Operating and Maintenance Handbook

EBHC ELECTRON BOMBARDMENT HEATER TEMPERATURE CONTROLLER

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WARRANTY

1. Subject to fair wear and tear and the due, observance of any installation user, storage, operating or maintenance instructions the Seller undertakes to replace or, at its option repair free of charge to the purchaser, any goods which the purchaser can establish are defective by reason of defective workmanship or materials which are returned to the Seller, carriage paid, within 12 months of the date of dispatch by the Seller. In the event, however, that the Seller supplies spare parts either direct, or that are fitted or installed or replaced by the Sellers' service center such spare parts will be subject to a warranty period of six months only.
2. The Purchaser cannot return any product for warranty repair without the prior approval of VACGEN and the issue of a Goods Return Number (GRN). This shall be obtained by contacting the service center at VACGEN. All returned products must be accompanied by a completed Declaration of Contamination form. Customers must, in the first instance, contact the local selling agent.
3. We reserve the right to decline to service equipment, we consider is in any way hazardous until a clearance or safety certificate, in a form satisfactory to VACGEN, has been completed and returned by the customer.

REPAIR

The following additional terms and conditions apply in the event that the customer elects to use the services of VACGEN workshop on a chargeable basis.

1. At its own cost the customer shall dispatch the equipment to the workshop, carriage paid, suitably packaged, protected and insured, bearing, a Goods Return Number (GRN)and a completed Declaration of Contamination certificate obtained from VACGEN in advance of shipment.
2. During the period that the equipment is on VACGEN premises, VACGEN will insure the equipment against all risks.
3. Vacuum Generator will provide an acknowledgement of the receipt together with an estimate of the repair charges. Such estimates are carried out on a visual basis and are therefore intended as a guide only. Formal fixed price repair quotations are available and involve the disassembly of the equipment to determine the full extent of the work necessary to restore the equipment to an acceptable standard. In the event that the customer chooses not to proceed with the repair VACGEN will make a charge to cover this examination effort.

Note:
The above are extracts from VACGEN Conditions of sale. Complete copies can be obtained from: VACGEN, Diamond Drive, Hailsham, BN27 4EL, UK, Phone 0044 1323 379335

Warnings

This equipment must be installed by qualified personnel.

Refer to the Operating Instructions for the proper use and maintenance of this equipment. Failure to observe these instructions may result in safety hazards.

Service work must only be carried out by personnel who are aware of the potential risks of working on live equipment.

The front panel mains switch must not be relied upon to provide adequate isolation from the mains supply for servicing or maintenance purposes. If full isolation is required, remove the mains input cable.

The EBHC generates potentially lethal voltages. Great care must be taken to ensure that no contact is made with the filament connections when the power supply is energised. Allow at least two minutes after switching off for the high voltage capacitors to discharge before handling any of the connections. The high voltage power supply delivers up to 650Vdc to the filament, and has sufficient power capability to cause serious injury if contact is made when energised.

The user should be aware of the potentials that may exist on the vacuum feedthrough connections. Avoid contact with the VG Thermocouple vacuum feedthroughs if the VG Thermocouple function is not grounded.

Equipment must be fully earthed to prevent dangerous electrostatic charge build-up.

It is the responsibility of the user to consider the safety requirements of hazardous materials used with this equipment and the consequence of any leakage, however caused. Consider possible reactions with materials of construction. Any equipment returned to VACGEN must have the correct Declaration of Contamination securely fastened to the outside of the packaging.

Take great care when changing any of the temperature control loop parameters; this could have a serious effect on the stability of the control system.

Do not operate the EBHC with any of the cabinet covers removed.

If in doubt contact VACGEN.

Important Notes

Attention is drawn to the following points which all users must be aware of. Please confirm that your EBHC has been received as specific and check the following -

1) The mains supply voltage setting is correct; this should be 220-240Vac or 110-120Vac, this will be identified on the rear panel.

2) The style of supplied mains cable assembly for the territory requested is correct.

3) The supplied VG Thermocouple cable assembly and type is correct.

4) The Power Output cable assembly has been supplied.

5) The communications hardware and software are included (if ordered). Note that the hardware will have been fitted to temperature controller.

6) The Eurotherm Handbook(s), as applicable, have been supplied.

7) The Accessories Pack - fuses and mating connector(s), have been supplied.

If the EBHC has not been supplied as expected, or something is missing, please contact VACGEN Sales Department, or your local Agent. If the EBHC has been received damaged inform the local carrier, the local agent, and/or VACGEN Sales Department. Retain all packaging in case the unit needs to be returned to VACGEN.

VACGEN product codes relating to the EBHC are listed below with a brief description -

ZEBHC Electron Bombardment Heater Controller 'K' VG Thermocouple, 220-240VAC
ZEBHCL Electron Bombardment Heater Controller 'K' VG Thermocouple, 110-1 20VAC
ZEBHCN Electron Bombardment Heater Controller 'N' VG Thermocouple, 220-240VAC
ZEBHCNL Electron Bombardment Heater Controller 'N' VG Thermocouple, 110-1 20VAC
ZEUCOMS8 Communications Hardware and Software Option, RS485
ZEUCOMS2 Communications Hardware and Software Option, RS422
ZEUCOMS3 Communications Hardware and Software Option, RS232
VACGEN requires a Declaration of Contamination to be included with any equipment returned for repair or service. Full details of this requirement are given in the Warranty section.

1.0 Introduction

The EBHC has been designed to be a simple to use, robust, user definable and accurate electron bombardment heater temperature controller which, together with the optional communications facility, makes this unit a very powerful package. The unit is 3U high, full rack width, and is compliant with relevant EU directives. A brief overview of the features of the EBHC, and the construction of the heater module, is given below.

1.1 Cables

The EBHC is supplied as standard with a mains IEC cable assembly.

Warning: The fuse in the supplied mains cable assembly is designed to protect the cord set only. You must ensure that the mains input fuse to the EBHC is of the correct type and value for your territory.

An output cable assembly and a VG Thermocouple compensating cable are also included to connect the EBHC to VACGEN vacuum feedthroughs. The EBHC must also be earthed via the rear panel stud provided, use 2.5mm^2 cable or braid connected to your system 'star-point' earth.

1.2 Filament Output Power

The maximum output voltage is 30Vac up to a maximum current of 2.5A. This covers standard VACGEN electron bombardment heater types and temperature ranges, and any other heater assembly with requirements that match the power (VA) limits. The maximum output current can be set to protect heater filaments from excess current, and/or used directly as an output level control to prevent excess temperature overshot.

1.3 VG Thermocouple

Most VG Thermocouple types can be accommodated with automatic cold-junction compensation. The EBHC will usually be configured for 'K' or 'N' VG Thermocouple types; other types are available as an option. The VG Thermocouple type and range is software selected, all that needs to be added is the correct type of compensation cable and connectors. Your EBHC will have been configured to the VG Thermocouple type requested at the time of ordering.

1.4 Temperature Controller

In normal operation the temperature controller will display actual and target temperatures (whether or not set point ramp-rate or self-tune is involved) or indicate if the temperature sensor has failed. In the full configuration mode, all parameters and values can be viewed and edited.
Control can be PID, PI, PD, P only or ON/OFF, with values automatically set or manually entered. A front panel control allows the operator to switch between two pre-programmed setpoints. The output power level is programmable (default is zero) if the sensor fails.

For processes where the maximum temperature must not be exceeded, the ramp-rate facility allows the user to define the temperature rise in programmed units (per second, minute or hour). A self-tuning algorithm automatically sets the PID and the under and overshoot values.

An RS232/485 communications package can be added at time of purchase or retro-fitted. This package also includes software, making external control extremely powerful and simple to use. The user should refer to the temperature controller manual which is supplied with the unit.

