thermionics laboratory, inc.

INSTRUCTION MANUAL

EPS-3000 EBEAM POWER SUPPLIES
[MODEL EPS-3000]

Version 2

FAILURE TO CONNECT AND OPERATE CORRECTLY CAN CAUSE DANGEROUS SITUATIONS, INCLUDING POTENTIALLY LETHAL CONSEQUENCES.

SEE WARNINGS ON PAGE 1 & 2

SERIAL # _____

3.2024
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WARNING

POWER SUPPLIES FOR ELECTRON BOMBARDMENT HEATING EMPLOY LETHAL VOLTAGES.

PLEASE READ THE MANUAL AND UNDERSTAND IT. DO NOT HESITATE TO CALL US AND ASK QUESTIONS ABOUT THE DEVICE AND PROCEDURES IF REQUIRED.

THIS DEVICE SHOULD BE INSTALLED AND OPERATED ONLY BY PROPERLY QUALIFIED PERSONNEL.

We at Thermionics want you alive and well, using our equipment to achieve your goals. With appropriate care this unit will operate safely and effectively. There is no risk that is worth your life.

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I. Preface

Congratulations! You have purchased a precision vacuum positioning device from Thermionics. This unit is capable of many years of use with minimal care and maintenance. This manual is a tool to aid you in obtaining this service.

We at Thermionics encourage your comments and suggestions on this manual.

II. Product Description

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WARNING WARNING WARNING WARNING

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<u>This power supply can generate ample voltage and current to kill.</u> All personnel involved in its installation and operation must be qualified to work on and with such equipment. All users must first be familiar with this manual, its safety warnings, and high voltage procedures in general.

Do not take short cuts. Please do not be in a hurry.

EACH and EVERY item in the following list must be strictly followed.

1. DO NOT partially connect this power supply to your equipment.
All connections to the manipulator **must be made** because they provide the return path for the e-beam electrons.
FAILURE to do this may cause unsafe situations, including lethal consequences.

1b. The rear panel of the power supply has a two conductor with ground, twist lock connector.

- This interlock enables the high voltage and filament power to be turned on.
- This must be connected to an SPST set of contacts that close when the chamber containing the electron gun is under vacuum. Depending on application, this may be:

1. a diaphragm switch
2. a filament relay on a controller for a hot cathode ion gauge
3. or other suitable contacts.

- It is imperative the contacts stay open unless vacuum is established in the chamber, and thus preclude human entry.

1c. Unplug this supply from the wall and wait at least 1 minute prior to working on the gun or sample area of the manipulator. This will allow the High Voltage capacitor to bleed down inside the power supply.

- Check for zero potential with a voltmeter before working on the sample

holder.
- Attach a safety-grounding strap to the exposed high voltage lines at the base of the heater assembly.
- Do not remove the strap until all work has been completed.

2. There is a grounding cable attached to the rear of the panel.
- This must be hard wired to the chamber, which will house the electron gun.
- This connection must be made prior to connecting the HV connector to the HV vacuum feedthrough.
- Verify the ground connection with a VOM.

3. The power supply operates on 220 VAC, using a 3-prong plug (grounding type).
- This must be connected to a correctly wired receptacle.
- IF one is not available, one must be installed.

4. DO NOT SWITCH ON the high voltage with the connector(s) disconnected from the vacuum feedthrough.
- This should only be done by a qualified technician under appropriate conditions for test purposes.

5. Protect the high voltage cable and connector from moisture.
- Bag and tape the connector when not in use. Either dirt or moisture can cause a HV leakage path.

NOTE: Care is especially important around liquid nitrogen.
- Condensation due to LN2 boil-off can cause leakage paths.
- Thoroughly insulate LN2 lines when they are near the cable or at the connector at the base of the manipulator or at the chamber wall.
- Do not run the cable on the floor. Mechanical damage or freezing by LN2 may cause failure of the insulation and thus produce a severe safety hazard.
- Replace any equipment showing damage or misuse.

6. The gun assembly can emit small stray streams of energetic electrons.
- To avoid a buildup of high voltage electrical charge, be sure all insulated conductors passing through the chamber wall are grounded.

7. The high voltage is exposed in the vacuum chamber.
- Be certain to constrain all conductors in the chamber in such a manner as to not allow them to reach the high voltage lines under any condition.
- It is common to break or melt thermocouples off of samples. If the

broken TC lines make contact with the HV, significant electrical damage would result to equipment as well as create a PERSONNEL SAFETY HAZARD.

