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^{-4} torr** or better
Poorer vacuum may result in source damage.

Excessive gas pressure may cause discharging or unstable beam current.

The optional Variable Leak Valve is fragile. See the valve manual for operation and adjustment information.

Read instructions before operating!

SEE THE DATA SECTION, AT THE END OF THE MANUAL, FOR TYPICAL OPERATING VALUES FOR THIS SYSTEM.

1. Installation:
   a. Install the IGL-2101 / IGPS-2101 Ion Gun and Power Supply system according to instructions in Sections 2.2 and 2.3.
   b. For optional bakeout of the IGL-2101, see procedures in Section 6.1.

2. Proper Vacuum:
   a. Ensure that the vacuum at the differential pumping port in the gun is **$1x10^{-4}$ torr** or better.
   b. If the gun is differentially pumped ensure that the differential pump is operational.

3. Make an initial check of the following items of the IGPS-2101 front panel controls:
   a. The green **POWER**, red **HIGH VOLTAGE**, amber **ECC ON/OFF**, and amber **DEF ON/OFF** rocker switches should all be off, **O** position.

4. On the back of the IGPS-2101, check all the small local/ remote slide switches labeled **PROGRAMMING**
   a. For manual control using the front panel controls, the slide switches should be in the **LOCAL** position (down).
   b. For remote control via the 50-pin connector the slide switches should be in the **REMOTE** position (up).
   c. For remote computer control via the 9-pin serial communication (RS-232 or RS422/RS-485), the slide switches should be in the **LOCAL** position (down).
   d. 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 4.4.1 Remote Programming to identify switches.)

5. Start the gas flow into the gun:
   a. Admit the gas to be ionized, and adjust the gas pressure in the source region of the gun by adjusting (either manually or automatically) the gas feed valve at the gas tank, or a user-supplied leak valve. Either background gas or an inert or active gas admitted through the gas inlet valve may be used. Go slowly when adjusting the gas. Make small changes, and wait for 5 to 10 minutes between changes.
   b. **For optional leak valve: See the Variable Leak Valve manual** (shipped with the valve or included in the Appendix) for installation, lubrication, changing the stop position, operation, and bakeout temperatures. Gently turn the two knobs on the side of the leak valve together: counterclockwise to open, and clockwise to shut the valve. **Operate gently as the sapphire in the seal mechanism of some valves is fragile.**
   c. The gas pressure takes time to stabilize and will need further adjustment later. The pressure at the differential pumping port is typically in the 10^{-3} to 10^{-5} torr range, while vacuum in the main chamber is in the 10^{-5} to 10^{-7} torr range.

CAUTION: Excessive gas pressure may cause discharging or unstable beam current.

6. Initial energizing of the Power Supplies:
   a. 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.
   b. The FlexPanel Control display screen will turn on, but do not try to operate yet.

7. Interlocks
   a. Check that the amber **INTERLOCK** LED is off.
   b. The LED will illuminate momentarily when the Power Supply is first energized to show that the Interlock circuitry is working.
   c. If the amber **INTERLOCK** LED stays lighted:
      i. Switch the green **POWER** switch off (**O** position) to de-energize the Power Supply.
      ii. Check that the cables are connected tightly.
      iii. Check that the top and bottom covers of the Power Supply are closed securely.
      iv. Check that the spare interlock is a closed circuit, either jumpered as shipped, or a closed external loop to the user's system.
      v. Reenergize the Power Supply after the fault is corrected.

4.2 NORMAL OPERATION cont>

NORMAL START UP PROCEDURE cont.

8. Controlling the Power Supplies:
   a. 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.
   b. If the **ZERO** LED lights:
      i. 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.
      ii. If the light does not clear, this indicates a problem with the circuitry or programming.

9. 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).

10. 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.

11. 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.

12. 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.

CAUTION

ENERGY and SOURCE supplies must be turned up gradually.

Excessive source current will reduce ion source lifetime. The recommended limit is **4.4 A** for a standard ion source.

Electron Energy should be at least 50 V prior to initial source adjustment.

13. Controlling the Ion Beam Energy:
    (Range 0 to +1000 eV, or +3000 eV with High Energy option)
    a. GRADUALLY adjust the **I+ ENERGY** control to the user-desired value for the ion beam acceleration energy.
       i. With the front panel FlexPanel Controls, select **I+ ENERGY** on the display screen with the adjacent gray button.
       ii. 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.
       iii. Push the button again or push **STORE** when finished.
    b. Monitor the **I+ ENERGY** voltage on the display screen meter.
    c. Discharging can be seen as jumping in the digital output.
    d. With FlexPanel Controls, the Ion 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 voltages:
    (Recommended initial values are shown in Table 4.2.3, also see the Data Section for typical operating values)
    a. Using the **FIELD CONTROL** FlexPanel control (encoder wheel), set the initial electron control voltages.
    b. Using the **EXTRACT** and **FOCUS** controls (encoder wheel), set the initial ion focusing voltages.
    c. Using the **E- ENERGY** control (encoder wheel), initially adjust the energy of the electrons that ionize the gas to between -50 V to and -100 V, depending on the type of gas used. For argon gas, 75 to 100 V is recommended initially.

