Laboratory Equipment Pty Ltd

INSTRUCTION MANUAL
MUFFLE FURNACES

Laboratory Equipment Pty Ltd
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Introduction
This Instruction Manual is for the guidance of operators of Laboratory Equipment furnaces and should be read before the furnace is connected to the electricity supply.

It is hoped that this manual will supply all the information that the customer should require for satisfactory operation of the furnace. If, however, there are any questions that remain unanswered then the customer should contact our Service Department.
Please quote the furnace type and serial number from the furnace rating label in all communications with Laboratory Equipment.

Unpacking
Remove all packing and protective wrapping from both the interior and exterior of the furnace. Check the furnace for any possible transit damage. Ensure all ordered accessories are present. If any physical damage or shortage is evident, do not discard the packaging material until the furnace is inspected by the distributor, agent or manufacturer.
NOTE: All claims for shortage or damage must be made within fourteen days (14) from delivery.
Subject to our standard published conditions of sale, we have reasonable grounds to believe that we have ensured, so far as is reasonably practicable that the products listed in our catalogue and brochures have been designed and constructed so as to be safe and without risk to health when properly installed and used in their environment by appropriate and trained personnel, and where applicable, in accordance with our published instructions.

Warranty
Laboratory Equipment guarantees this furnace against faulty parts and workmanship for a period of 12 months from the date of purchase. Silicone Carbide elements are covered for 6 months under normal working conditions, Molybdenum disilicide elements carry no warranty. Should any fault occur during the warranty period, other than those caused by neglect or physical damage, Laboratory Equipment will, at its discretion, repair or replace the faulty parts or equipment upon their return to the Laboratory Equipment factory, freight prepaid. Laboratory Equipment accepts no liability for consequential loss or damage caused through operation or malfunction of the furnace.

If the furnace is being operated overseas, advise Laboratory Equipment of the nature of the problem before return and instructions will be given on the removal and replacement of faulty parts to avoid return of complete furnace.

Installation Electrical
This equipment must be tagged and tested according to AS/NZS3760:2010 prior to use and thereafter on a regular basis dependent upon the environment.

It is preferable to locate the furnace close to a powerpoint and it is recommended that double adaptors are not used. Check the total wattage if connecting to multi point outlets. Check the rating plate for power requirements. Installation is to be carried out by a qualified electrician in accordance with the power requirements of the product specifications.

Initial Operation
The first time that the furnace is operated water vapour (steam) will be given off. Some of this steam may condense on the front of the furnace and drip onto the bench below. The case will be hotter than usual as some of the steam condenses on the inside of the furnace case. Heat up rates will also be slightly slower during the initial firing. The water vapour comes from atmospheric moisture that is absorbed by the ceramic fibre insulation during storage. A normal burn in period is 6-8 hours at 1000°C. After burn in and prior to first use (when cool) wipe the residual dust caused during shipment from the furnace with a damp cloth.

Description of Controls
SEE APPENDIX A
SEE ENCLOSED CD - If fitted with a Eurotherm Nanodac Controller.
SEE WEBSITE FOR EPC3016-
https://www.eurotherm.com/au/products/temperature-controllers-au/single-loop-temperature-controllers-au/epc3000-programmable-controllers/

Factors Influencing Furnace Life

Corrosive Materials
Materials such as sodium containing compounds, fluxes, case hardening compounds, acids and other reactive salts readily penetrate the ceramic lining of the chamber and attack the elements; they may also cause the chamber lining to melt.

When using such materials the furnace must be protected and care must be taken to avoid contamination of the furnace lining. The best method is to use a replaceable work-tube or hearth plate.

Metal Work Pieces
Care should be taken to avoid melting metal into the chamber walls. If metal is melted into the chamber walls the furnace should be switched off immediately. The heating element is cast into the chamber walls, and electricity can be conducted from the element if metal is melted into the walls. The element will need to be replaced to continue operation of the furnace.

Operating Temperature
Although the furnace is designed to operate at the maximum temperature, element life can be significantly prolonged by avoiding unnecessary operation at temperatures around the maximum.

