

4.2 NORMAL OPERATION

4.2.1 NORMAL START UP PROCEDURE

	 CAUTION
	Kimball Physics recommends that the gun be run only in a vacuum of 10^{-6} torr or better for a refractory metal cathode (10^{-7} torr for BaO cathode or 10^{-4} torr for Thoria cathode). Poorer vacuum may result in source damage. Read instructions before operating!

- Installation:
 - Install the ELG-2/ EGPS-1022 Electron Gun and Power Supply system according to instructions in Sections 2.2 and 2.3.
 - For optional bakeout of the ELG-2, see procedures in Section 6.1.
 - Refer to the Data Section for typical operating parameters.
- Proper Vacuum:
 - For standard refractory metal cathodes: Ensure that the vacuum in the chamber is **1×10^{-6} torr** or better.
 - For optional barium oxide (BaO) cathodes: Ensure that the vacuum is **1×10^{-7} torr** or better.
 - For optional thoria (ThO₂) cathodes: Ensure that the vacuum is **1×10^{-4} torr** or better. Although the iridium cathode can survive a brief accidental loss of vacuum, the gun should not be run in poor vacuum.
CAUTION: Poor vacuum may result in discharging or source damage.
- Make an initial check of the following items of the EGPS-1022 front panel controls:
 - The green **POWER**, red **HIGH VOLTAGE**, amber **ECC ON/OFF**, and amber **DEF ON/OFF** rocker switches should all be off, **O** position.
 - CAUTION: Optional pulsing must be off for start up.** With Dual Grid Power Supply pulsing option, the user-supplied TTL generator must be **DISCONNECTED** for initial start up or normal non-pulsing DC operation, otherwise the fixed grid will cut off the beam.
- On the back of the EGPS-1022, check all the small local/remote slide switches labeled **PROGRAMMING**
 - For manual control using the front panel controls, the slide switches should be in the **LOCAL** position (down).
 - For remote computer control via the 68-pin connectors (DAQ boards and LabVIEW™ program), the slide switches should be in the **REMOTE** position (up).
 - These switches may be changed at any time that the system is powered off. Different supplies can be run either locally or remotely by setting their individual switches. Front panel meters are not affected by these switches. (See Section 4.4.2 Remote Programming to identify switches.)
- Initial energizing of the Power Supplies:
 - Switch the green **POWER** rocker switch on (**I** position). to energize the supplies. The switch and the green **POWER ON** indicator on the back of the unit should light.
 - The FlexPanel Control display screen turn on, but do not try to operate yet.
- Interlocks
 - Check that the amber **INTERLOCK** LED is off.
 - The LED will illuminate momentarily when the Power Supply is first energized to show that the Interlock circuitry is working.
 - If the amber **INTERLOCK** LED stays lighted:
 - Switch the green **POWER** switch off (**O** position) to de-energize the Power Supply.
 - Check that the cables are connected tightly.
 - Check that the top and bottom covers of the Power Supply are closed securely.
 - Check that the spare interlock is a closed circuit, either jumpered as shipped, or a closed external loop to the user's system.
 - Reenergize the Power Supply after the fault is corrected.
- Controlling the Power Supplies:
 - Switch the red **HIGH VOLTAGE** rocker switch on (**I** position) to energize the High Voltage power supplies. The switch and the red **HV ON** indicator on the back of the unit should light.
 - If the **ZERO** LED lights:
 - Check that the individual supplies, such as Energy, have not been turned up prematurely. Push the small red **SHUTDOWN** button to zero all supplies. With remote control, check that all remote programming signals are zero.
 - If the light does not clear, this indicates a problem with the circuitry or programming.