8. Understand the limits of travel of your device and calibrate the range of operation.

- Do not do this by "feel".
- Visually watch the operation through a viewport.
- Forcing the system beyond its capabilities will cause mechanical & electrical damage and may endanger the operator's life.
- Do not change position of the electron bombardment heater assembly while the high voltage is on.

9. The sample plate **must** be at ground potential.

- This must be a secure connection.
- Do not operate the system in any other manner.
- If there is any doubt, verify electrical path to ground with a VOM.

10. WARNING

This electron gun assembly is capable of melting a molybdenum sample holder if operated at high output levels. Assuming a case where the sample would also be melted, an electron gun with an "acceleration orifice" would remain. This could spray energetic electrons out roughly in a direction normal to the sample face. Other equipment in the chamber should be prepared therefore for this eventuality by having grounded face surfaces.

11. Replace any items that may be damaged or worn.

12. /LO OPTION WARNING

The intrinsic heating cable must be attached to provide a return path for the e-beam electrons. Although similar to the HV connector, it has different keying. This prevents the HV cable from being inadvertently connected to the intrinsic heating connector.

If the intrinsic cable were not attached, and the e-beam heater were operated, lethal high voltage would appear on the intrinsic connector pins. This would be a serious safety hazard.

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IIII. Features

The EPS-3000 substrate power supply is especially designed to give the researcher exceptional operational control of the sample temperature while maximizing the life of the heater filament. Depending on the options selected, this is accomplished by providing:

- Maximum output:
  15 A at 20 VAC filament
  0-3,000 VDC bias
  0.50 A emission
- Input: 220 V 50/60 Hz AC
- True phase fired proportional control of heater element or high voltage bias
- Filament and high voltage current meters
- Adjustable minimum and maximum current limits
- Adjustable high voltage bias output for e-beam heating
- PID microprocessor based automatic temperature controller
- Auto-tuning
- Digital temperature read-out
- Single programmable ramp rate and dwell time
- Two programmable setpoints
- Up to three alarm relays
- Computer interface via RS 232
- Includes power cable, output cable and thermocouple cable
- Requires system thermocouple, type “K” or “C”

IV. Unpacking

All shipment containers should be visually inspected upon arrival for physical damage. Visual inspection of the product should also be done immediately. Shipping companies often require claims for damage is established upon arrival of goods.

All EPS models are shipped with custom foam-in-place packing. This is the only system we have found to provide adequate protection for shipment. The foam is separated approximately halfway inside the box with thin plastic. We recommend the packing box with packing be saved for possible future shipment or equipment storage.

V. Mounting

The EPS-3000 power supply is manufactured in chassis that will fit inside a relay rack, but without a relay rack type front panel. Due to its' weight, it should be placed only on the bottom of a rack. This power supply weighs more than 100 lbs.

VI. Controls, Fuses, Meters and Adjustments

CONTROLS:

AC POWER:
Toggle type, front panel mounted, with integral circuit breaker
Controls all power to the chassis.

TEMPERATURE CONTROLLER:
Refer to controller manual (attached).

MODE:

- Toggle 3 position, center off switch, with guard.
- This switch selects which mode of operation the user wishes:
  1. FULL MANUAL
  2. AUTOMATIC FILAMENT, MANUAL HIGH VOLTAGE
  3. AUTOMATIC HIGH VOLTAGE, MANUAL FILAMENT

WARNING: This switch position should not be changed with the main power switch on. Shut off the power before operating.

Filament Output Bias:
The output bias setting establishes a minimum power setting. This will keep some current passing through the filament whenever the supply is on, and the limit is set above "0". This is done to minimize the temperature swings in the filament and thus prolong filament life. If the user prefers, this can be left at "0".
This adjustment also supplies manual operation.

Filament Limit:
Adjusts maximum power output of automatic control when in "Filament Automatic" mode. This must be set correctly so as not to burn out filament assembly or over-heat sample.

High voltage Start / Stop:
Dual push button, with pilot light
Applies or disconnects power to the High Voltage power supply

High Voltage Output Bias:
Adjusts bias HV level,
0 to 2000 volts under load,
0 to 3000 volts, no load.
This also supplies manual HV adjustment.

High Voltage Limit:
Adjusts maximum power output of automatic control.
This must be set correctly so as not to burn out filament assembly or over-heat sample.

Meters:
Filament Output: 0-15 Amps
Bias Voltage: 0-5 KV
Bias Current: 0-500 ma

VII. Installation

Connections:

The following connections are made on the back panel and must be attached to the appropriate circuits prior to operation.

THESE ARE CRITICAL SAFETY ITEMS.

