Installation and Operation Manual

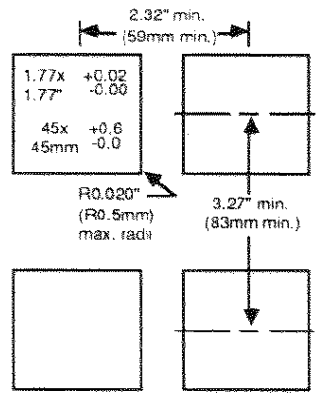
EUROTHERM CONTROLS

Models 91 and 91e PID - ON/OFF temperature controllers

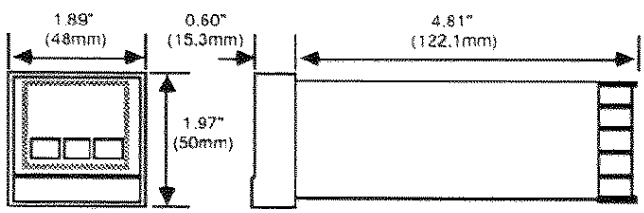
Features marked with an asterisk (*) are available only on units manufactured after January 1993 (Version 3.1).
Features marked with a double dagger (‡) are available only on units manufactured after May 1995 (Version 4.3).

1. Mechanical installation

- Prepare panel cutout.
- Install the optional front panel gasket (part no. BO133297) if required. Remove the backing from the gasket and apply it around the panel cutout on the *outside of the panel.*
- Slide instrument sleeve into the cutout from the front of the panel.
- Position the mounting bracket on the rear of the instrument sleeve with the 2 clips facing the rear and positioned on the top and bottom of the sleeve.
- While holding the sleeve, slide the mounting bracket towards the panel until the clips engage on the ratchets. While still pulling back on the sleeve, press on the upper left and lower right hand corners of the bracket to seat the mounting bracket. Another push on the clips with a screwdriver might be necessary to secure the installation.



Panel cutout and minimum spacing
Max. panel thickness: 0.51" (13mm)



Dimensions

Panel depth: with rear terminal cover: 4.96" (126.1mm)
with gasket fitted: less 0.060" (1.5mm)

2. Electrical connections

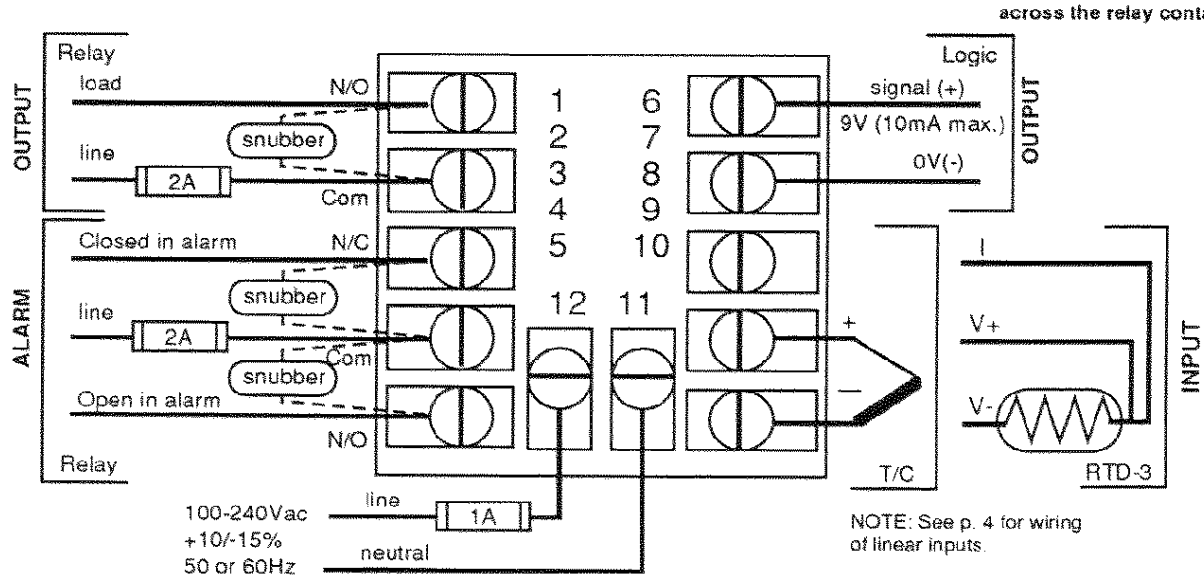
ELECTRICAL CONNECTIONS
WARNING! Ensure that the maximum voltage which is applied to the unit power supply, between any two isolated circuits, or between any isolated circuit and ground does not exceed 264Vac.

