Electronic Micro Systems Ltd.

Hot Plate Model 1000-1

Operation & Maintenance Manual

Features include:

1. Temperatures from 50^{o}C to 150^{o}C
2. Accurate to ±1% across working surface.
3. A vacuum port ensures intimate contact between substrate and hotplate.
4. Substrate size from 10 mm to 150 mm.
5. Computer Temperature Controller with digital readout

Applications

Uses include:

- Curing of photo resist
- Curing of epoxy
- Any work requiring precise temperature.

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Telephone 01725 513044 Fax 01725 513066

Thank you for purchasing your Hot Plate from EMS Ltd. This Hotplate has been designed to give many years of accurate service. It has been designed around some of the best materials available.

Services required

1. 220 / 240 V 50 Hz mains power supply capable of supplying 5 Amps.

2. Vacuum >> 15"

Installation

1. Connect the vacuum to a vacuum supply sufficient for your requirements.

2. Place on flat surface, making sure the fan in the base of the unit has a good airflow around it.

3. Connect to the mains power supply

4. At this stage, it is normal to calibrate your hotplate but it should be noted that even without calibration your EMS 1000 hotplate would give repeatable results from switch on.

Initial calibration and set up.

1. Go to page 4, the 'Quick Start Menu'

2. Set your required temperature (SP1 page 5) within the operating range of 50^o to 150^o C and run 'Auto tune' page 6.

3. For calibration of Set temperature go to page 18 and follow the instructions on calibrations to another instrument. You will need another means of measuring the hotplate surface temperature at this stage and the final accuracy of your hotplate will be directly affected by the accuracy of this instrument.

Note:

Before performing any form of maintenance or installation work on this equipment, remember to completely isolate it from the mains power.

Fault finding

In the unlikely occurrence of a fault, a circuit diagram is included on page 20 and a diagram of the pneumatics on page 21. The heater plate is a sealed unit and will have to be returned to EMS for service. The temperature controller is a CAL 9400 from Cal Controls and additional can be obtained from the Internet at www.cal-controls.com

EMS can be contacted by e-mail at service@emsl.fsnet.co.uk.

QUICK START Set Up for the CAL 9400 as fitted to the EMS 1000-1

After power-up the controller requires programming with the following information

Type of Sensor has to be set to K
Operating unit 9400
Allocation of Output Device to SP2
Temperature Setpoint e.g. Degrees

When the above information has been programmed into the Controller it will be operational with the following factory settings

Proportional band/ Gain	10 C/ 18 F
Integral time/Reset	5 mins
Derivative time/Rate	25 sees

Proportional cycle-time (Typical setting for relay output)	20 secs
DAC Derivatives approach control (Average setting for minimum overshoot)	1.5

NB: note that in program mode, **Functions** are shown in the upper **display screen (green) and Options in** the lower **display (Orange)**

Note In this manual the letter k is represented by the **character** 

Note: **During** the following procedure the display will revert to

after 60 seconds of key inactivity, but will retain any settings already completed. Should this occur, or in the event of becoming 'lost' in the program please start again checking any settings completed so far

QUICK START SET-UP

On power up the controller will display the self test sequence followed by the initial display

1 Select Input sensor.

Press and hold ∗ and use the ▲ or ▼ buttons to

Scroll through the sensor selection list until the sensor **K** is displayed as above

Release the buttons The display now read selected sensor type **K.**

Press ▲ once Display will now read

2 Select unit.

Press and hold ∗ and use the ▲ or ▼ buttons to scroll through the unit selection list until the correct unit is displayed. Release the buttons.
The display will read selected unit e.g.

Press ▲ once the display will now read

3 Select SP1 (Main setpoint output device)

Note: Dual Relay and Dual SSd Output Options onModels 9411 and 9422 have their outputs pre-configured.

Press and hold ∗ and use the ▲ or ▼ buttons to select **SSd**.
The controller will now read selected output device e.g.

4 To enter initial configuration into controller memory

Press and hold both ▲ or ▼ buttons for 3 seconds.
The upper display will now alternate **ParK** and measured variable (temperature) (e.g. **23**) **ParK** is displayed because a set point has not yet been entered as shown by the lower display

To display setpoint

Press and hold ∗ the displays will now read **unit** (eg. **°C**) and **0**

To enter setpoint

Press and hold ∗ and use ▲ button to increase or ▼ buttons to decrease the reading and scroll to required set point value. (The digit roll-over rate increases with time).