High Voltage Interlock:

- connect to vacuum switch,
- connector only supplied

The rear panel of the power supply has a two conductor with ground, twist lock connector. This interlock enables the high voltage to be turned on. This must be connected to an SPST set of contacts that close when the chamber containing the electron gun is under vacuum. Depending on application, this may be a diaphragm switch, a filament relay on a controller for a hot cathode ion gauge, or other contacts. It is imperative the contacts stay open unless vacuum is established in the chamber, and thus preclude human entry.

- The ratings on the cable and switch need to be greater than 2 amp at 24 VAC.

- Grounding cable:
- with eyelet,
- supplied, hard wire to chamber body

There is a grounding cable attached to the rear of the panel.

- This must be hard wired to the chamber, which will house the electron gun.
- This connection must be made prior to connecting the High Voltage connector to the High Voltage vacuum feedthrough.
- Verify the integrity of this connection between the power supply chassis and the chamber body with a VOM.

Output:

- 15 feet Output cable, attached

Protect the high voltage cable and connector from moisture.

- Bag and tape the connector when not in use. Either dirt or moisture can cause a HV leakage path.

Care is especially important around liquid nitrogen.

- Condensation due to LN2 boil-off can cause leakage paths.
- Thoroughly insulate LN2 lines when they are near the cable or at the connector at the base of the manipulator or at the chamber wall.
- Do not run the cable on the floor. Mechanical damage or freezing by LN2 may cause failure of the insulation and thus a severe safety hazard.
- Replace any equipment showing damage or misuse.

The output cable will be terminated differently, depending on what is ordered with the unit.

- When ordered with our FHV3-133-2 UHV electrical feedthrough, the connector will be attached to the end of the cable.
- If the power supply is ordered without a feedthrough, the output cable arrives without termination.

Warning:

IT IS THE CUSTOMER'S RESPONSIBILITY TO CORRECTLY TERMINATE THE OUTPUT CABLE, SUPPLYING APPROPRIATE PERSONNEL PROTECTION.

FAILURE TO TERMINATE THE OUTPUT CABLE CORRECTLY MAY CAUSE DAMAGE TO THE EQUIPMENT AND HUMAN INJURY OR DEATH.

Thermocouple:

- 15 feet Type K thermocouple cable, included

AC input:

- power cord supplied
- 220 VAC, < 6 amps, 3 prong (grounding type),

******* BE SURE THE MAIN AC POWER SWITCH IS OFF BEFORE CONNECTING THE POWER CORD TO THE 220 VAC SUPPLY OUTLET. *****

NOTE:

If your unit includes the /LO Interlock Option, refer to page 11 for additional cabling which must be connected.

Sample Grounding (electrical return path):

**********WARNING**********

This is an e-beam type heater. An electrical return path from the sample to the power supply must be maintained. This means the sample and platen must be electrically grounded whenever the heater is in operation. If an electrically isolated sample is needed, safety interlocks must be used to protect the equipment and the user.

Note for: STLC Transferable thermocouple platen users heating with E-gun heaters

RE: Platen grounding through thermocouple

SAFETY WARNING

A customer has had a damaging operational situation occur with potentially lethal consequences. We feel you need to be aware of the possibility and take action to avoid possible problems.

The customer was depositing insulating films in the chamber. Apparently the dock became coated. (The dock/platen interface provides the electron return path.) As he operated the E-gun, the electrons did not have a suitable path to ground. The transferable thermocouple was electrically connected to the sample. The thermocouple wires rose in potential, eventually burning out the temperature controller. A safety hazard was created, as the TC lines and feedthroughs are not suitable for high voltage.

It is conceivable to have the platen, and thus the TC lines, float up to 3,000 VDC.
This would be an extremely dangerous and potentially lethal situation.

It is critical for safe operation that a good electrical ground be maintained between the sample platen and the dock (ground). We recommend the following steps be taken:
Maintain good electrical contact between the dock and the platen. Depending upon your circumstances, this may mean opening up to clean the dock on a regular basis. Clean the back of the sample platen at each use.

Use one of the fingers (finger "C") as a secondary ground path. Connect a ground wire to the finger and a wire between the platen and the "C" platen insert. The wiping action of the finger will help assure this connection.

Route and protect all TC wires and feedthroughs in such a manner as to preclude human contact. This may mean using shielding braid over the TC wires. Safety cans over the TC feedthrough may be required.
/LO Interlock Option

The /LO Bias & intrinsic heating option to the power supply allows multiple use of the heating stage. This option protects the user from inadvertently attempting to e-beam heat the sample when a safe electron return path from the sample is not available.

TWO additional cables are attached to the rear of the power supply chassis and must be attached to the appropriate connectors before powering or operation.

Intrinsic sample heating power to chamber:
Attach to mating connector on chamber or manipulator.

