LAKEWOOD INSTRUMENTS
MODEL 2450e

MICROPROCESSOR-BASED REVERSE OSMOSIS MONITOR

INSTALLATION & OPERATION MANUAL

SERIAL #: _____

Lakewood Instruments
7838 North Faulkner Road, Milwaukee, Wisconsin 53224 USA
Phone (800) 228-0839 • Fax (414) 355-3508
http://www.lakewoodinstruments.com

IMPORTANT NOTICE

CAUTION: CHEMICAL FEED

All electromechanical devices are subject to failure from a variety of causes. These include mechanical stress, component degradation, electromagnetic fields, mishandling, improper setup, physical abuse, chemical abuse, improper installation, improper power feeds and exposure.

While every precaution is taken to insure proper functioning, extra precautions should be taken to limit the ability of over-feeding by limiting chemical quantities available, secondary shut-downs, alarms and redundancy or other available methods.

CAUTION: POWER SOURCE AND WIRING

Low voltage wiring and high voltage (110 plus) should not be run in the same conduit. Always run separately. Even shielded low voltage is not a guarantee of isolation.

Every precaution should be taken to insure proper grounding and elimination of shorting or Electromagnetic field (EMF) interference.

Lakewood Instruments

We thank you for your selection and purchase of a Lakewood Instruments product.

With proper care and maintenance, this device should give you many years of trouble-free service. Please take the time to read and understand this Installation and Operation Manual, paying special attention to the sections on **OPERATION** and **MAINTENANCE**.

If, in the future, any parts or repairs are required, we strongly recommend that only original replacement parts be used. Our Customer Service Department is happy to assist you with your parts or service requests.

☎ **Lakewood Instruments Customer Service and Technical Support Departments can be reached by calling (800) 228-0839 or faxing (414) 355-3508, Monday through Friday, 7:30 a.m. - 5:00 p.m. CST.**

✉ **Mail should be sent to:**

Lakewood Instruments
7838 North Faulkner Road
Milwaukee, WI 53224 USA

MODEL 2450e

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1.0 INTRODUCTION

The Model 2450e is a LONWORKS Technology, microprocessor based, menu driven, pH or ORP and conductivity, reverse osmosis monitor. The Model 2450e provides for pH or ORP and conductivity tracking and control, flow monitoring, and four relay outputs for alarms, setpoint control, and auto-flush functions. The Model 2450e is ANSI/UL approved.

Available options include: up to four 4-20 mA outputs and remote communications capability via RS232 by direct connect, over the phone lines with the use of a modem, or over the internet or intranet with the use of the WEBNode.

A security password is a standard feature to restrict access to the programming functions to authorized personnel only.

Five countdown timers are a standard feature for notification of required standard maintenance procedures.

The monitor will display: permeate conductivity, feed pH, permeate flow rate, concentrate flow rate, calculated feed flow rate, total permeate flow, total feed flow, relay status, the date and time, machine run time, permeate temperature, and calculated percent of recovery.

The Model 2450e uses the latest in microprocessor capability and is user-friendly with a graphical screen and 16-key numeric keypad. A large illuminated graphics screen, multiple inputs, and an intuitive menu characterize this new technology. It accepts multiple inputs and is easily configured. This controller can easily be upgraded in the field. It's a combination of reliability, accuracy, security and simplicity.

2.0 Benefits, Features, Specifications

Figure 1: *Model 2450e Reverse Osmosis Monitor*

FEATURES

- Uses 2-electrode conductivity sensor with ¾ MNPT process connection
- Uses differential pH sensor with ¾ MNPT process connection. pH input can be configured for ORP sensor.
- Two water meter inputs for Permeate and Concentrate flow rates.
- RS232 output for remote monitoring, control and data acquisition (-RS2L).
- Input for CIP lockout.
- Includes Real Time Clock (-RTC).

BENEFITS

The Model 2450e uses LONWORKS® Technology that is the latest in microprocessor capability, giving the user the highest level of application flexibility. A large illuminated graphics screen, multiple inputs and very easy setup with easy field upgrade characterize this new technology. Water meters and sensors are purchased separately.

- System run timer
- 5 Count down timers
  - Lubrication interval
  - Check CIP
  - Check Filters
  - Check Membranes
  - Check Sensor
- Four relays have user-selectable options:
  - pH/ORP setpoint;
  - Conductivity setpoint;
  - Temperature setpoint
  - Permeate flow setpoint;
  - Concentrate flow setpoint;
  - Percent recovery setpoint;
  - Auto-Flush
  - Various Alarms.
- 4-20 mA output for (-35L, select any four):
  - pH/ORP
  - conductivity
  - temperature
  - concentrate flow
  - permeate flow
  - percent recovery

SPECIFICATIONS

Inputs

Power	80-300 VAC
Sensor	2 or 4-electrode Conductivity pH or ORP differential
Temperature comp.	None, 500 NTC, 4K NTC
CIP switch	Dry contact
Water Meter Inputs	Two, open collector type.

Outputs

Relays	3 Amps @ 120 VAC
4-20 mA	Two, isolated w/-35L
RS232	Requires Windows based PC w/-RTC-RS2L

Monitor

pH Range	0-14 pH
pH Accuracy	± 0.05 pH
pH Resolution	0.01 pH
ORP Range	-1000 to +1000 mV
ORP Accuracy	± 5 mV
ORP Resolution	1 mV
Conductivity Range	0-100 or 0-1000 (with proper sensor)
Conductivity Accuracy	±1 or ±10 µS (with proper sensor)
Conductivity Resolution	1 or 10 µS (with proper sensor)
Deadband	Adjustable
Setpoints	Direct or Reverse
Keypad	Numeric
Display	Illuminated 128x64 pixel LCD
Ambient Temperature	32-158°F (0-70°C)
Enclosure	NEMA 4X
RATING	ANSI/UL

2.1 Ordering Information

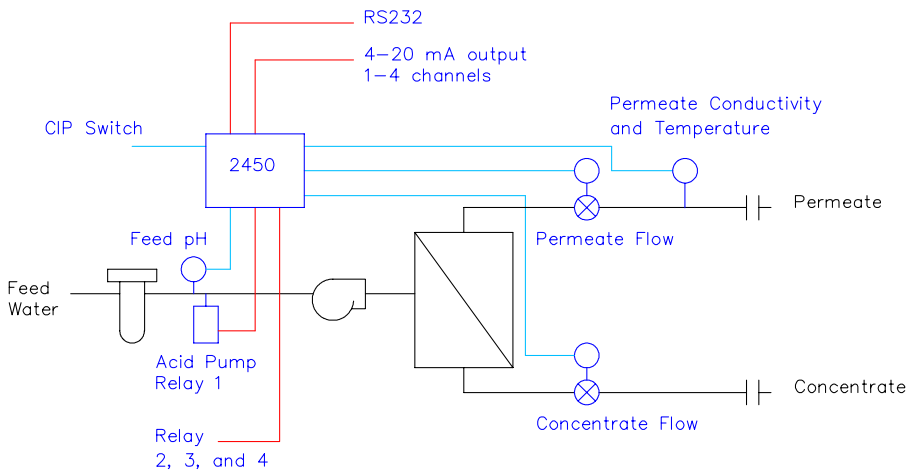


Figure 2: *Model 2450e Installation Schematic*

2450e LONWORKS Technology-based Reverse Osmosis Monitor.

MONITOR OPTIONS (select no more than two, two -35L may be purchased)

-35L Two 4-20 mA outputs (two -35L cards may be used for up to 4 outputs).
-RS2L Communications node with the LRWS program.

SENSOR OPTIONS

1104593	pH High Purity sensor, ¼ inch NPT flow cell
520-4-7I-10-STD	pH sensor 0-14 pH, ¾ inch NPT
530-4-7I-10	ORP sensor, ¾ inch NPT
540K0.1-4-10I-10-TC500	Conductivity Sensor 0-10 µS, ¾ inch NPT
540K.1-4-10I-10-TC500	Conductivity Sensor 0-100 µS, ¾ inch NPT
543-L-4-8I-10-STD	Conductivity Sensor 0-1000 µS, 1 inch NPT
543-M-4-8I-10-STD	Conductivity Sensor 500-100,000 µS, 1 inch NPT

AUTOTROL TURBINE WATER METER OPTIONS

1TM-NPT	1 inch turbine water meter with brass pipe thread adapters.
1TM-ESW	1 inch turbine water meter with PVC solvent weld adapters.
2TM-NPT	2 inch turbine water meter with brass pipe thread adapters.
2TM-ESW	2 inch turbine water meter with PVC solvent weld adapters.
49C25	25 ft cable for turbine meters.
49C50	50 ft cable for turbine meters.

SOFTWARE AND EXTERNAL MODEM OPTIONS

LRWS	*Windows*-based registered software for computer to communicate with 2000 Series Controllers.
WEBNode	IP/TCP device for use with 2000 series controllers.
EZWEB	Wireless internet interface for use with WEBNode and 2000 series controllers

2.2 Front Panel Description

LOCK SCREWS

The lock screws keeps your circuit boards secure and provides easy access for wiring and setup. Simply turn the lock screw and pull open the front panel.

16-BUTTON KEYPAD

ENT = for Menu selection and/or acceptance of selected values.

CLR = to exit a Menu selection and/or skip input options.

DSP = to change languages.

PRO = to program a Menu selection.

ENCLOSURE

A sturdy NEMA 4X rated enclosure protects your controller. Make sure it is properly mounted (SEE: **INSTALLATION; Mounting**). The power cord and receptacles can be removed so that the controller can be hardwired through ½" conduit knockouts.

Figure 3: ***Model 2450e***

3.0 Unpacking, Mounting and Installation

3.1 Unpacking

Inspect the shipping carton for obvious external damage. Note on the carrier's bill-of-lading the extent of the damage, if any, and ***notify the carrier***. Save the shipping carton until your Model 2450e controller is started up.

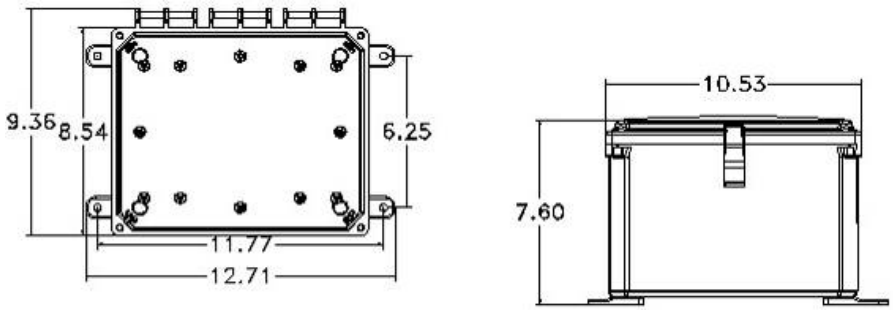
☎ **If shipping damage has occurred, call the Lakewood Instruments Customer Service Department at (800) 228-0839 and return the controller to the factory in the original carton.**

3.2 Mounting the Enclosure

The Model 2450e is supplied with four mounting feet. The Model 2450e can be mounted to a panel or to a flat non-vibrating wall.

- Attach the four mounting feet to the back of the controller enclosure.
- Install on smooth surface to prevent stress on the mounting feet.
- Do not install on vibrating wall.
- If enclosure is installed in corrosive environments, consider purging.
- Dimensions indicated as inches (millimeters).
- The enclosure material is PVC.
- Use #10 mounting screws (4).
- Avoid drilling or punching additional holes in the controller enclosure. Damage incurred as a result of any alteration to the enclosure is not covered under the Lakewood Instruments product warranty.

The dimensions of the enclosure in inches are:



The model 2450e has a shipping weight of about 8 lbs.

3.3 Sensor Installation

3.3.1 Conductivity Sensor Plumbing

The Conductivity sensor may be mounted in any position as long as the sensor tip is fully immersed in the active process water stream. Avoid connections in “dead leg” sections of pipe. An air pocket around the electrode tips will cause erroneous readings. The sensor electrodes should be in direct contact with the process flow (see DWG #04259 in the back of this manual).

Note: Remember to install isolation and bypass valves so that maintenance can be performed.

3.3.2 Conductivity Sensor Wiring

The model 2450e will accept the model 540K.1, the model 540K.01, the model 543M, the model 543L, and the model 543LL conductivity sensors. The conductivity sensor is wired directly to the I/O board inside the controller.

The 543 series sensors have 6 wires. They are as follows:

- Black wire — Electrode
- Red wire — Electrode
- White wire — Electrode
- Green wire — Electrode
- Black wire — Temp compensation
- Black wire — Temp compensation

The 540 series sensors have 4 wires. They are as follows:

- Black wire — Outer Electrode
- Red wire — Center Electrode
- White wire — Temp compensation
- Green wire — Temp compensation

For wiring instructions please refer to the drawings at the back of this manual.

The maximum allowed cable length between the sensor tip and the controller is twenty (20) feet. Cable length of conductivity sensors is measured from the electrode tips to the end of the wire. Lakewood Instruments guarantees operation up to 20 feet. If a cable extension is used, Lakewood Instruments will not guarantee operation of the sensor.

3.3.3 pH Sensor Plumbing

The pH sensor should be mounted vertically with the glass bulb facing down. It may be mounted at an angle as long as it is no more than 75° from the vertical position (see DWG #1240520-1a in the back of this manual). Due to the bubble position, however, the preferred mounting angle is no more than 45° from vertical.

The sensor must also be mounted in a location so that it is always wet. If is located in a pipe or tank with variable fluid levels, it is important that the sensor is installed where it can remain wet. Failure to do so will damage the sensor.

Remember to install isolation and bypass valves so that maintenance can be performed.

3.3.4 pH Sensor Wiring

The model 2450e will accept the model 520 pH sensor. The pH sensor is wired directly to the I/O board inside the controller.

The 520 series sensors have 4 wires and a coaxial cable with a BNC fitting. They are as follows:

- BNC center — pH signal
- BNC Shield — (not used)
- Black wire — Temp Compensation
- Red wire — Temp compensation
- White wire — Solution GND
- Green wire — Reference

For wiring instructions please refer to the drawings at the back of this manual.

The maximum allowed cable length between the sensor tip and the controller is fifteen (15) feet. Cable length of pH sensors is measured from the electrode tip to the end of the wire. Lakewood Instruments guarantees operation up to 15 feet. If a cable extension is used, Lakewood Instruments will not guarantee operation of the sensor.

Remember to install isolation and bypass valves so that maintenance can be performed.

☎ **If you have questions or need assistance, call Lakewood Instruments Technical Service Department at (800) 228-0839, Monday-Friday, 7:30 a.m. - 5:00 p.m. CST.**

3.4 Electrical Installation

3.4.1 Incoming Power 115/230 VAC

The Model 2450e can be powered from either 115 VAC or 230 VAC at 50/60 Hz. The Model 2450e controller comes with a power cord and receptacles. The power cord and receptacles are rated for 115VAC. If the controller will be powered by 230 VAC, the power cord and receptacles will need to be removed and the incoming power and the relay outputs will need to be hard-wired.

The incoming power is connected to terminal block TA at the bottom right corner of the power supply board. There is a hot or line input (terminal 4), a neutral input (terminals 2 and 3) and an earth ground input (terminal 1). The hot is wired to the fuse holder located on the bottom of the enclosure. The neutrals are wired directly to terminals 2 and 3 of terminal block TA. Refer to the drawing in the back of this manual for wiring instructions.

3.4.2 Relay Wiring

The relay outputs are of the same voltage as the power input. Ensure that the devices that are to be connected to the relay outputs are of the same voltage rating or damage will occur.