THE CONTROLLER IS NOW OPERATIONAL WITH FACTORY SETTINGS

Note: For precise control of an application the controller may need to be TUNED. Please study section headed FUNCTIONS and OPTIONS before moving to the section on AUTOTUNE.

AUTOTUNE

To precisely control an application the controller will need to be ‘tuned’ using the built-in ‘AUTOTUNE’ feature. Autotune ‘teaches’ the controller the main characteristics of the process and ‘learns’ by cycling the output on and off. The results are measured and used to calculate optimum PID values which are automatically entered in the controller memory.

During AUTOTUNE the optimum cycle-time is calculated but is not automatically implemented. The cycle-time requires manual acceptance unless pre-selected.

To ensure good control over a wide range of applications two versions of the Autotune program are provided, TUNE and TUNE AT SETPOINT.

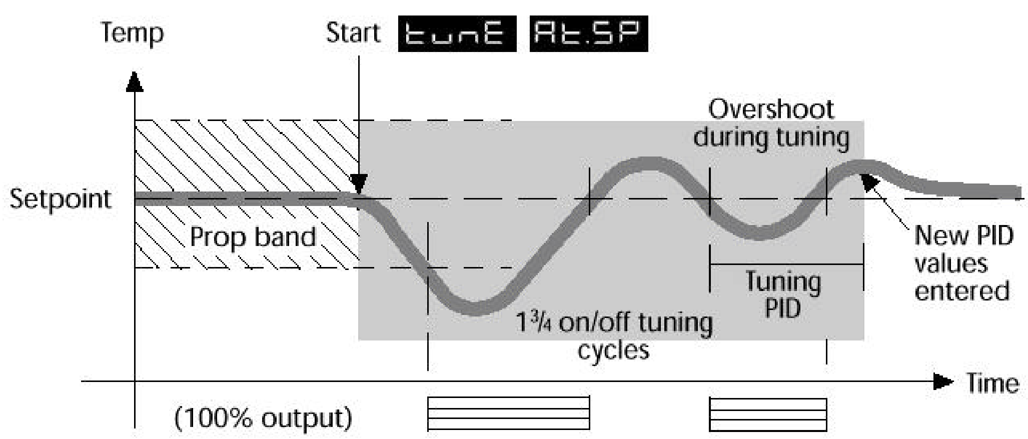
The TUNE method normally achieves the best results. Starting with the load cool, tuning occurs during warm-up preventing overshoot. This method of tuning is recommended.

The TUNE AT SETPOINT method is used for specialist applications. eg. Heat-cool, multizones and processes below 100°C/200°F. During the tuning cycle some overshoot occurs because the tuning cycle is at set point.

The DAC setting is not re-calculated.

When the **TUNE** program is complete the upper alternating display stops and only the process temperature is displayed. The PID values are entered automatically. The process temperature will rise to setpoint and control should be stable. If not, this may be because optimum cycle time is not automatically implemented. To set the cycle time see **PROPORTIONAL CYCLE-TIME**.

TUNE AT SETPOINT PROGRAM



Enter program mode and select

And from the display select …...

Exit program mode.

The TUNE AT SETPOINT program will now start. The upper display will alternate **tune** and the process temperature. The lower display will read the setpoint value.

Note: During tuning the main setpoint (SP1) LED will flash.

When the TUNE AT SETPOINT program is complete the upper alternating display stops and only the process temperature is displayed. The PID values are entered automatically. The process temperature will rise to setpoint and control should be stable. If not, this may be because optimum cycle time is not automatically implemented. To set the cycle time see PROPORTIONAL CYCLE-TIME.

REMINDER OF INSTRUMENT ADJUSTMENTS

Press ▲ ▼ together for 3 seconds for program entry or exit.

Press ▲ or ▼ to scroll through functions.

Press ∗ ▲ together or ∗ ▼ together to change levels or alter options.

Note: If in difficulty by becoming “lost” in program mode, press ▲ and ▼ together for 3 seconds to return to display mode, check the Menu Navigation summary above and try again.

The choice of cycle-time is influenced by the external switching device or load. eg. contactor, SSR, valve. A setting that is too long for the process will cause oscillation and a setting that is too short will cause unnecessary wear to an electro-mechanical switching device.

CYCLE-TIME SELECTION METHODS

The following methods of cycle-time selection may be used:

Autotune calculated (recommended)

After Autotune has been run and completed the calculated cycle-time can be manually accepted or adjusted to suit the switching device. For selection method see Select Autotune

Pre-select Autotune cycle-time

The controller can be programmed to automatically accept any calculated Autotune cycle-time.