**********/LO OPTION WARNING**********

The intrinsic heating cable must be attached to provide a return path for the e-beam electrons. Although similar to the HV connector, it has different keying. This prevents the HV cable from being inadvertently connected to the intrinsic heating connector.
If the intrinsic cable were not attached, and the e-beam heater were operated, lethal high voltage would appear on the intrinsic connector pins. This would be a serious safety hazard

Intrinsic sample heating power to supply:

This cable is supplied without termination. Terminate it correctly and attach cable to intrinsic heating power source. DO NOT pass over 20 amps through this circuit.

This option has a "FUNCTION" switch mounted to the front panel. This allows the following three modes of operation:

e-beam:

Allows e-beam heating of the sample. Intrinsic sample heating is disabled. Biasing of the sample or reading deposit beam current from the sample is also disconnected.

Bias:

Allows the application of a bias to the sample through the BNC (up to 500 volts) fitting on the face panel. Intrinsic heating and e-beam

heating are disabled.

Intrinsic:

Allows intrinsic heating of the sample up to 20 amps maximum. This setting disables e-beam heating and sample biasing.

NOTE:

Cooling must be used during intrinsic heating

When switching between e-beam operation and either bias or intrinsic operation:

- Power down the e-beam filament
- Turn off the high voltage
- Switch to the "pause" position to allow the power supplies to bleed down
- Stay in pause at least 2 minutes
- Switch to the intrinsic or bias position

NOTE: The intrinsic and bias switch positions have 5 second delays built into the circuit. The actual connections will be made after a 5 second wait.

8.0 Operation: (EPS-3000 with temperature controller)

This EPS-3000 consists of two separate power supplies in one unit. The filament supply is a conventional transformer type, controlled through a true proportioning output module. The final output has special HV isolation. The second power supply is an HV unit capable of high currents (up to 1/4 amp). The HV output is tied to one line of the filament output. The filament power alone can heat small samples with good thermal mounting to approximately 400 to 500 degrees C. To obtain higher temperatures, bias voltage must be applied to the filament. The temperature controller varies the power to the filament in the "Filament Automatic" mode, or the high voltage in the "High Voltage Automatic" mode. With a bias voltage applied in the "Filament Automatic" mode. The effective power delivered to the sample back changes greatly with variation of filament temperature.

With the power off, select the power supply mode of operation. This choice is made via the toggle switch mounted with switch guard beneath the black power modules on the face panel of the supply.

Settings: Your options are:

- **Switch to left**

Auto control of High Voltage
Manual control of Filament supply

- **Switch centered**

Manual control of both HV and Filament supplies

- **Switch to right**

Auto control of Filament supply
Manual control of HV supply

- **MANUAL OPERATION.....Switch centered**

In manual operation, the Output Bias ten-turn pots control the output of each supply. These knobs are located one each on the black power control modules. In the manual mode of operation, the Maximum Power adjustment does not have effect.

Initiate operation as follows:

1. Verify all cables are attached correctly.
2. Verify the chamber is at vacuum better than 1×10^{-6} torr
3. Verify proper sample and gun cooling is operating
4. Select manual mode

5. Turn all 4 adjustment knobs to "0"
6. Turn on AC power. The display will indicate actual temperature.
7. Slowly turn up the Filament Output Bias knob. Observe filament current on the front panel meter. Maximum current varies depending upon the filament of your gun. Most filaments should not be run at currents greater than 12 amps.
8. Turn on high voltage. This is done by push button switch on the front panel. The HV red light will illuminate.
9. Slowly turn the High Voltage Output Bias knob. Observe the high voltage and eventually, the emission current.
10. Operate unit to obtain the desired heating.
11. Turn down High Voltage to "0" when finished, and then turn off HV with the "off" pushbutton.
12. Turn down filament current to "0"
13. Turn off supply.

AUTOMATIC CONTROL Filament... switch to right

In filament automatic control, the PID temperature controller varies the power to the filament. The High voltage is set manually as in MANUAL operation.