The relay outputs are wired to the receptacles. The receptacle on the far left is relay #1 and the receptacle on the far right is relay #4. On the power supply board, relay #4 is on the far left and relay #1 is on the far right. If 115 VAC is used simply plug your devices into the molded receptacles. If 230 VAC is used, remove the receptacles and hard-wire your devices to the relay outputs.

Relay #1 and #2 have both a normally open and normally closed contact. This is designed for use with motorized valves. The normally open (NO) contact is connected to the open connection of the valve and the normally closed (NC) contact is connected to the close connection of the valve. The other two relays only have a normally open contact. Each relay output requires a neutral connection and an earth ground connection for proper operation.

Refer to the drawing in the back of this manual for wiring instructions.

WARNING! DO NOT **PLUG IN CHEMICAL PUMPS THAT ARE LARGER THAN 1/6 HORSEPOWER. THE CONTROL RELAYS ARE INTENDED FOR ELECTRONIC OR SMALL MOTOR-DRIVEN CHEMICAL PUMPS. LARGER PUMPS REQUIRE THE -HR OPTION WITH 25-AMP-RATED INTERPOSING RELAYS. CONTACT LAKEWOOD INSTRUMENTS FOR SPECIAL INSTRUCTIONS.**

3.4.3 CIP Switch Wiring

The model 2450e has a CIP switch input. The purpose of the CIP switch input is to disable the relay outputs for cleaning the system. The CIP switch input requires a digital contact. Any digital contact rated for 24 VDC and 500 mA may be used.

3.4.4 Water Meters Wiring

The Model 2450e will accept two water meter inputs; a Permeate and a Concentrate. Refer to the water meter manufacturer's manual for plumbing information.

The 2450e monitor will work directly with the following types of meters: Seametrics open collector output meters, Signet 2535 and 2540 paddle wheel meters, and the Autotrol 1 inch and 2 inch meters. Contact Lakewood Instruments for other types of water meters. The water meters are wired to terminal block P1 which is the top terminal block on the I/O board.

Refer to the drawing in the back of this manual for wiring instructions.

3.4.5 4-20 mA Output Wiring

If the -35L option is ordered, the model 2450e has two channels of 4-20 mA output. The model -35L2 adds an additional two channels of 4-20 mA output for a total of four 4-20 mA outputs. **NOTE: THE MONITOR MUST HAVE THE -35L OPTION CARD INSTALLED BEFORE ADDING THE -35L2 OPTION CARD.**

These outputs can be isolated (externally powered) or non-isolated (internally powered). The 4-20 mA outputs are wired directly to the -35L and -35L2 option cards. The -35L card uses channels A and B while the -35L2 card uses channels C and D.

Refer to the drawing in the back of this manual for wiring instructions.

4.0Functional Overview

4.1 Display

The model 2450e uses an illuminated 128x64-pixel LCD digital display for ease of viewing. It has multiple lines to display information such as the pH reading, conductivity reading, alarms, relay status, relay configuration, clock, flow totals for both water meters, and menu selections.

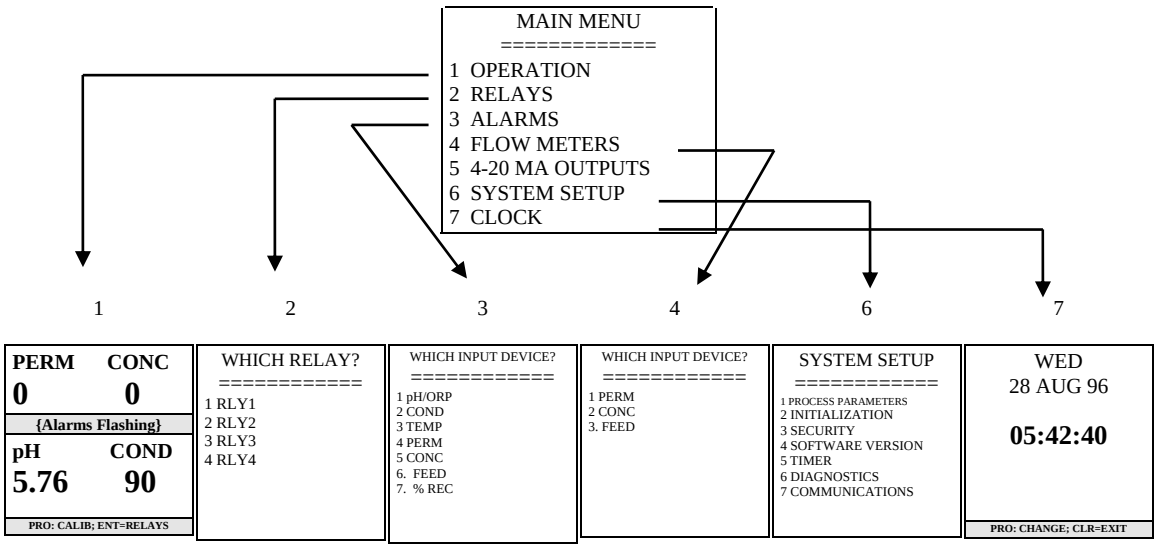
4.2 Keypad

The model 2450e uses a 16-key numeric keypad for ease of programming. The keys have the following functions:

ENT	To accept a setting or to enter a screen.
CLR	To exit a screen or to access the main menu.
PRO	To calibrate the controller.
DSP	To change languages.
UP arrow	To move about in the menu.
DOWN arrow	To move about in a menu.
Number keys	To input a value or to select a menu item.

4.3 Menu

The model 2450e is programmed and calibrated by the use of a menu. The complete **Main Menu** has 8 available options that can be accessed in the **Technician Level**. However, a list of only six options can be viewed at one time. Use the ↑ and ↓ keys to scroll through the options. As an introduction, here is a graphic overview of the first level of each option in the **Main Menu** to see how it operates. Complete details of each option are provided later in this manual.



4.4 Security Levels

The model 2450e has a security levels to prevent tampering of the controller. The Model 2450e offers three (3) security levels: 1) **View Only**, 2) **Operator** and 3) **Technician**. When the controller is in the **View Only** or **Operator** security level, the menu is locked out. In **View Only,** access is limited to manual operation of the relays, and viewing all of the process screens. In the **Operator** mode the user can operate the relays manually, view the process screens, and calibrate the controller. He cannot change any other settings. In the **Technician** mode the operator has full access to all of the menus.

A password is required to change from a tight security level to a less restrictive security level. Each level has its own factory-preset password (2222 for Technician, 1111 for Operator). If the controller is in the **View Only** or **Operator** mode just press the appropriate password on the keypad to change to a less restrictive security mode.

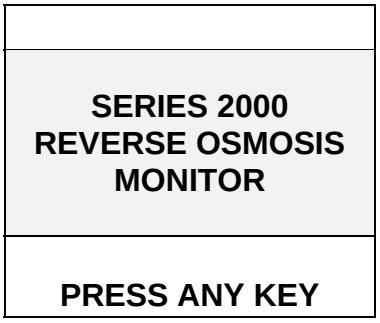
The passwords can be changed to personalized passwords from the **Technician Level Menu**.

NOTE: IF YOU USE PERSONALIZED PASSWORDS, MAKE SURE THEY ARE RECORDED IN A SAFE AND SECURE PLACE.

5.0 Starting Up the Monitor

5.1 Initial Power Up

Upon initial power up you will notice the Monitor will display:



This indicates that power has been applied to the Monitor and no one has touched the keypad. **This will also occur anytime there is a power outage and power has been returned to the Monitor.**

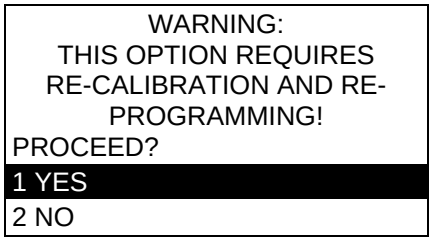
- Press any key on the keypad and you will see the **Operation Screen** on the screen.
- Press **CLR** on the keypad and you will see the **Main Menu** on the screen.
- Use the ↑ and ↓ arrow keys to move through the menu.

5.2 Initialization

Initialization restores the factory default settings to the controller. The whole controller can be initialized or just the calibration. It is suggested that you initialize the whole controller before you program the controller. This will clear any random settings that may be in the controller.

To initialize the whole controller:

- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**2**" **INITIALIZATION**.
- Press "**2**" **WHOLE CONTROLLER**. A warning will appear on the screen (see below). Press "**1**" to proceed, "**2**" to cancel.



5.3 Conductivity Preamp Setup

The internal preamp must be set up for the conductivity sensor that is used. Refer to the following tables for the preamp setup for Lakewood Instruments conductivity sensors.

RANGES

Cond Range	540 K.1	540 K.01	543M	543L	543LL
1-10	Range 4	Range 3	-	Range 2	Range 2
10-100	Range 3	-	Range 3	Range 2	Range 2
100-500	-	-	Range 2	Range 2	Range 2
100-1000	-	-	Range 2	Range 2	-
1000-10000	-	-	Range 1	-	-
10000-100000	-	-	Range 0	-	-

PREAMPLIFIER SETTINGS FOR THE MODEL 2450e

	Range 0	Range 1	Range 2	Range 3	Range 4
Voltage Gain	100	10	10	10	1
Sample R	20	20	200	2K	2K
Drive. Freq.	500 Hz	500 Hz	500 Hz	500 Hz	30 Hz

To set up the preamp:

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS** Select **Cond.**
- Press "**2**" **PREAMP SETUP**.
- Use the arrow keys to change the **VOLTAGE GAIN**, use the **ENT** key to move the cursor to the **SAMPLE R**.
- Use the arrow keys to change the **SAMPLE R**, use the **ENT** key to move the cursor to the **DRIVE FREQ**.

5.4 Cell Constant

The cell constant must be set up for the conductivity sensor that is used. Refer to the following table for the cell constants for Lakewood Instruments conductivity sensors.

CELL CONSTANTS

540 K.1	540 K.01	543M	543L	543LL
0.1	0.01	0.30	0.03	0.07

To set up the Temperature Compensation:

- From the Main Menu press "**7**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **Cond.**
- Press "**4**" **CELL CONSTANT**.

Use the keypad to enter the **CELL CONSTANT** as per the table above and press the **ENT** key.

5.5 Temperature Compensation

The model 2450e has a single temperature compensator input. This input is used to display the temperature of the permeate flow as well as to temperature compensate the pH and Conductivity readings. The input can come from either the pH or the conductivity sensor depending on which sensor is wired to the temperature compensation input. Set up the temperature compensation for the temperature compensator value of the sensor that is wired to the temperature compensation input. **NOTE: If the temperature compensator if the pH sensor is used, the temperature that is displayed will be the FEED WATER temperature NOT the permeate temperature.**

The model **520** series pH sensor has a **10K PTC** temperature compensator.

Refer to the following table for the temp compensators for Lakewood Instruments conductivity sensors.

TEMP COMPENSATION

540 K.1	540 K.01	543M	543L	543LL
500 NTC	500 NTC	4K NTC	4K NTC	1K PTC

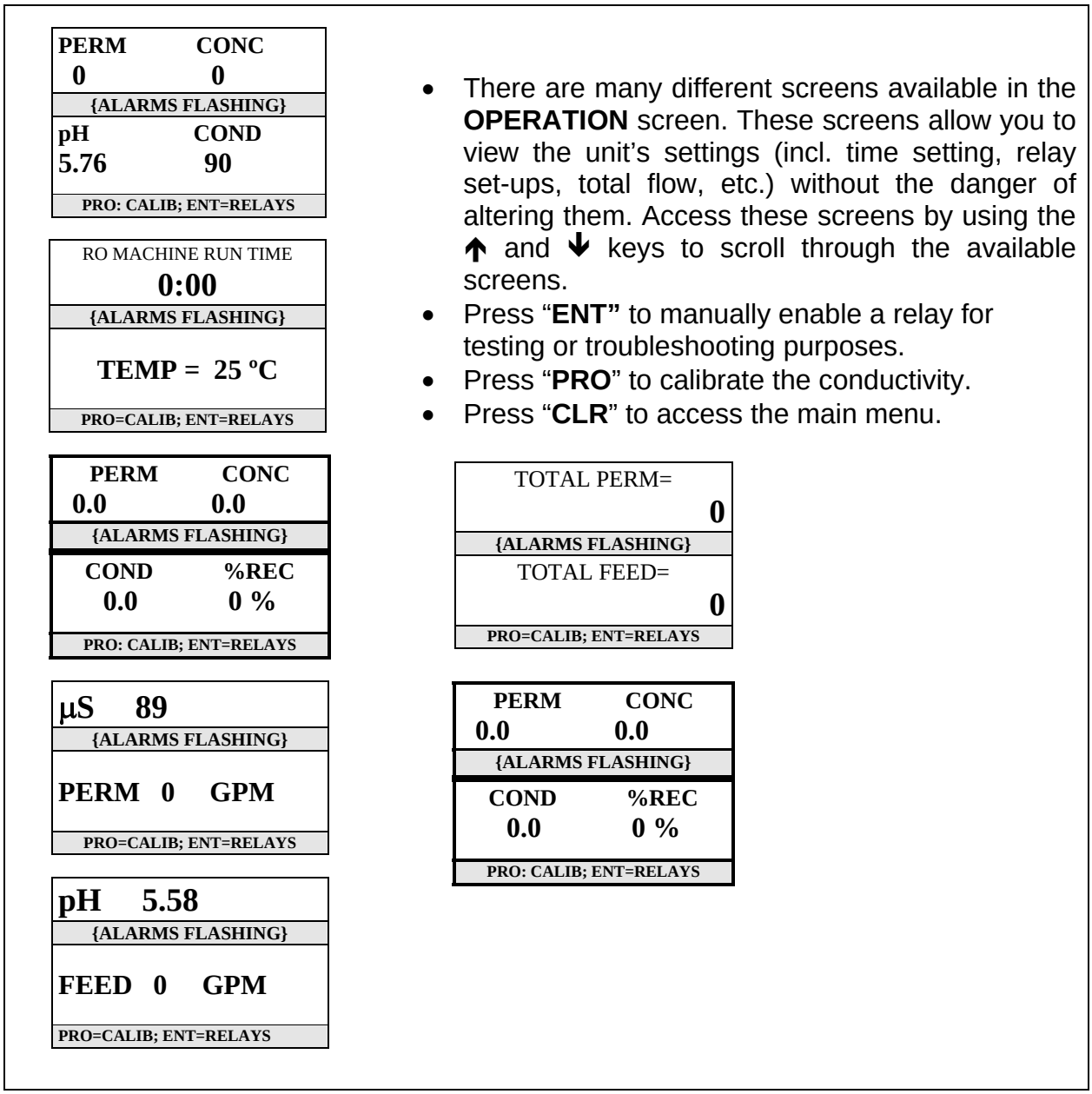
To set up the temperature compensation:

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.**
- Press "**3**" **TEMP**
- Press "**2**" **TEMP COMPENSATION**
- Select the value of your temperature compensator. Press "**ENT**".

6.0 Operation of the Controller

6.1 Operation Screen

The screen that is used the most in the 2450e controller is the Operation Screen. Below are the process screen views. The process screen has three sections. The top section is separated from the bottom section by the alarm bar in the middle section. The alarm bar is solid in appearance and flashes showing the current active alarms in sequence if there are multiple alarms.