Pre-select before Autotune

The controller can be programmed manually with any cycle-time between 0.1 and 81 sec. This cycle-time will not be changed by any Autotune functions.

PROPORTIONAL CYCLE-TIME

Factory set

To use the 20 sec factory set cycle-time no action is needed whether autotune is used or not.

CYCLE-TIME RECOMMENDATIONS

Output Device	Factory Setting	Recommended Minimum	Load max (resistive)
Internal relay rLY/rLY1	20 seconds	10 seconds	2A/250 Vac
Internal relay rLY2	20 seconds	10 seconds	1A/250 Vac
Solid state drives SSd/SSd1/SSd2	20 seconds	0.1 seconds	Externally fitted SSR (n/a)

NB: The last option is used in the EMS 1000-1

To Select AUTOTUNE CALCULATED CYCLE-TIME

On completion of Autotune enter program mode. Select

The controller will display **CYC.t**and **20** (the factory setting) in seconds

To view the calculated optimum cycle-time press and hold the ✻ button then press and hold ▼ until indexing stops. The controller will display the calculated cycle-time in the lower display e.g. **A 16**. This indicates that the calculated cycle-time is 16 seconds

If this cycle-time is suitable press and hold both ▲ and ▼ buttons for 3 seconds to enter it into the controllers memory.

If the calculated cycle-time is not compatible with the switching device press and hold the ✻ button then press and hold ▲ or ▼ until a more suitable cycle-time is displayed. Release the buttons, then press and hold both ▲ and ▼ buttons for 3 seconds to enter it into the controllers memory.

Pre-Select Automatic Acceptance of Any Autotune Cycle-time

Before selecting Autotune, enter program mode. Select

Press and hold the ✻ button then press and hold ▼ until indexing stops and **A - -** is displayed in the lower display

Note: **A - -** indicates that no cycle-time exists.

Press and hold ▼ to scroll to **tunE** The controller will now display

Press and hold the ✻ button and use ▲ to select either **on**or **At.SP**. Release ▲.

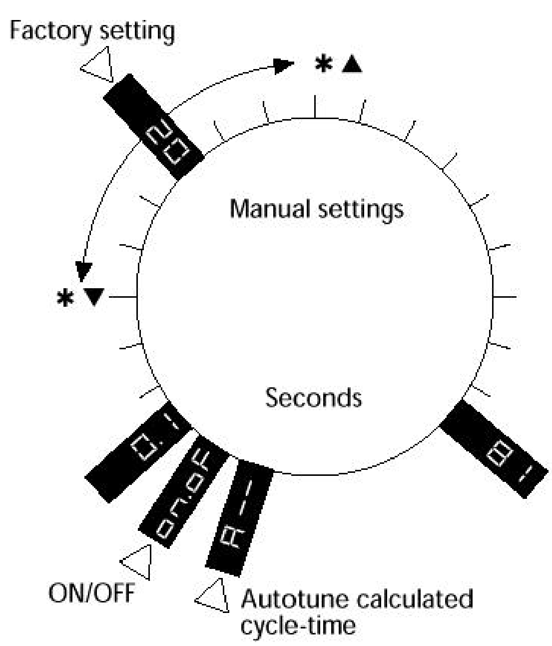
The controller will now run Autotune and will accept the calculated cycle-time.

To Pre-Select Cycle-time Before Autotune

Before selecting Autotune, enter program mode. Select ………………………………..

Press and hold the ✻ button, then press ▲ to increase or ▼ to decrease the displayed cycle-time. Release buttons when required value is displayed.

Select ……………………………………………………………………………………….
or index to another function then exit program mode.



RAMP-SOAK

This feature enables the controller to ramp up or down from current temperature to a target setpoint at a pre-determined rate. It then controls at the target setpoint for an adjustable soak period before switching off the heat output.