Procedure:

1. Verify all cables are attached correctly.
2. Verify the chamber is at vacuum better than 1 x 10^{-6} Torr
3. Verify proper sample and gun cooling is operating
4. Select "Filament Automatic" manual mode
5. Turn all 4 adjustment knobs to "0"
6. Turn on AC power. The display will show actual temperature and desired temperature. Adjust controller to desired temperature. (see controller module manual)
7. Slowly turn up the Filament Limit knob. Observe filament current on the front panel meter. Maximum current varies depending upon the filament of your gun. Most filaments should not be run at currents greater than 12 amps.
8. Turn on high voltage. This is done by push button switch on the front panel. The HV red light will illuminate.
9. Slowly turn the High Voltage Output Bias knob. Observe the high voltage and eventually, the emission current. This may need to be adjusted to obtain adequate heating.
10. Auto-tune controller module (see controller module manual)
11. Operate unit to obtain the desired heating.
12. Slowly adjust Filament Bias to maintain some filament heating even when the controller is not calling for more power. This power level should be set below electron emission filament temperatures.
13. Turn down High Voltage to "0" when finished, and then turn off HV with

the "off" pushbutton.
14. Turn down "Filament Current Limit" to "0"
15. Turn off supply.

AUTOMATIC CONTROL High Voltage.....switch to left

In High Voltage automatic control, the PID temperature controller varies the High voltage power. The Filament is set manually as in MANUAL operation.

Procedure:

1. Verify all cables are attached correctly.
2. Verify the chamber is at vacuum better than 1 x 10^{-6} Torr
3. Verify proper sample and gun cooling is operating
4. Select "High Voltage Automatic" manual mode
5. Turn all 4 adjustment knobs to "0"
6. Turn on AC power. The display will show actual temperature and desired temperature. Adjust controller to desired temperature. (see controller module manual)
7. Slowly turn up the Filament Bias knob. Observe filament current on the front panel meter. Maximum current varies depending upon the filament of your gun. Most filaments should not be run at currents greater than 12 amps.
8. Turn on high voltage. This is done by push button switch on the front panel. The HV red light will illuminate.
9. Slowly turn the High Voltage Limit knob. Observe the high voltage and eventually, the emission current. This may need to be adjusted to obtain adequate heating.
10. Auto-tune controller module (see controller module manual)
11. Operate unit to obtain the desired heating.
12. The "HV Bias" may need to be adjusted to limit the HV swings by the automatic controller and the resultant temperature oscillation. After adjustment, additional "auto-tunes" may need to be run.
13. Turn down High Voltage to "0" when finished, and then turn off HV with the "off" pushbutton.
14. Turn down "Filament Current Limit" to "0"
15. Turn off supply.

8.1 Initial Operation

INITIAL OPERATION AND HEATER CONDITIONING:

Before turning on the AC switch, high vacuum must be established in the chamber. We recommend operating initially at pressures less than 1×10^{-6} Torr. The connectors should be attached as required and verified, and the controls should be set as follows with the standard Tungsten filament.

Filament: OFF

Filament Minimum: Minimum ("0")

Filament Maximum:
approx. 3.84 (mechanical dial) Tungsten filament
approx. 3.00 (mechanical dial) Yttrium Oxide coated Iridium filament

High Voltage: OFF

High Voltage Minimum: Minimum ("0")

High Voltage Maximum: approx. 8.40

Control Mode Selector Switch: “center” (Auto control off)

Function Selector: “Heater”

The Eurotherm PID controller is a true proportional type and depending on operating temperature, a number of different tuning values can be set for best operation. We suggest the following settings for initial operation. Refer to the Eurotherm controller manual to make/change these controller settings:

Proportional Band (Pb): 150
ti 6
td 1

Heater conditioning:
The heater must be conditioned initially and again whenever it has been exposed to air or other possible contaminants. Insert a blank sample mount

(or sample if you prefer) into the dock.

Procedure:

NOTE: Read this procedure in its entirety and understand it before proceeding.

1. Verify AC power switch is “off”, and all cables are attached correctly.
2. Verify the chamber is at pressure less than 1 x 10^{-6} Torr
3. Verify proper sample or blank is in place
4. Verify heater cooling is operating
5. Verify the Selector mode switch is in the “center” (all manual) position.
6. Turn both filament and high voltage power supply on/off switches to “off”
7. Turn both “minimum” adjustment knobs to "0”
8. Leave the two “maximum” adjustment settings as adjusted from earlier runs, or as suggested in the initial setup procedure listed above.
9. Turn on AC switch. The controller should light and indicate the thermocouple temperature. Read the Eurotherm controller manual for its proper operation.
10. Turn on the filament rocker switch.
11. Increase the filament “minimum” knob to approximately 3 Amps and note the temperature of the sample.
12. Continue to increase the temperature to at least 200°C. Do not exceed 4 Amps with a standard Tungsten filament.
13. Allow the heater to run for 20 minutes to two hours depending on the condition of the unit. A new heater module from a sealed wrapper will only require a short time. A heater exposed to air for days will require considerably longer time to outgas. Note outgassing on the vacuum gauge. Reduce the heater power to keep the pressure under 1 x 10^{-6} Torr.
14. After outgassing, turn down and turn off the filament supply
15. Turn on the high Voltage and slowly turn up the minimum high Voltage Bias adjustment.
16. Monitor the emission current and high voltage on the meters. If any emission current is observed or any jumps/spikes on the meter are seen, turn down the adjustment and start increasing slowly again. Allow the system to “rest” for a few minutes at each 100 Volts of high voltage until the 500 Volt maximum is reached.

