

**FC 1800 #3 User Instructions and Logs  
For  
Microelectronics Laboratory  
Electrical Engineering Department  
University of Notre Dame**

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# General Precautions

## Contacts

For problems, clarification of procedures, or general information pertaining to this machine please contact one of the following personnel.

<b>Mark Richmond</b>	<b>631-6478</b>	<a href="mailto:Richmond.7@nd.edu">Richmond.7@nd.edu</a>
<b>Mike Thomas</b>	<b>631-7493</b>	<a href="mailto:Thomas.20@nd.edu">Thomas.20@nd.edu</a>
<b>Keith Darr</b>	<b>631-5497</b>	<a href="mailto:kdarr@nd.edu">kdarr@nd.edu</a>

**In Case of Emergency, Please Contact Notre Dame Security at**

**911**

**This user manual will not be moved away from the FC1800 #3.** This includes making copies. Note: you can download it from the web (addresses on front cover).

**High Voltages are exposed when doors are open.** Do not open the doors on this unit unless instructed to do so by one of the above personnel.

**Sweeping of the Electron beam is Mandatory.** Failure to sweep the beam can cause damage to the machine and cause you to lose your privileges to use this machine.

If any step does not respond as it should, stop and put the machine into standby if you can and contact help. If unsure on how to get to standby mode safely, leave the machine as it is and contact above personnel.

**Gloves will be worn at all times when working inside the chamber** of this machine.

**All users must be trained** on the use of this machine and in the authorized user list. If you are not on the list in Appendix C then you cannot use this machine.

A good vacuum practice is to have everything assembled, clean, and at hand whenever you open the chamber. The quicker the chamber is closed, the faster it will pump down to an acceptable and usable level.

This system uses a Cryo-pump. This pump should never be turned off or exposed to air/nitrogen when operating. Repeat offenders of this will lose their privileges to operate this machine entirely. If the Cryo-pump is allowed to warm up, it will take at least 2-4 hours to warm up and another 2-4 hours to pump down again.

This machine is used by many of the lab's Personnel. When done with this machine please clean up your materials after yourself and leave the machine in standby conditions.

## **Standby Conditions**

(These conditions allow for the safest and best conditions for the machine, your safety, and the best results for your research)

1. Main Chamber lid should be closed and under High Vacuum.
2. Valves that should be illuminated, open, or on in Standby conditions on the automatic pump down controller.
  - a. "D.P. Isolation"
  - b. "Diff pump"
  - c. Gate should be in the "away" position.
3. Valves that should not be illuminated or open in Standby Mode.
  - a. "Roughing" Valve
  - b. "Fore Line" Valve
  - c. "Mechanical Pump"
  - d. "Vent" Valve
  - e. "Hi Vac" Position
  - f. "Home" Position
4. Shutter should be on "Auto" and the indicator should not be illuminated.
5. Chilled water Valves should be on.
6. HV&Gun Controllers should be off.

## Depositing a metal (Start procedure)

Refer to Figure 1 on page #11 for all indicator light locations.

From Standby Conditions:

1. Fill out as much of the logbook located on top of the FC 1800.
2. Follow the procedure to “Change a sample” on Page #7.
3. Follow the procedure “Programming the SQM-160” to setup the film thickness monitor on Page #8.
4. Switch the pocket to the position of your desired source by rotating the thumbwheel on the Pocket Selector to the desired number. When the numeric display reads your position then the pocket has moved to your settings. The pocket metal list is located just below the SQM 160 Film Thickness Monitor.
5. Wait for the system vacuum to be below  $2.0 \times 10^{-6}$  to continue.
6. Pull up on the High Voltage Power Supply Breaker to turn it on. Located on the front of the High Voltage Power Supply.
7. Turn off the “Water Bypass valve” located above and behind the HVPS.
8. Open the front left main chamber door and turn the top chilled water valves (“E-Gun”) to on. Wait for 15 sec. Turn on the bottom chilled water valves (“Sensor”) as well.
9. Turn on Chilled water valves to the CV-14 HVPS. Located behind and above the HVPS.
10. Verify interlock light stacks on CV-14 HVPS Controllers:
  - a. On the Gun Controller:
    - i. “Vac Tank” is illuminated.
    - ii. “Vac Gauge” is illuminated.
    - iii. “Gun Water” is illuminated.
    - iv. “Aux” is illuminated.
    - v. “Focus” is illuminated.
    - vi. “Gun 1 Tank 1” is illuminated.
  - b. On the HVPS Controller:
    - i. “Power ON” is illuminated.
    - ii. “Triode Water” is illuminated.
    - iii. “Doors” is illuminated.
    - iv. “Air” is illuminated.
    - v. “PC Cards and key lock” is illuminated.
11. Verify “Emission Current” knob is fully counter clockwise.
12. Turn High Voltage on by depressing the “HV ON” button on the High Voltage Controller.
13. Switch on the Filament on by depressing the “GUN 1 Fil ON” button on the gun controller.
14. Open the shutter by pushing the shutter switch up on the shutter controller.
15. Verify filament is on by looking thru the view ports and making sure a white light is coming from the filament area. NOTE: May need to look thru bottom viewport due to Cryo Restriction Plate.
16. Advance Emission Current on the gun controller until you are just able to see the blue beam spot on the crucible when looking into the top view port.
17. Position the beam on the metal inside the crucible by adjusting the lat and long beam position on the XY controller for the settings you are wanting.
18. Verify sweeping of beam by increasing the Long and Lat Freq. switches on the XY controller if necessary. **Warning:** Failure to sweep the beam can cause damage to the source crucible, turret, FC 1800 system, your wafers, and/or your privileges to use this