CAUTION: Too low an Electron Energy may cause the user to set the Source or ECC too high which can damage the ion source.

4.2 NORMAL OPERATION

NORMAL START UP PROCEDURE cont.

Table 4.2-1 IGL-2101 / IGPS-2101 Voltages

Power Supply	STANDARD		HIGH ENERGY OPTION		Reference
	Range	Recommended Initial Setting	Range	Recommended Initial Setting	
I+ Energy (ion beam)	0 to +1000 V	+1000 V	0 to +3000 V	+3000 V	Ground
E- Energy (electron)	0 to -200 V	-50 V to -100 V	0 to -200 V	-50 V to -100 V	H.V. common
Field Control	0 to -1000 V	200 V	0 to -200 V	200 V	H.V. common
Extract	0 to -5000 V	1000 V	0 to -5000 V	1000 V	H.V. common
Focus	0 to -1000 V	650 V	0 to -3000 V	650 V	H.V. common

NOTE: Microamp discharges may occur in the ion gun after initial installation in the vacuum system, As high voltage surfaces "clean-up", this discharging should cease.

15. Energizing the Source supply for source filament heating:
    a. On the IGPS, the amber **ECC ON/OFF** rocker switch must be off (**O** position) for Source mode.
    b. GRADUALLY, adjust the voltage to the filament with the **SOURCE** control (encoder wheel).
    c. Monitor the **SOURCE** and **E- ENERGY** voltage and current meters while adjusting the **SOURCE** control.
    d. **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, 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.
    e. As power to the filament is increased, the ion gun will begin to emit electrons which will ionize the gas. Monitor the electron 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 and final ion beam. For prolonged ion source lifetime, it is advisable to use the lowest filament current possible. See the Data Section for typical source current ranges to produce the desired ion beam current at a given Energy. **The source current may be reduced somewhat after warm-up.** Refer to the table below for the correct current ranges for the ion source installed in the gun.

(Energizing the Source supply cont.)

    f. The energy of the electrons which ionize the gas may need to be increased to produce the maximum ion beam current. If desired, adjust the **E- ENERGY** control (encoder wheel), while monitoring the electron current and voltage meters and the final ion beam.
    g. **CAUTION:** If the **SOURCE** voltage and current values on the display screen become highlighted, 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.
    h. **CAUTION:** If the **Electron Current** meter goes beyond its normal range (becomes highlighted on the display screen), the FlexPanel metering circuitry can be damaged. The electron emission current range is up to 10 mA. Control the beam by either decreasing the Field Control voltage or decreasing the Source voltage.
    i. **CAUTION: With an optional Faraday cup, beam power must not exceed 2 Watts,** see Section 4.8.

NOTE: For some combinations of operating parameters, at lower Ion Energies, the Electron Energy setting can control the Ion Energy. When Electron Energy and Ion Energy are a similar magnitude, it is possible to get an electron beam, instead of an ion beam. **Thus at low Ion Energies, it is best to keep the Electron Energy lower than the Ion Energy**; for example at an Ion Energy of 500 eV, an Electron Energy of 150 eV will work well to produce an ion beam.

CAUTION: To protect the ion source lifetime, the filament current should not exceed the following levels. (Also see the Data Section for the normal operating range for the particular ILG-2101 gun.)

Table 4.2-2 IGL-2101 / IGPS-2101 Electron Emission and Source Currents

Electron Source type	Recommended max Electron current	Typical operating range Source current	Recommended max Source current
Standard Thoria coated cathode	10 mA	3.9 A to 4.3 A	4.4 A

4.2 NORMAL OPERATION

NORMAL START UP PROCEDURE cont.

16. Adjusting the gas pressure:
    a. Establish an appropriate pressure which gives a stable beam current, such that a small increase in gas pressure gives a corresponding increase in ion beam current. There is an optimum pressure which will provide maximum ion beam current; lower or higher pressures will give poorer performance. Too much gas can cause discharging.
    b. This pressure can be monitored at the differential pumping port or in the main chamber, while the ion beam is monitored at the target with a Faraday cup or other user-designed system.
    c. Allow time for stabilization after any change in pressure. Make small changes, and wait for 5 to 10 minutes between changes. (See Section 4.7 for pressure considerations.)