Note: If repeated arching/sparking is observed, the problem must be remedied before proper operation can occur. Arcing problems are usually caused by cleanliness problems, conductive films deposited on the heater parts and mechanical shorting by other conductive material in the chamber. Cleaning and/or rebuilding of the heater or rework of the supply wires in the chamber may be required.

17. Turn down and turn off the high voltage on completion of successful high voltage test.
18. Set filament and HV bias maximum adjustments for your application as described below.

Setting the Filament Maximum adjustment:

We recommend a maximum setting of 3.84 for the standard Tungsten filament and an initial maximum setting of 3.00 for the Yttrium coated Iridium filament, set on the mechanical dial. The maximum filament setting will need to be adjusted (increased) over the life of the Iridium filament when it is used in partial pressures of O_2 because of the degradation of the efficiency of the coating over time. If you wish, this adjustment can be determined for your application/situation as outlined below.

The "maximum' function is not a simple "clipping "of the output capability to a maximum power output. This function creates a maximum output and assigns this maximum as 100% of the power available to the proportional controller. This makes initial setting of this limit a little more involved.

1. To set this limit first turn the Selector mode switch to the "center" (all manual) position. Next, turn the Filament Maximum potentiometer to 0.0.
2. Next, set the Filament minimum potentiometer to 10.0 (It's maximum setting)
3. Now slowly increase the Filament Maximum Potentiometer monitoring the output current. Stop at the maximum current desired and note the potentiometer dial number. Lock this setting.
4. Turn the Filament Minimum down to 0.0
5. This Filament Maximum current will be the maximum power available in both the manual and automatic modes and the automatic control will indeed apply this level of power when attempting to reach a higher temperature. Setting this control at a lower level than the maximum recommended value will decrease the stress on the filament and provide greater filament life.

Note: Make changes slowly when adjusting the "maximum" setting if the power supply is operating. Changing this setting will make minor changes in the "minimum" power level setting and the effect of the PID controller power requests. Once the correct setting is established for your heating application, we recommend this adjustment be set and locked.

Setting the HV Bias Maximum adjustment:

We recommend a maximum setting of 8.40 for the standard Tungsten filament and for the Yttrium coated Iridium filament, set on the mechanical dial. If you wish, this adjustment can be determined for your application/situation as outlined below.

The HV Bias Maximum adjustment can be set in the same manner as the Filament Maximum. This adjustment will establish the maximum High Voltage that the Bias supply will achieve when operating in either manual or automatic modes. This function creates a maximum Bias output and assigns this maximum as 100% of the power available to the proportional controller or minimum adjustment. This makes initial setting of this limit a little more involved.

1. To set this limit first turn the Selector mode switch to the "center" (all manual) position. Next, turn the HV Bias Maximum potentiometer to 0.0.
2. Next, set the HV Bias Minimum potentiometer to 10.0 (It's maximum setting)
3. Now slowly increase the HV Bias Maximum Potentiometer, monitoring the output voltage. Stop at the maximum voltage desired and note the potentiometer dial number. Lock this setting.
4. Turn the HV Bias Minimum down to 0.0
5. We recommend a maximum setting of 8.40.
6. This HV Bias Maximum setting will be the maximum power available in both the manual and automatic modes and the automatic control will indeed apply up to this level of voltage when attempting to reach a higher temperature.

Note: Make changes slowly when adjusting the "maximum" setting if the power supply is operating. Changing this setting will make minor changes in the "minimum" power level setting and the effect of the PID controller power requests. Once the correct setting is established for your heating application, we recommend this adjustment be set and locked.

1. The heater is now ready to operate.

8.2 MANUAL OPERATION

In manual operation, the PID temperature controller will monitor the control thermocouple temperature only. *(Placement of this thermocouple is critical!)* The Filament and high voltage Bias are set manually. The system should be closely monitored at all times during manual operation.

Note: At high temperatures, the temperature of the filament is significantly influenced by the temperature of the back of the sample insert. Higher filament temperatures create higher emissions with no increase in filament current. This heater is capable of remarkably fast temperature change. Care must be taken not to allow significant temperature overshoot and/or thermal runaway.

Procedure:

NOTE: Read this procedure in its entirety and understand it before proceeding.