1.5 HT Bias Power Supply

This supply biases the filament to -650Vdc with respect to an earthed (OV) heater sample plate (the anode). Two impulse switches are provided for HT ON and HT OFF. lf an excessive emission current is detected this circuit automatically switches to off. The trip is reset using the OFF impulse switch - see section 6.0 Temperature Controller Operation, for further details.

1.6 HT Interlock

An interlock is provided to trip the HT power if the power cable is removed front the unit, or disconnected from the vacuum feedthrough. This interlock is for safety protection and must not be tampered with. See section 6.0 Temperature Controller Operation, for further details.

1.7 Electron Bombardment heater Assembly

The materials of construction in the immediate vicinity of the heater are principally refractory metals. The anode, cathode support tray, specimen clamps and screws are of molybdenum, with some smaller parts in tantalum. The anode is supported, and thermally insulated, by sapphire balls and alumina bushes. The cathode is of thoria- coated iridium and is supported and insulated by alumina.

The heater is supplied assembled onto a stainless steel backplate, with one molybdenum and two stainless steel radiation screens interposed between the backplate and the heater tray.

The power supplies to the anode and cathode are introduced into the vacuum system via a 4- way feedthrough attached to one of the system service ports, and hence to the heater assembly by means of insulated copper leads. Figure 1 shows the connections between the EBHC and the heater assembly.

2.0 Specifications

Refer to sections 4.4 to 4.6 on how your EBHC is configured from the factory.

2.1 EBHC Unit Specifications

Mains Voltage	220-240Vac, or 110-120Vac, 50/60Hz
Power Consumption	250VA
Filament Power	30Vac at 2.5A, maximum
Emission Power	650Vdc, 100VA, maximum

Temperature Controller:

Type	Eurotherm 2408
Sensor Types	K or N as standard, others as options
Sensor Ranges	K -200°C to + 1 200°C N -250°C to + 1200°C For others, consult Eurotherm handbook
Cold Junction	Automatic compensation, typically >30 to 1 compensation rejection of ambient temperature change
Sample Rate	9Hz
Accuracy	0.25% of reading +/- LSD or +/- 1°CIF
Control Mode	PID, PI, PD, P ONLY or ON/ OFF

Ramp Rate	0.01 to 99.99 degrees/second, minute or hour
Tuning	One-shot self-tune algorithm
Sensor Fail	Output programmable between 0-100%
Communications	RS232/485. 1200, 2400, 4800, 9600 or 19200 baud Modbus, Bisynch or SPI
Display	Dual 4-digit x 7 high intensity LED
Front Panel Controls	Illuminated mains ON/OFF, HT ON, HTOFF/RESET, OFF/SPI/SP2 switch, process current limit, temperature controller
Rear Panel Input	Overall filament current limit, heater output, VG Thermocouple input, IEC mains input and communications
Indicators	Output current, HT ON, HT OFF, HT TRIP, interlock and temperature controller

Fusing - Rear Panel	
Mains Input	F83,220-240Vac,2.5A (delay) or110-120Vac, 5.0A (delay), 20mm
Temp Controller	FS4,1.6A (delay) 20min
HT Power	FS 1, 220-240Vac, 800mA (delay), 20mm or 110-120Vac 1.6A (delay), 20mm
Filament Power	FS2, 2.5A (fast), 20mm

Fusing - Internal	
HT Output	FS5, 800mA (delay), 20mm

Environmental-	
Operating Temp	+5°C to +40°C
Storage	10°C to +70°C
Relative Humidity	5% to 85% RH
General	Non-explosive atmosphere. Electrically conductive pollution to be excluded from the cabinet

Dimensions-	
Height	3U, 134mm
Width	19 inch, full rack mounting
Depth	370mm, excluding mating connectors
Weight	15kg

EMC and Safety Standards - Compliant with relevant EU directives

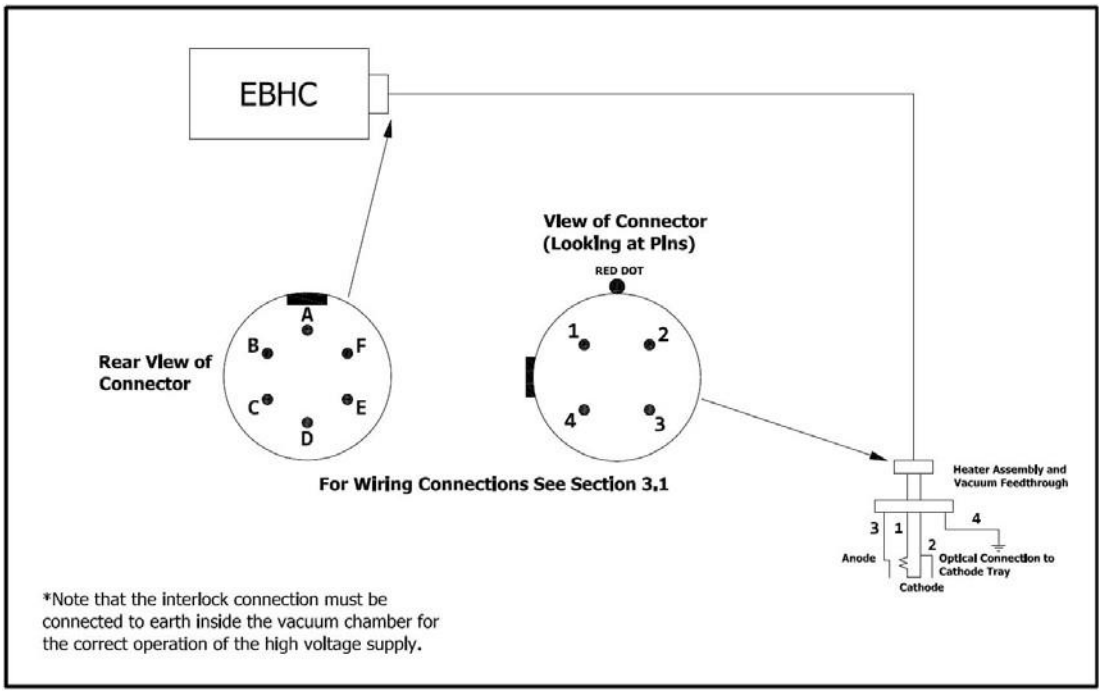


Figure 1 - Power cable connections between the EBHC and the heater module

2.2 EBH Heater Assembly Specifications

Heat Only Option	100°C to 1200°C
Heat/Cool Option	-180°C to 1 000°C
Heating Method	By conduction from a molybdenum platen, or by direct heating
Filament Type	Thoria-coated iridium
Anode Potential	0V (earth potential)
Cathode Potential	Nominal -650Vdc
Emission Power	100VA

3.0 Installation

For optimum performance the EBHC should be operated in a clean, dust-free environment and not be exposed to elevated ambient temperatures, toxic, corrosive, explosive, biological, or radioactive contamination, or any other harmful substances. The integrity of the unit case, operating controls and cables should be maintained in a good condition as degradation may jeopardize compliance with EU directives - as may any end-user modifications.

Connect the mains supply to the unit with the supplied molded IEC mains cable assembly. Note that VACGEN does not supply re-wireable IEC connectors.

The EBHC is supplied set to the mains input voltage requested at the time of ordering. If this is incorrect, please contact VACGEN Sales Department. We do not recommend that users change the mains input voltage configuration.

A separate earth stud is provided on the rear of the unit. This should be connected to the system 'star-point' earth, using 2.5mm^2 cable or braid.

3.1 Power Cable Connections to the Heater Module

The cable connections between the EBHC and the heater module, via the vacuum system feedthrough, are shown in figure 1. The connections are as follows:-

EBHC Connector		**Vacuum Feedthrough Connector**	
Pin A	Filament	Pin 1	Filament Cathode
Pin B	Filament plus emission bias (-600v)	Pin 2	Filament and bias cathode
Pin C	Earth	Pin 3	Earth (anode)
Pin D	Interlock	Pin 4	Interlock

Connect to Earth in vacuum chamber NOT to heater assembly anode.