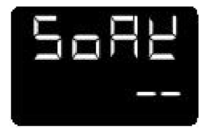
Set Ramp rate (0 to 9995 deg/hour)

Press ▲ and ▼ buttons for 3 seconds to enter program entry point

Press ▲ to scroll to
Press and hold ∗, then press ▲ or ▼ to scroll to required ramp value in the lower display

Set Soak (if required) 0 to 1440 minutes

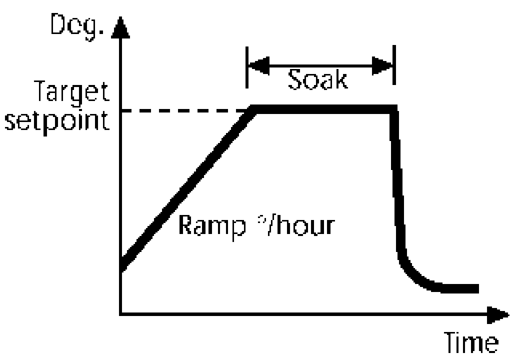
Press ▲ to scroll to

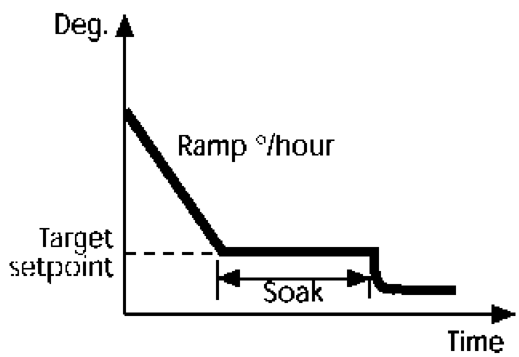


Press and hold ∗, then press ▲ or ▼ to scroll to required soak period in the lower display.

Set **Ramp On** (Off) : On : hold

Press ▲ to scroll to
Press and hold ∗, then press ▲ to select On





Exit program to enter settings into memory and commence ramp to target setpoint.

Notes

In **Ramp on** configuration, if power is removed from the controller, the Ramp will re-start when power is restored.

The **Ramp hold** option suspends the ramp at its last value.

If no **Soak** period has been set, control at target setpoint continues indefinitely.

SP2 deviation alarms follow the ramp setpoint and can be used to alarm “out of limits” ramp rate.

WARNING
The Soak timer is triggered when the ramp setpoint reaches the target setpoint. If the ramp rate is set too fast for the process, the Soak timer will be triggered before the process temperature reaches the target setpoint.

ERROR MESSAGES

SENSOR FAULT
Upper display alternates: **inPt** and **FaiL** Indicates: thermocouple burnout RTD/Pt100 open or short circuit or negative over-range.
Action: Check sensor/wiring

NON-VOLATILE MEMORY ERROR
Upper display alternates: **dAtA**and **FaiL** Action: De-power briefly.
Replace unit if problem persists

MANUAL POWER ERROR
Upper display alternates: **hAnd** and **FaiL** SP1 set to ON/OFF in **CYC.t**
Action: Select proportional mode

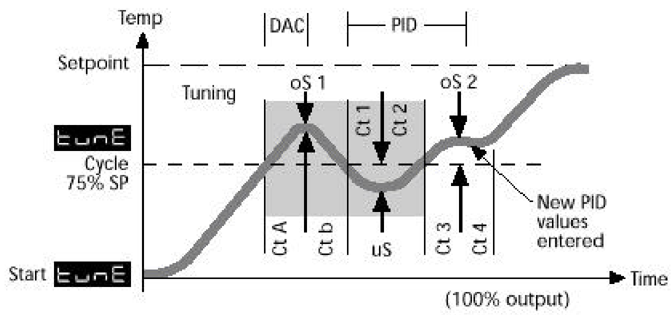
IMMEDIATE FAIL ON AUTOTUNE START
Upper display alternates: **PV tunE** and **FAiL**
Lower display 0
1. No setpoint entered.
Action: Enter setpoint
2. SP1 set to ON/OFF in
Action: Select proportional mode

Note: To reset and clear error press ▲▼ together briefly to cancel message.

FAIL LATER DURING AUTOTUNE CYCLE
The thermal characteristics of the load exceed the Autotune algorithm limits. The failure point indicated by any display 0.0 in ……………………………………………
e.g. Ctb = 0.0 see adjacent diagram.
Action: 1. Change the conditions. eg. raise setpoint
2. Try ………………………………………………………………………………
3. Check SP1.P percentage power
(see **IMPROVING CONTROL ACCURACY**)
4. If the error message persists, call CAL for advice.

READING AUTOTUNE TUNING CYCLE RESULTS IN tECh
1. Index to ……………………………………………………………………….
release ▲ or ▼, lower display will alternate **Ct.A** and value
2. Keep ✻ pressed and press ▲ once, the lower display will alternate **Ct.b** and value (eg. 19.6)
3. Repeat step 3 above to view:
Ct 1, Ct 2, Ct 3, Ct 4, oS 1, uS and **oS 2**.