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	 <h1 style="margin: 0;">CAUTION</h1>
	<p>ENERGY and SOURCE/ECC supplies must be turned up gradually.</p>
	<p>Excessive source current will reduce cathode lifetime. The recommended limit is 1.75 A for a standard refractory metal cathode.</p> <p>The Grid should be zero prior to initial source adjustment.</p>

8. FlexPanel Control display screen:
 - a. All supply meters should read zero initially (or close to zero, due to high sampling speed / resolution of chips and ripple at low end of scale).
9. If the gun has been run previously and all the desired settings have been stored with the manual **STORE** button, the system can be operated with same settings as used previously.
 - a. Press the red **RESUME** function button.
 - b. This will set all power supply controls to the values stored most recently.
 - c. All supplies will automatically be turned on, in an appropriate sequence, with the critical supplies, such as Energy and Source, being gradually ramped up to the set value.
 - d. At this point the gun can simply be run with the given settings until shutdown, or individual controls can be adjusted as described below in this section.
10. Changing program options with the FlexPanel Controls options (if desired):
 - a. Program options may be changed at any time. Settings are retained when the unit is turned off, and so only need to be set if changes are desired.
 - b. Push the red function button labeled **MENU** to display the list of options, such as screen brightness.
 - c. Using the selector buttons and the encoder wheel as directed on the screen, change the options.
 - d. When finished, push the lower right selector button for **Done** to enter the changes.
11. For optional remote computer control:
 - a. Open the National Instruments LabVIEW™ master program file, *EGPS-1022 Control [version].exe* (or *.vi*) in the Kimball Physics folder. It will start up LabVIEW™. Alternatively, open a user-designed program and follow its procedures.
 - b. Click the arrow in the menu bar to start the program.
 - c. Enter the operator's name for the data log, if desired. Answer message boxes, if any appear. Note that the remote/ local switches can not be changed from the computer.
 - d. On the computer control panel, start the program by clicking the **POWER** button. The button should turn all green, and the digital indicator meters should show 000. Note that this power button does not energize or shut down the EGPS.
 - e. Check that the **Energy, Source, Grid, 1st Anode, Focus, X and Y Deflection** controls are all set to zero with their numerical inputs.
 - f. Initially the **ECC ON / OFF** and **Deflection ON / OFF** toggle switches should be in the **OFF** position.
 - g. For initial start up, the settings toggle switch should be in the **Use Panel Controls** position.
 - h. The **Meter Mimic / DAQ Mode** switch must be in the **DAQ Mode** position for the program to run the gun.
 - i. If desired, scroll to the bottom of the screen and change any of the **User-Controllable Program Options**. These preferences, such as how quickly to ramp up supplies, will probably not need to be changed frequently.
12. If the gun has been run previously and all the desired settings have been saved with the LabVIEW™ remote control program, go to step # 26 below "Using saved LabVIEW parameter settings".

Table 4.2-1 ELG-2/ EGPS-1022 Bias Voltages

Power Supply	Range	Initial setting	Reference
Grid	0 to -50 V	0 V	H.V. common
1st Anode	0 to +200 V	50 V	H.V. common
Focus	0 to +2000 V	500 V	H.V. common

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CAUTION: To protect cathode lifetime, the Source Current should not exceed the following levels:

Table 4.2-2 ELG-2/EGPS-1022 Emission and Source Currents

Cathode type	Recommended max Emission current	Typical operating range Source current	Recommended max Source current
Standard refractory metal disc	20 μ A	1.50 A to 1.70 A	1.75 A
Barium oxide (BaO)	20 μ A	1.00 A to 1.20 A	1.25 A
Standard Thoria (ThO ₂)	20 μ A	1.60 A to 1.75 A	1.80 A