3.2 The Electron Bombardment Heater Module

Before installation of a new electron bombardment heater assembly into the vacuum system check for continuity between the cathode terminals using an ohmmeter. The cold resistance of the filament should be approximately 1 ohm. In addition, check with an insulation tester (or 'Megger'), that the anode-to-cathode and/or (depending on the presence of the link wire – see figure 1) cathode support, tray have an insulation resistance of at least 10Mohm at 500Vdc in (dry) air.

With use of the heater this insulation resistance will reduce. A reading of <2Mohm indicates that the assembly requires servicing; if this is the case contact VACGEN Service Department.

3.3 Communications Connections and Cable

Communications are via the rear panel 25-way 'D' connector. Use a twisted pair cable, overall screened, with bleed wire and connect to the Eurotherm temperature controller as shown below. Reverse connections 2 and 3 at your PC.

25-Way Connector Pin Function

1	Earth
2	RXB
3	RXA
7	Ground

4.0 Temperature Controller Settings

Refer to the Eurotherm handbook and to figure 2, in coalition with the following sections-

4.1 Controls and Displays

Button/Indicator	**Function**
Output 1	Illuminates when output is active. Power will be supplied to the heater if the front panel output switch is on SP1 or SP2 and the Process Trip is not active.
Output 2	Output 2 is not used on the EBHC.
Setpoint 2	Illuminated when SP2 selected
Remote Setpoint	Not used on the EBHC.
Auto/Manual	Toggles between auto and manual mode. Disabled in standard EBHC configuration.
Run/Hold	For use with programmer version controller. Not used in the EBHC.
Page	Press to select a new list of parameters.
Scroll	Press to select new parameter in list.
Down	Press key to decrease parameter value in lower readout.
Up	Press key to increase parameter value in lower readout.

Display	**Displayed Parameter**
Upper Readout	Measured temperature, process value, list header or parameter name.
Lower Readout	Setpoint, or parameter value.

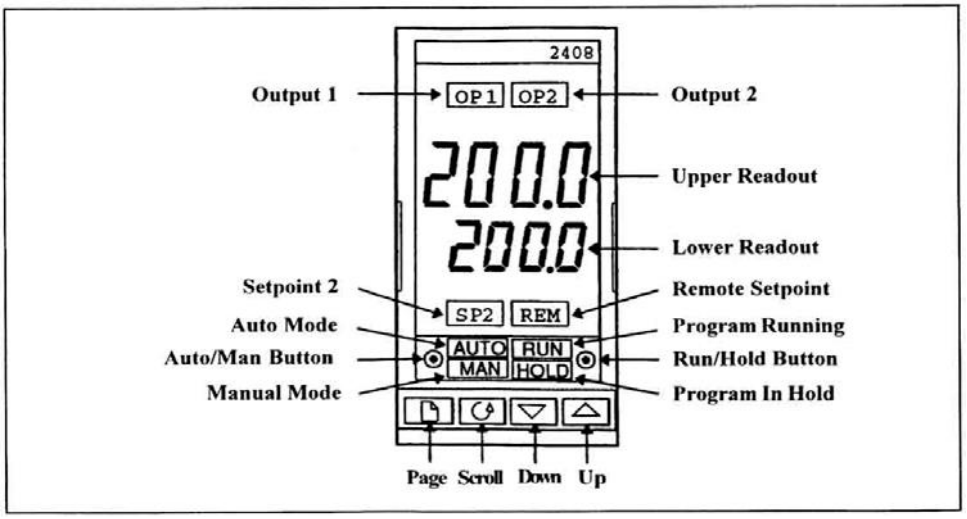


Figure 2 - Front panel controls and displays of the 2408 temperature controller

4.2 Home Screen

This is the temperature controller screen that you will normally see. This will indicate whether or not the controller output is ON, its measured temperature, the setpoint temperature, the ramp rate target temperature (if selected), and any other parameter lists and promoted parameters which can viewed and adjusted using the Page, Scroll and Up/Down buttons. If desired parameter is not available in the lists, refer to the following sections on access levels and editing.

Note. If no key is pressed for 45 seconds when in Operator, Full or Edit modes, the display returns to the Home screen.

4.3 Access Levels

The Eurotherm temperature controller has four access levels as described below:-

Level	Display Description		Password
Operator	OPEr	User can view and adjust parameters defined in Edit level	No
Full	FuLL	All parameters relevant to the configuration visible. All alterable parameters can be adjusted.	Yes
Edit	Edit	All parameters can he hidden or revealed, made alterable or read-only, these are then available in Operator level.	Yes
Configure	conF	Sets up the fundamental characteristics of the controller.	Yes

The EBHC will be supplied in Operator level, with all parameters relevant to the requested specification readable and alterable. Refer to the section below for Configuration and Edit levels set-up. Only change to Full level if you are completely conversant with the function of each parameter, and where there is no risk of tampering.

The procedure for entering passwords to gain entry to the different access levels is as follows:
With the EBHC powered-up, press the Page button until the display shows--

ACCS
LiST

then press the Scroll button. The display now shows:-

code
0

Warning: Great care should be exercised when changing configurations. Consult the Eurotherm manual

4.4 Factory Configuration Setup

List	Parameter	Setting	Description
inST			
	CTRL	Pid	PID Control
	Act	rEV	Control action, reverse acting
	COOL	Lin	Linear cooling type
	ti.td	SEC	Integral and derivative units, seconds
	dtyP	PV	Derivative type
	m-A	diSA	Manual button disabled
	r-h	diSA	Run/hold button disabled
	pwrF	OFF	Power feedback off
	Fwd.t	nonE	Feed forward type, none
	Sbr.t	Sb.OP	Sensor break, go to pre-set level
	FOP	no	Forced manual output, no
	bcd	nonE	BCD Input function
	GSch	no	Gain schedule enable
	LC.Hi	100	
PV			
	unit	°C	Instrument display units
	dEc.P	nnn	No decimal points in display
	rnG.L	-200(-250)	Low setpoint limit
	rnG.H	1200	High setpoint limit
iP			
	inpt	k.tc / n.tc	VG Thermocouple input
	CJC	Auto	Automatic cold junction compensation
	imP	Auto	Sensor break impedance
SP			
	nSP	2	Number of setpoints
	rm.tr	OFF	Remote tracking
	m.tr	OFF	Manual track
	rmP.U	Pmin	Setpoint rate limit units, per minute

	rmt	nonE	Remote setpoint, disabled
AL			
	AL 1	OFF	No alarm, 1
	Ltch	no	No latch, 1
	bLoc	no	No blocking, 1
	AL 2	)	
	AL 3	) As above.	No alarms fitted to EBHC as standard
	AL 4	)	
PROG	PtYP	nonE	Programmer disabled
LA			
	id	LoG.i	Logic input
	Func	SP.2	Setpoint 2
LB			
	id	Log.i	Logic input
	Func	nonE	No logic input function
HA	(When fitted with Comms module)		
	id	cmS	EIA-232 or EIA-485
	Func	mod	Modbus
	bAud	9600	Baud rate
	PrtY	nonE	No parity
	rES	Full	Full resolution
	dELY	no	No delay
HA	(No module fitted)		
	id	nonE	No module fitted
	Func	nonE	No function
JA	(No module fitted)		
	id	nonE	No module fitted
	Func	nonE	No function
IA			
	id	dC.OP	Module 1, DC output
	Func	HEAt	Heating output
	VAL.L	0	Output low %
	VAL.H	100	Output high %
	unit	voLt	Voltage output
	Out.L	0.0	Output voltage low
	Out.H	5.0	Output voltage high
2A			
	id	nonE	No module fitted
	Func	nonE	No function

3A	As 2A above		
CAL			
	rcAL	nonE	No calibration
	UCAL	no	User calibration
	Pt1.L	0	Low cal point
	Pt1.H	1000	High cal point
	OF1.L	0.0	Offset low
	OF1.H	0.0	Offset High
PASS	ACC.P	1	Access password
	cnF.P	2	Configuration password
Exit	YES/NO		Exit configuration

4.5 Factory Edit Setup

The edit access level is a factory set up as shown below. Refer to section 4.3 on how to access the Edit level. In the following, Altr = Alterable, HIdE = Hidden, PrO = Promoted (to operator level) and rEAd = read (not hidden).