Operating Time
The element deteriorates with time in operation so turning the furnace off when not in use saves element life as well as electricity. Unlike silicon carbide elements, there is no advantage in leaving the furnace switched on.

Use for "Burning Off"
If the furnace is regularly used for burning off materials (especially dental technicians and jewellers) it should be occasionally heated to above 800ºC to remove carbon residues from the chamber. The vent tube at the rear should be checked regularly to ensure that it has not been blocked by condensed residue.

Ceramic Tube Installation
A ceramic tube is included with the furnace. This tube should slide through the hole in the rear of the furnace and allows natural venting. DO NOT fix the tube into position as it should be able to move. Position it evenly between the inner liner and outer rear wall. The tube should angle slightly upwards at the rear as it allows for natural convection. Remove the tube and fill the hole with fibre wool if a more sealed environment is required.

Ashing Furnace to AS1038.4-1995 air/gas inlet tube connection.
Two ceramic tubes are fixed into the furnace. These will be mounted either above or below the furnace ceramic muffle. These tubes flow into slits between the front tile and ceramic muffle. The inlet to the tubes are located at the rear of the furnace. The tubes stop inside the stainless steel sheet metal casing.

Thermocouple
It is advised to check the thermocouple output periodically, either by a calibration test, or by comparing the output with a new reference thermocouple which has been subjected to high temperature for a minimum length of time. Connections for the thermocouple are at the rear behind the rear cover.

Failure to check the thermocouple may result in overheating of the load and furnace.

Safety Controller

The furnace is fitted with an inbuilt overheat safety protection being Alarm 4 (AL4 = High). It must be set to slightly above the desired set point temperature and will prevent overheating. It will maintain the Alarm Set Value. Change the AL4 value to slightly above the set point temperature as set out in the instruction page. The Alarm will be activated if the furnace exceeds the AL4 value or if the sensor is broken or damaged. If the alarm activates ALM will flash. Reset after temperature falls or fault repaired by pressing Menu and Scroll Keys together for 1 second to acknowledge the alarm (Ack).

Troubleshooting

SYMPTOM	REMEDY
Furnace does not heat - Temperature Controller lights Off.	1. Check the furnace plugged in and power switched on. 2. Check that power is available from the power socket by plugging another appliance into the power socket. 3. Call Laboratory Equipment or your local agent for assistance. 4. Check internal RCD has not tripped.
Furnace does not heat - Temperature Controller OP1 and ALM lights are on.	1. Reset alarm (Ack) 2. Check that ramp rate is set correctly; 3. Check door microswitch is engaged. 4. Possible fault relay or element call Laboratory Equipment or your local agent for assistance.
Furnace does not heat - Temperature Controller OP1 is on and ALM light is off.	1. Check that timer is set correctly; 2. Check that timer is reset (i.e. turn off/on); 3. Check door microswitch is engaged. 4. Possible faulty controller - call Laboratory Equipment or your local agent for assistance.
Furnace does not heat - Temperature Controller is indicating *SbEr.*	1. Thermocouple is faulty or has poor connection - check thermocouple and if necessary order replacement from Laboratory Equipment or your local agent.
Furnace overheats - Temperature Controller OP1 light is on.	1. Thermocouple lead wires shorted; 2. Thermocouple removed from furnace; 3. Thermocouple faulty; 4. Call Laboratory Equipment or your local agent for assistance.
Furnace overheats - Temperature Controller OP1 light is off.	1. Relay stuck on. Switch power off and call Laboratory Equipment or your local agent for service.
Temperature indicator reads backwards.	1. Thermocouple connected the wrong way around.

Safety Information
Isolate the furnace from the electrical supply before changing elements or thermocouples or undertaking other routine maintenance. Ensure that the furnace is cold.

When reconnecting the furnace, ensure that the electrical connections are sound including earth supply continuity.

Wear appropriate safety clothing when operating the furnace including a heat resistant face shield (tinted for eye protection), gloves and apron.

Load and unload "hot" work with furnace tongs.

Do NOT use the furnace in the presence of inflammable or combustible chemicals; fire or explosion may result.