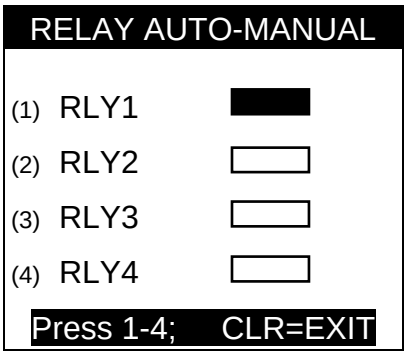


- There are many different screens available in the **OPERATION** screen. These screens allow you to view the unit's settings (incl. time setting, relay set-ups, total flow, etc.) without the danger of altering them. Access these screens by using the ↑ and ↓ keys to scroll through the available screens.
- Press "**ENT"** to manually enable a relay for testing or troubleshooting purposes.
- Press "**PRO**" to calibrate the conductivity.
- Press "**CLR**" to access the main menu.

6.2 Manual Operation of the Relays

All four of the relays can be operated manually. To manually operate the relays:

Go to the **Operation** screen. Press "**ENT**". You will be taken to a screen that looks like:



Press "**1-4**" to manually change the state of that particular relay. If the relay is already on, pressing that number will turn it off. A relay that is in manual control will stay in manual control even if this screen is exited. **WARNING: Manual control overrides everything. Use care when operating relays manually with no flow in the system.**

6.3 Calibration of Conductivity and pH

6.3.1 CALIBRATION of CONDUCTIVITY

The conductivity requires periodic calibration. Calibration is usually required after cleaning the sensor.

Calibration should always be performed with the sensor in the piping assembly with good flow past the sensor. It is necessary to have an accurate reading of the water to properly calibrate the controller. A hand-held conductivity meter that tests the sample works well for this purpose. Buffers should not be used for calibration purposes.

The model 2450e controller uses a single point calibration. A two point calibration is not necessary if using a Lakewood Instruments conductivity sensor.

- Ensure that the monitor is operating with good flow past the sensor.
- Take a sample of the water and measure with a hand-held conductivity tester.
- From the **Operation** screen, press "**PRO**" to enter the calibration screens.
- Press "**2**" **COND**
- Use the keypad to input the conductivity reading from the hand-held. Press "**ENT**".
- Take another hand-held sample to verify calibration.

6.3.2 CALIBRATION OF pH/ORP

The model 2450e monitor uses a single point calibration. A two point calibration is not necessary if using a Lakewood Instruments pH sensor because all Lakewood pH sensors have a slope of 59.14 mv per pH. If the slope has changed enough to require a two point calibration then the sensor should be cleaned or replaced.

We recommend that the pH calibrations only be performed with the sensor mounted as it will be used in the system. Buffers can be used to check calibrations but should not be used for calibration purposes.

It is necessary to have an accurate reading of the process water to properly calibrate the controller. A hand-held meter that tests the sample is best. Once you have obtained a reading, immediately enter the value into the controller. In the operation screen:

- Press **PRO.**
- Select **pH**.
- Select either **ZERO** or **SPAN (**see below).
- Use the number keys to enter the value, and then press **ENT**.
- Take a second sample with a hand-held pH meter and confirm the reading on the display.

6.3.2.1 ZERO or SPAN?

The model 2450e monitor is capable of performing a two point calibration using both the **ZERO** and **SPAN** calibrations. The operator must pick either **ZERO** or **SPAN** to perform a single point calibration. There are error messages associated with calibration points (see below). If an improper calibration is being performed an error message may appear.

To perform a good single point calibration the **ZERO** calibration should be performed at a lower pH than the **SPAN** calibration. A good rule of thumb is to perform a **ZERO** calibration if the measured pH is less than 7.00 pH and use the **SPAN** if the measured pH is greater than 7.00 pH.

6.3.2.2 CALIBRATION ERROR MESSAGES

The model 2450e will display calibration error messages to alert the operator of a possible calibration error. "**THE SPAN AND ZERO VALUES SHOULD BE AT LEAST TWO pH APART**" error message will occur if the zero and/or the span calibrations are performed within two pH of each other. If you receive this error message, initialize the calibration and repeat the calibration using the rule of thumb above.

The "**pH DEVIATION GREATER THAN 1.5 FROM DEFAULT CHK PROBE-CABLE-SOL'N**" error message will occur if the calibration value is more than 1.5 pH away from the value the controller thinks the pH should be based on the signal input from the sensor. This could indicate a failed sensor or interference in the system. If you receive this message perform a calibration check using buffer solutions.

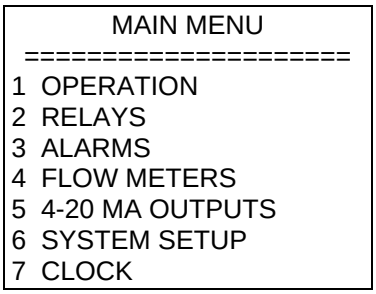
6.3.2.3 CALIBRATION CHECK OF pH or ORP IN BUFFER SOLUTIONS

To check the calibration of the sensor in buffer solutions, the sensor must be held in the center of a buffer solution. Perform the calibration check as follows:

- Initialize the calibrations.
- Shut down the system and remove the pH or ORP sensor.
- Place the sensor into the buffer solutions.
- Verify calibrations in at least two buffer solutions at least 2 pH or 200 mV apart.
- Re-install the sensor into the plumbing.
- Perform a single point calibration if necessary.

6.4 Main Menu

The **MAIN MENU** of the 2450e looks like this:



The **MAIN MENU** can be accessed from the **OPERATION** screen by pressing "**CLR**"**.** If "**CLR**" is pressed and the **MAIN MENU** does not appear, the controller is probably in the **VIEW ONLY** or **OPERATOR** security mode. If the controller is in the **VIEW ONLY** or **OPERATOR** security mode, enter the **TECHNICIAN** security password to be able to access the **MAIN MENU**.

To move about in the menu screen use the ↑ and ↓ keys to highlight the desired option and press "**ENT**" or simply press the number key for the desired option.

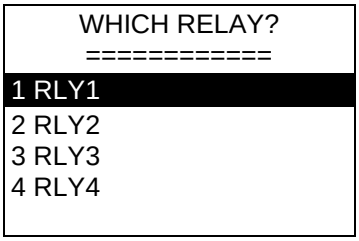
Use the "**ENT**" key to accept a setting or to enter a screen. Use the "**CLR**" key to reject a setting or to exit a screen. From anywhere in the menu, pressing "**CLR**" will take you one step closer to the **MAIN MENU**.

Certain menu items are only visible if certain conditions apply, such as: option cards are installed, or other parameters are configured. If a menu item does not appear in the menu it most likely means that the option is not installed or configured.

Each of the **MAIN MENU** options is discussed in detail later in this manual.

6.5 Configuring the Relays

To access the relay configuration screen from the **MAIN MENU,** press "**2**" or highlight **RELAYS** and press "**ENT**". The following screen will appear.

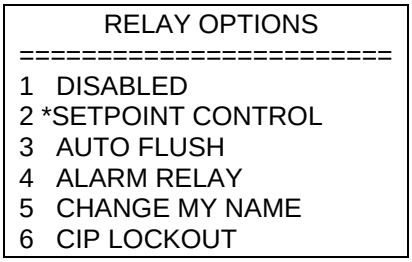


Select the relay that you want to program.

6.5.1 RELAY OPTION SCREEN

Below is the **RELAY OPTIONS** screen. The asterisk (*) next to one of the options tells you how that relay is configured.

There are multiple methods that the relays can be configured to operate. When a relay is selected for programming the following screen will appear.



6.5.1.1 Disabled

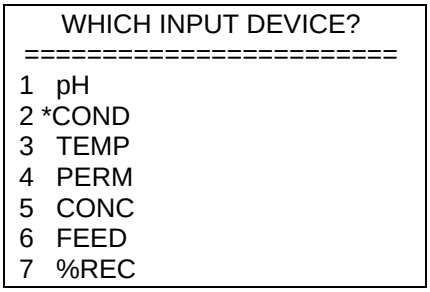
The relays can be disabled. When a relay is disabled, it will not energize automatically.

From the **RELAY OPTIONS** screen press "**1**" **Disabled** to disable the relay.

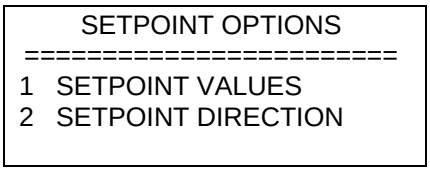
6.5.1.2 SETPOINT CONTROL

The relays can be configured to operate based on a setpoint from any of the inputs such as: **pH or ORP, CONDUCTIVITY, TEMPERATURE, PERMEATE FLOWRATE, CONCENTRATE FLOWRATE, FEED FLOWRATE, and PERCENT OF RECOVERY**.

When setpoint control is selected the following screen will appear.



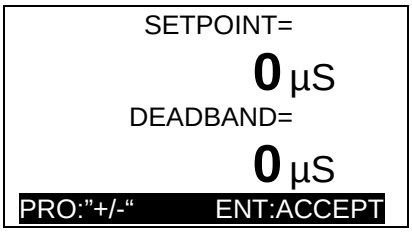
Select the desired input for setpoint control. You will be taken to a screen that lists that input with the instruction to "**PRESS ANY KEY**". Once you press any key on the keypad, the **SETPOINT OPTIONS** screen will appear:



To program the setpoint, select "**1**" **SETPOINT VALUES**.
To set the direction of operation, select "**2**" **SETPOINT DIRECTION**.

6.5.1.2.1 SETPOINT

In the **SETPOINT VALUES** screen you will set the **SETPOINT**, the **DEADBAND** and the **TIMEOUT** alarm.



The **SETPOINT** is the input device value that you are trying to maintain. Check with your water treatment engineer to determine the setpoints for your system needs.

- Use the keypad to enter the setpoint and press "**ENT**". You will automatically be moved down to the deadband.

6.5.1.2.2 DEADBAND

After the setpoint is established, the relay's deadband must also be set. "**Deadband**" refers to the amount of reading above and below the setpoint—a range within which the controller will not react. Due to continuous fluctuations in the input level, it is necessary to have this deadband range or stable readings will be difficult to obtain. The Deadband should be a small percentage of the setpoint. Half the deadband amount will be automatically put above the setpoint, and the other half below it.

For example, a Conductivity setpoint of 100 µS with a deadband of 10 µS would result in the relay turning on at 105 µS and turning off at 95 µS.

- Use the keypad numbers to enter the deadband value and press "**ENT**". You will automatically be switched to the **TIMEOUT** alarm screen.

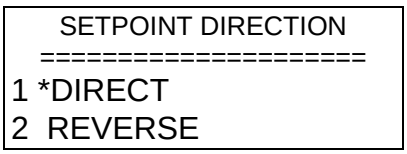
6.5.1.2.3 TIMEOUT

The **TIMEOUT** alarm is designed to notify the operator of a problem in the system such as, a pump has lost its prime or there is no chemical in the drum. It will also protect the system from overfeeding chemical when the indicated input does not display a change in actual reading. The **TIMEOUT** function will display a visual alarm on the display and **it will turn off the relay**. If a relay is configured as an alarm relay, the **TIMEOUT** alarm will energize the alarm relay.

- Use the keypad to enter the time in hours and minutes before this alarm will appear and press "**ENT**". Maximum setting is 17 hours and 59 minutes. To disable this function, set the **OVERFEED** time to 0:00.

6.5.1.2.4 SETPOINT DIRECTION

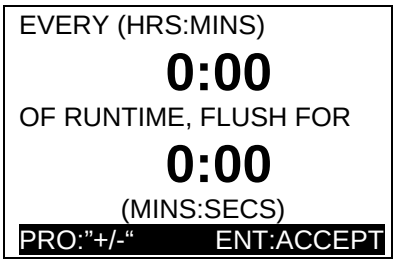
After configuring the SETPOINT, the DEADBAND, and the TIMEOUT alarm, the monitor will automatically move to the **SETPOINT DIRECTION** screen. To set up to operate the relay on a rising reading select **DIRECT** to activate *above* the setpoint. To set up to operate on a falling reading select **REVERSE** to activate *below* the setpoint.



- Select "**1**" **DIRECT** to turn on the relay when the reading rises above the setpoint, or select "**2**" **REVERSE** to turn on the relay when the reading falls below the setpoint.

6.5.1.3 AUTO FLUSH

The AUTO FLUSH feature is designed to turn on a relay for a user specified amount of time after a user specified amount of machine runtime. From the RELAY OPTIONS screen select "**3**" **AUTO FLUSH**



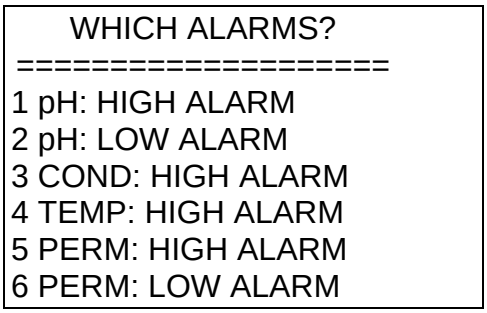
- Use the keypad to enter an amount of machine runtime, in hours and minutes, then press "**ENT**".
- Use the keypad to enter an amount of flush time, in minutes and seconds, then press "**ENT**".

6.5.1.4 Alarm Relay

The relays can be configured as alarm relays. The alarms that will cause the relay to activate are selectable from the controller alarms or from any node input alarms.

The controller alarms include: High and Low pH, High Cond, High Temp, High and Low Perm flow rate, High and Low Feed flow rate, High %REC, Lubrication Interval, Check CIP, Check Filters, Check Membranes, Check Sensor, Cond: Fouled Sensor, Shorted TC, Opened TC, High REF Impedance, Broken Glass, High REF Voltage, Low REF Voltage, CIP Switch Closed, and Relay Time Exceeded alarms.

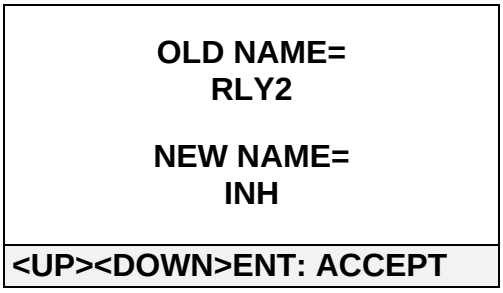
- From the **RELAY OPTIONS** screen press"**4**" **ALARM RELAY.** The controller will respond with the following screen.



- Only 6 alarms are shown at a time on the screen, use the arrow keys to scroll up and down the choices and select the alarms by pressing "**ENT**" when the desired alarm is highlighted. An asterisk (*****) will appear next to all alarms that are currently selected.

6.5.1.5 Change My Name

The name of each individual relay can be changed to any 4-character name. This is useful to designate the chemical name for each relay. Use the arrow keys to change the character and the ENT key to move to the next character.

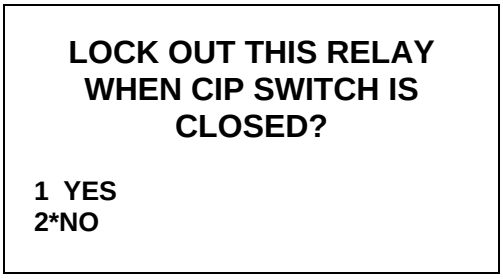


- From the **RELAY OPTIONS** screen press"**5**" **CHANGE MY NAME.**

6.5.1.6 CIP Lockout

Each individual relay can be locked out during a Clean-In-Place operation. The relay will be locked out when the CIP switch input registers a contact closure and the **CIP SWITCH CLOSED** alarm will be displayed on the **Operation** screen.

To lockout a relay during CIP operations, select "**6**" **CIP LOCKOUT** from the relay options screen for each relay you want to lock out.