List	Parameter	Settings
AL (Alarms)		HIdE
Atun (Autotune)		rEAd
	tunE	ALtr
	drA	HIdE
	drA.t	HIdE
	Adc	HIdE
Pid (PID)		rEAd
	SEt	ALtr
	Pb	ALtr
	ti	ALtr
	td	ALtr
	rES	HidE
	Hcb	ALtr
	Lcb	ALtr
	Pb2	ALtr
	ti2	ALtr
	td2	ALtr
	rES.2	HidE
	Hcb2	ALtr
	Lcb2	ALtr
SP (Setpoint)		rEAd
	SSEL	HIdE
	SP 1	ALtr
	SP 2	ALtr
	SP H	ALtr

	SP L	ALtr
	SP2.H	ALtr
	SP2.L	ALtr
	SPrr	PrO
	Hb.tY	HidE
IP (Input)		rEAd
	FiLt	ALtr
	CAL	HIdE
	CAL.S	HidE
	ADJ	HidE
	OFS.1	HidE
	mV.1	HidE
	CJC.1	HidE
	Li.1	HidE
	PV.SL	HidE
oP(output)		rEAd
	OP.Hi	ALt
	OP.Lo	ALtr
	Oprr	ALtr
	CYC.H	HIdE
	Ont.H	HidE
	Sb.OP	ALtr
cmS (communications)		rEAd (only if fitted)
	Addr	ALtr
inFo(Inforniation)		rEAd
	di SP	ALtr
	LoG.L	HidE
	LoG.H	HidE
	LoG.A	HidE
	LoG.t	HidE
	LoG.u	HidE
	rES.L	HidE
	w.OP	rEAd

ACCS(Access) LIST

codE	PASS
Goto	Use arrow buttons to go to new access level

4.6 Factory Operator Setup

Having configured the fundamental characteristics and edited parameters to those that are necessary, the EBHC will have the following value/conditions factory set. From the Home display, press the Page and Scroll buttons in turn to display the following list, and the values and conditions that have been assigned. These values and conditions are alterable using the Up Down buttons in the ranges shown. Refer to section 4.4 for range units, where applicable.

List	Parameter	Setting (Range)
Atun (Autotune)		
	tunE	OFF (ON/OFF)
Pid(PID)		
Select PID ½	SEt	Pid.1
Proportional Band 1	Pb	35
Integral Time 1	ti	30
Derivative Tune 1	td	5.0
Cutback High 1 Hcb		Auto
Cutback Low 1	Lcb	Auto
Proportional Band 2	Pb2	85
Integral Time 2	ti 2	30
Derivative Time 2	td2	5.0
Cutback High 2 Hcb2		Auto
Cutback Low 2	Lcb2	Auto

List	Parameter	Setting (Range)
SP(Setpoint)		
Setpoint 1	SP1	20
Setpoint 2	SP2	20
Setpoint Maxinium 1	SPH	1200
Setpoint Minimuni 1	SPL	-200 (-250)
Setpoint Maximuin 2	SP2.H	1200
SetpointMinirnum 2	SP2.L	-200 (-250)
Setpoint Raiiiprate	SPrr	OFF
iP (input)		
Input Filter T/C	FiLT	1.0
oP (Output)		
High Power Limit	OP.Hi	100.0
Low Power Limit	OP.Lo	0.0
Output rate Limit	OPrr	OFF
Sensor Break Output	SB.OP	0.0
ACCS(Access)	As previously described	

5.0 Circuit Description - High Voltage Control and Trip PCB

5.1 Overview

The high voltage control and trip circuit is designed to generate the emission bias voltage and to protect against excessive emission currents. Excess emission (acceleration) current can occur for a number of reasons. These include-

i) Operating the EB beater at pressures > 10^{-5} mbar
ii) A damaged or broken filament
iii) Coated filament assembly (insufficient isolation - assembly requires servicing)
iv) Filament current too high
v) Normal occurrence during conditioning of a new assembly and/or a 'gassy' filament

The EBHC high voltage supply is protected against excess current excursions by an internal unit protection fuse, FS5. However, the high voltage control and trip circuit is designed to switch off the high voltage supply before the fuse fails under normal operating conditions. The trip can he quickly reset from the EBHC front panel, and the high voltage supply re-established. Repeated tripping of the HV supply will eventually lead to the failure of fuse FS5 and, in such circumstances, the cause of this must be investigated.

5.2 Circuit Description

Refer to figure 4 which shows the high voltage control and trip circuit diagram. RI -4, D1, D2. C4 and C5 form a voltage-doubler producing approximately -650Vdc off load, this reduces to -600Vdc at 150mA load. BR1, C1-3 and IC1 form a standard on-board + 12Vdc regulated supply.

Current detection is via a linear Half-effect transducer which has the advantage of a high speed of operation (3 microseconds) and complete isolation. TDI produces an output of 6V +/-0.6V at 0 gauss.

Each 100mA of emission current produces approximately a 1V swing of the output of 1C2.9 1C2b is a voltage comparator with a reference of approximately 10V, set by R11 and R12. being equivalent to an emission current of 400mA. 1C3b/c is a bi-stable latch, conditioned at power-tip by R15, C10, 1C3c and 1C4a so that 1C3b output is high and 1C3c output is low. 1C4b -3-input NOR gate controls the high voltage supply via TR2 and the solid state relay RL2. All three inputs have to be low for the high voltage supply to be on. One output is connected to the bi-stable latch, on to the On/Off switches, and one to the opto-isolator, IC5, which detects the condition of the high voltage interlock.

When an excess current occurs IC2a output rises quickly to >10V, exceeding the IC2b reference whose output falls to 0V, this in turn toggles the bi-stable latch outputs. TR1 conducts to indicate a trip via a LED. The input to 1C4b, pin 2, goes high and pin 9 goes low, inhibiting RL2.

The start and stop switches are momentary in action. The start switch contacts are latched by RL1, which also operates the On/Off lamps.

After an excess current trip the bi-stable latch has to be reset before the high voltage circuit can be re-started. This is done by pushing and then releasing the Off switch; IC4a output toggle; setting 1C3b/c output to their former levels. The flashing HT trip light should then extinguish

5.3 High Voltage Supply Control and Indicators

At switch-on the EBHC HT Off button will be illuminated. When the high voltage supply is required, press and release the HT On button. The HT On button is now illuminated, and the HT Off button is extinguished. When the high voltage supply is no longer required, press and release the HT Off button; the HT On button is now extinguished and the HT Off button will be illuminated.

If an excess emission current is detected, the high voltage supply will automatically switch off and the HT Trip LED will flash. The HT trip can be reset by pressing and releasing the HT On button.

If the interlock LED is flashing, HT On will be inhibited. There must be an earthed connection within the vacuum chamber in order to complete the interlock. This has been designed to turn off the high voltage supply in the event of the power cable being disconnected do not tamper with the interlock.

6.0 Temperature Controller Operation

When switched on the Eurotherm temperature controller will perform a self-test prior to displaying the Home screen. Use the supplied output, power and VG Thermocouple cables to connect the EBHC to the vacuum feedthrough. Ensure that the in-vacuum VG Thermocouple is the same as the supplied cable as gross errors will result from a mis-match.

The VG Thermocouple hot junction must be kept in good contact with the heater face plate or the specimen by clamping or welding. The most accurate temperature control will, in general, be achieved when the VG Thermocouple is attached to the heater face plate as opposed to the specimen on test.