- machine. The beam spot should never come into contact with the crucible walls or turret at any time or location.
19. Close the shutter by pushing down on “shutter” switch on the shutter controller.
  20. Slowly ramp current over a couple of minutes to 2-3Angstroms per second on the film thickness Monitor. Allow the crucible to heat for approximately 2 minutes.
  21. Slowly increase emission current by turning the “emission current” control pot on the gun controller until you have reached your desired deposition rate.
  22. Zero Film thickness meter by pressing “zero” and open shutter by pressing up on the “shutter” toggle switch on the shutter controller. Wait until desired thickness is almost achieved.
  23. Close shutter by pressing down on the “shutter” toggle switch on the shutter controller and log your results.
  24. Set emission current to ZERO by rotating the “emission current” control pot fully CCW on the gun controller slowly but continuously.
  25. Switch off Filament by pressing the “GJN 1 FIL OFF” button on the gun controller.
  26. Switch off HV by pressing HV OFF, located on the High Voltage controller.
  27. Wait 10 minutes for turret and source to cool down from last deposition before continuing to the next step.
  28. Depress “GUN 1 off” button on the Gun Controller to turn off the Filament.
  29. Depress “HV Off” on the High Voltage Controller to turn off the High Voltage.
  30. Repeat step #3 thru step #29 for as many layers as you need.
  31. Push down on the High Voltage Circuit Breaker on the CV-14 High Voltage Power Supply.
  32. Close all chilled water valves.
  33. Open Bypass valve above and behind the HVPS \_ to \_ a turn (see diagram on wall).
  34. To remove your samples, follow the procedure “Changing a Sample from standby” on page #7.
  35. Verify the machine is in Standby.
    - a. Main Chamber lid should be closed and under High Vacuum.
    - b. Valves that should be illuminated, open, or on in Standby conditions on the automatic pump down controller.
      - i. “D.P. Isolation”
      - ii. “Diff pump”
      - iii. Gate should be in the “away” position.
    - c. Valves that should not be illuminated or open in Standby Mode.
      - i. “Roughing” Valve
      - ii. “Fore Line” Valve
      - iii. “Mechanical Pump”
      - iv. “Vent” Valve
      - v. “Hi Vac” Position
      - vi. “Home” Position
    - d. Shutter should be on “Auto” and the indicator should not be illuminated.
    - e. All Chilled water Valves should be off.
    - f. HV & Gun Controllers should be off.
    - g. Ion Vacuum Gauge should be heading into the  $10^{-6}$  range or better.
  36. Complete all logbook entries and verify that the logbook is completely filled out. Signing out of the logbook states that you are done with your deposition and have removed all samples, trash, and etc. Please take trash with you.