To avoid fire, do not expose combustible materials to heat from the open furnace door.

Safety Note Insulation
This furnace contains refractory fibres in its thermal insulation. The materials used may be in the form of fibre blanket or felt, vacuum formed board or shapes, mineral wool slab or loose fill fibre. Normal use of the furnace will not result in any significant level of airborne dust from these materials; but much higher levels may be encountered in maintenance or repair.

Whilst there is no evidence of any long-term health hazards, we strongly recommend that safety precautions are taken whenever the materials are handled.

Exposure to dust from fibre which has been used at high temperature may cause respiratory disease.

When handling fibre always use an approved mask, eye protection, gloves and long sleeved clothing.

After handling, rinse exposed skin with water and wash work clothing separately.

Before commencing any major repairs we recommend reference to:
- ECFIA Bulletin Number 11
- Guidance Note EH46 (U.K. Health and Safety Executive.)

We will be pleased to provide further information on request. Our Service Department will quote any repairs to be carried out on site at your premises or at our works.

Declaration of Conformity
Each product is thoroughly inspected and tested to not only ensure that it meets the specifications provided, but to also meet Australian Electrical Standard AS3820 and EMC Standard AS/NZ1044:1995,and therefore being accredited with a C Tick label.

Appendix A

Eurotherm Controllers 3216, 2416 and 2404 Instructions

The control panel is fitted with two controls: an ON/OFF SWITCH, and a TEMPERATURE CONTROLLER.

On/Off Switch
The On/Off switch isolates mains power to the temperature controller and to the solid state relay.
If access to electrical connections inside the equipment is required, ensure that the electrical power is switched off where the equipment is connected to the main supply.

Temperature Controller
The Eurotherm microprocessor temperature controller has the facility for a single ramping rate and then hold function. To set up a full program in °C/seconds/minutes/hours you must purchase the fully programmable optioned controller.

Indicator and Button Functions
The Eurotherm controller has the following buttons and indicators:

Indicator or button	Name	Function
OP1	Output 1	When lit, this indicates that the element output is on.
ALM	Alarm 4	When lit, this indicates that an alarm condition exists.
	Page button	Press to select a new list of parameters.
	Scroll button	Press to select a new parameter in a list.
	Down button	Press and release to view the set point or a selected parameter. Keep pressed to decrease the value.
	Up button	Press and release to view the set point or a selected parameter. Keep pressed to increase the value

Display
The display normally indicates actual temperature or parameter mnemonic and it will indicate set point temperature or parameter value when up or down keys are pressed.

Changing the Set Point (standard model)
Press the up and down arrows until the desired set point is displayed. Allow the controller to flash (store the value into memory). Nothing else is required to set or change the temperature.
If a non programmable controller is fitted now set the safety thermostat or set Alarm point (AL4) if required.

Changing the Set Point, Ramp Rate and Hold Timer (if programmable model is fitted)
The temperature controller's normal display shows the actual temperature. The set point can be changed using the /\ or \/ buttons and the equipment will hold at that temperature.
Pressing the scroll button once changes the display to **oP** or % output power.
Pressing the scroll button again changes the display to **Sprr** or set point ramp rate and

can be set to either OFF or from 1 to 60°C/min
Pressing the scroll button again changes the display to **dwEll** or set point hold time and can be set to either off or 999.9 minutes.
Pressing the scroll button again changes the display to **StAt** or program status and can be set to **on** or **off**. In the on status, the dwell timer will function, in the off status the controller ignores the dwell setting. The status will change to off automatically when the dwell period ends.

Autotune List (only perform if fault found or recalibrating)
Pressing the Page key once changes the display to the Autotune list **Atun**.
Pressing the Scroll key changes the display to **tune** or tune function selection. Auto tune may now be selected using the Λ or V buttons.

PID List
Pressing the Page key again changes the display to the PID List **PID**.
Pressing the Scroll key changes the display to **Pb**, **ti**, **td**, **Hcb**, and **Lcb**. The values for these may be accessed and changed using the Λ or V buttons. A full description of their meanings is in the Tuning section.

