3910 Chromalox®

ON/OFF Proportional Controller

ISO 9001 APPROVED FACILITY

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User's Manual
0037-75088

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Section 1
Introduction to the 3910 Controller

The Chromalox 3910 controller you have purchased gives you applications flexibility and a number of control features in a compact 1/4 DIN package. Before proceeding with installation and operation of your controller, it is important that you identify the model you have purchased. This will determine how you install and wire the controller, and how you may apply it. Check the serial number tag on the inside front door flap of the controller to confirm your model number.

Figure 1.1
Model Identification Table

Model	Digital Indicating 1/4 DIN Controller				
3910	ON/OFF - Proportional Controller				
	Code	**Control Output**			
	1	Relay, up to 230 Vac, 20 amp resistive load			
	5	Two Relays, each up to 230 Vac, 20 amp resistive load			
	7	Solid State Relay Drive, 20 Vdc at 40 mA			
	Control Output with Deviation Alarm Output				
	8	Control Output/Relay - Alarm Output/Relay			
	9	Control Output/SSR Drive - Alarm Output/Relay			
		Code	**Terminations**		
		1	Phoenix™ Terminal Strip		
			Code	**Instrument Power**	
			1	120 or 230 Vac, +10%, -15%, 50/60 Hz	
				Code	**Input Type/Indication Range**
				04	Type J Thermocouple, 0-999°F
				08	Type J Thermocouple, 0-500°C
				12	Type K Thermocouple, 0-1999°F
				18	Type K Thermocouple, 0-1100°C
3910-	1	1	1	04	Typical Model Number

Section 2
Installation

Inspection & Unpacking

On receipt of your 3910 controller, immediately make note of any visible damage to the shipment packaging and record this damage on the shipping documents. Unpack the controller and carefully inspect it for obvious damage due to shipment. If any damage has occurred, YOU must file a claim with the transporter, as they will not accept a claim from the shipper.

Storage

If the controller will not be immediately installed and placed into operation, it should be stored in a cool, dry environment in its original protective packaging until time for installation and operation. Temperature extremes and excessive moisture can damage the instrument.

Caution

The 3910 controller, the sensor or the device that the 3910 is switching can potentially fail, causing the process or process equipment to overheat. Overtemperature devices should be installed to provide additional process protection.

Installation Steps

Installation of the 3910 controller requires 3 steps:

Step 1 - Accessing Internal Adjustments
Step 2 - Mounting
Step 3 - Wiring

Step 1 Accessing Internal Adjustments

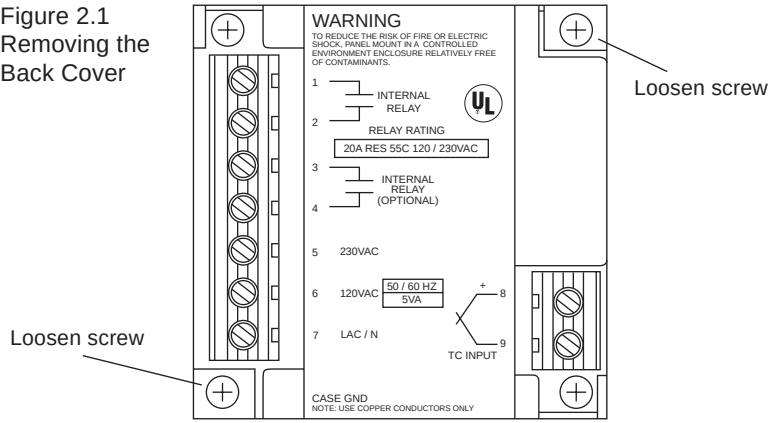
The back cover of the 3910 can be easily removed to access any of the following internal adjustments:

- Dead Band Jumper (page 17)
- Set Point Limit Potentiometer (page 15)
- Deviation Alarm Diodes (page 19)

The page numbers referenced above describe these internal adjustments. **Although it is not necessary, it is easier to make these adjustments prior to mounting and wiring the controller**. If you think that you may need or want to make one of these internal adjustments, read the pages referenced above **before** mounting and wiring the 3910.

To remove the back cover, loosen the two back cover screws shown in Figure 2.1 and lift the cover off of the controller chassis.

Figure 2.1
Removing the Back Cover



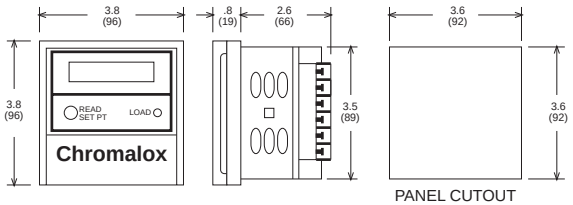
After completing the internal adjustment(s), replace the cover and re-secure the two screws.

Step 2
Mounting

The controller should be mounted in a location free from excessive dust, oil accumulations and moisture. It may be mounted in any position at ambient temperatures of 30°F to 130°F (0°C to 55°C).

Figure 2.2 gives the mounting dimensions for the controller.

Figure 2.2
Mounting Dimensions



Measurements are shown in inches.
Millimeters are shown in parenthesis.