Autotune tuning data and limits

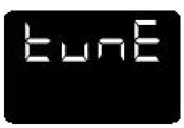


FUNCTION LIST (Levels 1 to 4)

LEVEL 1

Function Options [Factory settings] shown in brackets

SELECT AUTOTUNE



[oFF] on ParK At.Sp
Used to switch the Autotune feature on and off, to select **ParK**or Autotune at setpoint. **ParK**temporarily turns the output(s) off. To use select **ParK**and exit program mode. To disable re-enter program at **tunE** and select **oFF**.

SP1 OPERATING PARAMETERS

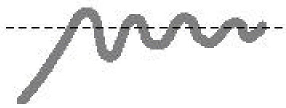
0.1 to * °C/°F [10ºC/18ºF]
SP1 proportional band/Gain or Hysteresis
* 25% sensor maximum
Proportional control eliminates the cycling of on-off control. Heater power is reduced, by time proportioning action, across the proportional band.

Too narrow
(oscillates)
increase **BAND**

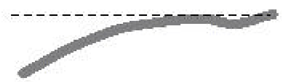
Too wide
(slow warm up and response)
decrease **BAND**

Function Options [Factory settings] shown in brackets

oFF 0.1 to 60 minutes [5.0]

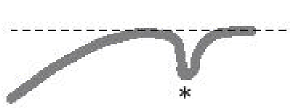


Too short
(overshoots and oscillates)



Too long
(slow warm up and response)

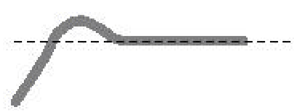
oFF 1 - 200 seconds [25]
SP1 derivate time/rate
Suppresses overshoot and speeds response to Disturbances



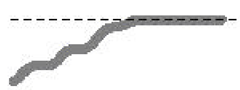
Too short
(slow warm up and response, under corrects)

Too long
(oscillates and over corrects)

0.5 - 5.0 x bAnd [1.5]
SP1 derivative approach control dAC
Tunes warm-up characteristics, independent of normal operating conditions, by controlling when derivative action starts during warm-up (smaller dAC value = nearer setpoint).



Too small
(overshoots)



Too large
(slow stepped warm up)

LEVEL 1 (continued)

Function **Options *[Factory settings] shown in brackets***

A - - on.oF 0.1 - 81 sec [20]
SP1 proportional cycle-time Determines the cycle rate of the output device for proportional control. Select **on.oF**for ON/OFF mode.

[0] to * °C/°F
SP1 offset/manual reset
±50% **bAnd**. Applicable in proportional and ON/OFF mode with integral disable: **Int.t oFF**.

[oFF] on
Lock main setpoint
Locks the setpoint preventing unauthorised adjustment.

PROGRAMMER SETTINGS

[0] to 9995 deg/hour
Sets the ramp rate

on [oFF] hoLd
Switches the ramp on or off, or hold at last ramp value

[oFF] 0 to 1440 min
Sets the soak time

There are a

series of
setting for the second set point ie SP2 but these are not used by the EMS 1000

LEVEL 2

Function **Options *[Factory settings] shown in brackets***
MANUAL CONTROL MODES

0 to 100 % 'read only'
Read SP1 output percentage power

[oFF] 1 to 100 % (not in ON/OFF)
SP1 manual percentage power control. For manual control should a sensor fail. Record typical SP1.P values beforehand.

100 to 0 % duty cycle [100]
Set SP1 power limit percentage. Limits maximum SP1 heating power during warm-up and in proportional band.

LEVEL 2 (Continued)

Function **Options *[Factory settings] shown in brackets***

INPUT SELECTION AND RANGING

[1] 0.1
Select display resolution: for display of process temperature, setpoint, **OFSt, Set.2, hi.SC, LoSC**.

sensor minimum [sensor maximum]
°C/°F
Set full scale

[sensor minimum] sensor maximum
°C/ºF
Set scale minimum (default 0°C or 32°F)

Select input sensor **[nonE]**

[nonE] °C °F bAr Psi Ph rh SEt
Select °C/°F or process units

LEVEL 3

OUTPUT CONFIGURATION

Note: ‘Read only’ after initial configuration. **rSET ALL**full reset to factory settings required to change **SPl.d** subsequently.