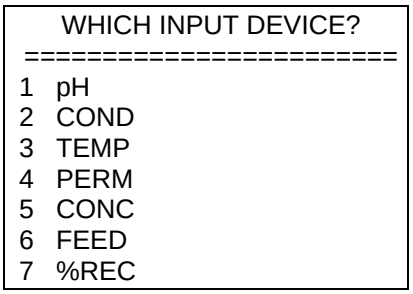


- Select "**1**" **YES** to lock out the relay during CIP operations**.**
- Select "**2**" **NO** to allow the relay to operate normally during CIP operations.
- An asterisk (*) appears next to the current selection.

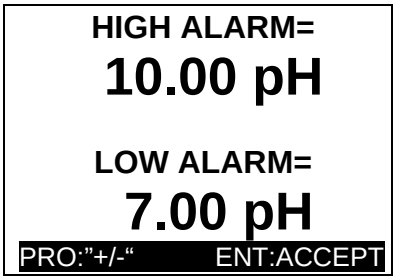
6.6 Configuring the Alarms

The Model 2450e is equipped with multiple alarms. This menu option allows you to program the specific values for these alarms. When an alarm is received, it will appear as a flashing message in the middle of the Operation screen and any configured alarm relays will be activated. Consult your water treatment specialist when determining the proper High and Low Alarm values for your system.

To access the alarm configuration screens from the **MAIN MENU,** press "**3**" or highlight **ALARMS** and press "**ENT**". The following screen will appear.



Select the desired alarm input. You will be taken to that input's alarm configuration screen:



- Use the keypad to enter the High Alarm point and press "**ENT**". If that input has a low alarm associated with it, you will automatically be moved down to the Low Alarm.
- If applicable, use the keypad to enter the Low Alarm point and press "**ENT**".

NOTE: Concentrate flow rate does not currently have high or low alarms associated with it.

6.7 Flow Meters

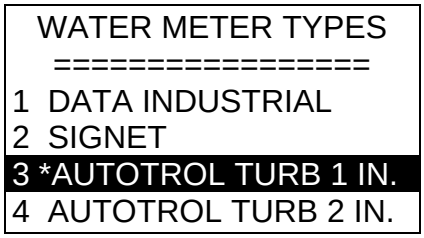
The 2450e series controllers include two flow meter inputs for use as the Permeate and Concentrate. These inputs will work directly with the following types of **open collector output meters**: Data Industrial, Signet paddle wheel meters, and the Autotrol 1 inch and 2 inch turbine meters. Contact Lakewood Instruments for other types of water meters.

The Permeate, Concentrate, and Feed flow **rates** as well as the Permeate and Feed flow **totals** are displayed on the Operation screen. The Concentrate flow total is not displayed. The **Feed** flow meter input is the **sum** of both the Permeate and the Concentrate flow meter inputs.

The Permeate and Concentrate flow meter inputs are programmed using the following procedures.

To get to the flow meter configuration screen:

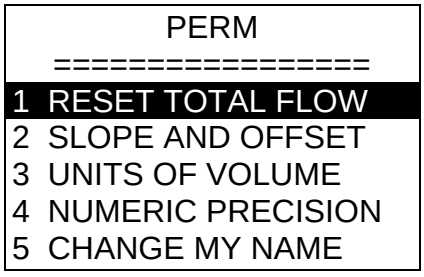
- From the **main menu**, press"**4**" **FLOW METERS**. This will take you to the **WHICH FLOW METER** screen**.**
- Press"**1**" for **PERM,** press"**2**" for **CONC,** or "**3**" for **FEED**.
- This will take you to the **WATER METER TYPES** screen as shown.



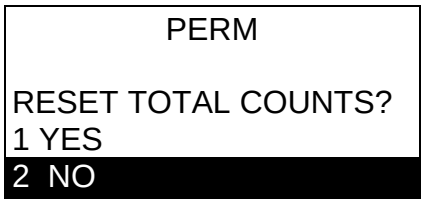
- Use the keypad to select the type of flow meter that you are using.

6.7.1 Data Industrial

If **DATA INDUSTRIAL** is selected the following screen will appear:

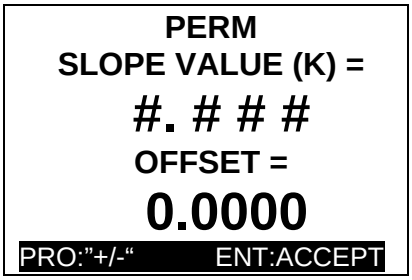


RESET TOTAL FLOW
This screen is used to reset the total flow for this input back to zero.



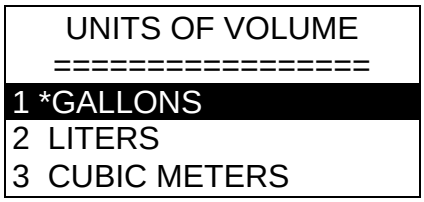
- Select "**1**" **YES** to reset the total flow to zero
- Select "**2**" **NO** to keep the current flow meter total.

SLOPE and OFFSET
This screen is used to configure the monitor for your particular Data Industrial flow meter.



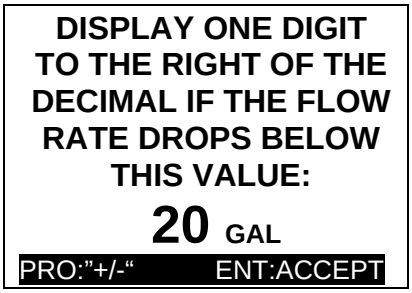
- Use the keypad to enter the **SLOPE** or **K factor** value for your particular water meter then press "**ENT**".
- Use the keypad to enter the **OFFSET** value for your particular water meter then press "**ENT**".

UNITS OF VOLUME
This screen is used to configure the units of volume to be displayed to Gallons, Liters, or Cubic Meters.



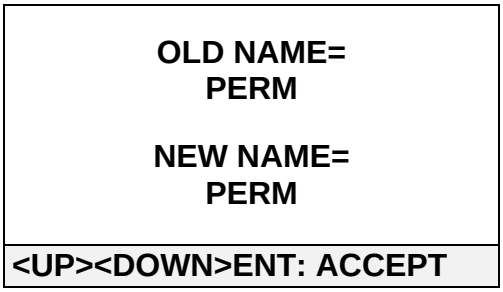
- Press"**1**" for **GALLONS,** press"**2**" for **LITERS,** or press "**3**" for **CUBIC METERS**.

NUMERIC PRECISION
This screen is used to display one digit to the right of the decimal point when displaying the flow rate of this flow meter. The user can select the flow rate **BELOW** which the decimal point is activated.



- Use the keypad to enter the **FLOWRATE** value then press "**ENT**".

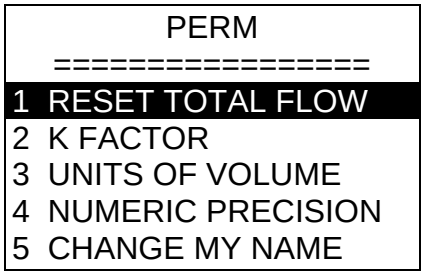
CHANGE MY NAME
The name of flow meter input can be changed to any 4-character name.



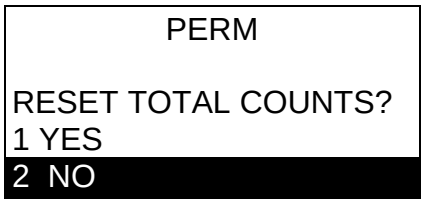
- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.7.2 SIGNET

If **SIGNET** is selected the following screen will appear:

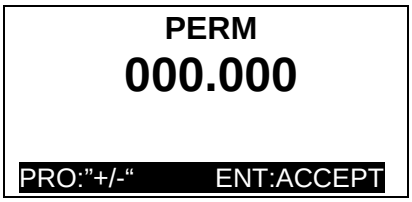


RESET TOTAL FLOW
This screen is used to reset the total flow for this input back to zero.



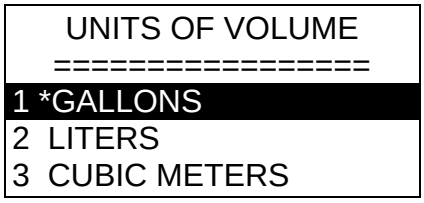
- Select "**1**" **YES** to reset the total flow to zero
- Select "**2**" **NO** to keep the current flow meter total.

K FACTOR
This screen is used to configure the monitor for your particular Signet flow meter.



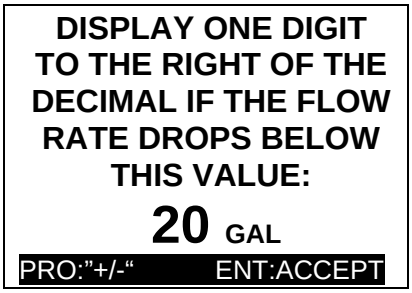
- Use the keypad to enter the **K factor** value for your particular flow meter then press "**ENT**".

UNITS OF VOLUME
This screen is used to configure the units of volume to be displayed to Gallons, Liters, or Cubic Meters.



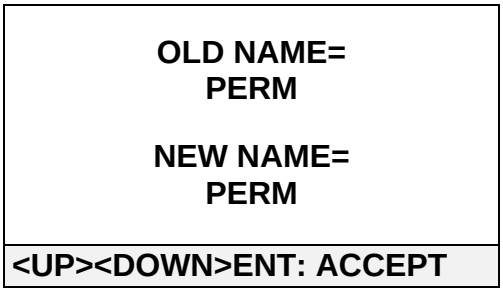
- Press"**1**" for **GALLONS,** press"**2**" for **LITERS,** or press "**3**" for **CUBIC METERS**.

NUMERIC PRECISION
This screen is used to display one digit to the right of the decimal point when displaying the flow rate of this flow meter. The user can select the flow rate **BELOW** which the decimal point is activated.



- Use the keypad to enter the **FLOWRATE** value then press "**ENT**".

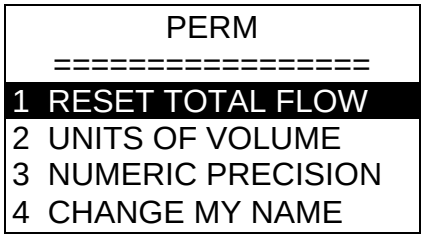
CHANGE MY NAME
The name of flow meter input can be changed to any 4-character name.



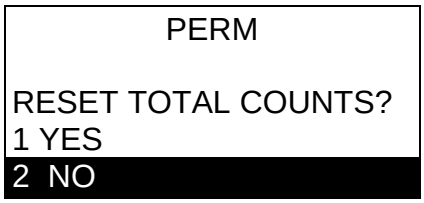
- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.7.3 AUTOTROL TURBINES 1 INCH OR 2 INCH

If an **AUTOTOL 1 IN. or 2 IN.** turbine is selected the following screen will appear:

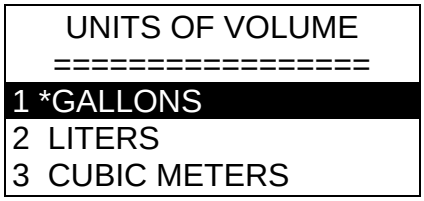


RESET TOTAL FLOW
This screen is used to reset the total flow for this input back to zero.



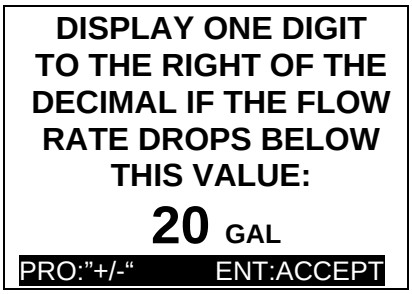
- Select "**1**" **YES** to reset the total flow to zero
- Select "**2**" **NO** to keep the current flow meter total.

UNITS OF VOLUME
This screen is used to configure the units of volume to be displayed to Gallons, Liters, or Cubic Meters.



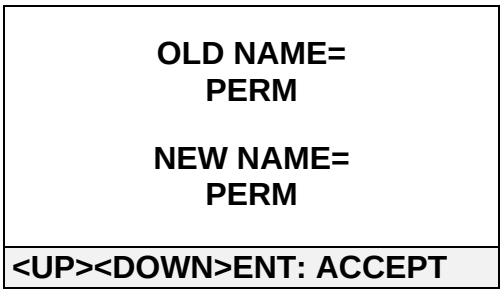
- Press"**1**" for **GALLONS,** press"**2**" for **LITERS,** or press "**3**" for **CUBIC METERS**.

NUMERIC PRECISION
This screen is used to display one digit to the right of the decimal point when displaying the flow rate of this flow meter. The user can select the flow rate **BELOW** which the decimal point is activated.



- Use the keypad to enter the **FLOWRATE** value then press "**ENT**".

CHANGE MY NAME
The name of flow meter input can be changed to any 4-character name.

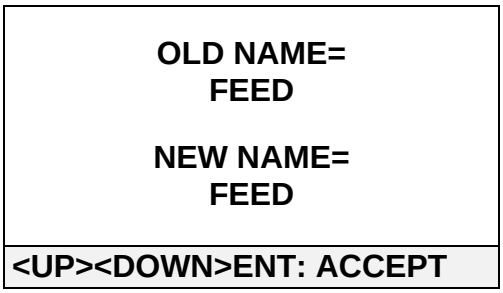


- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.7.4 FEED FLOW

The Feed Flow indication is the sum of the Permeate and Concentrate flow meter inputs; it does not have its own wired input.

The name of FEED input can be changed to any 4-character name.



- Use the arrow keys to change the character and the **ENT** key to move to the next character.

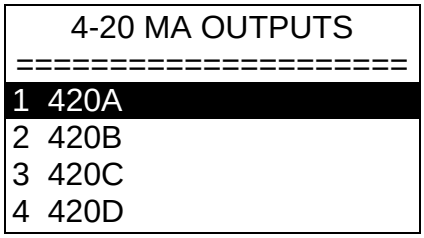
6.8 4-20 mA OUTPUTS

The-35L option card adds two channels (channels A and B) of 4-20 mA output. The addition of the -35L2 option card adds two additional 4-20 mA output channels (channels C and D). The -35L option card must be installed in the monitor before installing the -35L2 option card. **NOTE: The -35L option card must be installed for this menu selection to be functional.**

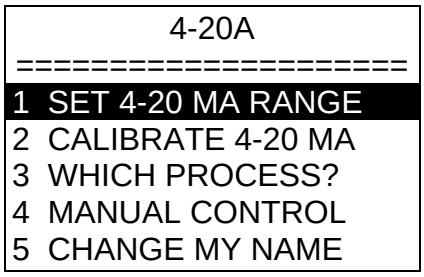
The 4-20 mA output screens are used to set the range, calibrate the 4-20 mA output, configure the output to a process, take manual control of the 4-20 mA output, and change the name of the output.

To access the 4-20 mA output screens from the main menu:

- From the **main menu**, press"**5**" **4-20 mA OUTPUTS**. This will take you to the **OUTPUT CHANNEL** selection screen**.**
- Press"**1**" for **CH A,** press"**2**" for **CH B,** or "**3**" for **CH C,** or "**4**" for **CH D**.



Each channel is configured separately and when a channel is selected the following screen will appear:



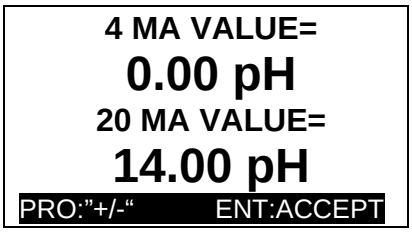
NOTE: When configuring a channel of 4-20 mA output, the process should be selected before setting the range.

6.8.1 SET the 4-20 mA RANGE

NOTE: When configuring a channel of 4-20 mA output, the process should be selected before setting the range.

The range of the output channel should match the range of the device to which the output is sent.