Power
Respect the polarity of the AC power supply: line wire must be connected to terminal 12, and the neutral must be connected to terminal 11.

Output
- Relay (terminals 1 and 2): Contact is closed during ON phase of output cycle (yellow "OP" lamp ON). Relay channel operative only when **H.ct** parameter (heat cycle time) is 5s or greater. A snubber may be required; see below.
- Logic (terminals 6 and 7): Signal goes high (current flows) during ON phase of output cycle (yellow "OP" lamp ON). Connect only to opto-isolated device loads, never connect to any grounded circuit. Keep wiring run shorter than 3' (1m) and well away from noise generating circuits.

Alarm relay (terminals 3, 4, and 5)
The alarm output is failsafe: the relay is de-energized during the alarm condition or power down. The attached alarm circuit should be designed for failsafe operation and fused appropriately. A snubber may be required; see below.

Snubbers
Connect snubbers CZ140398 (22nf + 100Ω) across the appropriate output or alarm relay contacts when driving AC inductive loads (mechanical contactors and solenoids). *Do not use snubbers when driving high impedance loads.* The snubber passes 1mA in 120Vac circuits, and 2mA in 240Vac circuits; this is sufficient to hold in certain relays with high impedance coils *and should not be used in such installations.*
WARNING! When an alarm contact is to be implemented as part of a systemwide failsafe alarm scheme, it is the user's responsibility to verify that the effect of the snubber does not interfere with the operation of the circuit. Certain high impedance circuits are not able to detect a contact opening when the snubber is placed across the contact. In these cases the snubber should not be installed across the relay contact.



NOTE: See p. 4 for wiring of linear inputs.

Input

WARNING! The input sensor intended for use with this instrument is to be connected uniquely to the input terminals 9 and 10 and never looped to inputs of other instruments. The paralleled inputs of other instruments interfere with proper operation of the sensor break detection circuitry.

NOTE. The input circuit and the logic output are NOT isolated from one another.

Use of shielded, twisted pair is recommended. The shield must be connected to terminal 10 even when grounded elsewhere.

- Thermocouple: Use appropriate compensation cable. Keep loop resistance as low as possible (1kΩ maximum).
- RTD: Use 3 copper wires of same length and diameter. (20Ω/lead maximum resistance.)

Rear terminal cover

After wiring, attach rear terminal cover BD133125 with screw FY133264U001.

3. Configuration

CONFIGURATION PROCEDURE

1. Cycle power OFF and ON. Self test follows: **tESt** appears followed by **1111, 8888**, then the 4-digit configuration code. Touch and hold secret key *only* after 4-digit configuration code appears to enter configuration mode.
2. See configuration code with left digit blinking.
3. Enter new code (refer to *Configuration code* table):
   ▼ = select digit position (1 through 4)
   ▲ = modify digit value.
4. To exit configuration mode do one of these:
   Secret key = accept new configuration; parameter value check follows.
   ---- = abort; return to previous configuration.

Configuration code

1st (left) digit
alarm function

0	Off (no alarm function)
1	Deviation low alarm
2	Deviation high alarm
3	Deviation band alarm
4	Full scale low alarm
6	Full scale high alarm
5	Sensor break alarm
7	Loop break alarm

"Alarm function" assigns alarm type to alarm relay output. Sensor break and loop break alarms are always displayed even if not assigned to alarm relay.

2nd digit: Model 91 only
sensor type

		full specified range: Model 91 °F min	°F max	°C min	°C max
0	RTD (units' precision display)	-148	752	-100	400
1	RTD (tenths' precision display)	-99.9	752.0	-99.9	400.0
2	J—Fe/SAMA constantan	32	1472	0	800
3	K—Chromel™/Alumel™	32	2372	0	1300
4	L—Fe/Konstantan	32	1472	0	800
5	N—NiCroSil/NiSil	32	2372	0	1300
6	R—Pt-13%Rh/Pt	32	2912	0	1600
7	S—Pt-10%Rh/Pt	32	2912	0	1600