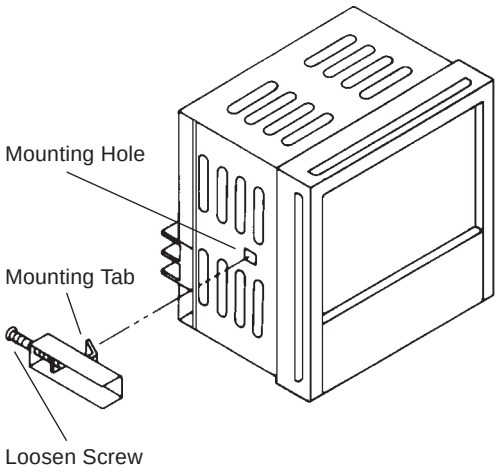
1. Cut a square mounting hole (3.6” x 3.6”) in the panel or mounting surface and place the controller through the cutout.

2. Two mounting brackets are provided to secure the controller in the cutout. Loosen the screws on the two brackets. Place the mounting tabs into the mounting holes located on the sides of the controller.

3. From the rear of the controller, tighten the screws until the brackets are tight against the panel, securing the controller in the panel cutout.

4. For other mounting configurations, the mounting bracket tabs may be placed in the controller casing vent slots.

Figure 2.3
Mounting
Diagram



Important Wiring Information

To insure that the 3910 controller performs optimally, it is imperative that you read this section and become familiar with “Good Wiring Practices” critical to eliminating electrical noise. Failure to follow good wiring practices can result in poor temperature measurement and ineffective high limit control.

Snubbers

Snubbers should be used to protect the controller from electrical noise generated by inductive loads such as motors, solenoids, coils and relays operating near the 3910 controller. The recommended snubber is a .1uf capacitor (600 Vdc rating) in series with a 100 ohm resistor and is available from Chromalox (PCN 314448). The wiring diagram in this manual illustrates the snubber connection(s).

Good Wiring Practice

Read and follow these Good Wiring Practices when connecting this and any other controller:

1. Do not run sensor leadwires and power leads together in the same conduit or wire tray.

2. When planning the system wiring, be sure to consider the importance of separating wiring into functionally similar bundles—i.e. power leads, sensor leads, output signal lines, etc. If the power leads and sensor leads must cross, they should cross at a 90° angle to each other (perpendicular).

3. Locate all sources of noise in your system—motors, contacts, solenoids, etc. Then design your system such that wiring is separated as far as possible from these noise sources.

4. Shielded, twisted wire should be used for the control circuit signals if they are run in parallel with other control circuit signal wires, or if they are run distances greater than 2-3 feet.

5. To protect against noise, use shielded cables for all low power signal lines.

6. Additional information on good wiring practices is available from IEEE, 345 East 47th St., NY, NY 10017. Request IEEE Standard No. 5128-1982.

Step 3
Wiring

Make all electrical wiring connections on the back of the controller **before** power is applied to the unit.

All wiring must comply with local codes, regulations and ordinances. This instrument is intended for panel mounting and the terminals must be enclosed with a panel. Use National Electric Code (NEC) Class 1 wiring for all terminals except the sensor terminals.

Instrument Power Connections

Check the serial number tag located inside the door flap to confirm the model number of your controller. The model number identifies the instrument power of your controller.

Instrument Power	3910 - ****1****	120 or 230 Vac
Control Output Type	3910 - **1******	1 Relay
	3910 - **8******	
	3910 - **5******	2 Relays
	3910 - **7******	Solid State
	3910 - **9******	Relay Drive
Alarm Option	3910 - **8******	Relay Output
	3910 - **9******	

Make the instrument power connections for your application type (120 Vac or 230 Vac) as shown in Figure 2.4 or 2.5 on the following page (page 8).

Figure 2.4
120 Vac
Instrument Power
Connections

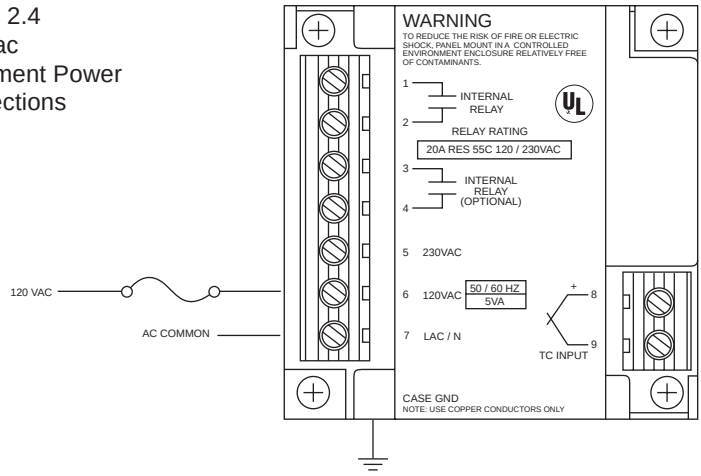
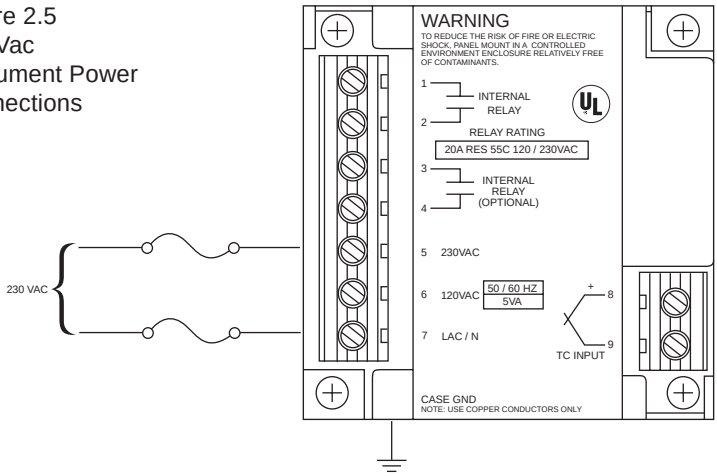