When **SET 4-20 MA RANGE** is selected the follow screen is displayed:

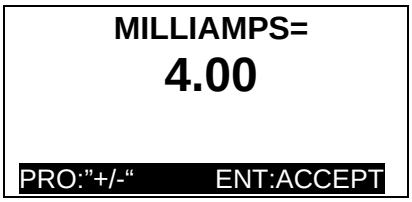


- Use the keypad to enter the **4 MA** value then press "**ENT**".
- Use the keypad to enter the **20 MA** value then press "**ENT**".

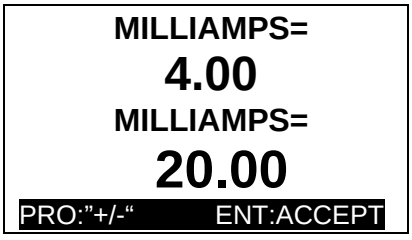
6.8.2 CALIBRATE 4-20 mA

The 4-20 mA needs to be calibrated to the actual output to be accurate. A milliamp meter is necessary to calibrate the 4-20 mA output. Connect the milliamp meter in-line with one leg of the 4-20 mA output. Refer to the drawing in the back of this manual for wiring instructions.

- From the **4-20 mA Setup** screen, press"**2**" **CALIBRATE 4-20 MA.** The screen will show the current 4 mA reading:



- Use the keypad to enter the milliamp reading from the milliamp meter for the **4-**mA point. Press "**ENT**". The screen will show the current 20 mA reading:

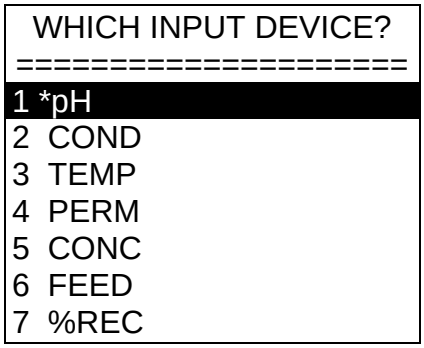


- Use the keypad to enter the milliamp reading from the milliamp meter for the **20**-mA point. Press "**ENT**".

6.8.3 WHICH PROCESS?

The four channels of 4-20 mA output can be configured to pH, conductivity, temperature, permeate flow rate, concentrate flow rate, feed flow rate, or percent of recovery.

- From the **4-20 mA Setup** screen, press"**3**" **WHICH PROCESS?**.

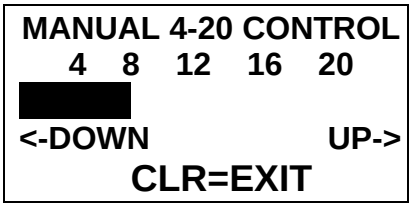


- Use the up and down arrow keys to select the process that will control that channel of 4-20 mA output. Press "**ENT**".

6.8.4 MANUAL CONTROL

Manual control is used to temporarily change the 4-20 mA output.

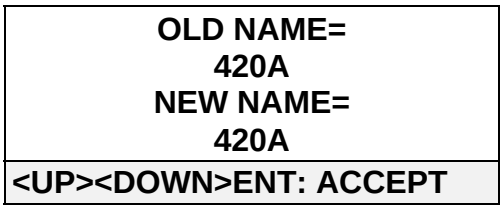
- From the **4-20 mA Setup** screen, press "**4**" **MANUAL CONTROL**.



- Use the up and down arrow keys to raise or lower the 4-20 mA output. The dark bar indicates the current output. To exit this screen press "**CLR**".

6.8.5 CHANGE MY NAME

The name of 4-20 mA output channel can be changed to any 4-character name.

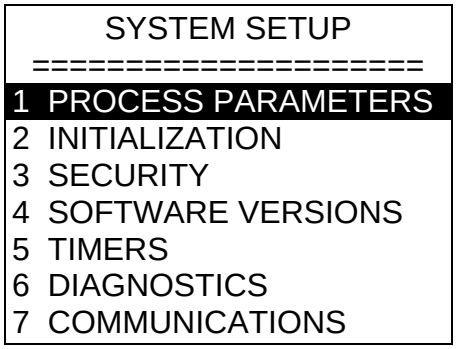


- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.9 SYSTEM SETUP

The system setup menu is used to set up the process parameters, initialize the controller, check the software versions, change the security passwords, check the diagnostics, set up the communications, set up the timers.

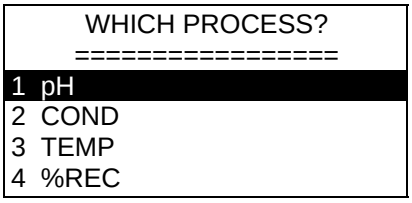
- From the **MAIN MENU**, press "**6**" **SYSTEM SETUP**.



6.9.1 PROCESS PARAMETERS

There are sub-screens in the process parameters screen for each of the process inputs. For the model 2450e there are screens for each of pH/ORP, conductivity, temperature, and % recovery. The WHICH PROCESS? screen will appear on the screen once Process Parameters is selected.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.**

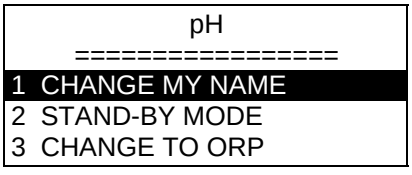


- Use the number keys to select the desired process input.

6.9.1.1 pH/ORP

The pH/ORP process parameters screen allow the user to change the name of the pH/ORP input, place the pH input into stand-by mode, and switch the input between pH and ORP.

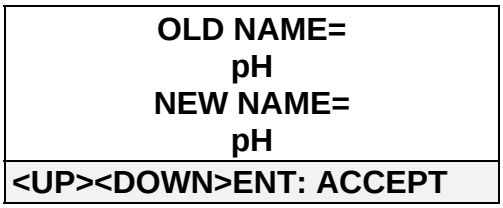
- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **pH(ORP).**



6.9.1.1.1 pH/ORP – CHANGE MY NAME

The name of the pH/ORP input can be changed to any four character name.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **pH(ORP).**
- Press "**1**" **CHANGE MY NAME.**

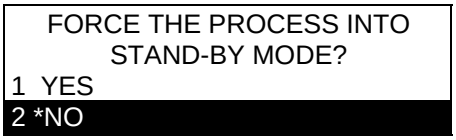


- Use the arrow keys to change the character and the **ENT** key to move to the next character.

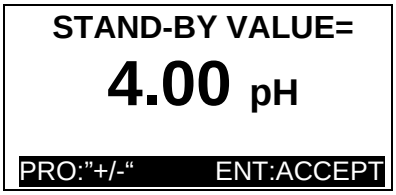
6.9.1.1.2 pH/ORP – STAND-BY MODE

The pH/ORP input can be placed into the stand-by mode. The stand-by mode locks the pH/ORP reading into a solid value specified by the user. This helps to prevent spurious alarms when the pH/ORP input is not in use.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **pH(ORP).**
- Press "**2**" **STAND-BY MODE.**



- Press "**1**" **YES** to place the pH/ORP input into the STAND-BY mode**.** The following screen appears:



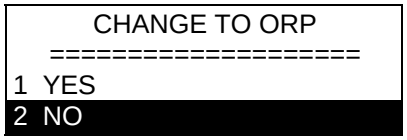
- Use the keypad to set the stand-by value and press the **ENT** key.

NOTE: When the pH/ORP input is placed into the STAND-BY mode, the pH value on the OPERATION screen will flash constantly.

6.9.1.1.3 pH/ORP – CHANGE TO ORP (pH)

The pH/ORP input can be selected to pH or ORP. The default setting is set to pH. To change the input from pH to ORP or ORP to pH:

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **pH(ORP).**
- Press "**3**" **CHANGE TO ORP (pH).**

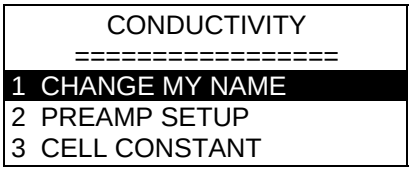


- Press "**1**" **YES** to change the pH/ORP input to the selected type**,** or press "**2**" **NO** to leave the pH/ORP input at the current type.

6.9.1.2 CONDUCTIVITY

The conductivity process parameters screen allow the user to change the name of the conductivity input, and configure the electronics for the conductivity sensor.

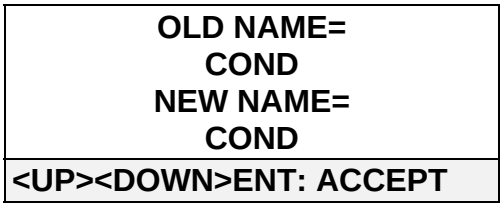
- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **COND.**



6.9.1.2.1 COND – CHANGE MY NAME

The name of the conductivity input can be changed to any four character name.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **COND.**
- Press "**1**" **CHANGE MY NAME.**



- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.9.1.2.2 COND – PREAMP SETUP

The internal preamp must be set up for the conductivity sensor that is used. Refer to the following tables for the preamp setup for Lakewood Instruments conductivity sensors.

RANGES

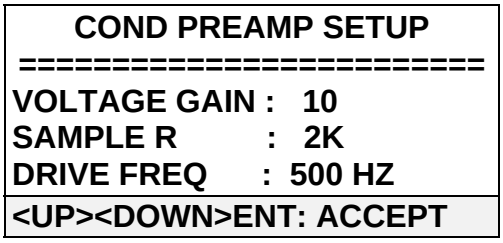
Cond Range	540 K.1	540 K.01	543M	543L	543LL
1-10	Range 4	Range 3	-	Range 2	Range 2
10-100	Range 3	-	Range 3	Range 2	Range 2
100-500	-	-	Range 2	Range 2	Range 2
100-1000	-	-	Range 2	Range 2	-
1000-10000	-	-	Range 1	-	-
10000-100000	-	-	Range 0	-	-

PREAMPLIFIER SETTINGS FOR THE MODEL 2450e

	Range 0	Range 1	Range 2	Range 3	Range 4
Voltage Gain	100	10	10	10	1
Sample R	20	20	200	2K	2K
Drive. Freq.	500 Hz	500 Hz	500 Hz	500 Hz	30 Hz

To set up the preamp:

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS** Select **Cond.**
- Press "**2**" **PREAMP SETUP**.



- Use the arrow keys to change the **VOLTAGE GAIN**, use the **ENT** key to move the cursor to the **SAMPLE R**.
- Use the arrow keys to change the **SAMPLE R**, use the **ENT** key to move the cursor to the **DRIVE FREQ**.
- Press **ENT** to accept the settings.

6.9.1.2.3 COND – CELL CONSTANT

The cell constant must be set up for the conductivity sensor that is used. Refer to the following table for the cell constants for Lakewood Instruments conductivity sensors.

CELL CONSTANTS

540 K.1	540 K.01	543M	543L	543LL
0.1	0.01	0.30	0.03	0.07

To set up the Cell Constant::

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **COND.**
- Press "**3**" **CELL CONSTANT**.

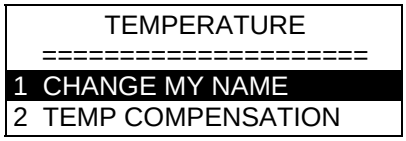
- Use the keypad to enter the **CELL CONSTANT** as per the table above and press the **ENT** key.

6.9.1.3 TEMPERATURE

The temperature input is provided by the conductivity sensor.

The temperature process parameters screen allows the user to change the name of the temperature input, and configure the temperature compensation input.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **TEMP.**



6.9.1.3.1 TEMP – CHANGE MY NAME

The name of the temperature input can be changed to any four character name.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **TEMP.**
- Press "**1**" **CHANGE MY NAME.**

OLD NAME= **TEMP** **NEW NAME=** **TEMP**
<UP><DOWN>ENT: ACCEPT

- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.9.1.3.2 TEMP – TEMP COMPENSATION

The temperature input is provided by the conductivity sensor. The temperature compensation must be set up for the sensor that is used. Refer to the following table for the temperature compensation values for Lakewood Instruments conductivity sensors.

	540K.1	**540K.01**	**543M**	**543L**	**543LL**
TEMP COMP	**500 NTC**	**500 NTC**	**4K NTC**	**4K NTC**	**1K PTC**

To set up the Temperature Compensation:

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **TEMP.**
- Press "**2**" **TEMP COMPENSATION**.

TEMP COMPENSATION ==========
1 NONE
2 *500 NTC
3 4K NTC
4 10K NTC
5 100 PTC
6 1K PTC
7 3K PTC
8 10K PTC

- Use the arrow keys to highlight the **TEMP COMPENSATION** value and press the **ENT** key. The asterisk (*) indicates the current configuration.

6.9.1.4 Percent Recovery

The % recovery process parameters screen allows the user to change the name of the % recovery input.

6.9.1.4.1 % REC – CHANGE MY NAME

The name of the % recovery input can be changed to any four character name.

- From the Main Menu press "**6**" **SYSTEM SETUP.**
- Press "**1**" **PROCESS PARAMETERS.** Select **%REC.**
- Press "**1**" **CHANGE MY NAME.**

OLD NAME= **%REC** **NEW NAME=** **%REC**
<UP><DOWN>ENT: ACCEPT

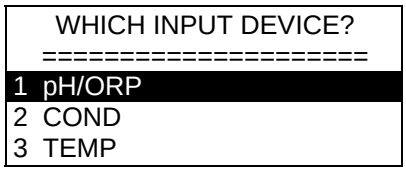
- Use the arrow keys to change the character and the **ENT** key to move to the next character.

6.9.2 INITIALIZATION

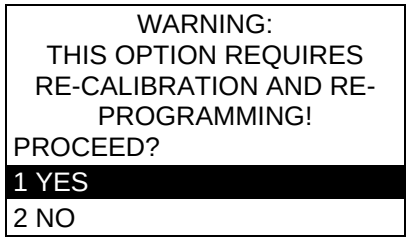
Initialization restores the factory default settings to the monitor. The whole controller can be initialized or just the calibrations. This will clear any random settings that may be in the monitor.

To initialize the calibrations:

- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**2**" **INITIALIZATION**.
- Press "**1**" **CALIBRATIONS**. The WHICH INPUT DEVICE screen will appear.



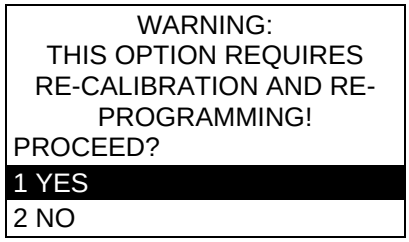
- Use the arrow keys to highlight the input to initialize and press the **ENT** key.



- Use the arrow keys to highlight "**1**" **YES** and press the **ENT** key.

To initialize the whole controller:

- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**2**" **INITIALIZATION**.
- Press "**2**" **WHOLE CONTROLLER.**



- Use the arrow keys to highlight "**1**" **YES** and press the **ENT** key.

NOTE: Initializing the WHOLE CONTROLLER deletes all user settings and will require reprogramming the Whole Controller.

6.9.3 SECURITY (CHANGE THE PASSWORDS)

The security password can be changed from the factory default settings to any four-digit value of your choice.

To change the security passwords:

- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**3**" **SECURITY**.

```
      CHANGE PASSWORD
    ====================
1  OPERATOR
2  TECHNICIAN
```

- Press "**1**" **OPERATOR** to change the operator password or Press "**2**" **TECHNICIAN** to change the technician password.

```
            TECHNICIAN

PASSWORDS ARE 4 KEYS
ENTER A NEW PASSWORD

OLD PASSWORD= ****
NEW PASSWORD= ****
VERIFY        = ****
```

- Use the keypad to enter the old password. If the password has not been changed before, the old password for **OPERATOR** is **1111** and the password for **TECHNICIAN** is **2222**.
- Use the keypad to enter the new password.
- Use the keypad to enter the new password a second time for verification

If you lose your password, contact Lakewood Instruments for assistance.