Warning: The VG Thermocouple junction can rise to a high potential if isolated from ground. Avoid contact with the VG Thermocouple vacuum feedthrough if the junction is not at ground potential. Never operate the EBHC with any of the covers removed.

6.1 Outgassing a New Heater Assembly

Any new heater assembly, or an assembly containing a new filament, should be thoroughly outgassed prior to any sample processing taking place. This should be done *slowly* and *progressively* by increasing the target sample temperature in steps, rather than attempting to proceed directly to a high temperature. The vacuum system pressure must be carefully monitored if the pressure rises above $10.^{-5}$ mbar, the outgassing process should be stopped until the system pressure recovers.

Proceed as follows. Set the front panel current limit fully counterclockwise. Use the temperature controller Up/Down buttons to set a target temperature of 200°C. *Do not* set the HT ON at this stage. Set Output switch to SP 1 and slowly rotate the front panel current limit potentiometer to give a meter reading of ~2.0Amps. Carefully monitor the vacuum system pressure and when this has recovered set a new target temperature of 300 °C. When system pressure has fully recovered, set front panel current limit potentiometer fully CCW.

Set a new target temperature of 350 °C . Press and release the HT ON button. Very slowly rotate the current limit potentiometer until an emission current is established, which will be noted by an increase in the rate of temperature rise. A 'very good' filament will emit at 1.7A; a 'normal' filament will emit at between 1.8 and 2.0A. When the temperature has stabilized and the system pressure recovered, increase the target temperature in steps of 50°C. Keep a constant check on the vacuum system pressure and adjust the current limit potentiometer as necessary, noting that the current demand will be lower when the setpoint temperature is approached/reached Too high a current, or a very 'gassy' filament, will cause a high voltage flashover and an HT Trip. If this occurs, rotate the current limit potentiometer fully CCW, reset and re-start the high voltage, and set a lower current limit.

Continue outgassing until the expected maximum target temperature has been achieved and the heater assembly is not outgassing.

6.2 Setting a Maximum Output Current

Ensure that the pressure in the vacuum system is 10^{-5} mbar or better.
The EBHC will have been factory set for a filament current limit range of ~0.6A(minmum) to a maximum of 2.5A. This is set by means of the front panel 'Current Limit' potentiometer. The rear panel 'Overall Current Limit' potentiometer was factory adjusted for 2.5A maximum with front panel potentiometer fully clockwise. With these two potentiometers a front panel potentiometer range from minimum(~0.6A) up to maximum (~0.7- 2.5A) can be set.
In normal operation (after the heater assembly has been conditioned and outgassed) it is recommended that the front panel current limit is only set high enough to achieve the highest temperature required and not necessarily to an arbitrary value. This reduces temperature overshoot (see also Autotune) and increases stability. If faster rate of rise is required, then current limit may also have to be increased. For a controlled temperature rise see Ramp Rate and adjust current limit to achieve set rate.

Note:- In full electron bombardment operation (with the high voltage on), small changes in current can have a large effect on the rate of temperature rise. Always adjust the current limit potentiometer slowly.

6.3 Entering and Using Set Points

Setpoint 1 can be directly entered from the Home display, as can Setpoint 2, when this is selected using the front panel setpoint switch. Use the UP/Down buttons to enter the required setpoint. Alternatively, press the Page button until the SP list header is reached, the Scroll button to select a parameter within the list, and the Up/Down buttons to set the value.

From the SP list you can set values for SPI, SP2, SP H, SP L, SP2.H, SP2.L and SPrr. See Section 4.6 for a brief description and the range of these parameters.

Two separate setpoints can be set with upper and lower limits. In operation, the front panel setpoint switch can be used to change the process control from SPI to SP2, giving a step change facility. If a value has been assigned to the SPrr, (Setpoint ramp rate) parameter then the process will try to achieve or control to this rate. In this case the output current limit must be set high enough for the controller to achieve the required rate. Pressing the Scroll button when in ramp rate control will display the on-going target temperature on the lower display, and the actual measured temperature on the upper display.

6.4 Positive Temperatures (above 0ºC)

For positive temperatures it is simply a matter of entering a setpoint, starting the high voltage supply, and increasing the output current limit to a level that will achieve that setpoint. However, the PID values may not be correctly matched to your process, and reference should be made to section 6.11 on how to auto-tune or section 6.10 on how to set PID values manually.

Different temperatures may have differing optimum PID and cutback values, and some over or undershoot may be seen. Where different target temperatures are required, it is advisable to autotune for each level, then fine tune if necessary by manually altering values, record the final values so that they can be manually entered each time the process is repeated. Where the process is critical and no overshoot is permissible, use the setpoint ramp rate facility (see Section 6.7).

6.5 Negative Temperatures (below 0°C)

For temperatures between that of liquid nitrogen (- 197°C) and the system ambient, adjust the setpoint to its minimum (-200 or -250°C) and the setpoint switch to OFF. In most cases the high voltage supply will not need to be switched on (HT ON) since steady state negative temperatures can be maintained by resistive heating alone. However, processes which require rapid temperature 'jumps' may require the use of the high voltage supply to achieve the required rate of change of temperature.

If, for example, a temperature of -100°C is required, cool the system using a flow of liquid nitrogen to a steady temperature below that which is required (i.e.-200 to -150°C). Adjust the setpoint switch to SP 1 or SP2 (whichever has been set for the process) and increase the current limit potentiometer if this is fully counterclockwise. The EBHC will now heat the system to the required temperature.

6.6 Running a Ramp Rate

The ramp rate parameter has already been 'promoted' to the home list. To set this facility, press the Scroll button until the SPrr parameter is displayed. The factory set range for this parameter is OFF to 9999 degrees/minute; set the desired rate and scroll back to the home screen. Press the Scroll button to show the on-going target temperature on the lower display and actual temperature on the upper display. Ensure the current limit is set at a level to achieve the rate required. When the ramp rate facility is no longer required, repeat the above sequence and set the parameter OFF.

6.7 Selecting PID and Cutback Sets

There are two sets of PID and cutback values that can be assigned to SP 1 and SP2. This can be selected using the SEt parameter in the PID list of the Operator access level. See section 4.3 for details of how to gain entry to the different access levels. Note that if you are in the Home screen, Operator level is available by using the Page button to select PID list, the Scroll button to select the SEt parameter, and the Up/Down keys to select either Pid.1 or Pid.2 as required.

6.8 Setting Control Type

In most processes, full PID control is suitable for stable control. Control can also be set for PI; PD, P only or. ON/OFF, This is further described below:-

i) **ON/OFF Control** (proceed to ii) if you do not wish to use ON/OFF control)

Select the CTrL parameter in the inST list of the Configuration access level. See section 4.3 for details of how to gain entry to the different access levels, Use the UP/Down keys to select ON.OF.

In the Edit and Operator access levels PID and OP lists have now been replaced by an ON.OF list. All displayed parameters should be made alterable in the Edit access level, a brief description of the available parameters is given below:

List	Parameter	Description
On-OF	hYS.H	Sets the level of hysteresis in display units
	ont.H	Minimum output time in seconds
	SB.OP	Sets the output level in % if the sensor fails

ii) PI, PD or P only Control

Select the PID list of the Operator access level. Use the Scroll button to select ti, td, ti2

or td2, and use the Down button to switch the parameter(s) OFF, or to select PI, PD or P only control.

Warning: The control typesetting will have a fundamental effect on the stability of the process control loop.