Operating the Equipment
When the equipment is first turned on the controller will carry out self checks and then start controlling at the set point value.
Set the parameters detailed in the manual.
To reset the controller after dwell end (**End**) or other alarm press the PAGE and SCROLL keys simultaneously. If a ramp dwell program is to be run again set status back to **on**.
When running the equipment at a new temperature that varies more than about 25% from the previous temperature it may be necessary to run the auto tuning program to reset the PID parameters. **The equipment will overshoot the set point when running the auto tune program especially at low temperatures.**

Error Messages

Alarm	What it means	What to do about it
FSH1	*Full Scale High Alarm:* The equipment measured temperature has exceeded the equipment maximum temperature.	This fault may be caused by a faulty solid state relay or by exothermic reaction of the equipment load. Reset the alarm by pressing the Page and Scroll buttons simultaneously and check the operation of the solid state relay.
EE.Er	*Electrically Erasable Memory Error:* The value of an operator or configuration parameter has been corrupted.	This fault will automatically take you into configuration level. Check all of the configuration parameters before returning to operator level. Once in operator level, check all of the operator parameters before resuming normal operation. If the fault persists or occurs frequently, contact Laboratory Equipment Pty Ltd.
S.br	*Sensor Break:* Input sensor is unreliable or the input signal is out of range.	Check that the sensor is correctly connected.

L.br	*Loop Break:* The feedback loop is open circuit.	Check that the heating and cooling circuits are working properly.
Ld.f	*Heater circuit fault:* Indication that the power controller device has detected a fault in the heating circuit.	Check the functioning of the power control device and heating circuit. (E.g. fuse failure).
LLLL	*Out of range low reading*	Check the value of the input
HHHH	*Out of range high reading*	Check the value of the input
Err1	*Error 1:* ROM selftest fail	Return the controller for repair
Err2	*Error 2:* RAM selftest fail	Return the controller for repair
Err3	*Error 3:* Watchdog fail	Return the controller for repair
Err4	*Error 4: Keyboard failure* Stuck button or a button was pressed during power up.	Switch the power off and then on without touching any of the controller buttons.

Tuning

In tuning, you match the characteristics of the controller to those of the process being controlled in order to obtain good control. Good control means:

- Stable, ‘straightline’ control of the temperature at set point without fluctuation.
- No overshoot, or undershoot, of the temperature set point.
- Quick response to deviations from the set point caused by external disturbances, thereby rapidly restoring the temperature to the set point value.

Tuning involves calculating and setting the value of the parameters listed in Table 41. These parameters appear in the ‘Pid’ list.

Table 41 Tuning parameters

Parameter	Code	Meaning or Function
Proportional band	Pb	The bandwidth, in display units, over which the output power is proportioned between minimum and maximum.
Integral time	ti	Determines the time taken by the controller to remove steadystate error signals.
Derivative time	td	Determines how strongly the controller will react to the rateofchange of the measured value.
High Cutback	Hcb	The number of display units, above set point, at which the controller will increase the output power, in order to prevent undershoot on cool down.
Low cutback	Lcb	The number of display units, below the set point, at which the controller will cut back the output power, in order to prevent overshoot on heat up.

Relative cool gain	rEL	Only present if cooling has been configured and a module is fitted. Sets the cooling proportional band: divide the Pb value by the rEL value.

AUTOMATIC TUNING

TWO AUTOMATIC TUNING PROCEDURES ARE PROVIDED IN THE 2408 AND 2404: ● A one shot tuner, which automatically sets up the initial values of the parameters listed in Table 41 on the previous page.

● **Adaptive tuning,** which continuously monitors the error from set point and modifies the PID values, if necessary.

Oneshot Tuning

The 'oneshot' tuner works by switching the output on and off to induce an oscillation in the measured value. From the amplitude and period of the oscillation, it calculates the tuning parameter values.

If the process cannot tolerate full heating or cooling being applied during tuning, then the level of heating or cooling can be restricted by setting the heating and cooling power limits in the 'oP' list. However, the measured value *must* oscillate to some degree for the tuner to be able to calculate values.