6.9.4 SOFTWARE VERSIONS

Sometimes it is necessary to verify the software versions of the controller for troubleshooting purposes. To obtain the software versions:

- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**4**" **SOFTWARE VERSIONS**.
- The software versions will be displayed. Use the arrow keys to view all software versions. To exit this screen, press "**CLR**".

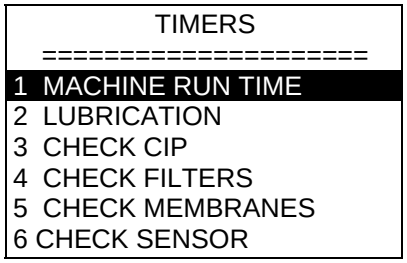
6.9.5 TIMERS

The model 2450e includes timers for machine run time, lubrication interval, check CIP, check filters, check membranes, and check sensor. The machine run time timer keeps track of actual machine run time and counts up. All the other timers are based on machine run time and count down from a user programmed machine run time and will trigger timer alarms notifying the user that an action needs to be performed.

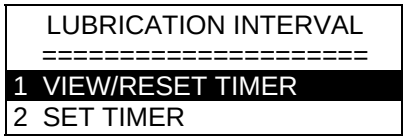
The timer setup screens allow the user to reset the timers to zero and, in the case of all timers except the machine run time, allow the user to set the number of hours until the timer alarm occurs.

To access the timers:

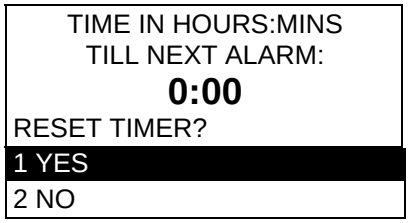
- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**5**" **TIMERS**.



- Use the arrow keys to highlight the timer and press the **ENT** key.



To view or reset the timer press "1" VIEW/RESET TIMER.



- Press "1" YES to reset the alarm timer to the user programmed time.

To set the timer press "2" SET TIMER.

- Use the keypad to set the timer and press the **ENT** key.

6.9.6 Diagnostics

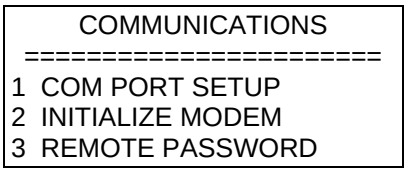
The diagnostics screen is used for troubleshooting purposes. Contact Lakewood Instruments for assistance.

6.9.7 Communications

The model 2450e has an option for remote communications, the –RS2L option. If this option is installed, the communications option is configured from this screen. This screen is used to set up the com port, initialize the modem, and set the remote password.

To set up the communications option:

- From the **Main Menu**, press "**6**" **SYSTEM SETUP**.
- Press "**7**" **COMMUNICATIONS**.



6.9.7.1 Com Port Setup

Com port setup is used to set up the com port for use with a modem or direct connect.

- To set up the com port press "**1**" **COM PORT SETUP**

```
COM PORT PARAMETERS
======================
BAUD RATE:    19200
DATA  BITS:   8
STOP  BITS:   1
PARITY    :   NONE

<UP><DOWN>  ENT: ACCEPT
```

- Use the arrow keys to change the baud rate. If using the direct connect method of communicating, ensure that the baud rate at the controller and the baud rate in the LRWS software match.
- The standard values for the **DATA BITS** is 8, **STOP BITS** is 1, and **PARITY** is NONE. Normally these will not need to be changed.

6.9.7.2 Initialize Modem

Before a modem can be used by the controller it must be initialized. The initialization screen gives four choices of modems.

To initialize the modem:

- From the Communications menu, press "**2**" **INITIALIZE MODEM**

```
INITIALIZE MODEM
======================
1  HAYES ACCURA
2  U.S. ROBOTICS
3  ZOOM
4  OTHER MODEM
```

- Select your modem from the list. If your modem is not listed and you select **OTHER MODEM** use the keypad to enter the initialization string for your modem.
- If the modem fails to initialize, check the 25-pin connector, the phone cable, the modem, and the –RS2L option card.

6.9.7.3 Remote Password

Remote communications to the Lakewood Instruments 2000 series controllers is protected with an 8-digit password. The remote password is required to make changes to the model 2450e controller using the communications option card.

The remote password screen in the communications menu is used to change the remote password. **The remote password can only be changed at the controller.**

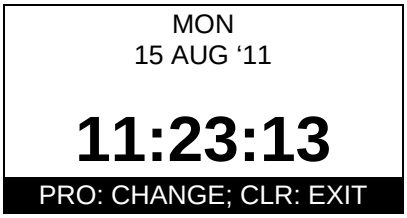
To change the remote password:

- From the communications menu, press "**3**" **REMOTE PASSWORD**.
- Use the keypad to enter the old password. Enter the new password. Repeat the new password again for verification. **NOTE: The default password is 12345678.**
- Set the remote password in the LRWS program to match the new password for this controller.

6.10 SETTING THE CLOCK

The clock uses the 24 hour or military time. **06:00:00** is 6 a.m. **18:00:00** is 6 p.m. To set the clock:

- From the **Main Menu** press "**8**" **CLOCK**. The following screen will appear:



- Press "**PRO**" to change the clock settings.
- Use the up and down arrow keys to change the day of the week. Press "**ENT**".
- Use the number keys to change the date. Press "**ENT**".
- Use the arrow keys to change the month. Press "**ENT**".
- Use the number keys to change the year. Press "**ENT**".
- Use the number keys to change the hour. Press "**ENT**".
- Use the number keys to change the minutes. Press "**ENT**".
- Use the number keys to change the seconds. Press "**ENT**".
- Press "**CLR**" to exit this screen.

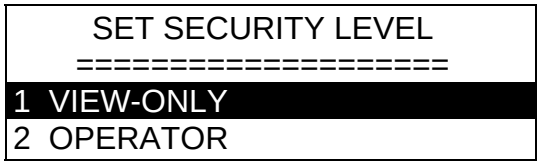
You must press "**ENT**" all the way through this menu for the settings to take affect.

6.11 Changing the Security Levels

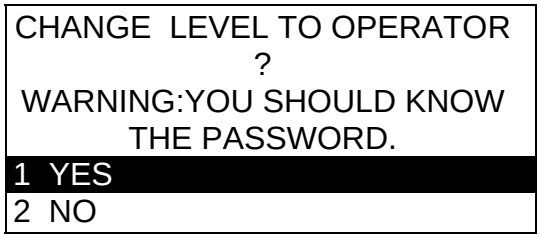
The model 2450e has three security levels: Technician, which allows full access to all screens; Operator, which allows access to the operations screens, manual relay screen, and calibration screens; and View-Only, which allows access to the operations screens, and manual relay screen.

The security level can be change to prevent any unwanted tampering of the controller. To change the security level from **Technician** to **Operator** or **View-Only**:

- From the **Main Menu**, press "**0**". *(Note that "**0"** does not appear on the menu screen.)*



- Select **VIEW-ONLY** for the most restrictive level or **OPERATOR** for a less restrictive level of access.



- Select **YES** to change the security level to a more restrictive level. The controller menu now functions at the new security level.

To return to the **Technician** security level:

- From the **Operation** screen, use the keypad to enter the 4-digit numeric password for the Technician security level:

Note: The default Technician password is 2222 and the Operator password is 1111. Passwords can be changed in the SYSTEM SETUP menu.

7.0 Maintenance

Periodic maintenance is required to ensure trouble free operation of the model 2450e controller. The following sections cover the required maintenance.

7.1 Sensor Maintenance

Routine maintenance is necessary in order to maximize the efficiency and accuracy of your sensor.

7.1.1 Conductivity Sensor

Clean the electrode end of the Conductivity sensor at least once per month. Cleaning of the Conductivity sensor may need to be performed more frequently if it is in a high fouling environment.

- Remove power from the controller and shut off the sample flow.
- Remove the sensor from its plumbing.
- Clean the electrodes with a wire brush. A soft steel brush is preferable to a brass brush. Do not use cloth to clean the electrodes. Cloth has oils that will foul the sensor.
- If there is oil on the sensor glass, use isopropyl alcohol to clean the electrode.
- It is recommended that you use a 10% Muriatic or HCL acid to clean the sensor if necessary.
- Wash the sensor off with tap water.
- Install the sensor in its plumbing.
- Restore sample flow and check for leaks.
- Restore power to the controller.
- Perform a calibration of the Conductivity.

7.1.2 pH/ORP Sensor

Clean the electrode end of the pH or sensor at least once per month. Cleaning of the pH or ORP sensor may need to be performed more frequently if it is in a high fouling environment.

- Remove power from the controller and shut off the sample flow.
- Remove the sensor from its plumbing.
- Be careful not to touch the glass electrode. Do not use cloth to clean the electrode. Cloth has oils that will foul the sensor.
- If there is oil on the sensor glass, use isopropyl alcohol to clean the electrode.
- It is recommended that you use a 10% Muriatic or HCL acid to clean the sensor.
- Wash the sensor off with tap water.
- Install the sensor in its plumbing.
- Restore sample flow and check for leaks.
- Restore power to the controller.
- Allow the reading to stabilize for approximately 30 minutes.
- Perform a calibration of the pH or ORP.

7.2 Replacing the Fuse

The Model 2450e contains a 10A, 250V fuse. The fuse holder is located on the bottom of the enclosure. It is accessible from the outside of the box. Replacement fuses must be a fast blow type. If the fuse is blown, the display will be blank and the four power supply lights inside the controller enclosure will be dark when the unit is connected to power. Refer to the troubleshooting section of this manual for more information about blank displays.

8.0 TROUBLESHOOTING

PROBLEM	WHAT THIS MEANS	CORRECTIVE ACTION
Conductivity Calibration Error message: "SENSOR READING HIGHER THAN EXPECTED."	The Monitor is being told the conductivity is 50% more than it thinks it is by default.	1. Is the Monitor being calibrated to TDS when configured for conductivity? 2. Verify that the sensor tip has no accumulated solids and has not bridged to piping (creating a short). 3. Clean tip.
Conductivity Calibration Error message: "SENSOR READING LOWER THAN EXPECTED."	The Monitor is being told the conductivity is 50% less than it thinks it is by default.	1. Is the sensor fouled? 2. Are all valves open? 3. Clean or replace sensor.
Conductivity drifts or changes after calibration.	Calibration may have been done before the reading stabilized. The sample line may contain electrical noise.	1. When calibrating, wait at least 15 seconds to 1½ minutes for reading to stabilize. 2. To reduce electrical noise, use grounded metal fittings on the inlet and outlet of the Monitor plumbing.
Water meters not accumulating.	Check the manufacturer's user manual for that particular water meter.	1. There may be a wiring problem. 2. The K factor is improperly configured. 3. If using a turbine meter, verify that turbine is actually spinning.
"NODE NOT RESPONDING" error message.	This message occurs when one circuit board in the Monitor cannot communicate with another board.	1. Check that all boards are mounted correctly and that all connectors are fully mated. 2. The Monitor may not have the option board that is trying to be accessed. 3. The board that is trying to be accessed may not be working.

PROBLEM	WHAT THIS MEANS	CORRECTIVE ACTION
Display is blank.	Open the front panel. Look at the yellow LED's on the rear power board. Are they on?	1. If LED's are on, check ribbon cable. Is it properly seated? 2. If LED's are not on, does the unit have power?
pH reading is off by more than 1 pH unit.	Probe calibrated using span, or the pH probe is bad.	1. Re-initialize calibration. 2. Recalibrate pH using zero only. 3. Replace pH sensor.
mV reading is off by more than 100 mV.	ORP Probe might be inaccurate.	1. Re-initialize calibration. 2. Recalibrate zero, span, or both. 3. Replace ORP sensor.
Relays don't turn ON/OFF during normal operation.	Relays may be affected by other software variables.	1. Is the relay manually turned on or off? 2. Is the CIP input activated? 3. You must have permeate or concentrate flow for a relay configured as setpoint to function.
Chemical pump will not feed chemical.	Pumping may be affected by other software variables.	1. Is the pump manually turned on or off? 2. Is the CIP input activated? 3. You must have permeate or concentrate flow for a relay configured as setpoint to function and trigger pump operation.
Chemical pump feed reverse of what you expected.	Relay setpoint not properly configured.	Determine whether you need the relay configured for direct or reverse setpoint feed.
{ALARM FLASHING} **"RLY1:TIME EXCEEDED"** **"RLY2:TIME EXCEEDED"** **"RLY3:TIME EXCEEDED"** **"RLY4:TIME EXCEEDED"**	The relay was not able to control the pH/ORP setpoint within the programmed over-feed time. The relay is locked out until the alarm goes away.	1. Reprogram the over-feed time via "RELAYS/SETPOINT". 2. Determine why the chemical feed is failing to control the solution pH/ORP. 3. To reset the alarm, temporarily stop permeate and concentrate flow.

PROBLEM	WHAT THIS MEANS	CORRECTIVE ACTION
{ALARM FLASHING} "pH :HIGH ALARM" or "ORP :HIGH ALARM"	The pH/ORP has exceeded the user-programmed high alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "pH :LOW ALARM" or "ORP :LOW ALARM"	The pH/ORP has exceeded the user-programmed low alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "COND:HIGH ALARM"	The conductivity has exceeded the user-programmed high alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "TEMP:HIGH ALARM"	The temperature has exceeded the user-programmed high alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "PERM:HIGH ALARM"	The permeate flow rate has exceeded the user-programmed high alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "PERM:LOW ALARM"	The permeate flow rate has exceeded the user-programmed low alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "FEED:HIGH ALARM"	The feed water flow rate has exceeded the user-programmed high alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "FEED:LOW ALARM"	The feed water flow rate has exceeded the user-programmed low alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "%REC:HIGH ALARM"	The percent recovery has exceeded the user-programmed high alarm value.	See "ALARMS" in Main Menu.
{ALARM FLASHING} "LUBRICATION INTERVAL"	The lubrication interval timer has expired.	See "SYSTEM SETUP/TIMERS" to reset the timer.
{ALARM FLASHING} "CHECK CIP"	The Check CIP interval timer has expired.	See "SYSTEM SETUP/TIMERS" to reset the timer.
{ALARM FLASHING} "CHECK FILTERS"	The Check Filters interval timer has expired.	See "SYSTEM SETUP/TIMERS" to reset the timer.

PROBLEM	WHAT THIS MEANS	CORRECTIVE ACTION
{ALARM FLASHING} "CHECK MEMBRANES"	The Check Membranes interval timer has expired.	See "SYSTEM SETUP/TIMERS" to reset the timer.
{ALARM FLASHING} "CHECK SENSOR"	The Check Sensor interval timer has expired.	See "SYSTEM SETUP/TIMERS" to reset the timer.
{ALARM FLASHING} "COND:FOULED SENSOR"	The conductivity sensor has become fouled.	Check cable, sensor, and wiring.
{ALARM FLASHING} "SHORTED TC"	The temperature compensation input is shorted.	Check cable, sensor, and wiring.
{ALARM FLASHING} "OPENED TC"	The temperature compensation input is opened.	Check cable, sensor, and wiring.
{ALARM FLASHING} "pH :HI REF IMPEDANCE" or "ORP :HI REF IMPEDANCE"	1. A high reference impedance exists in the pH/ORP sensor. 2. A wire may be broken in the sensor. 3. KCl solution in the sensor may be leaking (pH only).	1. Replace pH/ORP Sensor. 2. Sensor must be grounded.
{ALARM FLASHING} "pH :BROKEN GLASS"	The pH sensor glass may be broken.	1. Check glass bulb on the pH sensor. 2. Replace sensor if necessary.
{ALARM FLASHING} "pH :HIGH REF VOLTAGE" or "ORP :HIGH REF VOLTAGE"	High reference voltage exists in the pH/ORP sensor.	Check sensor wiring.
{ALARM FLASHING} "pH :LOW REF VOLTAGE" or "ORP :LOW REF VOLTAGE"	Low reference voltage exists in the pH/ORP sensor.	Check sensor wiring.
{ALARM FLASHING} "CIP SWITCH CLOSED"	1. The Clean-in-Place switch input condition has become asserted. 2. Relays are locked out.	None, unless the input is wired incorrectly.