Function **Options *[Factory settings] shown in brackets***

[nonE] rLY SSd rLY1 rLY2 SSd1
Select SP1 output device

[nonE] SSd rLY rLY2 rLY1 SSd2
Read SP2 output device
(read only)

EMS 1000-1 does not use Set point 2

LEVEL 3

OUTPUT CONFIGURATION (continued)

Function Options ***[Factory settings] shown in brackets***

Sensor burn-out/break protection
Caution: Settings affect fail safe state.

	SP1	SP2
[uP.SC]	Upscale	Upscale
dn.SC	Downscale	Downscale
1u.2d	Upscale	Downscale
1d.2u	Downscale	Upscale

Select output modes: Direct/Reverse
Caution: Settings affect fail safe state.

	SP1	SP2
[1r.2d]	Reverse	Direct
1d.2d	Direct	Direct
1r.2r	Reverse	Reverse
1d.2r	Direct	Reverse

Select Reverse on SP1 for heating and Direct for cooling applications.

Select SP1/2 LED indicator modes

	SP1	SP2
[1n.2n]	Normal	Normal
1i.2n	Invert	Normal
1n.2i	Normal	Invert
1i.2i	Invert	Invert

[0.0] to ±25% sensor maximum
Sensor span adjust
For recalibrating to a remote standard e.g. External Meter, data logger.

[0.0] to ±25% sensor f/s
Zero sensor error, see SPAn

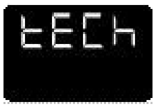
[oFF] on
Select control accuracy monitor

[Var] hi Lo
Read control accuracy monitor

LEVEL 3

OUTPUT CONFIGURATION (continued)

Function Options ***[Factory settings] shown in brackets***



[Ct A] **CT b** **Ct 1** **Ct 2** **Ct 3**
Ct 4 **oS** **1 uS** **oS 2**

Refer to the Autotune tuning cycle data

Software version number

[nonE] ALL
Resets all functions to factory settings

Caution: Note current configuration before using this function, otherwise initial configuration and OEM settings must be re-entered.

LEVEL 4

Access to level 4 is gained through …………………………………………… in level 3.

Press and hold ▲ and ▼ for 10 seconds.

Enter level 4 at **Lock**, release ▲ and ▼ together.
Display reads ……………………………………………………………………..

Program security using Lock

Select from three **Lock** options:

Press and hold ✻, press ▲ to index.

LEV.3 locks level 3 and 4 only- Technical Functions.

LEV.2 locks levels 2, 3 and 4 only - Configuration and Technical Functions.

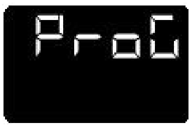
ALL locks all functions

Note: Locked functions and options may be read.

LEVEL 4 (continued)

Function Options ***[Factory settings] shown in brackets***

Press ▼ to access following functions



[Auto] StAY
Program mode auto-exit switch
Auto-exit returns display to normal if 60 seconds of key inactivity, select StAY to disable

[oFF] on
Disable SP2 alarm annunciator -AL-Select on to disable-AL-

dir 1 to 32 [6]
Display sensitivity
dir= direct display of input **1** = maximum, **32**= minimum sensitivity

0.1 to 1.0 [0.5]
Derivative sensitivity

CALIBRATION TO ANOTHER INSTRUMENT

If the controller and instrument readings are different, the

and/or

function in Function Menu Level 3 will require adjustment.

Adjust **zero** to make an equal adjustment across the full scale of the controller and **span** to make a correction when the error increases/decreases across the scale.

1 To adjust using the **zero** function

1.1 Substitute measured values in the expression:
Instrument reading – controller reading = **zero**

Example:

Instrument reading = 396°
Controller reading = 400°
396 – 400 = (-)4°

1.2 Adjust **zero** to (-) 4° to correct error.
To make a correction when there are different errors across the scale.

2 Adjust using the **span** function

2.1 Chose a temperature near the bottom and another near the top of the scale.

2.2 Run the process at the lower temperature (**T1**). Note the error (**E1**) between the controller and the instrument readings.

2.3 Repeat at the upper temperature (**T2**) and note error (**E2**).

2.4 Substitute the values for **T1 , T2 , E1** and **E2** in the expression below to calculate

$$\frac{\mathbf{E2 - E1}}{\mathbf{T2 - T1}} \mathbf{\ X\ hi.SC = SPAn}$$

For **hi.SC** settings see level 2.

