NPL Polarized Source Group
Technical Note # 90-4

The Initial Evacuation and Bakeout of the Illinois/CEBAF Polarized Electron Source

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The Initial Evacuation and Bakeout of the Illinois/CEBAF Polarized Electron Source

This procedure outlines the technique followed for the initial bakeout of the Illinois/CEBAF polarized source. This procedure must be used each time there are major changes in the source. The duration of the bakeout and the problems with the vacuum during the ramp-up to full temperature will increase as the fraction of the parts that are new (not previously baked) increases.

1. If using the sorption pump pair, attach them to the gun pump out port and cool them down for about 1 hour; if using the Alcatel, attach it to the gun pump-out port.
2. Remove all non-bakeable items such as magnets, steering coils, and the corona shields. Also, replace the bellows guide rods with "bakeout" guide rods on both the cesiator and the stalk. Insert the spacer clips on both the cesiator and the stalk bellows to hold them in an extended position. Finally, remove the stalk heater assembly (it will be re- installed after the hot-box has been lowered into place).
3. Remove the pinched off copper tubing from the NF_3 leak valve and purge the leak valve with nitrogen.
4. Install blank flanges over the NF_3 leak valve ports, and open the leak valve for the initial pumpout.
5. Make sure that the first all-metal valve under the gun and the up to air valve are closed.
6. Evacuate the chamber with the roughing pump (either the Alcatel or the sorption pump pair). If using the sorbtion pump pair, use the first pump until the pressure reaches between 1.0 and 0.1 torr, then switch to the second. If using the Alcatel, exercise the ion pumps when the pressure reaches about 1 millitorr by turning on both the main and the bakeout ion pumps for about 30 seconds. Then turn the ion pumps off, and continue pumping with the Alcatel alone until the asymptotic pressure has been reached (see the next step); this will typically take about 30 minutes.
7. Monitor the chamber pressure using the Pirani gauge on the RGA. When the Alcatel is used, it will typically reach a pressure of 1×10^{-5} within about a half an hour; when the sorption pump pair is used the asymptotic pressure is typically 2×10^{-4} after a similar length roughing period. When this asymptotic pressure has been reached turn on the bakeout ion pump.
8. Valve off the roughing pump(s) after the bakeout pump has started.

9. When the pressure falls below 10^{-7} Torr, use the RGA to leak check the chamber. For the initial bakeout, an extended leak test should be performed by enclosing the entire gun in a helium bag and watching for any signs of leaks for at least an hour; this procedure is necessary to catch small leaks and "tortuous path" leaks such as those that might occur in the vicinity of the ceramic weld ring.). A common sign of a leak is when the peak at mass 28 is larger than the peak at mass 18 and the peak at mass 14 is larger than the peak at mass 12. The mass 40 and mass 32 peaks can also be useful guides. Since all of these peaks will be somewhat system dependent, and also evolve in time as a system is baked repeatedly, your best guide will be to keep good records and compare the RGA spectra from one bakeout to the next.

10. Take an RGA spectrum from the system before beginning the bakeout to document the residual gas pressures. Then turn off the RGA and remove the r.f. head. The spectrum obtained just after the initial assembly (and before the first bakeout) of the Illinois/CEBAF polarized source is attached to this document as an example of what you can expect.

11. Close the NF_3 leak valve.

12. If the cesiator has been changed or re-charged its operation should be checked at this point before continuing with the bakeout preparations. To check the operation of the cesiator wait until the pressure has dropped below 10^{-7} torr, then heat the cesiator, open the cesiator valve and monitor the white light photocurrent. (See the cathode fabrication procedure in NPL Source Note # 90-5 for details.) If there is a white light response, valve off the cesiator. Leave the cesiator at its operating temperature for the bakeout.

13. Place thermocouples around the chamber and attach them to the Molytek chart recorder (see the attached diagram). The thermocouple attached to flange on the window in the lower chamber is used as the input to the bakeout controller for the hot box heater.

14. Wrap any areas that are not enclosed by the bakeout shroud with aluminum foil, heater tape, more aluminum foil, and a layer of fiberfrax.

15. Install the hot air deflector on the table top. It should be placed so that it is directly in the path of the hot air just after it enters the hot box, and deflects it at a right angle on its way into the box. This placement has been found to produce the most even temperature distribution for the bake. (A future revision to the hot box will have the deflector "built in.")

16. Carefully lower the bakeout shroud ("hot-box") over the gun; then seal the slot for the bakeoup pump connection using fibrefrax.

17. Check that the stalk heater is well-coated with MoS_2, then insert it through the hole in the top of the "hot-box," attach the stalk heater and thermocouple wiring, and connect the stalk nitrogen line. Turn on the nitrogen to a pressure of 30" of water

as measured by the magnehelic gauge. Make sure that the cesiator and the stalk are both in the "out" position; spacer clips should have already been inserted to hold them there.

18. Proceed to the bakeout cycle following the steps outlined here:

    (a) Begin by programming the controller to ramp from room temperature to 220 C in 8 hours and then to soak at 220 C. Note that the stalk controller should be programed so that the temperature of the GaAs sample is held 20 C above the temperature of the rest of the gun throughout the bake cycle if a "bulk" GaAs sample is used. If an antimony-capped GaAs sample is used the stalk controller should be set to match the temperature of the gun, and the high-temperature cleaning of the GaAs in step (c) below should be omitted. Further note that the heater tapes used (eg., on the bakeout pump valve) must be set to track the main oven temperature.