Figure 2.5
230 Vac
Instrument Power
Connections



Sensor Input Connections

The thermocouple input is connected at terminals 7 (+) and 8 (-) as indicated by the wiring decal on the back of the controller. The table below shows **typical** color coding for the thermocouples used with this controller:

T/C Type	Material	Plus(+)	Minus (-)
J	Iron/Constantan	White	Red
K	Chromel/Alumel	Yellow	Red

If shielded thermocouple wire is used, the shield must be grounded at one end only, preferably at the case ground (CASE GND) of the controller.

If thermocouple extension wire is required, it **must** be the same type of extension wire as the thermocouple (for example, if the thermocouple is Type J, the extension wire must be Type J).

Control Output Connection

Make the control output connection(s) for your controller type as illustrated in Figure 2.6, 2.7 or 2.8.

Relay Output—A relay output is generally used to drive small resistive loads (<20A at 120V or 230V) or a contactor. When driving a contactor load, connect a snubber circuit in parallel with the contactor coil to protect the controller from electrical noise (as discussed on page 6).

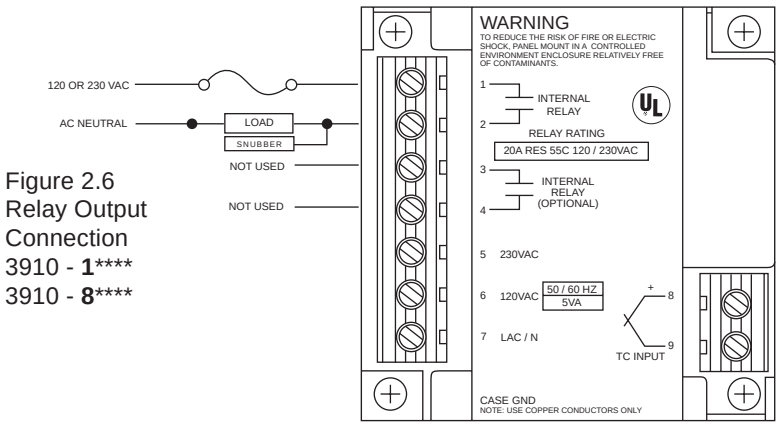


Figure 2.6
Relay Output
Connection
3910 - **1******
3910 - **8******

Two-Relay Outputs—The two relay model may be used to drive contactors. It can also directly drive two single phase loads up to 20 amps each, or 3-phase, 2-leg loads. Snubber circuits should be connected in parallel with the contactor coils (page 6).

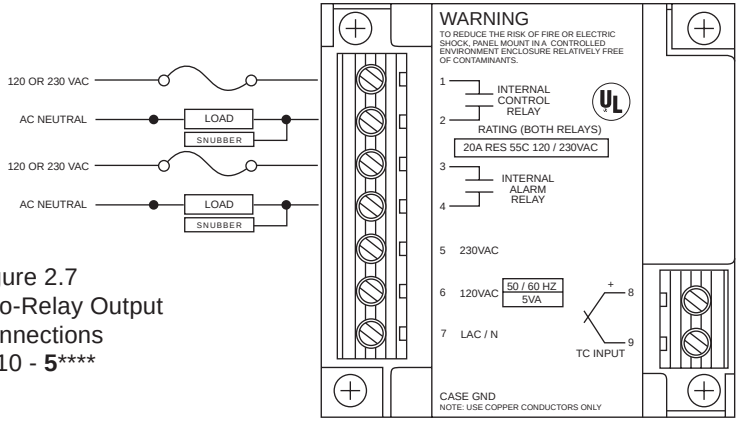


Figure 2.7
Two-Relay Output Connections
3910 - **5******

Solid State Relay Drive Output—The solid state relay (SSR) drive output is a 20 Vdc signal that will drive SS relays (such as the Chromalox 4115 or 4117 Power Modules) which accept 3-32 Vdc input signals. Be sure to separate the SSR wiring and all a.c. wiring.