A Oneshot Tune can be performed at any time, but normally it is performed only once during the initial commissioning of the process. However, if the process under control subsequently becomes unstable (because its characteristics have changed), you can retune again for the new conditions.

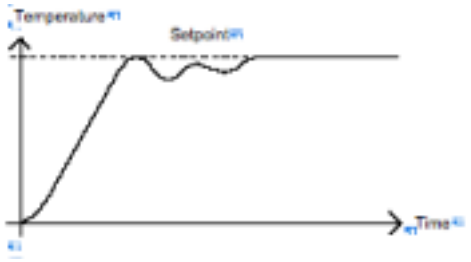
It is best to start tuning with the process at ambient temperature. This allows the tuner to calculate more accurately the low cutback and high cutback values which restrict the amount of overshoot, or undershoot.

How to tune

1. Set the set point to the value at which you will normally operate the process. 2. In the 'Atun' list, select 'tunE' and set it to 'on'.
3. Press the Page and Scroll buttons together to return to the Home display. The display will flash 'tunE' to indicate that tuning is in progress.
4. The controller induces an oscillation in the temperature by first turning the heating on, and then off. The first cycle is not complete until the measured value has reached the required set point.
5. After two cycles of oscillation the tuning is completed and the tuner switches itself off.
6. The controller then calculates the tuning parameters listed in Table 41 and resumes normal control action.

If you want 'Proportional only', 'PD', or 'PI' control, you should set the 'ti' or 'td' parameters to OFF before commencing the tuning cycle. The tuner will leave them off and will not calculate a value for them.

Typical automatic tuning cycle



Calculation of the cutback values

Low cutback and *High cutback* are values that restrict the amount of overshoot, or undershoot, that occurs during large step changes in temperature (for example, under start-up conditions). If either low cutback, or high cutback, is set to 'Auto' the values are fixed at three times the proportional band, and are not changed during automatic tuning.

Adaptive tune

Adaptive tuning is a background algorithm, which continuously monitors the error from set point and analyses the control response during process disturbances. If the algorithm recognises an oscillatory, or underdamped response, it recalculates the Pb, ti and td values. Adaptive tune is triggered whenever the error from set point exceeds a trigger level. This trigger level is set in the parameter 'drA.t', which is found in the Auto tune list. The value is in display units. It is automatically set by the controller, but can also be manually readjusted.

Adaptive tune should be used with:

1. Processes whose characteristics change as a result of changes in the load, or set point.
2. Processes that cannot tolerate the oscillation induced by a Oneshot tune.

Adaptive tune should not be used:

1. Where the process is subjected to regular external disturbances that could mislead the adaptive tuner.
2. On highly interactive multi loop applications. However, moderately interactive loops, such as multizone extruders, should not give a problem.

MANUAL TUNING

If for any reason automatic tuning gives unsatisfactory results, you can tune the controller manually. There are a number of standard methods for manual tuning. The one described here is the ZieglerNichols method.

With the process at its normal running temperature:

Set the Integral Time 'ti' and the Derivative Time 'td' to OFF.

Set High Cutback and Low Cutback, 'Hcb' and 'Lcb', to 'Auto'.

Ignore the fact that the temperature may not settle precisely at the set point. If the temperature is stable, reduce the proportional band 'Pb' so that the temperature just starts to oscillate. If the temperature is already oscillating, increase the proportional band until it just stops oscillating. Allow enough time between each adjustment for the loop to stabilise. Make a note of the proportional band value 'B' and the period of oscillation 'T'.

Set the Pb, ti, td parameter values according to the calculations given in Table 42.