2nd digit: Model 91e only
sensor type

		full specified range: Model 91e °F min	°F max	°C min	°C max
0	RTD (units' precision display)	-148	1112	-100	600
1	RTD (tenths' precision display)	-99.9	999.9	-99.9	600.0
2	J—Fe/SAMA constantan	-328	2192	-200	1200
3	K—Chromel™/Alumel™	-418	2502	-250	1372
4	L—Fe/Konstantan	-148	1652	-100	900
5	N—NiCroSil/NiSil	32	2372	0	1300
6	R—Pt-13%Rh/Pt	32	3213	0	1767
7	S—Pt-10%Rh/Pt	32	3213	0	1767
8	T—Cu/Adams constantan	-427	752	-255	400
9	Platinel II™	-418	2543	-250	1395
A	B—Pt-30%Rh/Pt-6%Rh *	1112	3308	600	1820
B	Linear a—2-point entry scaling ‡				
C	Linear b—point-and-span entry scaling ‡				

3rd digit

	upper range limit	prop. band units
0	400°C (752°F)	%
1	400°C (752°F)	°C or °F
2	800°C (1472°F)	%
3	800°C (1472°F)	°C or °F
4	Full specified range	%
5	Full specified range	°C or °F

Lower range limit from tables, above

- *Prop band in % expressed as % of 400°C (or 752°F)*
- *Prop band in % expressed as % of 800°C (or 1472°F)*
- *Prop band in % expressed as % of full specified range*

4th (right) digit

	display	control type	output action
0	°F	ON/OFF	direct
1	°F	ON/OFF	reverse
2	°F	PID	direct
3	°F	PID	reverse
4	°C	ON/OFF	direct
5	°C	ON/OFF	reverse
6	°C	PID	direct
7	°C	PID	reverse

Select "reverse" for heating applications and "direct" for cooling applications.

CONFIGURATION EXAMPLE

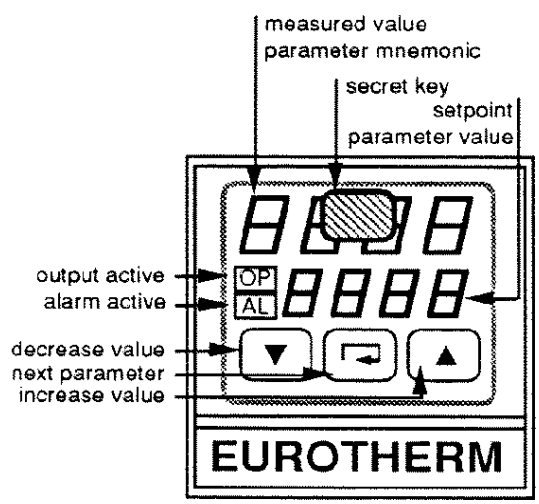
6253:

1st digit (**6**): full scale (absolute) alarm.
2nd digit (**2**): type J thermocouple input.
3rd digit (**5**): full specified range for input and proportional band display in degrees.
4th digit (**3**): display units in °F, reverse-acting PID control.

4. Operation

BASIC OPERATION

- To light up buttons: touch any button on front panel.
- To modify setpoint: ▲ and ▼.
- To enter protected list: use — until **AL.SP**, then "secret key". Continue with — to view parameters. [Model 91e only: It is possible to enter the protected list from the °C or °F display with the "secret key".]
- To modify a parameter value: with the parameter mnenomic in upper display, use ▲ and ▼.
- To return to measured value display when in protected list: "secret key".



ALARMS

Temperature alarms (configuration codes "1" through "4" and "6" for operation)

If the measured value enters the alarm condition as defined by the configuration code, the red "AL" lamp lights up and the alarm relay is de-energized (failsafe operation). The alarm is non latching; the lamp goes out and the alarm relay is re-energized as soon as the measured value enters the "safe" condition.

Sensor break alarm (configuration code "5" for alarm relay output). If the controller has detected that the sensor circuit has failed, then the output power level is forced to 0% and **SnSr FAIL** is displayed.

A failed sensor is detected:

- if the input signal is out of the selected sensor's range,
- if the input is open circuit, or
- if the controller's operating temperature is outside of the 0-55°C operating range (thermocouple inputs only).

Upon reinstatement of the input sensor, the controller resumes controlling with the same output power level used at the moment of the break.