Example:	T1	T2
Instrument reading	58°	385°
Controller reading	60°	400°
Error	**E1**(-) 2°	**E2**(-) 15°

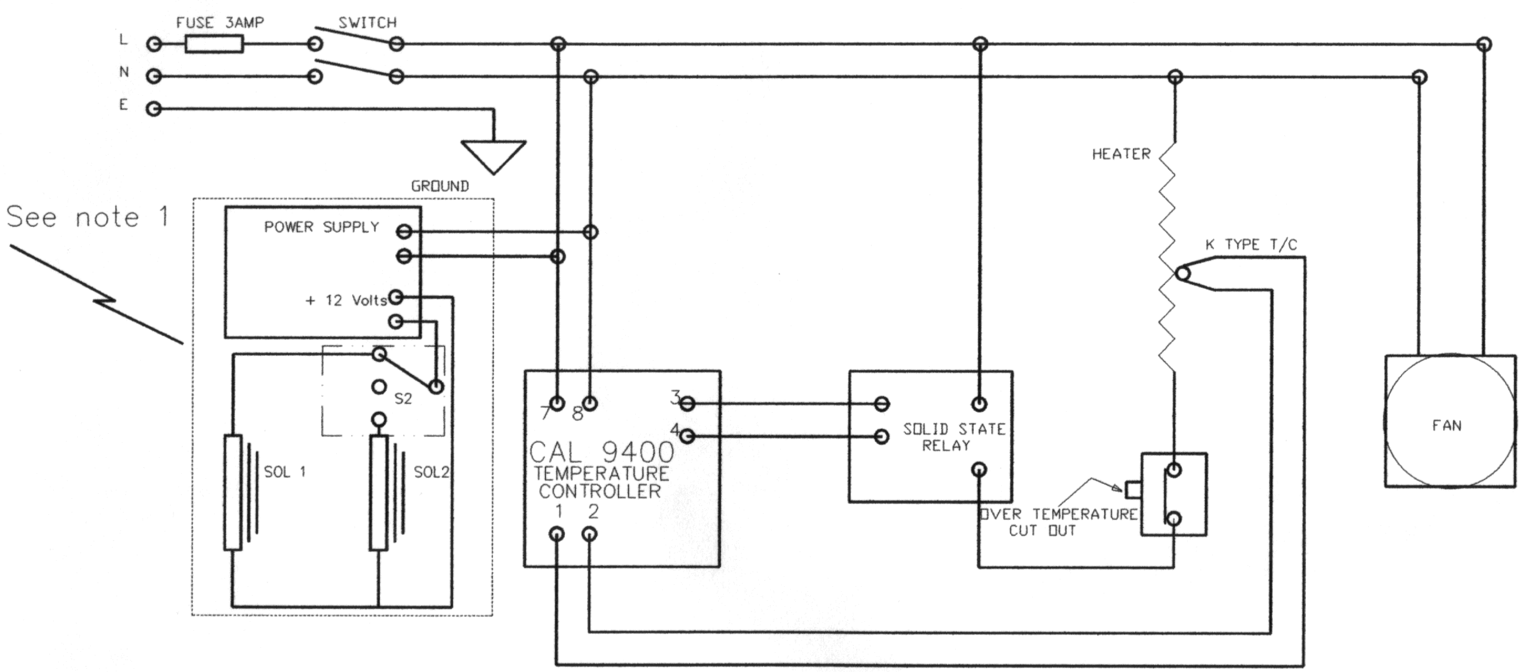
$$\frac{(-15) - (-2)}{385 - 58} \times 450 = \frac{(-13) \times 450}{327} = (-)17.9$$