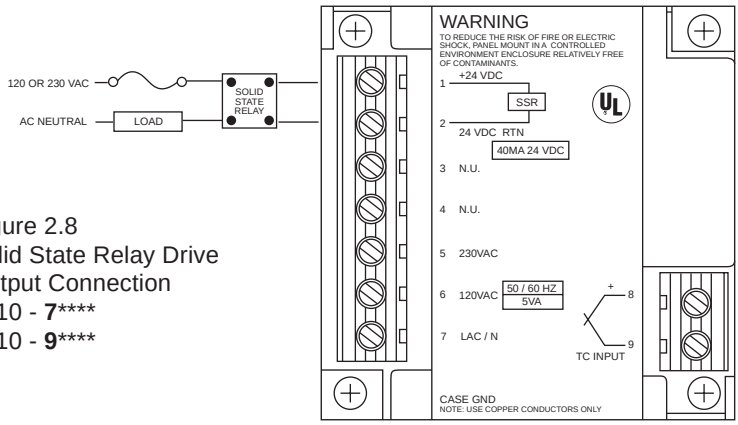
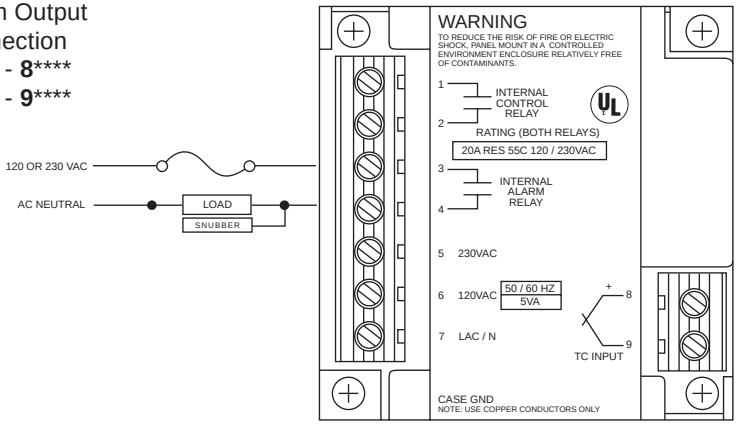


Figure 2.8
Solid State Relay Drive Output Connection
3910 - **7******
3910 - **9******

Alarm Output Connection

The alarm relay output connections are made at terminals 3 and 4, if your controller has the alarm option. Make the wiring connections as shown in Figure 2.9, using the recommended snubber circuit (page 6).

Figure 2.9
Alarm Output
Connection
3910 - **8******
3910 - **9******



Before applying power to the controller and proceeding with Operation, verify that all wiring is correct.

In this section you will learn how to make the following selections and adjustments:

Set Point
Set Point Limit
Control Mode - ON/OFF
Proportional
Dead Band
Cycle Time
Manual Reset
Alarm Mode
Alarm Set Point

Initial Power-Up

When power is applied to the 3910, it will begin operating using the factory set point. The process temperature as measured by the thermocouple will appear in the digital display, and the LOAD and ALARM LEDs will indicate if the control output (load) is on and an alarm condition exists.

To read the set point, simply press and hold the READ SET PT pushbutton. The set point will appear in the digital display.

The 3910's front panel displays and indications, and the adjustment potentiometers located behind the front door flap are shown in Figure 3.1. Familiarize yourself with the front panel before proceeding with this section.

Figure 3.1
Front Panel
Identification

3910 Controller
3910-**1******
3910-**5******
3910-**7******

LED indicates Open Sensor and Process Out of Range

Pushbutton to select Set Point for Digital Display

Cycle Time Adjustment

Manual Reset Adjustment

Digital Display for Process Temperature and Set Point

LED indicates Control Output ON

Set Point Adjustment Knob

ON/OFF or Proportional Control Selection and Proportional Band (Gain) Adjustment

3910 Controller
with Alarm Output

3910-**8******
3910-**9******

LED indicates Alarm Condition

Deviation Alarm Set Point Adjustment

Remote Alarm Reset

Read Set Point—To **read** the set point, press and hold the READ SET PT pushbutton. The current set point will appear in the digital display.

Adjust Set Point—To **adjust** the set point, locate the SET POINT knob behind the front door flap. Press the READ SET PT pushbutton so that the set point is displayed, and at the same time turn the SET POINT knob until the desired set point appears in the digital display. Release the pushbutton.

NOTE: Set point adjustment can be accelerated by inserting a screwdriver in the hole in the set point knob and turning the knob with the screwdriver.

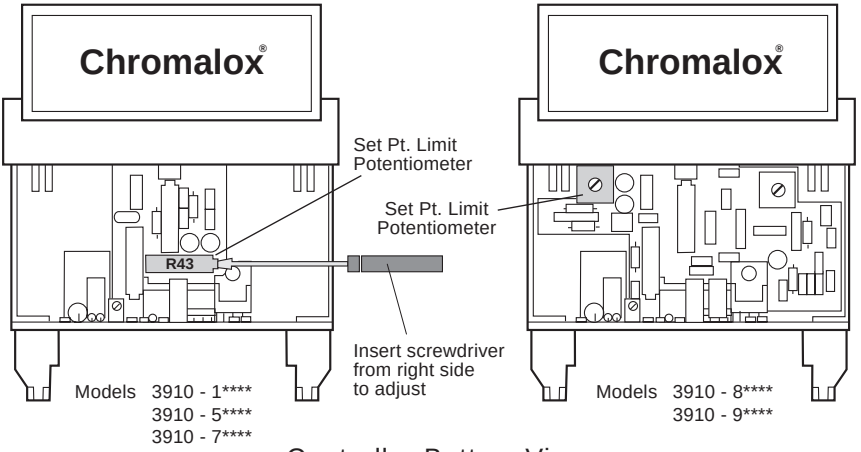
Set Point Limit—The 3910 has a set point limit feature that allows you to preset an upper limit for the set point adjustment. The set point limit can be used to prevent dangerous overheating that could be caused by accidental or miscalculated set point settings.