Loop break alarm (configuration code "7" for alarm relay output)

If the unit detects a break in the control loop, then **LP.Br** is displayed. The display (and optional relay operation) is latching. To reset, touch any key. The output level is determined by the control algorithm during the alarm condition.

To determine starting values for the **LP.br** parameter:

PID control: Set **LP.Br** equal to or slightly longer than **Int.t**.

ON/OFF control: Set **LP.Br** equal to one period of oscillation around setpoint (ON + OFF times).

For both types of control: increase **LP.Br** if spurious alarms occur; decrease for greater sensitivity.

NOTE: The above described operation of sensor break and loop break alarms always occurs irrespective of the configuration of the alarm relay.

Adjustable parameters

Mnemonic	Parameter	Adjustable range	Comments
OPEN LIST			
none	Setpoint	Upper limit: "SP.Hi" Lower limit: "SP.Lo"	Not adjustable during self tuning.
°C or °F	Display units	View only.	Display units selected in configuration.
tunE	Self tune on demand	Disable self tune: "OFF" Initiate self tune: "on"	Not displayed for ON/OFF control or if "SP.rr" enabled.
AL.SP	Alarm setpoint	Configured input sensor range for full scale (absolute temperature alarms 0 to upper range limit for deviation alarms	Alarm function selected in configuration. "AL.SP" operative only for temperature alarms: configuration codes "1" through "4" and "6". Due to hysteresis, deviation band alarm setting must be at least 2°C (or 4°F).
PROTECTED LIST			*Not accessible if self tuning in progress.*
ConF	Configuration code	View only in this list	Can be changed upon power up only.
Id	Instrument model ident.	View only: "91E"	Not included in Model 91 parameter list.
ProP	Proportional band	°C—2 to 400°C ("1 to 400°C) °F—4 to 720°F ("2 to 720°F) ‡ lin a— 1, 0.1, or 0.01 to "dSHi" - "dSLo" ‡ lin b— 1, 0.1, or 0.01 to "dSSn" or equivalent in percent.	Becomes hysteresis for ON/OFF control. Units (°C, °F or %) selected in configuration.
Int.t	Integral time constant	OFF plus 10 to 2000s	Valid for PID control only
dEr.t	Derivative time constant	OFF plus 1 to 200s	Valid for PID control only
OFSt	Calibration offset	-50.0 to 50.0°C (-90.0 to 90.0°F)	Display value = measured value + offset
			Appears for temperature inputs only.
SP.Hi	Setpoint high limit	Configured input sensor range	Must be greater than "SP.Lo"
SP.Lo	Setpoint low limit	Configured input sensor range	Must be less than "SP.Hi"
H PL ‡	Maximum power limit	0.0 to 100.0%	
H.ct	Heat cycle time	Model 91: 1 to 20s Model 91e: 0.2 to 60.0s (5s or more for relay output)	Valid for PID control only, but for ON/OFF control disables relay output if set to 4s or less.
SP.rr	Setpoint ramp rate	OFF plus 0.1 to 50.0°C/min (0.2 to 90.0°F/min.)	Model 91e only. Self-tuning inhibited if ramping enabled.
LP.br	Loop break time constant	OFF plus 10 to 4000s	
LinE	Line frequency	50 Hertz: "50" 60 Hertz: "60"	Set to line frequency upon installation.

Display Messages

Message	Display condition	User action/comments
LOOP STATUS MESSAGES		
SnSr FAIL	Sensor fail. Input open or reversed; measured value outside of configured range.	Verify input sensor and connections. Message disappears when input signal is reinstated.
measured value LP.br	Loop break. Output at 0 or 100% and measured value moves less than 1/2 of "ProP" setting toward setpoint within time setting of "LP.br".	Verify output device, fuses, wiring and heater. Acknowledge by touching any key.
measured value SP.rr	Setpoint ramping in progress.	Model 91e only. Setpoint and "SP.rr" parameter still user-adjustable during ramping.
flashing value	Display overrange or out of specified accuracy range	Unit should not be used in this range.
SELF TUNE MESSAGES		
measured value tunE	Self tuning in progress. Message alternates with setpoint.	Annunciation only. Adjustment of setpoint and PID values inhibited during self tuning.
tunE FAIL	Self tuning operation has failed because controller cannot maintain setpoint.	Acknowledge by touching any key. Remove cause of failure: e.g. heater fuse blown, etc.
LinE FAIL	Loss of controller power during self-tuning operation renders sampled data questionable.	Acknowledge by touching any key. Verify power supply. Reinitiate self tuning procedure.