13. Controlling the Electron Beam Energy:
(Range 0 to -2000 eV)
- GRADUALLY adjust the **ENERGY** control to the user-desired value for the electron beam acceleration energy.
 - With the front panel FlexPanel Controls, select **ENERGY** on the display screen with the adjacent gray button. Turn the encoder wheel, clockwise to increase the voltage displayed next to the label. Turn more quickly to make larger changes, then turn slowly for fine adjustment. Push the button again or push **STORE** when finished.
 - With the LabVIEW™ remote computer control, use the **Energy** digital control increment button by clicking the up arrow to increase the voltage. The associated **Fine/Coarse** slide switch changes the increment by a factor of ten.
 - Monitor the **ENERGY** Voltage on the display screen or on the computer digital meter labeled **Beam Energy**.
 - Discharging can be seen as jumping in the digital output or on the red horizontal slide bar of the computer control panel.
 - With FlexPanel Controls, the Energy power supply voltages are gradually ramped up to the value set. The internal programming has a preset slew rate so that the voltage is increased in a number of steps. However, it is still advisable to make adjustments gradually and observe the effects.
14. Setting the initial biases:
- Refer to Table 4.2.1 and the Data Section for typical values.
 - The GRID must be set at zero initially.** Excessive grid voltage will suppress emission from the cathode, possibly causing the user to incorrectly increase the source current to increase emission.
 - Using the **1st ANODE** and **FOCUS** controls (encoder wheel or computer control) adjust the initial Anode and Focus voltages as desired.
- NOTE:** Microamp discharges may occur in the gun after initial installation in the vacuum system, As high voltage surfaces “clean-up,” this discharging should cease.
15. Energizing the Source supply for cathode (filament) heating:
- The **GRID** control should be set at zero initially.
 - On the EGPS or computer, the **ECC ON/OFF** switch must be **OFF** (O position) for Source mode.
- (Energizing the Source supply cont.)
- GRADUALLY, adjust the voltage to the filament with the **SOURCE** control (encoder wheel or computer control).
 - Monitor the **SOURCE** voltage and current, and **EMISSION** current meters while adjusting the **SOURCE** control.
 - CAUTION: With FlexPanel Controls, care must be taken not to increase the Source voltage too rapidly with the encoder wheel.** Due to capacitance in the cathode system and protection in the power supply circuitry, there is a delay in the response to voltage changes. Make small changes, and then wait until the Source voltage has stopped drifting up, before continuing. Because the encoder wheel has a variable rate of increase/decrease, it is possible to turn the Source up higher than is intended.
 - As power to the filament is increased, the electron gun will begin to emit. Monitor the emission current while adjusting the Source to achieve the desired emission current. A change of 0.1 amp can cause a large change in emission. For prolonged cathode lifetime, it is advisable to use the lowest filament current possible. See the Data Section for typical source current ranges to produce the desired beam current at a given Energy. The source current may be reduced somewhat after warm-up. **Refer to Table 4.2-2 for the correct current ranges for the cathode installed in the gun.**
 - CAUTION:** If the **SOURCE** voltage and current values on the display screen become highlighted (or if the **Overcurrent** button on the computer turns yellow), this is a warning that indicates that the Source current has reached or exceeds the recommended maximum operating current. Running the Source current this high greatly reduces the cathode lifetime.
 - For Thoria cathodes:** During heating, there will be a burst of emission current due to activation. When emission is first observed, watch for the burst and wait a couple minutes until it subsides. Then increase the source to get the desired current. If the source is too high initially, the burst can go over the current limit, causing the poly-fuse to trip.
 - CAUTION:** If the **EMISSION** meter goes much beyond its normal range (becomes highlighted on the display screen), the FlexPanel metering circuitry can be damaged. The standard Emission current range is up to 20 μ A. Control the beam by either increasing Grid or decreasing Source voltage.
 - CAUTION: With an optional Faraday cup, beam power must not exceed 2 Watts, see Section 4.8.**