The Set Point Limit is set at 100% of sensor span when shipped from the factory (i.e. 1000°F for Type J thermocouples and 2000°F for Type K thermocouples). An internal potentiometer allows you to adjust the set point limit from a range of 100% to 20% of sensor span. To adjust the set point limit, remove the back cover of the 3910 as described on page 4. Locate the set point limit potentiometer shown in Figure 3.2.

USE EXTREME CAUTION: The set point limit can be set with the instrument power to the controller either off or on. If the power is left on, the limit must be adjusted only by a qualified electronic technician at a test bench, using an insulated screwdriver. LINE VOLTAGE WILL BE EXPOSED.

Disconnect the control output while adjusting and verifying the set point limit to avoid dangerous overheating.

Figure 3.2 Set Point Limit Potentiometer



Controller Bottom View

To adjust the set point limit:
1. Press and hold the READ SET PT button. Turn the SET PT knob on the front faceplate to its full clockwise position (FULL ON) or until the setpoint stops changing.

2. Turn the set point limit potentiometer until the digital display reads the desired set point limit. In the full (clockwise) position, the set point limit is 100%, or more, of span.

3. After reaching the desired set point limit setting, be sure to readjust the process set point to the application's setting using the SET PT knob.

To verify the set point limit setting, attempt to adjust the set point past the set point limit.

Control Mode

Select Control Mode—The control mode, ON/OFF or Proportional, is selected with the PROP BAND potentiometer located behind the front door flap. These two control modes are defined in the Glossary, page 28.

For ON/OFF control, turn the PROP BAND potentiometer to the full counterclockwise position to the ON/OFF mark. The potentiometer is in the ON/OFF position when shipped from the factory.

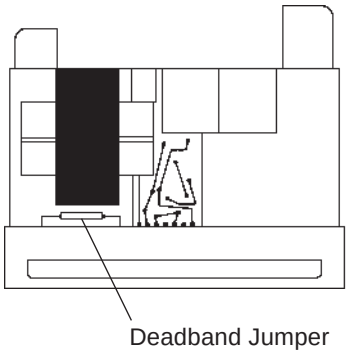
Control Mode (continued)

For Proportional control, turn the PROP Band potentiometer clockwise to the beginning of the proportional band range (marked by notches around the potentiometer).

ON/OFF Control

Deadband—The 3910 controller deadband setting is 2.5°F. If wider excursions from set point can be tolerated, the deadband may be changed to 10°F. To change the deadband, remove the back cover from the controller as described on page 4. Locate and remove the deadband jumper shown in Figure 3.3.

Figure 3.3 Deadband Jumper



Proportional Control

Adjust Proportional Band—The objective of the proportional band adjustment is to find the proportional band setting at which the process temperature stabilizes and does not oscillate. The temperature will most likely stabilize above or below set point (known as “offset”). This offset will be corrected by the Manual Reset adjustment.

During the proportional band adjustment procedure, the process should be allowed to reach a “steady” condition after each proportional band adjustment is made and before the next adjustment is attempted. A “steady” condition may be defined as a repeated pattern of temperature oscillations or a constant temperature.

To adjust the Proportional Band:

1. Turn the CYCLE TIME potentiometer to its full counterclockwise position.

2. Turn the MAN RESET potentiometer clockwise to mid-position.

3. Allow the process to reach a steady condition.

4. If the temperature display stabilizes and there is no temperature oscillation, the Proportional Band setting needs no further adjustment. Proceed to the Manual Reset adjustment.

5. If the temperature display is oscillating, incrementally increase (clockwise) the PROP BAND, allowing the process to reach a steady condition after each adjustment.

6. Repeat step (5) until the temperature display stabilizes and there is no oscillation. The proportional band setting needs no further adjustment.

Adjust Manual Reset—Manual Reset adjusts the offset between process temperature and set point and is adjusted with the MAN RESET potentiometer. If the process temperature stabilizes below or above set point, increase (clockwise) or decrease (counterclockwise) MAN RESET until the process temperature equals the set point temperature. Allow time for the process to respond and stabilize between adjustments.

Adjust Cycle Time—The output cycle time is adjusted differently for Relay Control Outputs and Solid State Relay Drive Outputs. The CYCLE TIME potentiometer is used to make cycle time settings. As the potentiometer is turned clockwise, the cycle time increases.

Relay Cycle Time: 15 to 60 seconds
SSR Drive Cycle Time: 1 to 30 seconds

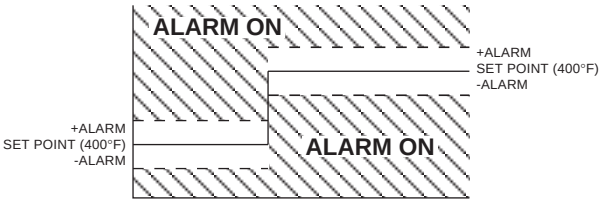
For Relay Outputs, adjust the cycle time to the slowest cycle time that will provide satisfactory control. The full clockwise potentiometer position is the slowest cycle time setting. Use caution when setting the cycle time on contactor driven loads. A cycle time setting that is too fast will cause added wear on the contactor and shorten the contactor life.