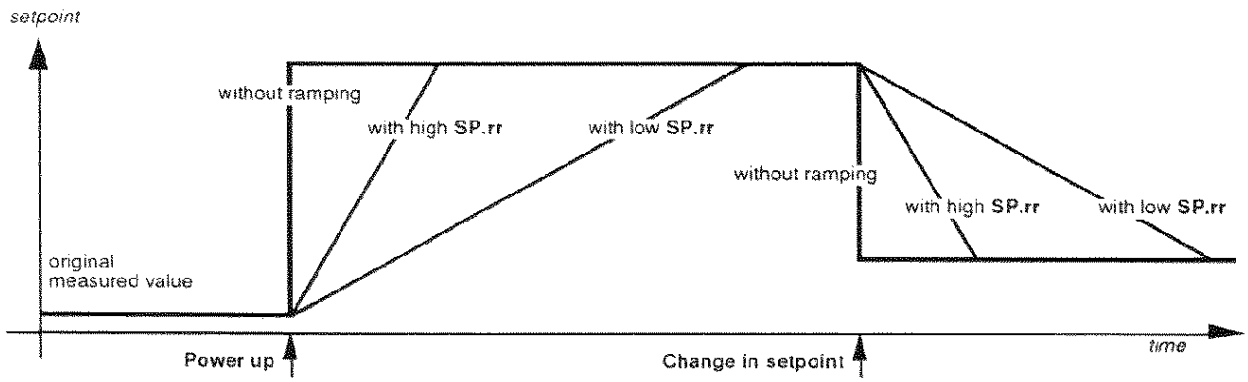
RAMP TO SETPOINT OPERATION (Model 91e only)
The setpoint ramping feature is enabled by setting **SP.rr** to any value except **OFF**. Ramping is initiated only by one of two conditions:

- power-up
- change in setpoint.

Upon power up, ramping always starts from the current measured value. The instantaneous setpoint follows a straight line to the target setpoint (the setpoint normally displayed along with the measured value). The speed at which the ramping progresses is selectable by **SP.rr** and remains constant for all ramps until **SP.rr** is changed. When the measured value follows a ramping setpoint through an alarm region, the alarm is detected, annunciated and output as follows:

- Full scale high and low alarms (configurations "4" and "6"). The alarm is non latching; crossing the alarm setpoint into the "safe" region ends the alarm condition.
- Deviation alarms (configurations "1", "2" and "3"). The deviation alarm follows the ramping setpoint. If the measured value cannot track the setpoint within the bounds of the deviation alarm, an alarm condition is generated.

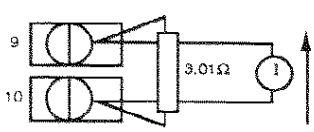
NOTE: Any value for **SP.rr** except **oFF** inhibits self tuning operation.



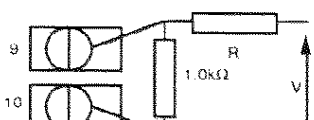
LINEAR INPUT SETUP
Electrical connections
For all inputs use a shielded twisted pair.

- Millivolt inputs (-10 to 70mV). Connect signal leads directly to input terminals 9 (+) and 10 (-).
- 0-20mA and 4-20mA inputs. Connect 3.01Ω shunt (part no. CA 9G3 R01) across input terminals 9 (+) and 10 (-).
- Higher voltage inputs. Voltage divider network is required (resistors supplied by user). Refer to table for suggested values. Resistor specifications: 1%, 0.125W minimum, ±100ppm metal or metal oxide film.

CAUTION: Use of the shunt or voltage divider inhibits operation of the sensor break detection feature.



0-20mA and 4-20mA input



Voltage inputs

Nominal range	R
-20 to 200mV	2.2kΩ
-0.1 to 1 V	15.0kΩ
-0.5 to 5V	75.0kΩ
-1 to 10V	150kΩ
-2.5 to 25V	392kΩ

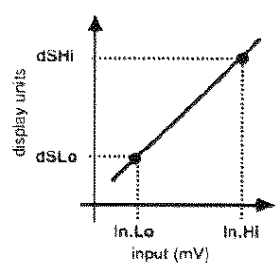
Scaling procedure
There are 2 methods for entering and scaling linear inputs:

- Linear a: 2-point scaling (configuration code "C").,
- Linear b: point and span scaling (configuration code "D").