1. Verify AC power switch is “off”, and all cables are attached correctly.
2. Verify the chamber is at a pressure less than1 x 10^{-6} Torr
3. Verify proper sample insert is in place
4. Verify heater cooling is operating
5. Verify the Selector mode switch is in the “center” (all manual) position.
6. Turn both filament and high voltage power supply on/off switches to “off”
7. Turn both “minimum” adjustment knobs to "0”
8. Leave the two “maximum” adjustment settings as adjusted from earlier runs, or as suggested in the initial setup procedure listed above.
9. Turn “on” chassis AC power switch. The Eurotherm PID controller display will show actual temperature and desired temperature. Verify the control mode switch under the Eurotherm PID controller is in the middle position (“off”).
10. Turn on the filament rocker switch and slowly turn up the Filament “minimum” knob. Observe filament current on the front panel meter. If the desired temperature is met with the filament alone, do not turn on the high Voltage, but simply adjust the filament output to obtain the desired temperature. Do not exceed 4 Amps with a standard Tungsten filament.
11. If your desired temperature is not achieved with the filament alone, leave the filament set at 3.7 to 4.0 Amps and proceed to add High Voltage Bias for electron beam heating.
12. Turn on High Voltage Bias switch. Slowly increase the “Minimum” High Voltage Bias knob, while watching the Emission meter. Once emission is observed, allow the temperature to stabilize. *WARNING: the temperature will increase quickly. Do not overshoot your desired*

temperature. Very small adjustments to the filament current or High Voltage Bias power will/may have dramatic effect on the sample temperature.

13. Increase High Voltage Bias adjustment until the desired temperature is obtained. We recommend using 25°C increments allowing time for the temperature to stabilize.
14. Optimizing heater operation. Once the desired temperature is obtained, the settings may be slowly optimized to minimize filament temperature (filament Amps) while getting maximum power from the electron beam heating. This is done by slowly reducing the filament amps while increasing the High Voltage Bias power. Optimum filament life will be achieved with High Voltage Bias settings of between 400 to 480 Volts under load.
15. The necessary (correct) filament current will change over the life of the filament. This setting needs to be high enough to provide emission, but no higher than necessary to provide adequate resistance to the extraction of electrons from the filament and to maximize filament life. Initial current will be about 3.6 amps Maximum current may be as high as 7 amps. Note the increasing sample temperature and allow temperature to stabilize at its maximum.
16. Allow the system to operate, making minor output adjustments as required.
17. When finished turn down "Filament Minimum Limit" to "0" and turn off the filament supply.
18. Turn down Minimum High Voltage to "0" and then turn off HV switch.
19. Turn off main supply switch.

8.4 AUTOMATC CONTROL

In automatic control, the Eurotherm PID temperature controller varies the High voltage Bias or Filament power, depending on the position of the “control” mode switch. The supply not controlled by the automatic controller is set/adjusted manually.

CAUTION

Starting Off a heating session in automatic control (either Filament or High Voltage Bias mode) is difficult and may create undesirable temperature overshoot before final stable temperature is obtained. This process may/will shorten filament life. The PID settings and final desired temperature will significantly affect this. The ERH heater is remarkably fast and powerful, creating a possible situation where the time delay between when the back of the sample platen is actually over-temperature but the thermocouple measuring sample temperature has not yet “received” the energy to report the hotter condition. The momentary “error differential” in temperature can be as high as several hundred degrees, depending on heater control settings, sample mounting, thermocouple placement and thermal characteristics of the sample itself. We strongly recommend manually achieving the desired sample temperature slowly and then switching to automatic mode once the sample temperature has been reached and is stable. This procedure is described below. Automatic control may not be appropriate in all applications.

Procedure:

NOTE: Read this procedure in its entirety and understand it before proceeding.

1. Verify the AC power switch is “off”, and all cables are attached correctly.
2. Verify the chamber is at a pressure less than 1 x 10^{-6} Torr
3. Verify proper sample insert is in place
4. Verify heater cooling is operating
5. Verify the Selector mode switch is in the “center” (all manual) position.
6. Turn both Filament and High Voltage Bias supply on/off switches to “off”
7. Turn both “minimum” adjustment knobs to "0".
8. Leave the two “maximum” adjustment settings as adjusted from earlier runs, or as suggested in the initial setup procedure listed above.
9. Verify the control mode switch is in the center (“off”) position
10. Turn “on” chassis AC power. Verify the Eurotherm PID controller is in “AUTOMATIC” mode. The display will show actual temperature and desired temperature. Adjust controller to desired temperature. (See controller module manual). NOTE: This does NOT refer to the 3 position “mode” switch under the Eurotherm PID Controller.
11. Manually increase the temperature of the sample to slightly over the

final desired temperature (10°-20° via the Manual procedure listed above. Allow the temperature to stabilize and optimize heater operation.