For Solid State Relay Drive Outputs, a fast cycle time will produce better control of loads by providing fast response and little time lag. Since solid state relays have no mechanical parts that can be worn down by rapid switching, the cycle time can be adjusted as fast as desired.

Alarm Modes

The alarm option on the 3910 controller is a +/- Deviation Alarm that tracks the control set point. The alarm is actuated whenever the process temperature deviates from the Process Set Point more than the predetermined amount (alarm set point) in either a positive or negative direction. This is illustrated in Figure 3.4.

Figure 3.4
+/- Deviation
Alarm Mode

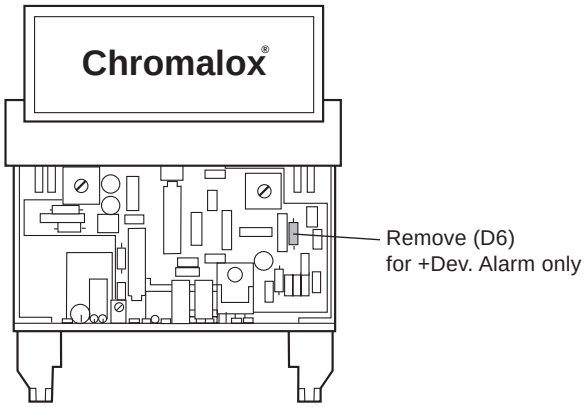


Deviation Alarm = 50°F
Set Point = 200°F, Alarm ON at 250°F and 150°F
Set Point = 400°F, Alarm ON at 450°F and 350°F

The alarm mode can be changed to a + Deviation or - Deviation Alarm mode by removing an internal diode. These two alarm modes are illustrated in the Glossary, page 26.

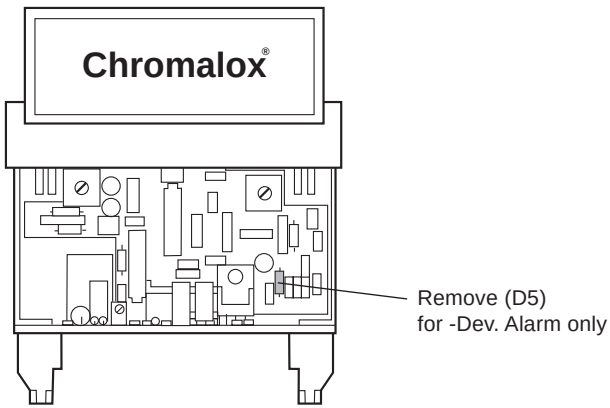
To change the Alarm Mode, remove the back cover of the controller (see page 4) and remove the internal diode as shown in Figure 3.5 or 3.6.

Figure 3.5
+ Deviation
Alarm Diode



Controller Bottom View

Figure 3.6
- Deviation
Alarm Diode



Controller Bottom View

Alarm Set Point

Adjust Alarm Set Point—The alarm set point may be adjusted from 5°F to 50°F (3°C to 28°C) by turning the ALARM DEV SET PT potentiometer behind the front door flap. The alarm set point is set at approximately 5°F when in its full counterclockwise position, and increases as it is turned clockwise.

To adjust the Alarm Set Point:

1. Connect instrument power to the controller.

2. Establish a constant temperature input into the controller sensor input (for example, ambient temperature is relatively constant). Make note of that temperature (for example, 75°F).

3. Set the Alarm mode for a + Deviation or +/- Deviation alarm.

4. In the following steps, you will adjust the process set point to simulate an alarm condition, thus verifying the Alarm Set Point. The process set point should be adjusted to equal the ambient temperature minus the deviation (Process Set Point = Ambient - Deviation). for example, if a 20°F deviation alarm set point is desired and the ambient temperature input is 75°F, set the process set point to 55°F.

5. Adjust the Alarm Dev. Set Point potentiometer until the alarm LED turns on. This verifies that the alarm deviation is set at 20°F. Return the process set point to its original setting.

6. If a - Deviation alarm mode is desired, adjust the process set point such that Process Set Point = Input Temperature (Ambient) + Deviation. For example, if a 20°F - Deviation alarm set point is desired and the ambient temperature is 75°F, set the process set point to 95°F. Adjust the Alarm Dev. Set Point potentiometer until the alarm LED turns on, verifying that you have reached a 20°F Alarm Set Point. Return the process set point to its original setting.

The 3910 controller has been calibrated and tested at the factory prior to shipment. Calibration on receipt is not necessary.

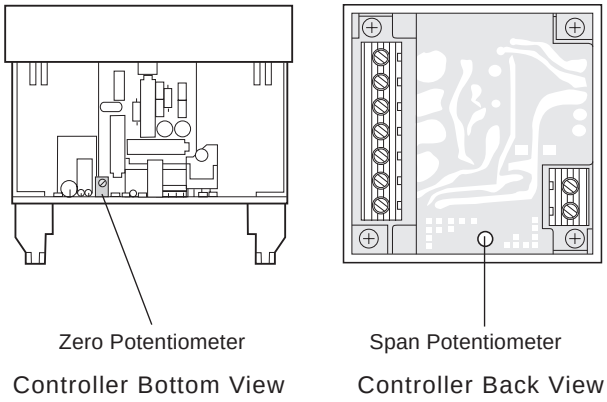
Equipment Required

A precision thermocouple simulator and a small instrument screwdriver are necessary to calibrate the controller.