CAUTION: Excessive gas pressure may cause discharging, or result in unstable ion beam current due to unstable electron emission or interference with ion extraction.

17. Improving the beam characteristics, field control:
    (Range 0 to -200 V):
    a. Using the **FIELD CONTROL** (encoder wheel), adjust the Field Control voltage as necessary to control ion beam current, and improve beam uniformity and spot size.
    b. The ratio of ion beam current (the actual current leaving the gun) to electron emission current (total current off the cathode to ground) will be improved with some empirically-determined field control bias.

18. Improving the beam characteristics, ion control
    (Range 0 to 1000 V or 5000 V with High Energy option):
    a. Using the **EXTRACT** controls (encoder wheel), adjust the ion extraction voltage as necessary to improve ion beam current and transport the beam to the focus element.
    b. The Extract will probably not need to be adjusted much.

19. Improving the beam characteristics, Focus voltage
    (Range 0 to 1000 V or 3000 V with High Energy option):
    a. Using the **FOCUS** control (encoder wheel), adjust the Focus voltage as necessary to obtain the desired spot size.
    b. The Focus voltage setting depends on the desired spot size and the working distance (i.e. the distance from the end of the ion gun to the target), as well as the settings of the various bias voltages.
    c. With the IGL-2101, two different Focus values may produce a minimum spot with a given set of parameters.

20. For centering Deflection:
    (Range -150 V to +150 V See also Section 4.6):
    a. On the IGPS, switch the amber **DEF ON/OFF** rocker switch on (**I** position) to energize the supplies.
    b. Using the **X DEFLECT** and **Y DEFLECT** controls (encoder wheel), adjust the Deflection plate voltages as needed to center or position the beam in the X and Y directions within the target plane.
    c. If desired, set the Deflection outputs to be proportional to Ion Energy so that the spot position will be more constant as the beam energy is changed.
       i. Push the red **MENU** button and select **set proportional outputs** with its gray 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 **I+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**.
    d. If deflection is switched off and then back on with the IGPS rocker switch, the controls will return to the previously set values to simplify repositioning of the beam.
    e. An optional Raster Generator Deflection Unit (RGDU) can be used as an alternative to the IGPS-2101 for deflection (see Section 4.7).

21. With optional Port Aligner: Beam position can be mechanically adjusted by ±2º. 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.

4.2 NORMAL OPERATION

NORMAL START UP PROCEDURE cont.

22. Adjustment of any control may require “fine-tuning“ of the others to achieve the desired spot size, beam current and beam current uniformity, as the potentials interact in complex ways.
    a. **The effect of these elements is also very dependent of the gas pressure.**
    b. Magnetic fields in the vacuum lab environment may make it necessary to readjust parameters as beam energy is varied.

NOTE: Variations in electron emission current or in the gas pressure in the ionization region will affect the stability of the ion beam current. To maintain a constant electron emission current, operate the IGPS in the Electron Current Control (ECC) feedback mode. However, it is recommended to use the Source mode for preliminary starting of the gun.

23. For optional feedback-stabilized Electron Current Control (ECC): See also Section 4.4.
    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), decrease the Source voltage to zero.
    c. Switch the amber **ECC ON/OFF** rocker switch on (**I** position) for ECC mode.
    d. GRADUALLY adjust the **SOURCE** control (encoder wheel) to set the desired electron emission current, as shown on the **Electron current** meter, associated with the **E- ENERGY** control. Monitor as described for Source mode.

24. For more information on the use of options and features, such as Electron Current Control (ECC), Remote Control, Deflection, Rastering, Differential Pumping, etc., see specific sections in this chapter.

This completes the Normal Start Up Instructions.

4.2.2 NORMAL SHUT DOWN PROCEDURE

1. Secure (turn off) the IGL-2101 / IGPS-2101 system in the following sequence:
    a. Push the red **SHUTDOWN** button. Wait until all meters read zero.
    b. Switch the amber **DEF ON/OFF** rocker switch off (**O** position).
    c. 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.
    d. Switch the red **HIGH VOLTAGE** switch off (**O** position).
    e. Switch the green **POWER** switch off (**O** position).

2. Shut off the gas being ionized at the tank and valves.

3. After securing the system, **wait at least 30 minutes** for cool down of the ion gun, before venting the vacuum system. This procedure avoids possible damage to the electron source cathode and avoids the formation of oxidation layers on apertures caused by venting the gun while still hot.

H.V. WARNING: The red SHUTDOWN button sets all the individual power supply voltages to zero, but does not shut down the entire unit. 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.