12. Now switch the “Mode” switch from the center position (“off”) to either HV Bias or Filament control modes. No change in power or temperature should occur.
13. Slowly lower the minimum knob setting of the power supply that is now being controlled by the PID controller. The sample temperature will decrease with the reduction in power and the OP1 Light on the PID controller will come on once the temperature has dropped below the desired temperature (set point).
14. Once the temperature stabilizes at the set point value, continue to reduce the “minimum” adjustment down to “0”. You are now in automatic control mode.
15. Proceed to operate.

WARNING:
NEVER allow electron bombardment sample heating equipment to operate unattended, due to the large number of failure scenarios and their possible consequences. Catastrophic failure may result.

1. When finished, you may simply turn off the AC power switch. Be sure to turn the selector switch to the center” manual” position and the two “minimum limits” to “0” as well in preparation for the next use.
2. You may choose to lower the temperature slowly by reducing the set point in the auto mode, reducing the” minimum limit” setting on the controlled supply as needed if it has not already been reduced to “0”.
3. You may also choose to switch the supply back into “manual” mode and reduce the temperature manually. Care must be used so as not to cause a sudden reduction of power to the sample and thus a sudden thermal change. Increase the “minimum limit” adjustment slowly on the supply being controlled by the controller. Once the temperature starts to increase slightly above the set point and the demand light on the controller is off, switch to the “manual” position. Reduce the filament and bias minimums to control temperature reduction.
4. Turn off main supply switch.

Notes on using ERH heaters in partial pressures of Oxygen:

The standard ERH heater is designed to provide up to 1,200°C platen temperature in HV/UHV environments (<10^{-6} Torr). The normal expected filament life is >200 hours using the standard Tungsten filament at full temperature. Significantly better filament life is enjoyed at lower

temperatures. Customers have operated ERH Heaters at higher pressures and environments with reduced filament life.

The ERH Heater is available in ERH-O_2 model for use in partial pressures of oxygen up to 1 x 10^{-5} Torr. The filament used is a coated Iridium filament that is more robust for oxidizing conditions and other components are changed. Expected filament life is reduced to 50-100 hours at 1,200°C platen temperature with greater life available at lower temperatures.

As the ERH-O_2 is operated, reduced performance at a given power level will be noticed. Filament temperature will need to be increased over time to continue to operate at a given temperature. This is normal.

Notes on the Eurotherm PID temperature Controller

The Eurotherm PID controller is a full-featured unit that can provide operational services beyond what has been mentioned here. It is capable of ramp-and-soak operation and numerous controls on temperature overshoot. An RS232 connector is provided for computer communication with the controller. Please refer to the controller manual for further information.

CAUTION

Included in the features of this controller is an “auto tune” feature, but we strongly caution users about implementing this capability. The ERH heater is uniquely fast and powerful. The “auto tune” process may generate significant temperature overshoot when used with this heater. We ***do not*** recommend its use.

9.0 Troubleshooting:

Symptom	Possible cause	Remedy
No HV Bias is achieved and "HV Bias" switch does not light	HV fuse blown	Replace with correct new fuse (Sec. 7)
No Filament current and "Filament" switch does not light	Filament fuse blown	Replace with correct new fuse (Sec. 7)
Same as above	Output fuse blown	Check for shorting in filament wiring and replace fuse
No Filament current and Filament switch does light	Filament burned out	Replace heater filament
Same as above	Filament circuit wiring open	Disconnect supply from chamber and check wiring
HV Bias is not steady and intermittently draws current	Arcing /shorting in heater	Replace heater or disassemble and clean heater components
Temperature oscillates above and below set point under controller mode	Proportional band set too low	Increase proportional band setting
Short filament life experienced	Operated at too high pressures	Keep pressure below 10^{-6}
Same as above	Operated in oxidizing environments	Change to Iridium filament and do not exceed 10^{-5} O_2
Same as above	Operated above temperature rating	Check rating for your unit/application and do not exceed
Significant temperature overshoot and/or type K thermocouples melting	Filament power increased too quickly	Slowly increase power in manual mode, then switch to automatic operation
Same as above	Reference/control thermocouple not located thermally close enough to sample platen	Move thermocouple and/or secure with better thermal properties
Same as above	Operating heater above its specification	Operate as lower temperatures
Bias indicated, no emission	Platen not grounded	Ground platen
	Filament current too low	Increase current
	Filament elevation incorrect	Mechanically adjust filament

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