## To change a Sample:

**Refer to Figure #1 on page #12 for all indicator light locations.**

1. Close the Gate valve by pressing down on the switch labeled "Gate".
2. Verify the indicator light switches from "Away" to "Home".
3. Close the "High Vac" valve by pressing down on the switch labeled "High Vac" on the Automatic Pump Down Controller.
4. Verify the "High Vac" light comes on and the "Home" light goes out.
5. Turn off Ion Gauge filament by pressing up on the Filament switch.
6. Verify the Ion Gauge filament switches off.
7. Open the N<sub>2</sub> "Vent" valve by pressing up on the switch labeled "Vent" on the Automatic Pump Down Controller.
8. Verify the "Vent" light illuminates.
9. Verify the "D.P. Isolation" light is illuminated and if not press up on the switch labeled "D.P. Isolation".
10. Allow a couple of minutes for the lid to come up to atmosphere pressure.
11. After the lid has been released from vacuum, the lid will pop up slightly. Pull up and open the lid. Be careful when doing this step. The Liquid Nitrogen (LN<sub>2</sub>) stacks move with the lid, make sure these do not catch or hit anything behind the machine. Also if Liquid Nitrogen (LN<sub>2</sub>) is hooked up there will also be a "line" running to the tank, make sure not to damage it as well.
12. Make sure a new and clean plastic shield is in place for your deposition. As a rule, Always verify there is a new shield installed when you put your sample in and always change the shield after your deposition.
13. Clean lower shield with wipe and alcohol.
14. Install or remove samples on the FC1800 #3 plate holder.
15. Verify the Lid O-ring has not popped out of the groove.
16. Verify the Cryo Restriction Plate is properly installed.
17. Pull down the lid and set it gently down on the O-ring.
18. Start mechanical pump by depressing the "ON" button on the M.P. Control.
19. Wait for 10-15 seconds for the mechanical pump to pump down.
20. Close N<sub>2</sub> "Vent" Valve by pressing down on the switch labeled "Vent" on the Automatic Pump Down Controller.
21. Verify the "Vent" indicator goes out.
22. While holding down on the lid with a slight amount of pressure, open the "roughing" valve by pressing up on the switch labeled "roughing" on the Automatic Pump Down Controller. You should feel the lid "pull down" with the vacuum almost immediately.
23. Verify the "roughing" indicator illuminates.
24. Close "roughing" Valve when the Thermocouple gauge reads less than 10<sup>-1</sup> Torr by pushing down on the switch labeled "Roughing" on the Automatic Pump Down Controller.
25. Verify the "Roughing" indicator goes out.
26. Open "High Vac" by pressing up on the switch labeled "High Vac" on the Automatic Pump Down Controller.
27. Verify "High Vac" indicator goes out and the "Home" indicator illuminates.
28. Verify the "D.P. Isolation" light is illuminated and if not press up on the switch labeled "D.P. Isolation".
29. Open the Gate valve by pressing up on the switch labeled "Gate".
30. Verify the "Home" indicator goes out and the "Away" indicator illuminates.
31. Shut off the mechanical pump by depressing the "stop" button on the M.P. Controller.
32. Turn on the Ion Gauge filament by pressing down the Filament switch.

33. If installing a sample, return to page #5 and step #3. If removing a sample, return to page #6 and step #34.

## **Programming the SQM 160:**

This monitor is capable of retaining the characteristics of 9 different films. However due to the many different films we use here at ND, the number of users this machine has, and the amount of use it sees I suggest that you verify your information every time you use this machine.

1. If you start using this monitor and it is displaying CRYSTAL 1, press “Xtal life” button to bring it back to its normal view. This reading shows the amount of life the Crystal has left.
2. Press “Zero” button to zero the monitor readings.
3. On the film thickness monitor. Press the “program” button.
4. Pick your film by rotating the knob to “Film 1”.
5. Press “Next” button. “Density” should be displayed. Density and Z-Factor charts will be available in Appendix B and posted on side of the control rack as well.
6. Rotate the knob until the density you want is displayed.
7. Press “Next” button. “Tooling” should be displayed.
8. Rotate the knob until the tooling for your sample holder is displayed. Appendix A contains a list of tooling factors for the different sample holders and will be posted on side of control cabinet as well. **NOTE:** There will be specific sample holders for this machine and will be labeled FC 1800 #2”. **WARNING:** Do not use the numbers from FC 1800 #1 or #3, these numbers will be wrong for the setup in the FC1800 #2.
9. Press “Next” button. “Z-Factor” should be displayed.
10. Rotate knob until the Z-Factor you desire is displayed. Density and Z-Factor charts will be available in Appendix B and posted on side of control rack as well.
11. Press “Next” button. “Finl Thk” should be displayed. This step saves the last setting of “Z-factor” into the program.
12. Press “Program” button to exit program mode. It is now ready for the deposition.
13. Go to step 4 on page #6.

**NOTE:** The Film thickness monitor does not stop sampling the deposition when you close the shutter. You will need to watch the monitor and log the thickness when you close the shutter.