6.9 Setting PID Values Manually

Use this facility to manually enter PID values either to fine-tune a process control, or to enter known values for a particular process. Press the Page button until Pid List is displayed. Use the Scroll button to access the parameters and the Up/Down buttons to alter values. From the Pid list you can set values for Pb, ti, td, Hcb, Lcb, Pb2, ti 2, td2, Hcb2 and Lcb2. Either of the two sets of PID values and cutback values can operate on SP1 or SP2 - see section 5.7 on how to access the two PID and cutback sets. The function of the PID parameters is briefly described below:

Ph	Proportional band	The bandwidth in display units over which the output power is proportioned between maximum and minimum.
ti	Integral time	Determines the time taken by the temperature controller to remove steady-state error signals.
td	Derivative time	Determines how strongly the temperature controller will react to the rate-of-change of the measured value.
Leb	Low cutback	The number of display units below setpoint at which the temperature controller will cutback the output power in order to prevent overshoot on heat up.
Hcb	High cutback	The number of display units above the setpoint at which the temperature controller will increase the output power in order to prevent undershoot on cool down.

6.10 Autotuning

PID and cutback values can be automatically set using this facility. Press the page button until Atun List is displayed. Press the Scroll button to display tunE/OFF, and use either the Up or Down buttons to set the parameter ON, Select the setpoint from the front panel switch and set a current limit. See Section 6.8 above for brief description of parameters set by autotune.

Warning: The autotune procedure sets the temperature controller output to 100% and 0% in sequence as it calculates temperature rise and decay. The current limit must be set so as not to damage your process. The setpoint can also be exceeded during this process,
Enter a lower setpoint if any overshoot is unacceptable.

After an autotune this parameter will automatically set itself OFF. Note that you cannot autotune if the SPrr (setpoint ramp rate) parameter is not set to OFF.

6.11 Sensor Break

If, during a process, the in-vacuum VG Thermocouple becomes open circuit, or the out-of-vacuum connection becomes broken, the EBHC output will assume the percentage output as set by the parameter SB.OP. This is factory set to 0.0, but is alterable, in order to match the requirements of different processes. Refer to section 4.6 for Instructions on how to access this parameter and how to view or adjust the value.

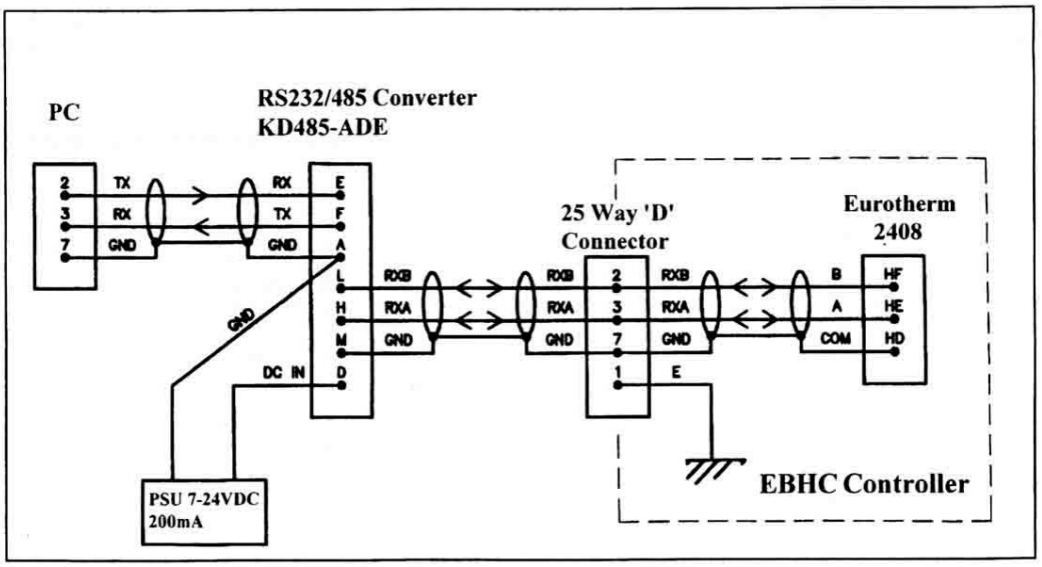
The Eurotherm temperature controller upper display will flash S.br, indicating an open sensor circuit. The lower display continues to show setpoint temperature which can be adjusted in the normal manner.

7.0 External Communications

If your EBHC has been supplied with the communications option, please refer to the supplied Eurotherm Controls handbook. This explains the installation procedure and operation of the software in detail. Remember, your cabling from the EBHC to your PC must be as described in section 3.3.

7.1 Getting Started with the Software

Refer to section 3.3 for information on how to connect the communications function to the EBHC. Set up the communications link and start up your computer. If using a PC and you have opted for the RS485 comms module, you may need an RS232 to RS485 converter (see drawing below).
If starting from Windows, double click on the Eurotherm icon, if starting from the DOS prompt type IPS (return). An error message will be displayed if insufficient free memory is available to run the software.
The computer will display the main IPS screen and scan the communications link for any
connected temperature controllers. The EBHC will be factory set for an address of 1 (displayed as 0. 1). When this has been detected, assuming the communications link is functioning correctly, the '2000' controller icon will be displayed. The temperature controller has now been recognized and the REM indicator on the front of the temperature controller will flash on/off until the communications link is disconnected.
Double click on the '2000' controller icon to display the Operating List screen. All relevant parameters can now be selected by the mouse, and values amended by means of keyboard
Input.



Warning: Before changing parameter value/type the user must be aware of any, effects that this may have on the functioning of the control loop.

Reference should now be made to the supplied temperature controller handbook for information on how to set preferences, on how to use the different screens, and for recording trends etc.

8.0 Maintenance and Service

The EBHC generates potentially lethal voltages.

Great care must be taken to ensure that no contact is made, with the filament connections when the power supply is energized Allow at least two minutes after switching off for the high voltage capacitors to discharge before handling any of the connections. The high voltage power supply delivers tip to 650Vdc to the filament, and has sufficient power capability to cause serious injury if contact is made when energized.

In order to maintain compliance with relevant EU directives, only use recommended spares when servicing; these must have the same specifications and ratings as the original components. Spares can be purchased from VACGEN. Be aware that end-user modifications can jeopardize compliance. Do not add to or modify cable forms, or alter cable form routing.

Servicing must only be carried out by qualified personnel who are aware of the potential risks of working on live equipment.

The front panel mains switch should not be relied upon to provide adequate isolation from the mains supply for servicing or maintenance purposes.