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16. Improving the beam characteristics, Focus voltage:
 - a. Using the **FOCUS** control (encoder wheel or computer control), adjust the Focus voltage as necessary to obtain the desired spot size. With the LabVIEW™ computer panel, the red arrow thumb slide control can be used for easier adjustment.
 - b. The Focus voltage setting depends on the desired spot size, the working distance (i.e. the distance from the end of the electron gun to the target) and the 1st Anode setting. With the ELG-2, two different Focus values may produce a minimum spot with a given set of parameters.
 - c. **NOTE:** In some cases, if Energy is low and the Focus voltages are set too high, the Focus lens may act as an electron mirror, and **the spot may disappear.**
 - d. In the ELG-2, the Focus, Grid and 1st Anode are floated on Energy, as so do not need to be set as proportional using the panel display menu.
17. Improving the beam characteristics, Grid voltage:
 - a. Using the **GRID** control (encoder wheel or computer control), adjust the Grid voltage as necessary to control beam current and improve the beam uniformity.
 - b. The ratio of Beam current (the actual current leaving the gun) to Emission current (total current off the cathode to ground) will be improved with some empirically-determined grid bias.
 - c. Higher Grid voltages will reduce or cut off electron emission
 - d. **For systems with Dual Grid Pulsing option:**
See Section 4.7.
18. Improving the beam characteristics, 1st Anode voltage:
 - a. Using the **1st ANODE** control (encoder wheel or computer control), adjust the 1st Anode (G-2) voltage to improve beam current.
 - b. A higher 1st Anode voltage produces a smaller spot, and is particularly needed for a small spot at high Energies.
19. Deflection with Manual Control Deflection Unit (MCDU) (Section 4.5)
 - a. On the EGPS, switch the amber **DEF ON/OFF** rocker switch on (**I** position) to energize the supplies. This is necessary for either local or remote control.
 - b. On the computer, switch the **Deflection ON / OFF** toggle switch to **ON**. Set the desired range with the **Deflection Scale Range** switch. The range sets the sensitivity of the Deflection slide controls and meters.
 - c. Using the **X DEFLECT** and **Y DEFLECT** controls (encoder wheel or computer control), adjust the Deflection plate voltages as needed to center or position the beam in the X and Y directions within the target plane. With the LabVIEW™ computer panel, the red arrow thumb slide control can be used for easier adjustment.
 - d. If desired, set the Deflection outputs to be proportional to Energy so that the spot position will be more constant as the beam energy is changed.
 - i. Push the **MENU** button and select **set proportional outputs** with its selector button. Then select **change proportional sources**.
 - ii. Select **SLAVE OUTPUT** and turn the encoder wheel to choose **X DEFLECT**. Then select **SOURCE OUTPUT** and choose **ENERGY**. Push **Done**.
 - iii. Repeat for **Y DEFLECT**.
 - iv. Press **Done** until the screen returns to the control / meter display.
 - v. To cancel the proportional relationship, repeat the process choosing **SOURCE OUTPUT : FULL RANGE**.
 - vi. When using computer/ remote control, this program option is not available. However, setting files with the appropriate X and Y Deflection voltages for different Energies can be saved with the LabVIEW™ program.
 - e. If deflection is switched off and then back on again with either the EGPS rocker switch or computer toggle switch, the controls will return to the previously set values to simplify repositioning of the beam.
20. With optional Port Aligner: Beam position can be mechanically adjusted by $\pm 2^\circ$. Loosen the two locking screws on the discs, rotate one or both Port Aligner discs as needed while observing the spot, and then lock the position by tightening the two locking screws.
21. Saving settings with FlexPanel Controls:
 - a. At any point, the current setting of all power supply controls can be saved by pushing the red **STORE** button. Only one set of parameters is stored.
 - b. To return to the stored values, push the red **RESUME** button.
 - c. **NOTE:** With a Thoria cathode, the stored settings should not be near the maximum emission. Otherwise, when resume is used, the activation burst may go over the current limit. Save at a lower source or higher grid, and then adjust by hand after using resume.