**NOTE1:** The Film Thickness Monitor should be on at all times.



## **LN<sub>2</sub> operations (Start Procedure):**

Refer to Figure 1 on page #12 for all indicator light locations.

See Figure #7 on page #17 for the LN Controls

From Standby Conditions:

1. Fill out as much of the logbook located on top of the FC 1800.
2. Follow the procedure to "Change a sample" on Page #7.
3. Follow the procedure "Programming the FDC 8000" to setup the film thickness monitor on Page #8.
4. Switch the pocket to the position of your desired source by rotating the thumbwheel on the Pocket Selector to the desired number. When the numeric display reads your position then the pocket has moved to your settings. The pocket metal list is located just below the FDC 8000.
5. Wait for the system vacuum to be below  $9.0 \times 10^{-7}$  to continue.
6. Turn Cold Plate to "LN Flow".
7. Turn on LN Tank.
8. On the Meissner Trap Controller, flip the switch to "Auto".
9. Wait 2 hours.
10. Wait until the Vacuum on the Ion Gauge Controller is in the middle of the  $10^{-7}$  range.
11. Turn Substrate Plate LN2 Cooling controller keyswitch to "ON".
12. Turn the Substrate Plate Temperature Indicator to "ON".
13. On the Substrate Plate LN2 Level controller to "Auto".
14. Wait until the Substrate Plate Temperature Indicator reads about 80 Kelvin.
15. Pull up on the High Voltage Power Supply Breaker to turn it on. Located on the front of the High Voltage Power Supply.
16. Open the front left main chamber door and turn the top chilled water valves ("E-Gun") to on. Wait for 15 sec. Turn on the bottom chilled water valves ("Sensor") as well.
17. Turn off the "Water Bypass valve" located above and behind the HVPS.
18. Turn on Chilled water valves to the CV-14 HVPS. Located behind and above the HVPS.
19. Verify interlock light stacks on CV-14 HVPS Controllers:
  - a. On the Gun Controller:
    - i. "Vac Tank" is illuminated.
    - ii. "Vac Gauge" is illuminated.
    - iii. "Gun Water" is illuminated.
    - iv. "Aux" is illuminated.
    - v. "Focus" is illuminated.
    - vi. "Gun 1 Tank 1" is illuminated.
  - b. On the HVPS Controller:
    - i. "Power ON" is illuminated.
    - ii. "Triode Water" is illuminated.
    - iii. "Doors" is illuminated.
    - iv. "Air" is illuminated.
    - v. "PC Cards and key lock" is illuminated.
20. Turn High Voltage on by depressing the "HV ON" button on the High Voltage Controller.
21. Switch on the Filament on by depressing the "GUN 1 Fil ON" button on the gun controller.
22. Open the shutter by pushing the shutter switch up on the shutter controller.

23. Verify filament is on by looking thru the view ports and making sure a white light is coming from the filament area. NOTE: May need to look thru bottom viewport due to Cryo Restriction Plate.
24. Advance Emission Current on the gun controller until you are just able to see the blue beam spot on the crucible when looking into the top view port.
25. Position the beam on the metal inside the crucible by adjusting the lat and long beam position on the XY controller for the settings you are wanting.
26. Verify sweeping of beam by increasing the Long and Lat Freq. switches on the XY controller if necessary. **Warning:** Failure to sweep the beam can cause damage to the source crucible, turret, FC 1800 system, your wafers, and/or your privileges to use this machine. The beam spot should never come into contact with the crucible walls or turret at any time or location.
27. Close the shutter by pushing down on "shutter" switch on the shutter controller.
28. Slowly ramp current over a couple of minutes to 2-3Angstroms per second on the film thickness Monitor. Allow the crucible to heat for approximately 2 minutes.
29. Slowly increase emission current by turning the "emission current" control pot on the gun controller until you have reached your desired deposition rate.
30. Zero Film thickness meter by pressing "zero" and open shutter by pressing up on the "shutter" toggle switch on the shutter controller. Wait until desired thickness is almost achieved.
31. Close shutter by pressing down on the "shutter" toggle switch on the shutter controller and log your results.
32. Set emission current to ZERO by rotating the "emission current" control pot fully CCW on the gun controller slowly but continuously.
33. Switch off Filament by pressing the "GJN 1 FIL OFF" button on the gun controller.
34. Switch off HV by pressing HV OFF, located on the High Voltage controller.
35. Wait 10 minutes for turret and source to cool down from last deposition before continuing to the next step.
36. Depress "GUN 1 off" button on the Gun Controller to turn off the Filament.
37. Depress "HV Off" on the High Voltage Controller to turn off the High Voltage.
38. Repeat step #3 thru step #29 for as many layers as you need.
39. Push down on the High Voltage Circuit Breaker on the CV-14 High Voltage Power Supply.
40. Close all chilled water valves.
41. Open Bypass valve above and behind the HVPS \_ to \_ a turn(see diagram on wall).
42. Turn off LN<sub>2</sub> Tank.
43. Allow 15 minutes for machine to use LN<sub>2</sub>.
44. Behind the machine, Turn Cold plate to N<sub>2</sub> Purge.
45. Open the Trap Purge slowly.
46. Wait 1 hour for machine to warm up.
47. To remove your samples, follow the procedure "Changing a Sample from standby" on page #7.
48. Verify the machine is in Standby.
  - a. Main Chamber lid should be closed and under High Vacuum.
  - b. Valves that should be illuminated, open, or on in Standby conditions on the automatic pump down controller.
    - i. "D.P. Isolation"
    - ii. "Diff pump"
    - iii. Gate should be in the "away" position.
  - c. Valves that should not be illuminated or open in Standby Mode.