2.5 Therefore adjust **span** to (-) 18 to correct error.

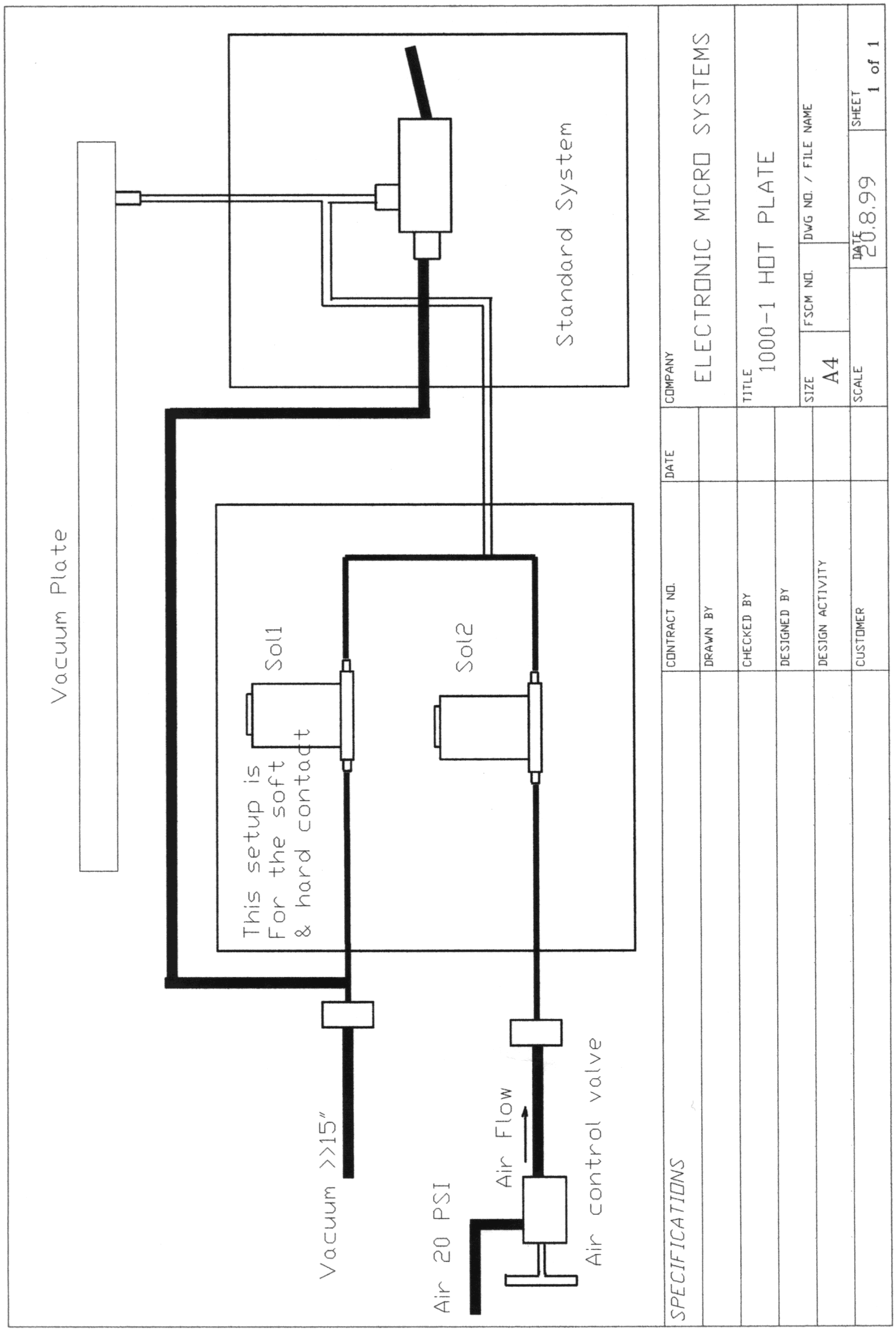
Notes:

(1) After making the adjustment the reading will immediately change. Allow time for the temperature to stabilise at **T2** before making any further adjustment.
At this point, a **zero** adjustment may be needed, refer to step 1 above.

(2) Check that the temperature correctly stabilises at **T2** and then adjust setpoints to **T1**. If an error is resent at **T1** repeat from step 2.



SPECIFICATIONS Note 1	CONTRACT NO.	DATE	COMPANY
Sol 1 & Sol2 only on special plates to order	DRAWN BY		ELECTRONIC MICRO SYSTEMS
	CHECKED BY		TITLE E.M.S. 1000-1 HOT PLATE
	DESIGNED BY		
	DESIGN ACTIVITY		SIZE A4 | FSCM NO. | DWG NO. / FILE NAME
	CUSTOMER		SCALE | DATE 10.5.93 | SHEET 1 of 1


Vacuum Plate
Standard System
Sol1
Sol2
This setup is
For the soft
& hard contact
Vacuum >>15"
Air 20 PSI
Air Flow
Air control valve
SPECIFICATIONS
CONTRACT NO.
DRAWN BY
CHECKED BY
DESIGNED BY
DESIGN ACTIVITY
CUSTOMER
DATE
COMPANY
ELECTRONIC MICRO SYSTEMS
TITLE
1000-1 HOT PLATE
SIZE
A4
FSCM NO.
DWG NO. / FILE NAME
SCALE
DATE
20.8.99
SHEET
1 of 1