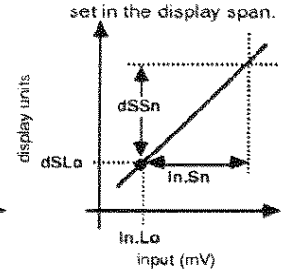
Linear a and Linear b
1. Set display decimal point position parameter, **dP**, to desired value.
2. If reading the input signal directly from the source, connect source (from signal generator or sensor) to input terminals. Apply a signal equal to a known low value for the first setup point.
3. Scroll through the protected list until **In.Lo**. Press and hold on ▲ or ▼ until **rEAd** appears, release, then push the button again. [Alternatively, if no input signal is required or the exact value is known, the input value in millivolts can be set in with ▲ or ▼.]
4. Scroll to **dSLo**. Then set in the corresponding display value with ▲ or ▼.

Linear a only
5. Again, if reading the input signal directly from the source, apply a signal equal to a known high value for the second setup point.
6. Scroll through the protects list until **In.Hi**. Press on ▲ or ▼ until **rEAd** appears, release, then push the button again. [Alternatively, if no input signal is required or the exact value is known, the input value in millivolts can be set in with ▲ or ▼.]
7. Access **dSHi**. Then set in the corresponding display value with ▲ or ▼.

Linear b only
8. Access **In.Sn**. With ▲ or ▼ set in the input signal span in millivolts.
9. Access **dSSn**. With ▲ or ▼ set in the display span.



Linear a: 2-point scaling



Linear b: point & span scaling

LINEAR INPUT SCALING (Replaces "OFSt" parameter in protected list)

In.Lo	Input for low setup point	-9.99 to 70.00mV input signal range	Both linear a and b inputs. To read input signal value from rear terminals: Hold UP or DOWN until "rEAd" appears, release, then press the button again.
dSLo	Display value for low setup point	-999 to 9999, -99.9 to 999.9, or -9.99 to 99.99 process units	Both linear a and b inputs.
In.Hi	Input for high setup point	-9.99 to 70.00mV input signal range	Linear a inputs only. To read input signal value from rear terminals: See procedure for "In.Lo", above.
dSHi	Display value for high setup point	-999 to 9999, -99.9 to 999.9, or -9.99 to 99.99 process units	Linear a inputs only.
In.Sn	Input signal span	0.00 to 70.00mv	Linear b inputs only.
dSSn	Display span	-999 to 9999, -99.9 to 999.9, or -9.99 to 99.99 process units	Linear b inputs only.

TUNING AND ADJUSTMENTS

WARNING: The two PID tuning procedures presented here are based on perturbation response; the step changes involved may be detrimental to sensitive systems.

NOTE: Model 91e only: Set **SP.rr** to **oFF** before performing either of these tuning procedures.

PID self tuning procedure

1. Set appropriate values for all parameters except **ProP**, **Int.t**, and **dEr.t**.

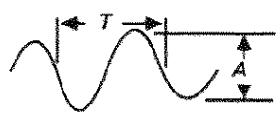
For PI control set **dEr.t** = **oFF** .
For PD control set **Int.t** = **oFF** .
For proportional only control set **Int.t** = **dEr.t** = **oFF** .
Model 91e only: The value for **LP.br** is also determined if the starting value is not set to **oFF**.

2. Initiate self tuning by setting **tunE** to **on**. The **tunE** message will flash in the lower display.
3. Wait for the tuning operation to finish: **tunE** will no longer be displayed.
4. The values for **ProP**, **Int.t**, and **dEr.t** can be viewed in the protected list (as well as **LP.br** for the Model 91e).
5. See the *Display messages* table for tuning messages.

PID manual tuning procedure

NOTE: Wait a sufficient period of time after each adjustment to see if the system will stabilize.