Locating Calibration Adjustments

Remove the back cover from the controller as described on page 4. Figure 4.1 identifies the zero and span calibration potentiometers.

Figure 4.1
Zero and Span Calibration Potentiometers



Calibration Procedure

1. Connect the sensor simulator to terminals 7 and 8, making sure to connect the (+) to 7 and (-) to 8.

2. Set the sensor simulator to a minimum value (200°F for J T/C, 350°F for K T/C) and adjust the zero potentiometer until the digital display equals the sensor input value (200°F or 350°F).

(continued on next page)

Calibration Procedure (continued)

3. Set the sensor simulator to a maximum (900°F for J T/C, 1600°F for K T/C) and adjust the span potentiometer until the digital display equals the sensor input value (900°F or 1600°F).

4. Repeat steps 2 and 3 as many times as necessary until **both** displays equal their respective sensor input values.

5. Calibration complete.

Control Mode (Field Selectable)	ON/OFF or Proportional

Control Adjustments

Control Set Point	0 to 999°F (0 to 500°C)
Set Point Limit	20 to 100% of sensor span
Deadband	2.5°F, field changeable to 10°F
Proportional Band	5 to 100°F nominal, adjustable
Manual Reset	Adjustable over 100% of the proportional band
Output Cycle Time (Adjustable)	SSR Drive Output—1 to 30 seconds Relay Output—15 to 60 seconds
Control Action	Reverse acting (heating)
Set Point Accuracy	+/-0.1% of span

Control Outputs

(1) Relay	Normally-open, SPST, rated at 120 or 240 Vac (resistive Load): 20 amps, 150,000 operations 15 amps, 200,000 operations 5 amps, 800,000 operations Mechanical life, 10 million operations
(2) Relays	Two normally-open, SPST, each rated at 120 or 240 Vac (resistive load): 20 amps, 150,000 operations 15 amps, 200,000 operations 5 amps, 800,000 operations Mechanical life, 10 million operations
Solid State Relay Drive	Transistor output of 20 Vdc at 40 mA

Alarm Output Option

Alarm Relay	Normally-open (closed on alarm), non-latching relay, rated 20 amps at 120 Vac, resistive load
Repeatability	+/-1°F
Reset Differential	10 to 15% of the deviation from set point (20°F set point = 2°F differential)
Range or Deviation Setting	5 to 50°F nominal

Input Specifications

Type J Thermocouple	0 to 999°F, 0 to 500°C
Type K Thermocouple	0 to 1999°F, 0 to 1100°C
Input Loop Resistance	Up to 150 ohms
Cold Junction Compensation	Automatic, typically less than 0.1°F per 1°F over ambient 50 to 120°F

Indications

Open Sensor Indication	Red LED lamp for J thermocouple input, "1" illuminates for K thermocouple input Upscale burnout, output turns off
Control Output Indication	Yellow LED "LOAD" Lamp
Accuracy of Indication	+/-0.5% of span over mid-80% of scale
Resolution	1°F
Repeatability	+/-0.1% of span
Alarm Output	Red "ALARM" LED

General

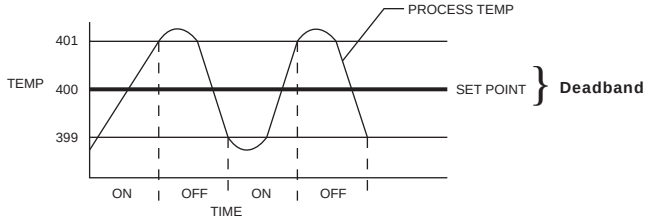
Instrument Power	120 or 230 Vac, +10%, -15%, 50/60 Hz, 10 VA nominal power consumption
Operating Environment	30 to 130°F with relative humidity less than 95% non-condensing
Dimensions	Requires 3.6" x 3.6" (92 mm x 92 mm) panel cutout Depth behind panel of 2.6" (66 mm) Projection at front of panel 0.8" (20 mm)
Mounting	Two screw-in mounting brackets to secure controller in panel cutout
Influence of Line Voltage Variation	Maximum change of +/-1°F for +/-10% nominal line voltage

Noise Rejection

Common Mode	Less than 2°F with 230 Vac, 60Hz applied from sensor input to instrument case
Series Mode	Less than 2°F with 100 mV, peak to peak series mode noise

Deadband

In ON/OFF control, the deadband represents an area about set point in which no control action takes place, and determines at what temperature the control output switches ON and OFF.



Narrow deadband settings give more accurate control but result in more frequent output switching, which can cause early failure of electromechanical contactors.

Deadband on the 3910 controller is 2.5°F, and can be changed to 10°F by clipping an internal jumper (see page 17 for instructions).

Deviation Alarm Modes

+/- **Deviation Alarm**: This deviation alarm is actuated whenever the process temperature deviates from the Process Set Point more than the predetermined (Alarm Set Point) amount above or below the Process Set Point. If the Process Set Point is changed, the alarm "tracks" the set Point and maintains the same deviation from set point.