9.0 FACTORY SERVICE

Technical Support for Lakewood Instruments can be reached by calling (800) 228-0839 or faxing (414) 355-3508, Monday through Friday, 7:30 a.m. – 5.00 p.m. CST.

NOTE: ***IF YOU CALL FOR TROUBLESHOOTING HELP, PLEASE HAVE THE MODEL NUMBER, SERIAL NUMBER, AND ANY OPTIONS PERTAINING TO YOUR UNIT AVAILABLE FOR REFERENCE.***

Mail and returns should be sent to:

Lakewood Instruments
7838 North Faulkner Road
Milwaukee, WI 53224 USA

When any merchandise is to be returned to the factory, please call and obtain a Return Goods Authorization (RGA) number and have the following information available:

- Customer's name, address, telephone and fax numbers (shipping and billing).
- A hard copy purchase order number for cases where repairs or parts are required that are not under warranty.
- A contact person's name and telephone number to call if the equipment is beyond repair or to discuss any other warranty matter.
- Equipment model and serial numbers.
- Reason for return, e.g., repair, warranty, incorrect part, etc.

We will then fax to your attention an RGA form that must accompany the returned item.

NOTE: ***THE RGA NUMBER MUST BE CLEARLY WRITTEN ON THE OUTSIDE OF THE PACKAGE(S) BEING RETURNED.***

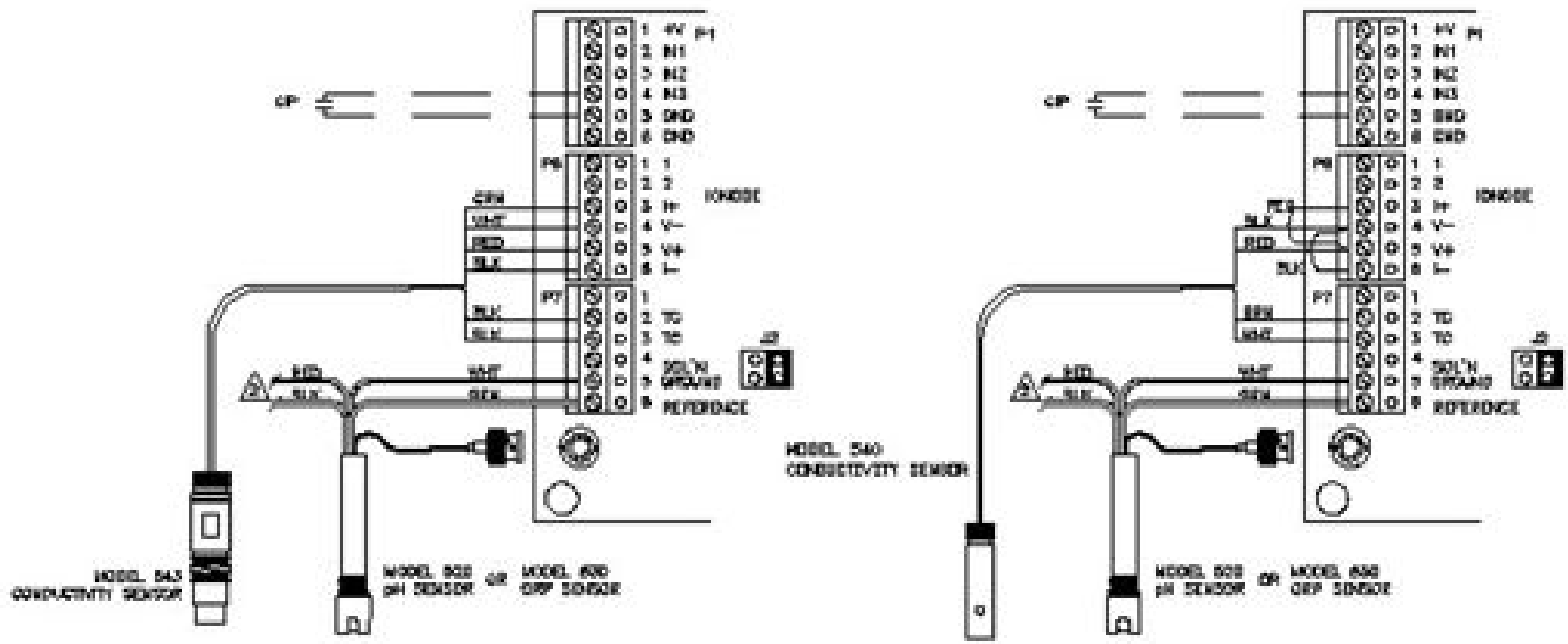
ANY ITEMS SENT BACK TO THE FACTORY WITHOUT AN RGA NUMBER WILL BE REFUSED AND RETURNED TO SENDER

10.0 DRAWINGS

NOTES: UNLESS OTHERWISE SPECIFIED;

2. RED & BLACK T.C. WIRES FROM THE 520 SENSOR ARE NOT USED ON THE MODEL 2450.

REVISION HISTORY					
REV	DESCRIPTION	ECO	DWN	DATE	APVD
A	RELEASE	1133	CV	8/22/97	
B	ADDED GREEN WIRE	1279	BZ	8/12/97	JOB
C	REVISED, ADDED VIEW	1313	CV	12/10/97	JOB
D	ADDED ORP TEXT	1755	CV	7/8/98	JOB
E	ADDED NOTE 2	1876	BZ	2/28/98	
F	ADDED 540 SENSOR		PSD	6/01	



NOTICE ON REPRODUCTIONS

Lakewood INSTRUMENTS

TITLE: WIRING DIAGRAM
SENSOR WIRING, LOW POWER M-2450

FINISH			
ORDER NO.	DWN CV	DATE 8/22/97	
CUSTOMER	CHKD BLEAMONT	DATE 8/22/97	SIZE B
CUSTOMER LOC.	APVD JWZ	DATE 8/29/97	
DO NOT SCALE	APVD JOB	DATE 8/28/97	SCALE NONE

DWG NO/TN 1197070_1F REV F

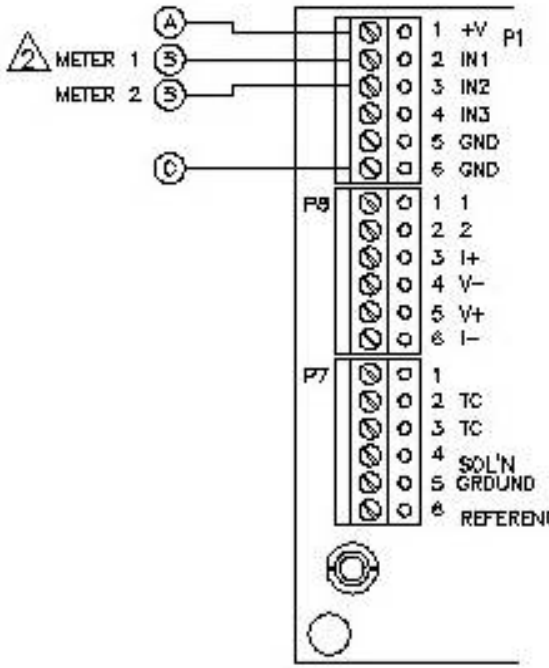
FILE TYPE DWG SHEET 1 OF 1

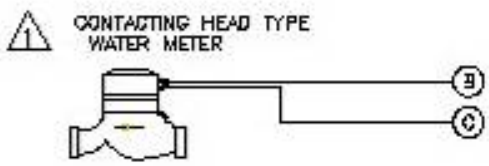
NOTES: UNLESS OTHERWISE SPECIFIED;

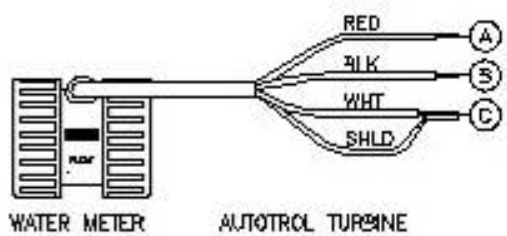
1. 2450: CANNOT BE USED WITH CONTACTING HEAD METER.
2. 2450: METER 1 IS PERMEATE, METER 2 IS CONCENTRATE.
3. CUSTOMER SUPPLIED, 10K RESISTOR ØPULL-UP).
4. ONLY OPEN COLLECTOR OUTPUT WATER METERS MAY BE USED.

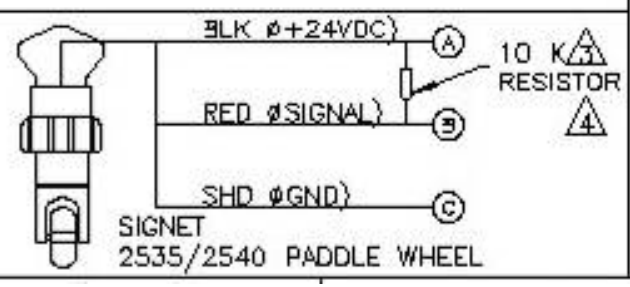
REVISION HISTORY

REV	CONC	DESCRIPTION	[illegible]	[illegible]	DATE	APVD
A		RELEASE	[illegible]	EV	[illegible]	
B		REVISED	[illegible]	EV	[illegible]	
C		REVISED	[illegible]	EV	[illegible]	
D		REVISED	[illegible]	EV	[illegible]	[illegible]
E		ADDED NOTE 3	[illegible]	EV	[illegible]	[illegible]
F		REMOVED SIGNAL GND BOARD	[illegible]	EV	[illegible]	









NOTICE ON REPRODUCTIONS

Lakewood INSTRUMENTS

TITLE: WIRING DIAGRAM
WATER METER INPUTS, M-2000 SERIES

SIZE: C | DWG NO: 1109544-3F | REV: F

DO NOT SCALE | SCALE: NONE | FILE TYPE: [illegible] | SHEET 1 OF 1

REVISION		REVISION HISTORY			
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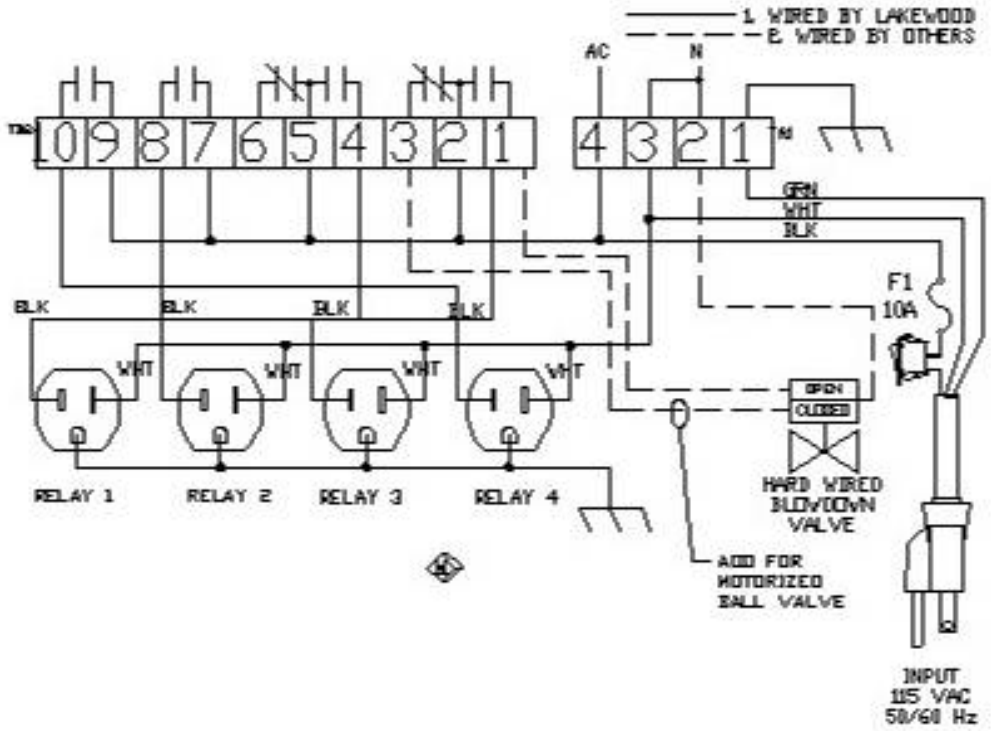
A	A	RELEASE	10042	PSG/ 5-3-06	LRS/ 7-28-06



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DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

MATERIAL

TOLERANCES UNLESS NOTED
FRACTIONS X ± | DECIMALS ± | ANGLES ±
XX ±
XXX ±

FINISH

PROJECT:

LIBRARY:

DWN	PSG	DATE 5-3-06
CHKD	RCL	DATE 7-28-06
APVD	LRS	DATE 7-28-06
VERSION		

Lakewood INSTRUMENTS

TITLE
WIRING DIAGRAM,
2000 SERIES NEMA ENCLOSURE

SIZE	PN	REV
A	1268647	A
SCALE: NTS	SHEET: 1	DWG NO: 1268647-1a
		REV: A

THIRD ANGLE

REVISION HISTORY					
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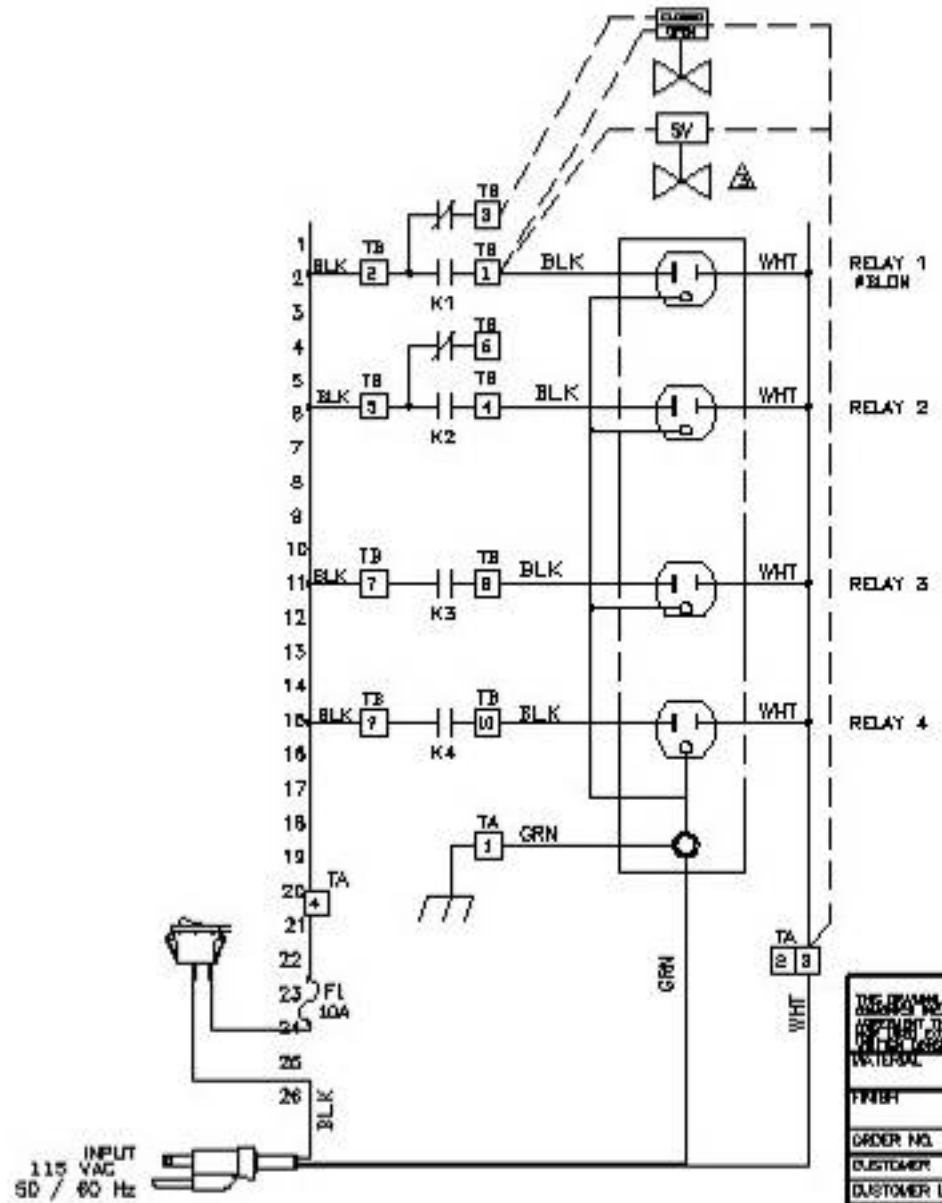