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22. Adjustment of any control may require “fine-tuning” of the others to achieve the desired spot size, beam current and beam current uniformity. Magnetic fields in the vacuum lab environment may make it necessary to readjust parameters as beam energy is varied.
23. For optional feedback-stabilized Emission Current Control (ECC): See also Section 4.3.
CAUTION: Do not use ECC with pulsing.
 - a. Although protection against excessive source current is built into the ECC circuitry, it is best to employ the ECC mode **after** the approximate operating parameters have been determined in Source mode.
 - b. Using the **SOURCE** control (encoder wheel or computer control), decrease the Source voltage to zero.
 - c. On the EGPS or computer, set the **ECC ON / OFF** switch to **ON** (I position) for Source mode.
 - d. GRADUALLY adjust the **SOURCE** control (encoder wheel or computer control) to set the desired emission current, as shown on the **EMISSION** meter. Monitor as described for Source mode.
24. For pulsing, see Section 4.7. With either a Pulse Junction Box or a Dual Grid Power Supply, pulsing is controlled directly, not by the LabVIEW™ computer program.
25. Saving settings with LabVIEW™ computer remote control program (optional):
 - a. After the settings of various parameters have been determined for optimal beam alignment and gun performance, they can be saved as a file for future use. The settings will be different for different energy levels and for different operating conditions, such as working distance.
 - b. Click the **Save Current Settings** button and save the file with an appropriate new name using the dialog box that appears.
26. Using saved LabVIEW™ parameter settings (optional):
 - a. To use one of the previously saved files, switch the Settings toggle switch to the **Use Saved Settings** position.
 - b. In the dialog box that appears, choose the appropriate file for the Energy level and other operating conditions.
 - c. The numerical control boxes and digital meters will change to reflect the settings. The toggle switch will return to the Use Panel Controls position.
 - d. When first starting or if the change in Energy or Source value is too great a step, the program will make the change in a more gradual series of steps.
 - e. At this point the gun can simply be run with the given settings.
 - f. Alternatively, some of the parameter controls can be adjusted manually with the computer panel as described above, while the preset values are used for the others. Adjustment of any control may require “fine-tuning” of the others.
27. For more information on use of options and features, such as Emission Current Control (ECC), Remote Control, Deflection, Rastering, Pulsing etc., see specific sections in this chapter.

This completes the Normal Start Up Instructions.

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4.2.2 NORMAL SHUT DOWN PROCEDURE

1. Secure (turn off) the ELG-2 / EGPS-1022 system in the following sequence:
 - a. Push the red **SHUTDOWN** button. Wait until all meters read zero.
 - b. On the computer, turn off the LabVIEW™ program by clicking the **POWER** button. The green button light and digital readouts should go off. **Do not just close the window** as the program voltages may remain at the values set before the window was closed. Turning off the program does not turn off the power supply units.
 - c. With optional pulsing, turn off the user-supplied pulse generator. With a Dual Grid Power Supply, also disconnect the generator.
 - d. Switch the amber **DEF ON/OFF** rocker switch off (**O** position).
 - e. Switch the amber **ECC ON/OFF** rocker switch off (**O** position) for Source mode to ensure that the gun will not be turned on at full power.
 - f. Switch the red **HIGH VOLTAGE** switch off (**O** position).
 - g. Switch the green **POWER** switch off (**O** position).
2. After securing the system, **wait at least 30 minutes** for cool down of the electron gun, before venting the vacuum system. This procedure avoids possible cathode damage and the formation of oxidation layers on apertures caused by venting the gun while still hot.
3. If the gun has a **barium oxide (BaO) cathode**, it is best to store the gun in vacuum. If it must be stored out of vacuum, it should be placed in a clean, dry environment such as a tightly sealed plastic box with desiccant. When operation is resumed, the BaO cathode may need to be reactivated if the gun has been exposed to atmosphere. See instructions in the Appendix.

H.V. WARNING: The red SHUTDOWN button sets all the individual power supply voltages to zero, but does not shut down the entire unit. Also, turning off the computer does not turn off the system. High Voltage will still be present until the entire sequence is completed. **Before performing any troubleshooting or maintenance on the power supply, ensure that the Power and High Voltage switches are off, then disconnect the power cord from the AC main outlet, and wait at least 3 minutes for any voltage to discharge.**

This completes the Normal Shut Down Instructions.