- i. "Roughing" Valve
    - ii. "Fore Line" Valve
    - iii. "Mechanical Pump"
    - iv. "Vent" Valve
    - v. "Hi Vac" Position
    - vi. "Home" Position
  - d. Shutter should be on "Auto" and the indicator should not be illuminated.
  - e. All Chilled water Valves should be off.
  - f. HV & Gun Controllers should be off.
  - g. Ion Vacuum Gauge should be heading into the  $10^{-6}$  range or better.
49. Complete all logbook entries and verify that the logbook is completely filled out. Signing out of the logbook states that you are done with your deposition and have removed all samples, trash, and etc. Please take trash with you.

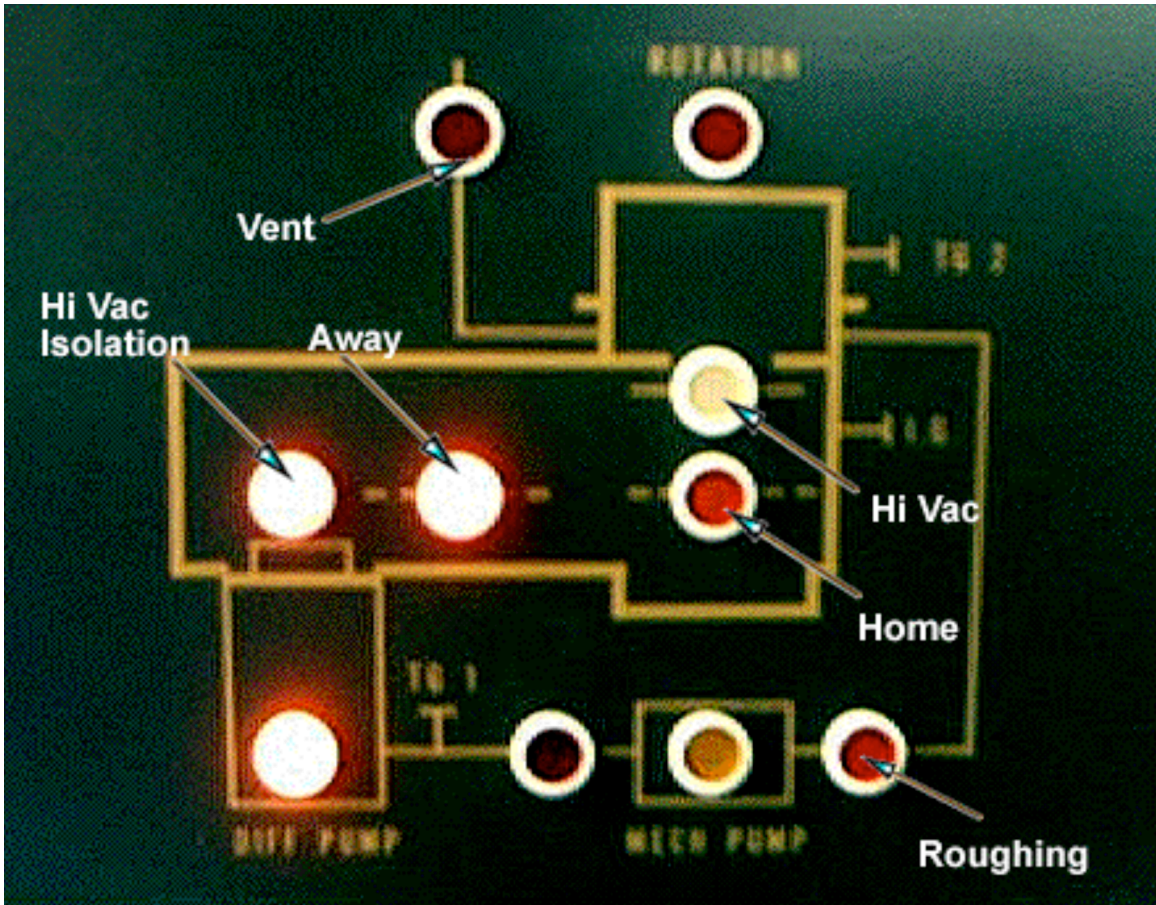


Figure 1: Indicator Panel of Automatic Pump Down Controller



Figure 2: HVPS Controls  