1. WIRING BY LAKEWOOD ————————
2. WIRING BY OTHERS — — — — — —
3. IF RECEPTACLE NOT USED, WIRE BLOWDOWN VALVE BETWEEN TB1 AND TA3
4. RELAY CONTACTS RATED 10A / 250 VAC, 1/3HP / 240 VAC

NOTICE ON REPRODUCTIONS

MATERIAL	FRAC	DECIMALS .X ± .1 .XX ± .05 .XXX ± .010	ANGLES ±.5°
FINISH	±1/16		
ORDER NO.	DWN PSG	DATE 11-16-08	
CUSTOMER	CHKD	DATE	
CUSTOMER LOC.	APVD	DATE	
DO NOT SCALE	APVD	DATE	

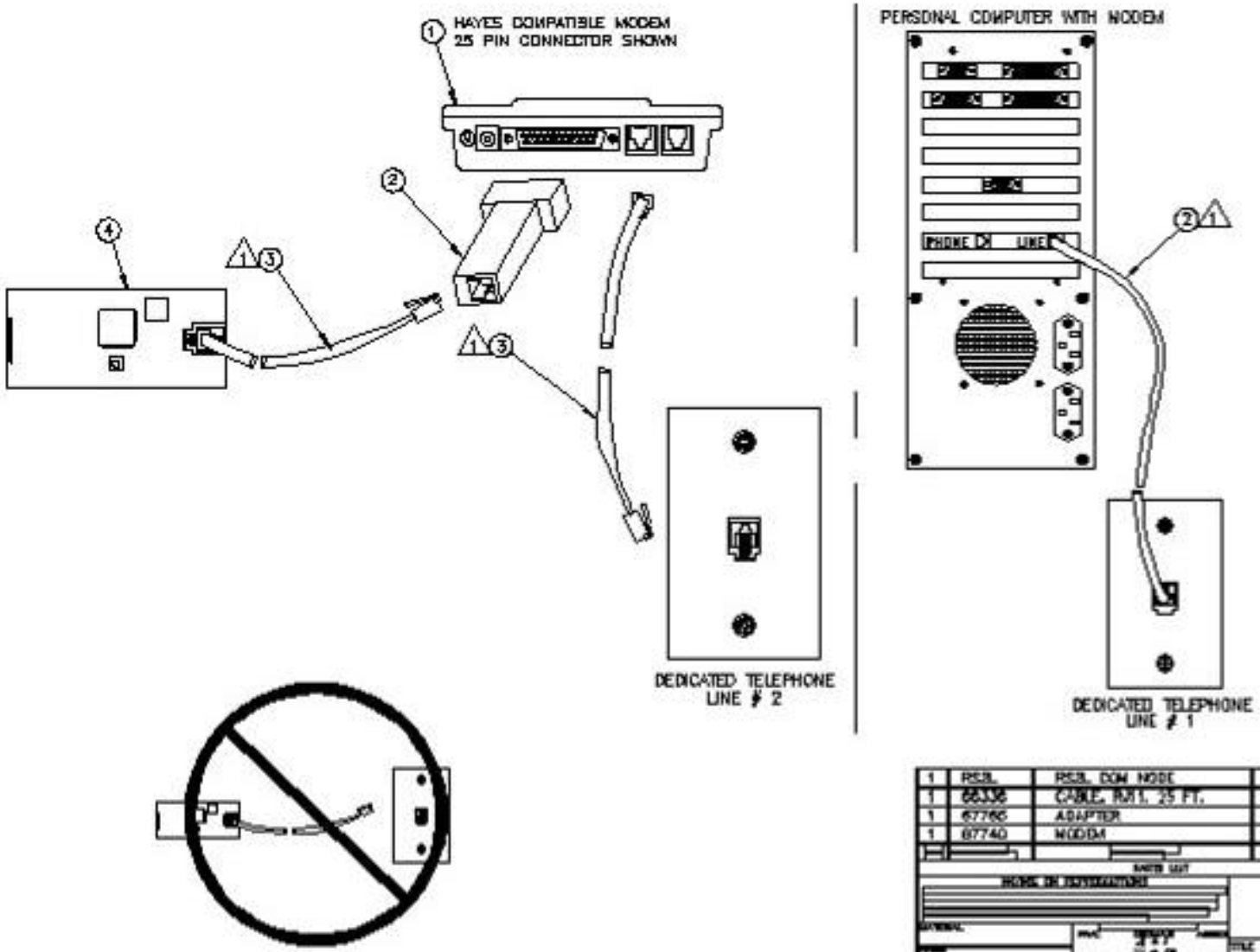
Lakewood INSTRUMENTS

TITLE: ELECTRICAL SCHEMATIC 2000 SERIES, NEMA ENCLOSURE

SIZE B | THIRD ANGLE | DWG NO/PN 1268647-2a | REV A

SCALE NONE | FILE TYPE DWG | SHEET 1 OF 1

NOTES: UNLESS OTHERWISE SPECIFIED:
1. STANDARD FOUR CONDUCTOR TELEPHONE CABLE UP TO 50 FEET IN LENGTH MAY BE SUBSTITUTED.



DO NOT PLUG RS2L DIRECTLY INTO TELEPHONE LINES

1	RS2L	RS2L COM NODE	ASSEMBLED PCB, M-2000	4
1	66336	CABLE, RJ11, 25 FT.		3
1	67766	ADAPTER	25 P MALE 8 CONN TO RJ11 DTE	2
1	67740	MODEM	HAYES COMPATIBLE	1

Lakewood INSTRUMENTS

INSTALLATION LAYOUT
COMNODE TO 25P DTE, BER 2000, RS2L

C 1109708-1d D

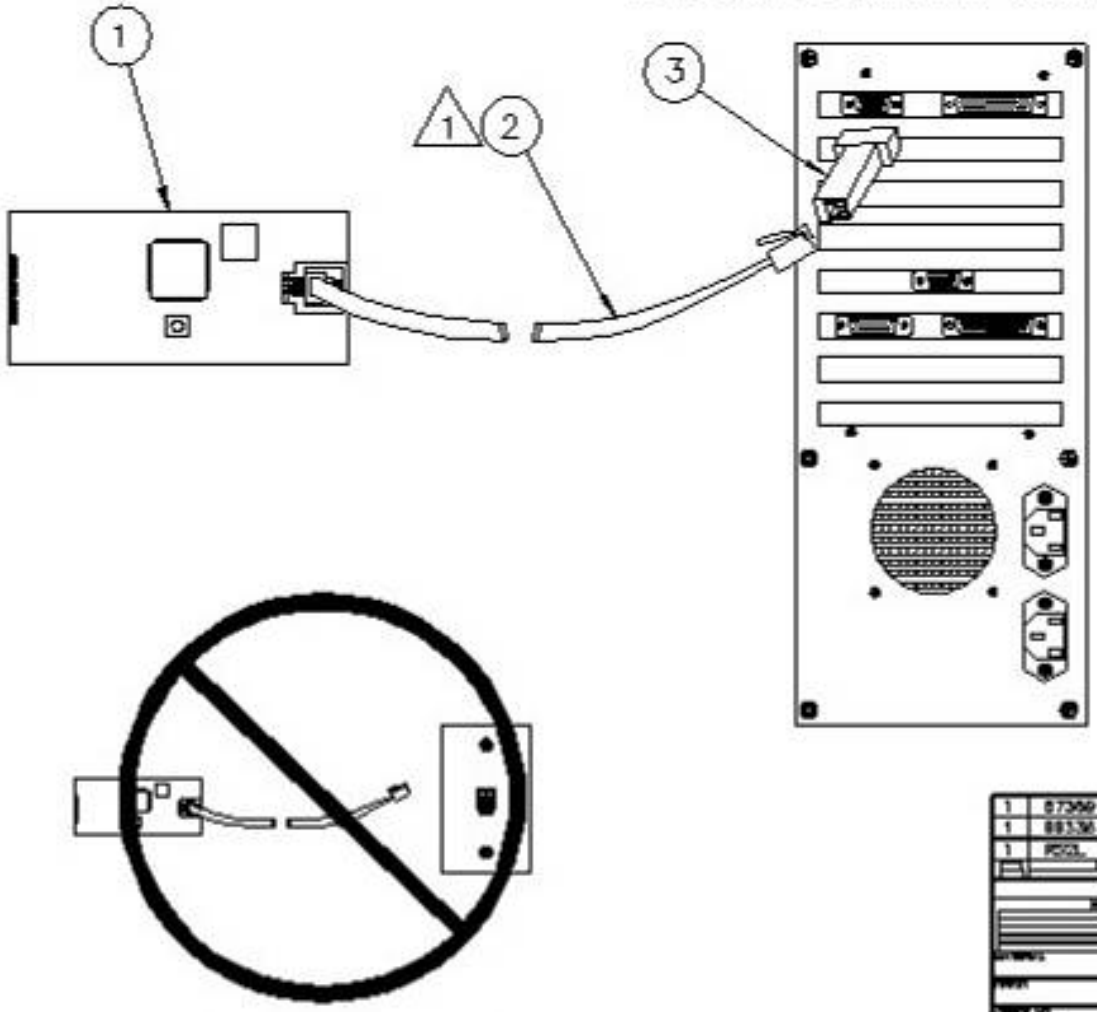
DO NOT SCALE

NOTES: UNLESS OTHERWISE SPECIFIED;

1. STANDARD FOUR CONDUCTOR TELEPHONE CABLE UP TO 50 FEET IN LENGTH MAY BE SUBSTITUTED.

REVISION HISTORY						
REV	ZONE	DESCRIPTION	[illegible]	[illegible]	DATE	APVD
A	[illegible]	RELEASE	[illegible]	[illegible]	[illegible]	
B		RELEASED	[illegible]	[illegible]	[illegible]	
D		RELEASED	[illegible]	[illegible]	[illegible]	[illegible]

PERSONAL COMPUTER WITH MODEM



DO NOT PLUG RS2L DIRECTLY INTO TELEPHONE LINES

1	87369	ADAPTER, 9 PIN	MALE CONN TO RJ11 DTE	3
1	88336	CABLE, RJ11	25 FT	2
1	RS2L	RS2L COM MODE	ASSEMBLED PCB, M-2000	1

PARTS LIST

Lakewood INSTRUMENTS

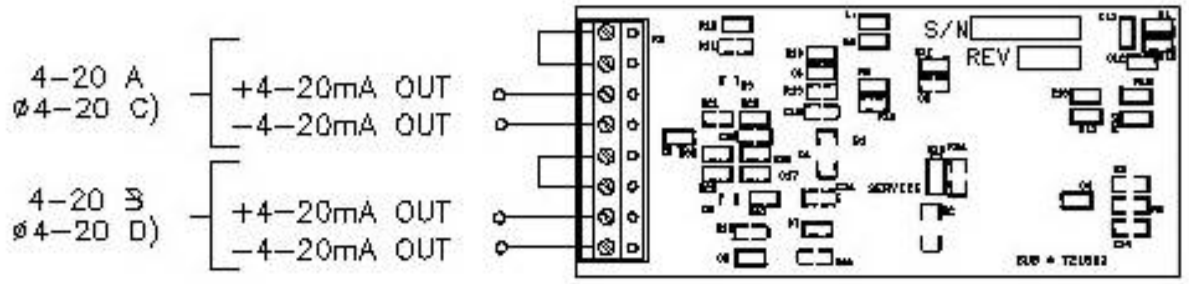
INSTALLATION LAYOUT
RS232 DIRECT CONNECT TO 9 PIN,RS2L

C | 1109708-Bc | REV D

DO NOT SCALE | SHEET 1 OF 1

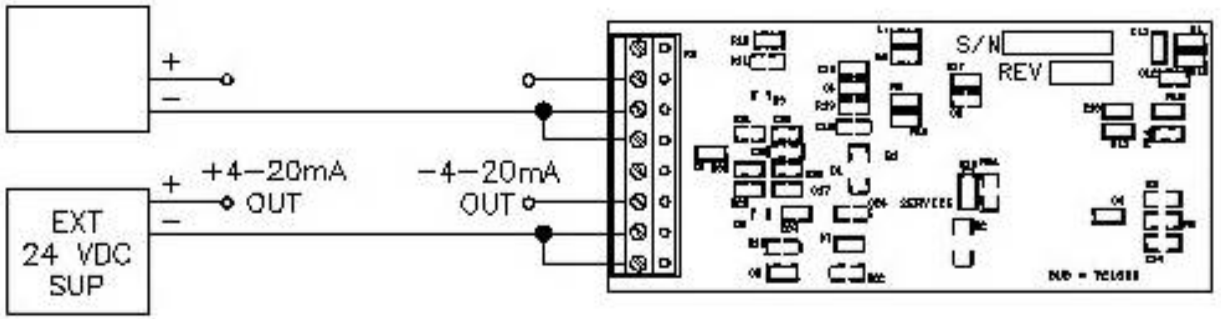
NOTES: UNLESS OTHERWISE SPECIFIED;

1. LOADS MUST BE LESS THAN 600Ω.



INTERNAL POWER

OPTIONAL EXTERNAL 24 VDC SUPPLY



REVISION HISTORY						
REV	CONC	DESCRIPTION	ECO	RVS	DATE	APVD
A		RELEASE	[illegible]	[illegible]	[illegible]	
B		REVISED	[illegible]	[illegible]	[illegible]	

NOTICE OF REPRODUCTIONS

Lakewood INSTRUMENTS

TITLE: WIRING DIAGRAM POWER SUPPLY, 24VDC, 4 TO 20 mA

SIZE: C | DWG NO: 1109707-1b | REV: B

SCALE: NONE | FILE TYPE: [illegible] | SHEET 1 OF 1

DO NOT SCALE

For more information call toll free in the USA (800) 228-0839

Manufactured in the USA

Lakewood Instruments

7838 North Faulkner Road, Milwaukee, WI 53224 USA
Phone (800) 228-0839 • Fax (414) 355-3508
h t t p : / / w w w . l a k e w o o d i n s t r u m e n t s . c o m