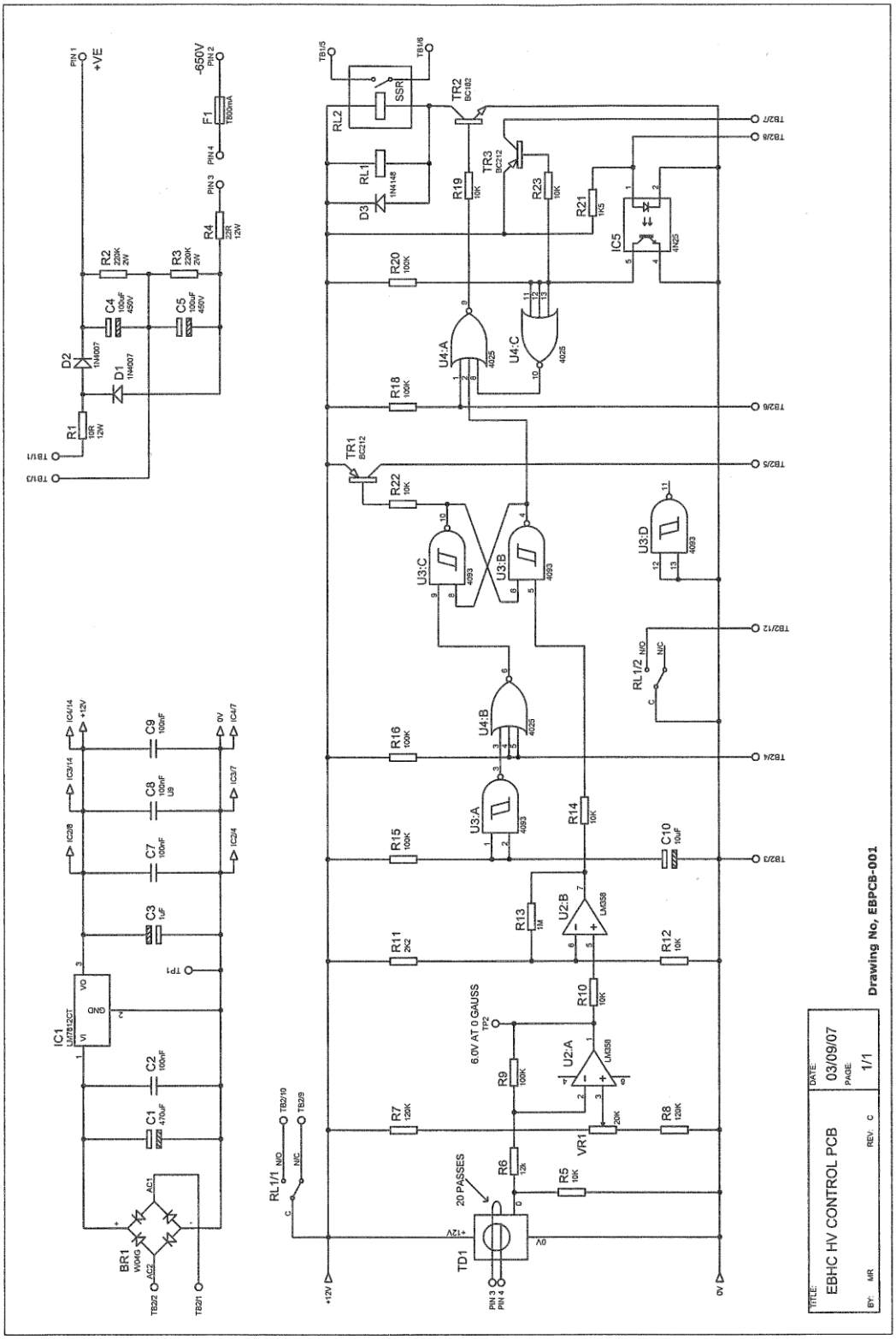
The EBHC is designed as a reliable and robust unit and should not require any regular maintenance. Basic preventative maintenance should be carried out every six months. The unit should be inspected for visible signs of overheating, corrosion, loose or broken electrical connections or accumulation of contamination (oil, dust or dirt). Repair any obvious defects or return the unit to VACGEN for repair. Clean the unit as necessary. Only use fuses of the correct rating and type; see section 2.1. If it is necessary to replace the internal fuse, FS5, (high voltage output) the EBHC must be completely isolated from the mains supply; allow at least 2 minutes for the high voltage to decay. Slide the fuse carrier as indicated by the arrow to remove the fuse. Do not replace with a fuse of higher value. All unit cabling must be maintained in good condition; replace if damaged, especially if the outer sheathing is cut, cracked or burnt.