1. Set the setpoint to the normal operating temperature. **ProP** = minimum, **Int.t** = **oFF** , and **dEr.t** = **oFF** . Observe the peak-to-peak amplitude (*A*) and



period (*T*) of the oscillation of the measured value. This oscillation may not necessarily be centered about the setpoint.
2. Set **ProP** = 1.1 x *A*. If stable (probably not at setpoint) go to 3. If not, increase **ProP** until the temperature is stable.
3. Set **Int.t** = *T*. Wait at least 2 x *T*. If system becomes stable at setpoint, go to 4. If not, increase **Int.t** in small (<30%) steps until the temperature is stable at setpoint.
4. Set **dEr.t** = **Int.t**/6. If stable, go to 5. If not decrease **dEr.t** in small steps until temperature is stable. (**dEr.t** might have to be turned **oFF** .)
5. The loop should now be stable at setpoint. If not, try the following:
   - If **Int.t** is shorter than the period of oscillation, increase **Int.t** to be slightly longer than the period. If stability is not achieved after several small increases, then try:
   - Increase **ProP** in several small (<30%) steps. If oscillations continue, try:
   - Set **dEr.t** = **oFF** . If the temperature is still unstable, try:
   - Set **Int.t** = **oFF** . If stable, go to step 3 above and repeat. If not, increase **ProP** until temperature is stable, then go to step 3.

ON/OFF control adjustment

The hysteresis band (represented by **ProP**) should be set as small as possible to minimize ripple of the measured value, but large enough to reduce wear on devices such as mechanical contactors.

CAUTION!

Before installing, operating or servicing this unit supplied by Eurotherm, please read the following:

INSTRUCTIONS FOR SAFE USE OF EUROTHERM EQUIPMENT

(Note: These instructions represent good engineering principles and are applicable to all control equipment of the same type, whether from Eurotherm or any other supplier.)

ENCLOSURE OF LIVE PARTS

This unit should be installed inside a suitable grounded metal enclosure to prevent live parts being accessible to human hands and metal tools. It is recommended that rear terminal covers (available as an option) be fitted.

WIRING

It is important to connect the unit correctly in accordance with the installation data on this sheet. Wiring should conform to appropriate standards of good practice and local codes and regulations. Conductors should be commensurate with voltage and current ratings of the units.

OUT-OF-LIMITS ALARMS

In applications where excessive deviation of a controlled parameter due to equipment failure could cause damage to machinery or materials, or injury to personnel, it is strongly recommended that an additional separate unit with its own input sensor be used to give alarm indication or to shut down the process or both, as may be appropriate. (Note: The alarm function built into controllers may not give sufficient protection in these circumstances). When the controller alarm function or separate alarm units are used they should be checked for correct operation at regular intervals.

CONFIGURATION

Many instrument functions are user selectable from the front panel. It is the user's responsibility to verify that the instrument configuration is correct. Personal injury, property loss and equipment damage could result from an improperly configured instrument.

GROUNDING

This instrument has internal circuits which are isolated or "floating." This is necessary to prevent the occurrence of a "ground loop" in signal circuits. To avoid possible shock hazards in the event of an internal fault causing breakdown of insulation, it is recommended that all equipment connected to this unit be enclosed in a grounded metal enclosure. Sheaths of thermocouples (or other sensors) should be properly grounded by a separate conductor (instead of being dependent on grounding via the machine framework).

ESD PRECAUTIONS

This instrument contains static sensitive components. Care should be taken to avoid electrostatic discharge (ESD) and thus reduce incidents of damage to the instrument when removed from its sleeve. Any manipulation of the instrument printed circuit boards should be performed on a conductive surface with the personnel in contact with the surface by means of a grounded, metal or conductive plastic wrist strap with a 1MΩ series resistor.

SUPPLY ISOLATORS

Every electrical system should be provided with means for isolating the system from the AC supply to allow safe working during repair and maintenance. SCRs and triacs are not adequate means of isolating the supply, and should always be backed by a suitable mechanical disconnect switch.

HAZARDOUS ATMOSPHERES

This unit is not suitable for use in areas subject to hazardous atmospheres. No Eurotherm product should be connected to a circuit which passes into or through a hazardous area unless appropriate precautions are taken (even though the instrument itself may be located in a safe area). Such an installation should conform to the requirements of the relevant Authority. (In the USA: Factory Mutual Research Corporation and Underwriters' Laboratories, Inc.).

PROCEDURE IN THE EVENT OF TROUBLE

Before beginning any investigation of a fault, the electrical supplies to all equipment concerned should be switched off and isolated. Units suspected of being faulty should be disconnected and removed to a properly equipped workshop for testing. There are no user-servicable parts inside this unit.

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