High Voltage and Beam Control sitting on top of the CV14 power supply.



Figure 3: Lid Interior  
Lid Sample holder in the center and cooling coils on the outer edge of the lid.

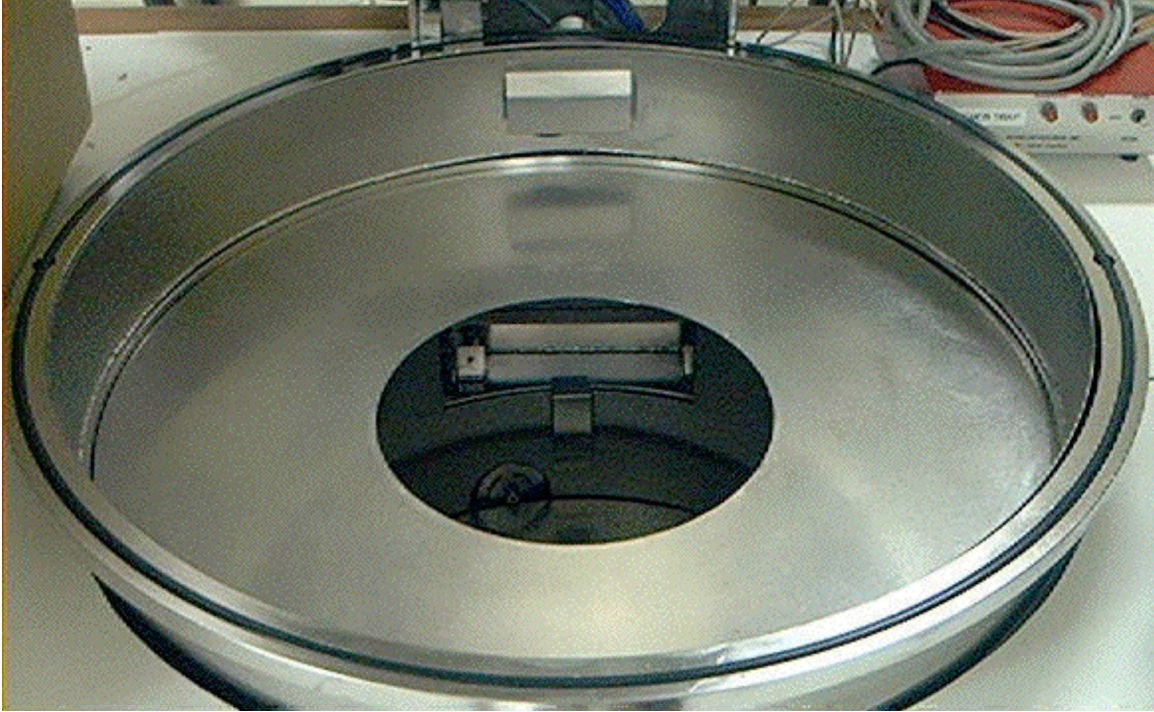


Figure 4: Gate restriction plate;  
To protect the lid interior never start beam without this in place.

Figure 5: SQM 160



Figure 6: Shutter Control (Top Left), Mechanical pump Control (Top Right), and Pocket Selector (Bottom).





Figure 7: Regeneration Control (Top Left) And LN controls (Bottom and top Right).

## **Appendix A:**

### Density & Z Ratio Charts

## **Appendix B:**

### Tooling Information

**Cold Plate : 110**

## **Appendix C:**

### Authorized Users

See logbook on the machine for accurate listing of users