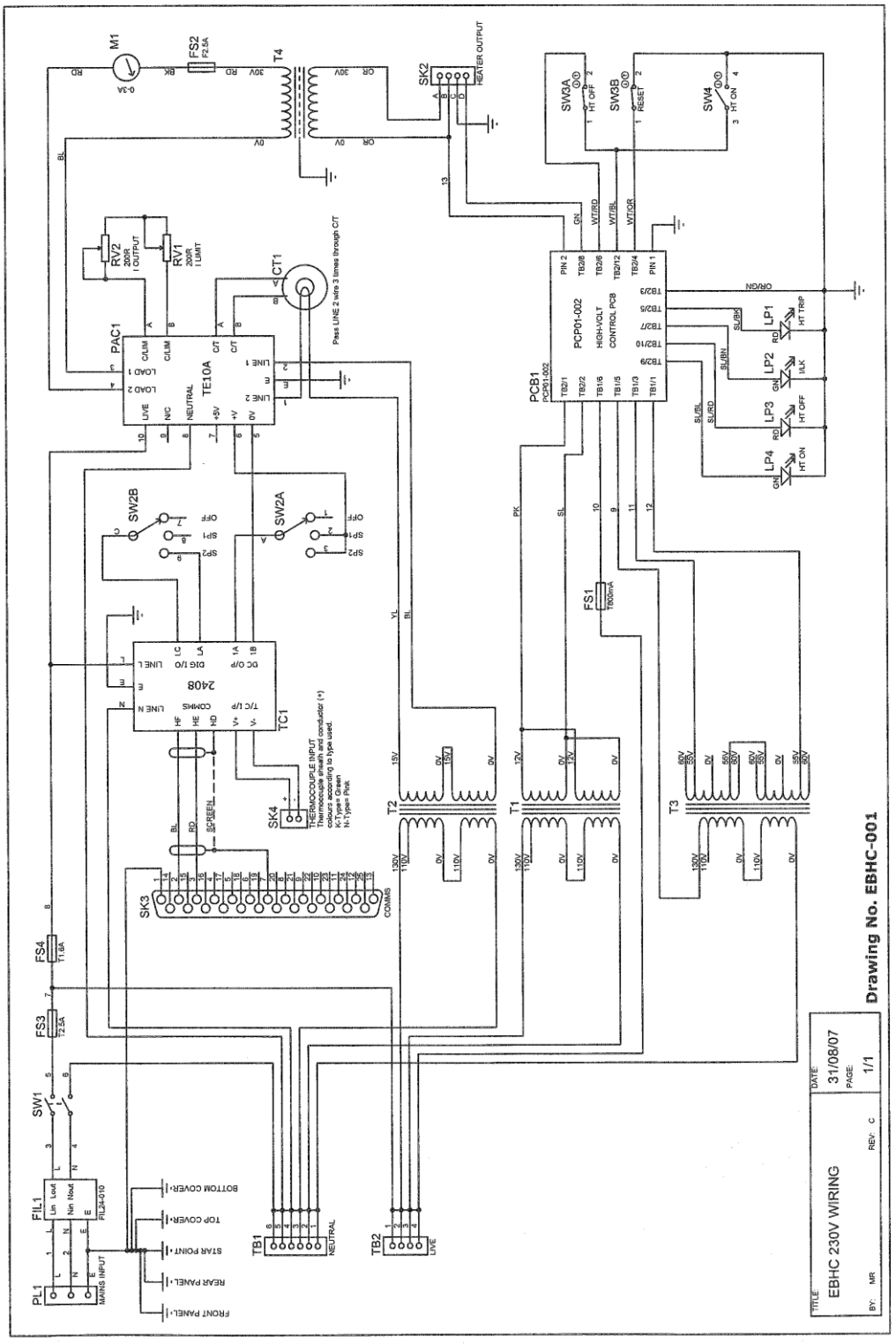
Schematic Diagrams

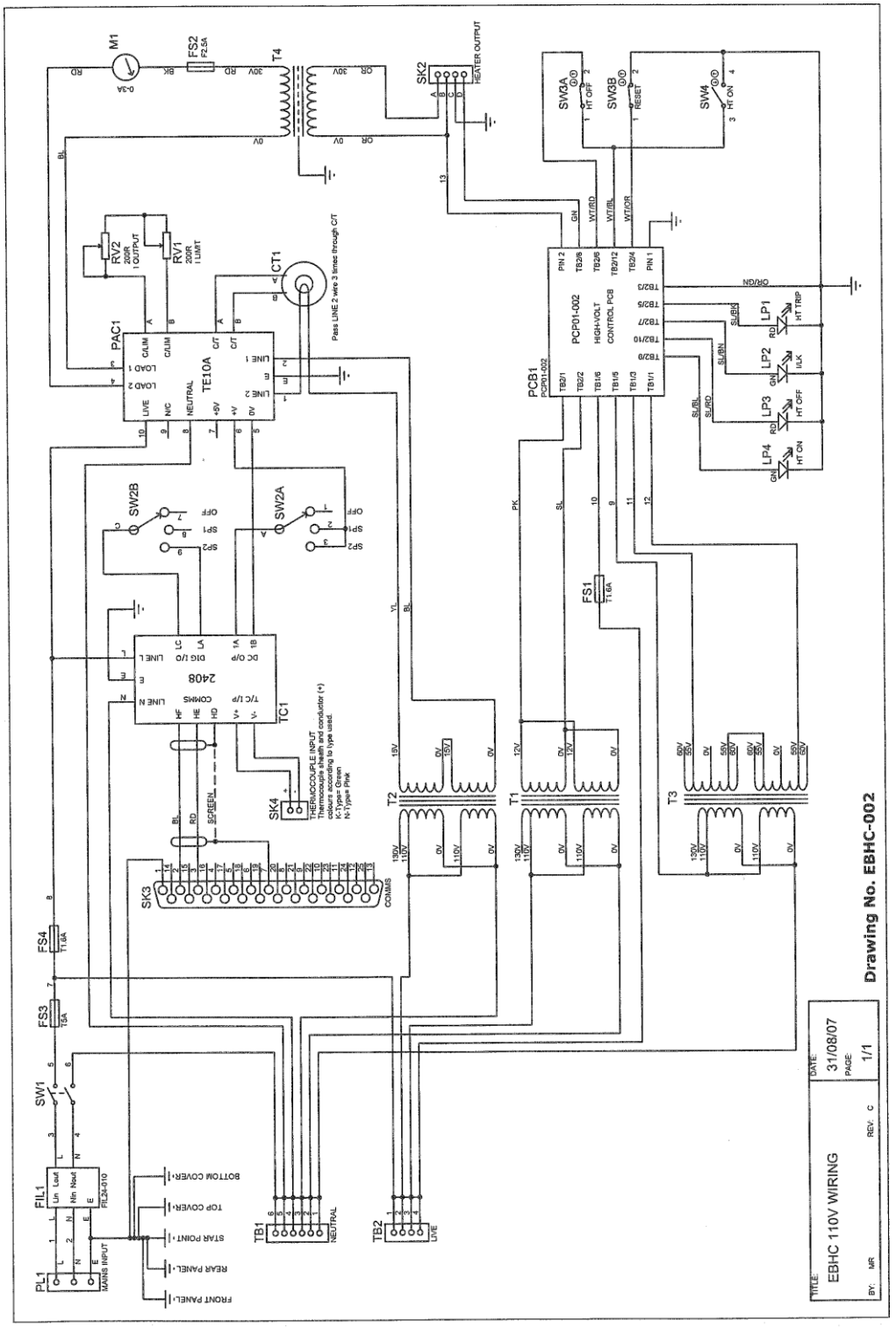
Refer to the circuit diagrams in figures 5 and 6. These show arrangements for the low (110Vac) and high (240Vac) mains input voltage versions. All wiring inside the EBHC is numbered where applicable and indicated on the schematics. Do not remove the wiring identifications.

Safety Declaration Form

If the EBHC is to be returned to VACGEN for servicing, please complete the Declaration of Contamination of Equipment and Components form.
Failure to do so may increase the repair turn-round time. See Page 32.


+VE
-650V
F1
T800mA
R1
R2
R3
R4
C1
C2
C3
C4
C5
C7
C8
C9
D1
D2
D3
RL1
RL2
SSR
TR1
TR2
TR3
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
R18
R19
R20
R21
R22
R23
C10
VR1
IC1
IC5
U2:B
U3:A
U3:B
U3:C
U3:D
U4:A
U4:B
U4:C
RL1/1
RL1/2
TD1
BR1
TP1
TP2
6.0V AT 0 GAUSS
20 PASSES
+12V
0V
Drawing No. EBPCB-001
TITLE: EBHC HV CONTROL PCB
DATE: 03/09/07
PAGE: 1/1
REV: C
BY: MR


Drawing No. EBHC-001
EBHC 230V WIRING
DATE 31/08/07
PAGE 1/1
REV: C
BY: MR
M1
FS2
T4
SK2
HEATER OUTPUT
SW3A
SW3B
SW4
HT OFF
RESET
HT ON
RV2
300R
I OUTPUT
RV1
300R
I LIMIT
CT1
Pass LINE 2 wire 3 times through C/T
PAC1
TE10A
LOAD 1
LOAD 2
LIVE
NEUTRAL
LINE 1
LINE 2
PCB1
PCP01-002
HIGH-VOLT CONTROL PCB
LP1
HT TRIP
LP2
I/LK
LP3
HT OFF
LP4
HT ON
SW2B
SW2A
OFF
SP1
SP2
FS1
T800mA
2408
TC1
THERMOCOUPLE INPUT
Thermocouple sheath and conductor (+) colours according to type used.
K-Type= Green
N-Type= Pink
SCREEN
SK4
SK3
COMMS
T2
T1
T3
FS4
T1.6A
FS3
T2.5A
SW1
FIL1
FIL24-010
PL1
MAINS INPUT
BOTTOM COVER
TOP COVER
STAR POINT
REAR PANEL
FRONT PANEL
TB1
NEUTRAL
TB2
LIVE


Drawing No. EBHC-002
EBHC 110V WIRING
DATE: 31/08/07
PAGE 1/1
REV: C
BY: MR
M1
FS2
T4
SK2
HEATER OUTPUT
SW3A
SW3B
SW4
HT OFF
RESET
HT ON
RV2
200R
I OUTPUT
RV1
200R
I LIMIT
CT1
Pass LINE 2 wire 3 times through CT
PAC1
TE10A
LOAD 1
LOAD 2
LINE
NEUTRAL
PCB1
PCD01-002
HIGH-VOLT CONTROL PCB
LP1
HT TRIP
LP2
I/LK
LP3
HT OFF
LP4
HT ON
SW2B
SW2A
FS1
T1.6A
2408
TC1
THERMOCOUPLE INPUT
Thermocouple sheath and conductor (+)
K-Type= Green
N-Type= Pink
SCREEN
SK4
SK3
COMMS
T2
T1
T3
FS4
T1.6A
FS3
T5A
SW1
FIL1
FIL24-010
PL1
MAINS INPUT
BOTTOM COVER
TOP COVER
STAR POINT
REAR PANEL
FRONT PANEL
TB1
NEUTRAL
TB2
LIVE

Service and Repair Form

Declaration of Contamination of Equipment and Components

Serving and repairs will only be carried out if the conditions for Servicing and Repair are complied with in full, according to the VACGEN Ltd. Conditions of Sale. A summary of these requirements are included on the inside front cover of the Operating Instructions. The manufacturer will refuse to accept any equipment without a signed declaration attached to the OUTSIDE of the packaging. This declaration can only be completed and signed by authorized and qualified staff.

1 Description of Equipment and Components

Equipment Type……Model Number……
Serial Number…… Your Reference Number……

2 Reasons for return……
……
……
……

3 Condition of Equipment

YES ( ) NO ( ) Toxic?
YES ( ) NO ( ) Explosive?
YES ( ) NO ( ) Radioactive?
YES ( ) NO ( ) Corrosive?
YES ( ) NO ( ) Biological Hazard?
YES ( ) NO ( ) Other Harmful Substances?

Equipment and Components that have been contaminated, WILL NOT be accepted without written evidence of decontamination.

5 Contamination Materials

List all the substances, gases and by-products that may have come in contact with the equipment, giving trade name, manufacture, chemicals names or symbols.
Please note that any of these listed, must be completely removed, so it is safe to handle and weld, without giving off health threatening gases. Please enter details below and/or attach data sheets
……
……
……

6 Legally Binding Declaration

I hereby declare that the information supplied on this form is complete and accurate.
There by stating that the goods offer no risk to health or safety
Organisation…… Name……
Country…… Job Title……
Post/ZIP code…… Telephone……
Email……
Signature…… Date……

Return goods to: VACGEN, Diamond Drive, Hailsham, BN27 4EL, UK, Phone 0044 1323 379335
(Form VGF33)