Example:
Process Set Point = 200°F
+/- Dev. Alarm Set Point = 50°F
Alarm actuates when process temperature is equal to or greater than 250°F, or equal to or less than 150°F.

Deviation Alarm Modes (cont.)

+ Deviation Alarm: This alarm actuates when the process temperature is **equal to or greater than the Process Set Point plus the Alarm Set Point**. When the Process Set Point is moved, the deviation alarm "tracks" or moves with it, maintaining the same deviation from set point.

Example:
Process Set Point = 200°F
Alarm Set Point = 50°F
Alarm actuates when process temperature is equal to or greater than 250°F.

- Deviation Alarm: Similar to the deviation alarm described above, the -deviation alarm actuates when the process temperature is **equal to or less than the Process Set Point less the Alarm Set Point.**

Example:
Process Set Point = 200°F
Alarm Set Point = 50°F
Alarm actuates when process temperature is equal to or less than 150°F.

Manual Reset

Manual reset applies to proportional control. Manual reset allows the adjustment of the control output in an amount sufficient to return the process variable to the process set point. Increasing the manual reset setting increases temperature; therefore, if the process temperature is stabilizing below set point, increase the manual reset. Manual reset is sometimes called the "trim" or "droop" setting.

ON/OFF Control

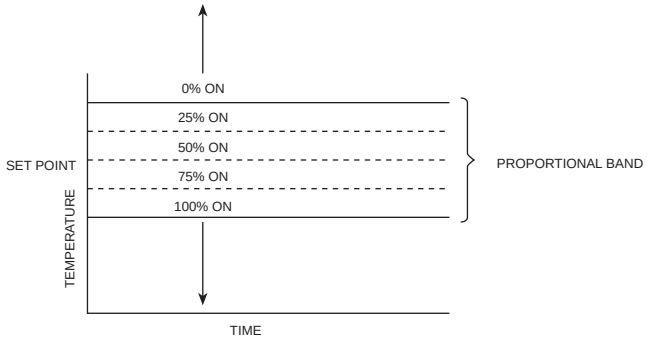
With ON/OFF control, the temperature is controlled about the set point by turning the output 100% ON or 100% OFF at set point. ON/OFF control is recommended for loads that cannot tolerate rapid cycling, such as pumps, air conditioning, etc. See **Deadband** for more information on ON/OFF control.

Proportional Control

Proportional control is a type of control action that proportions its control output to maintain a set point, instead of merely turning it full ON or full OFF, as with ON/OFF control. See **Proportional Band** for more information on Proportional Control.

Proportional Band

The Proportional Band is the temperature range about set point where the proportional control action is active from 0% to 100% of output.



Set Point Limit

The Set Point Limit feature allows you to preestablish an upper limit for the set point adjustment. This prevents dangerous overheating of the process.

Section 7
Warranty and Return

Warranty

Chromalox warrants only that the products and parts manufactured by Chromalox, when shipped, and the work performed by Chromalox, when performed, will meet all applicable specifications and other specific product and work requirements (including those of performance), if any, and will be free from defects in material and workmanship under normal conditions of use. All claims for defective or nonconforming (both hereinafter called defective) products, parts or work under this warranty must be made in writing immediately upon discovery, and in any event, within one (1) year from delivery, provided, however all claims for defective products and parts must be made in writing no later than eighteen (18) months after shipment by Chromalox. Defective and nonconforming items must be held by Chromalox's inspections and returned to the original f.o.b. point upon request. THE FOREGOING IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES WHATSOEVER, EXPRESSED, IMPLIED AND STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

Limitations

Notwithstanding the provisions of this WARRANTY AND LIMITATIONS Clause, it is specifically understood that products and parts not manufactured and work not performed by Chromalox are warranted only to the extent and in manner that the same are warranted to Chromalox by Chromalox's vendors, and then only to the extent that Chromalox is reasonably able to enforce such a warranty, it being understood Chromalox shall have no obligation to initiate litigation unless buyer undertakes to pay all costs and expenses therefore including but not limited to attorney's fees, and indemnifies Chromalox against any liability to Chromalox's vendors arising out of such litigation.

Upon buyer's submission of a claim as provided above and in its substantiation, Chromalox shall at its option

either (i) repair or replace its products, parts or work at the original f.o.b. point of delivery or (ii) refund an equitable portion of the purchase price.

Warranty

The foregoing is Chromalox's only obligation and buyer's exclusive remedy for breach of warranty, and is buyer's exclusive remedy against Chromalox for all claims arising hereunder or relating hereto whether such claims are based on breach of contract, tort (including negligence and strict liability) or other theories, buyers's failure to submit a claim as provided above shall specifically waive all claims for damages or other relief, including but not limited to claims based on latent defects. In no event shall buyer be entitled to incidental or consequential damages and buyer should hold Chromalox harmless therefrom. Any action by buyer arising hereunder or relating hereto, whether based on breach of contract, tort (including negligence and strict liability) or other theories, must be commenced within one (1) year after the date of shipment or it shall be barred.

Returns

Items returned to Chromalox Instruments and Controls must be accompanied by a Return Authorization Number. This number may be obtained from Chromalox Instruments and Controls, Customer Service Department, telephone number (615) 793-3900. It should appear on the exterior of the shipping carton and on the shipping documents. Defective items will be repaired or replaced at our option, at no charge.