Table 42 Tuning values

Type of control	Proportional band 'Pb'	Integral time 'ti'	Derivative time 'td'
Proportional only	2xB	OFF	OFF
P + I control	2.2xB	0.8xT	OFF
P + I + D control	1.7xB	0.5xT	0.12xT

Setting the cutback values

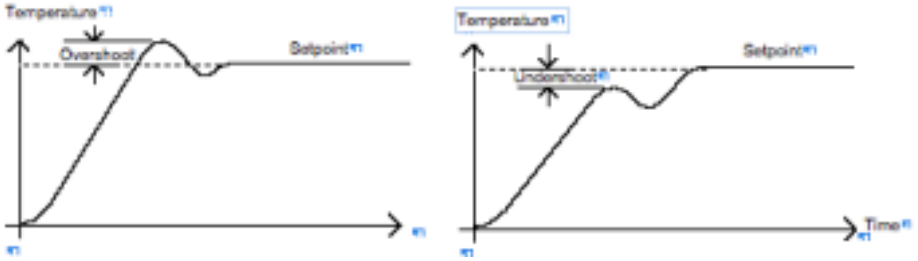
The above procedure sets up the parameters for optimum steady state control. If unacceptable levels of overshoot or undershoot occur during start-up, or for large step changes in temperature, then manually set the cutback parameters ‘Lcb’ and ‘Hcb’.

Proceed as follows:

1. Set the low and high cutback values to three proportional bandwidths (that is to say, Lcb = Hcb = 3 x Pb).
2. Note the level of overshoot, or undershoot, that occurs for large temperature changes (see the diagrams below).

In example (a) increase ‘Lcb’ by the overshoot value. In example (b) reduce ‘Lcb’ by the undershoot value.

Example (a) Example (b)



Where the temperature approaches the set point from above, you can set ‘Hcb’ in a similar manner.

Integral action and manual reset

In a full three term controller (that is, a PID controller), the integral term ‘ti’ automatically removes steady state errors from the set point. If the controller is set up to work in two term mode (that is, PD mode), the integral term will be set to ‘OFF’. Under these conditions the measured value may not settle precisely at set point. When the integral term is set to ‘OFF’ the parameter *manual reset* (code ‘rES’) appears in the ‘Pid LiSt’ in ‘FuLL’ level. This parameter represents the value of the power output that will be delivered when the error is zero. You must set this value manually in order to remove the steady state error.

Automatic droop compensation (Adc)

The steady state error from the set point, which occurs when the integral term is set to ‘OFF’ is sometimes referred to as ‘droop’. ‘Adc’ automatically calculates the manual reset value in order to remove this droop. To use this facility, you must first allow the temperature to stabilise. Then, in the auto tune parameter list, you must set ‘Adc’ to ‘on’. The controller will then calculate a new value for manual reset, and switch ‘Adc’ to ‘OFF’. ‘Adc’ can be repeated as often as you require, but between each adjustment you must allow time for the temperature to stabilise.

Safety Thermostat (if fitted)

The chamber is fitted with an overheat safety protection thermostat. It must be set to slightly above the desired set point temperature and will prevent overheating. It will maintain the set value only and will not switch off the chamber. Change the thermostat value to slightly above the set point temperature once the temperature has stabilized at the set value on the controller, then turn back the thermostat until it “clicks” at this point it will switch off the heaters. Turn it clockwise again until it “clicks” on again and then continues turning so it is around 5°C above the set value on the controller. The safety thermostat is now set to turn off the heaters should it overheat. Setting the thermostat simply by using the numbers on the dial may cause the

thermostat to interfere with the operation of the chamber. To be sure, set it using the “click” method outlined above.

Eurotherm Controller Instructions for Manual Calibration

Indicator and Button Functions

The Eurotherm controller has the following buttons and indicators:

Indicator or button	Name	Function
	Page button	Press to select a new list of parameters. (Left most key)
	Scroll button	Press to select a new parameter in a list.(2nd key from left)
	Down button	Press and release to view the set point or a selected parameter. Keep pressed to decrease the value.
	Up button	Press and release to view the set point or a selected parameter. Keep pressed to increase the value

1. Press and hold in the Menu (left most key) until LVL3 appears on the screen.
2. The controller will then ask for the COD (password) enter 3 using the up arrow.
3. If successful push Menu once to display INPUT.
4. Press (not hold) the Scroll buttons (2nd key from left) until it displays PV.OFS. Change this value using up and down keys only to calibrate the temperature on your external logger.
5. Then press the Menu key until ACCES is displayed. Press the Scroll button once to display LVL3 and GOTO. Use the down arrow to change to LVL1.
6. Controller will flash and return to the main user screen.