate. Release the CAL LO pushbutton and verify that the CAL LED's are no longer illuminated. Repeat this process for relay boards #2 and #3.

6. *First Pump On (Level "B") Calibration*
   Raise the level in the vessel to the point at which the first pump is to turn on. Depress and hold the CAL HI pushbutton on relay board #1 until the CAL LED's illuminate. Release the CAL HI pushbutton and verify that the CAL LED's are no longer illuminated.

7. *Second Pump On (Level "C") Calibration*
   Raise the level in the vessel to the point at which the second pump is to turn on. Depress and hold the CAL HI pushbutton on relay board #2 until the CAL LED's illuminate. Release the CAL HI pushbutton and verify that the CAL LED's are no longer illuminated.

8. *Third Pump On (Level "D") Calibration*
   Raise the level in the vessel to the point at which the third pump is to turn on. Depress and hold the CAL HI pushbutton on relay board #3 until the CAL LED's illuminate. Release the CAL HI pushbutton and verify that the CAL LED's are no longer illuminated.

9. *High Alarm (Level "E") Calibration*
   Raise the level in the vessel to the desired High Alarm point. Depress and hold the CAL HI pushbutton on relay board #4 until the CAL LED's illuminate. Release the CAL HI pushbutton and

verify that the CAL LED's are no longer illuminated.

The calibration procedure is now complete and the level-Lance is ready for operation. On each cycle the sequence in which the actual pumps come on will be rotated to equalize wear, but the first, second and third pumps will always come on at calibrated levels.

7. TROUBLESHOOTING CHART

If operational problems are encountered, locate the appropriate symptom in the chart and take the given corrective action.

SYMPTOM OBSERVED	POSSIBLE CAUSE	CORRECTIVE ACTION
No operation: -Relays de-energized. -No LED's lit.	No power to unit.	Check mains, wiring, and breaker.
	Fuse blown.	Replace fuse.
No operation: -RCVR FAIL alarm LED ON.	Receiver unit failure.	Consult the factory.
Will not calibrate: -PFM FAIL alarm LED ON. -CAL FAIL alarm LED ON.	PFM input is out of range.	Check PFM input connections. See PROBE CIRCUIT ELECTRICAL CHECK (7.1).
		Consult the factory.
Will not calibrate: -PFM FAIL alarm LED ON.	PFM input is out of range.	Check PFM input connections. See PROBE CIRCUIT ELECTRICAL CHECK (7.1).
		Consult the factory.
CAL FAIL alarm LED On after calibration.	Control points were not successfully stored in EEPROM.	Re-calibrate.
	Defective microprocessor board.	Consult the factory.
Unit locked up: -CAL LED's do not come on when the CAL switches are pushed. -Control points do not operate.	Problem in PFM circuit.	See PROBE CIRCUIT ELECTRICAL CHECK (7.1).
	Malfunction induced by RFI from relay contacts with inductive load.	Install suppression networks in parallel with the load.
	Defective microprocessor board.	Consult the factory.
Relays do not operate.	Level not on probe.	Check level.
	Improper calibration.	Re-calibrate.
	Time delay too long.	Reduce delay time.
	Problem in relay circuit.	See HARDWARE TEST (4.1.2).
Erratic relay operation.	PFM board or relay boards improperly installed.	Verify that all the plug-in boards are firmly inserted in their sockets.
	Dip selector switches (SW1 of the main processor board and SW3 of the relay boards) are not firmly actuated.	Reactivate the dip switches to insure they are firmly actuated.

7.1 PROBE CIRCUIT ELECTRICAL CHECK

When a probe circuit problem is indicated, the following procedure should help to isolate it. A multimeter is needed to perform these tests. Perform the tests in the order given.

MEASUREMENT	READING	REMARKS
On PFM input board, voltage between GND and SIG terminals with PFM transmitter disconnected.	11 to 13 VDC	Normal, proceed.
	<11 VDC	Defective PFM input board. If problem remains, replace microprocessor board.
	>13 VDC	Defective PFM input board. If problem remains, replace microprocessor board.
On PFM input board, voltage between GND and SIG terminals with PFM transmitter connected.	[illegible] to [illegible] VDC, may be erratic	Normal, proceed.
	1 to [illegible] VDC	Defective PFM transmitter or interconnection wiring reversed.
	0 VDC	Interconnection wiring shorted.
On PFM input board, current between the SIG terminal and its wire from the PFM transmitter. Note: Meter is in series with the (+) lead and the SIG terminal.	Approximately 5 to 15 mA, may be erratic, and vary with meter used	Normal, proceed.
	0 mA	Interconnection wiring open.
	Steady 1 to 5 mA	Abnormal, proceed.
	Steady 17 to 26 mA	Abnormal, proceed.
Remove PFM transmitter and measure resistance between center rod of probe and ground using highest scale on meter. Do not touch the probe or meter leads as your body resistance will change the reading.	Greater than 10 Megohm	Normal – problem is most likely a defective PFM transmitter.
	Less than 1 Megohm	Defective probe (shorted) or bare probe used in conductive material.
	1 to 10 Megohm	Leaky probe – probably not causing a problem now but possible future problem.

On PFM Transmitter, voltage between Signal Plus (+) and Signal Minus (-) with the receiver connected.	**0 VDC**	**Open circuit condition exists in the interconnecting wiring.**

8. REPLACEMENT PARTS LIST:

ROBERTSHAW PART NUMBER	DESCRIPTION
018KB041	Cover, Relay Output PCA
044KX173	Relay Output PCA (Without Cover)
044KX177	Microprocessor PCA, 120/240 VAC
044KX177-01	Microprocessor PCA, 18-30 VDC
044KX230	Standard PFM Transmitter Electronics
044KX254	PFM Input PCA
130GD025	Fuse, 1/4 A (for AC units)
130GC045	Fuse, 1 A (for DC units)
190KB107-01	Lamp, 24 V (for explosion-proof units)
190KB107-02	Lamp, 120 V (for explosion-proof units)
190KB107-03	Lamp, 220 V (for explosion-proof units)
190KB103-01	Indicator, LED, Green
190KB103-02	Indicator, LED, Red
250KB066-01	Relay, DPDT
440KB292-07	Standoff, Snap-In
909GM079	Kit, Probe Pin
909GM170	Kit, Arc Suppression
909GM174-01	Kit, Remote PFM Mounting, NEMA 4
909GM174-02	Kit, Remote PFM Mounting, NEMA 4X
909GM190-01*	Kit, Relay PCA Installation
909GM190-02*	Kit, Relay PCA With Light Installation

* A relay kit is used to add another relay (and light if required) to an existing controller.
Additional lights may not be added to an explosion proof enclosure.

NOTES:

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