        During the initial bakeout one expects significant trouble from water. This will occur at about 70 C. It may be necessary to sit at this temperature for a long period of time during the initial bake to avoid over-current tripouts of the ion pumps. The 30 liter/second pumps should be kept at long-term currents below 5 mA. If the current begins to rise above that value, slow the rate of temperature rise of the bakeout immediately. If this measure is not adequate to bring the current back below 5 mA, then stop the temperature rise before the pump current reaches 10 mA. If the pump current ever reaches 10 mA., shut it off and cool things down a bit before starting up again. The temperature rise can be conveniently stopped using the appropriate pushbutton on our controller. It should be obvious that shutting down the pump is undesirable, so monitor the pump current carefully so you can take "evasive action" as necessary during the initial bakeout.

        If water is a really serious problem (which will depend on the state of the parts prior to the bake) it may occur that the pressure will initially drop as the temperature is raised above 70 C due to the fact that most of the water has been baked off the surface and the other things have not yet begun to desorb significantly.

        As the temperature approaches the flat-top value (220 C), watch carefully for overshoot and oscillation. Adjust the controller as necessary. If the adjustments don't work within the first oscillation or so, lower the set temperature for the flat top so the peaks of the oscillation stay below 220 C, and keep it lowered until the controller adjustments have eliminated the oscillation and overshoot.

    (b) Maintain 220 C for at least 24 hours or until the bakeout ion pump current has stabilized at a minimum value and turning on the main ion pump does not cause large pressure bursts in the bakeout pump current. (Throughout the soak cycle you must exercise the main ion pump as described below.) The current should be stable to $\leq 0.4\%/hour$ (corresponding to $\leq 10\%/day$) before the 220 C cycle is ended. For the initial bakeout the stable current is likely to be a few hundred microamperes. After repeated bakeouts, the current will typically stabilize near 100 μA.

Once the temperature has stabilized on the flat top and the pressure has begun to drop (indicating that we are gaining ground with respect to the ultimate vacuum we will achieve), but before the bakeout ion pump current has fully stabilized, you should begin exercising the main ion pump. It will initially disgorge a lot of garbage. Turn it on and run it for 5 to 10 minutes every few hours. (If you are using "old-fashioned" ion pump supplies, it will probably be necessary to set the pump's power supply to "start" mode when you turn it on. Be sure to return it to the normal (protected) mode after the 5 to 10 minutes are up.) This procedure (of exercising the main ion pump every few hours) should continue until there is no pressure "burst" associated with the turning on of the main ion pump; rather the effect of turning on the main ion pump will be that the pressure in the bakeout pump quickly falls to roughly half its original value with a similar current in the main ion pump. After there is no effect from turning on the main ion pump it may well be necessary to continue the bake on the "flat top" for as long as 70 to 90 hours during an initial bakeout of a system. The criterion for stopping the plateau heating and beginning the cooldown is that there is no effect on the bakeout pump current from turning the main ion pump on, and the current in the bakeout ion pump is stable to better than 10%/day.

(c) After the bakeout pump current has stabilized heat the stalk incrementally while holding the overall gun temperature at 220 C. The cycle consists of ramping the stalk temperature from 240 to 580 C over about 30 minutes, holding it at that temperature for 30 minutes, and then returning it to 240 C over about 30 minutes. Watch for any significant pressure rise during this cycle for possible evidence of a vacuum leak in the stalk. (This entire step is omitted if an antimony-capped sample is used.)

(d) Ramp down to 120 C over 6 hours.

If the bake was successful there will be a pressure drop by a factor of 10 for a 60 to 80 degree Centigrade temperature drop. If you have fallen by the factor of 10 with only a 60 degree drop, things are looking well. If you haven't fallen by a factor of 10 after an 80 degree drop you probably have a leak. (Go directly to Jail; do not pass GO, do not collect $200.)

(e) Maintain 120 C for 24 hours.

This gives the internal parts that are well connected to the outside time to stabilize in temperature. During the 120 C soak, exercise the main ion pump every few hours (see step b above). At the end of the 120 C soak start up the main ion pump and valve off the bakeout pump, so that the remainder of the cooldown uses only the main ion pump. The idea here is to avoid "back contamination" of the system from the bakeout ion pump.

(f) Finally, ramp back down to room temperature over 8 hours. A plot of the bakeout ion pump current as a function of time during the initial bakeout of the Illinois/CEBAF source is attached to this report for reference.

19. Make sure that the main pump is on and the bakeout pump is valved- off (but left operating). Turn off the bakeout controller, the stalk controller, and any variacs that were used for heater tapes.

20. Remove the bakeout equipment (thermocouples, heat tapes, the heat deflector, etc.); then check for loose bolts (tightening any that are found). If you are cautious, you may want to leak check the system using the RGA. The leak test should be done with particular care in stressed areas (e.g. the stalk and cesiator). The leak check can be omitted if the "after-bake" RGA spectrum shows no signs of a problem.

21. Take an RGA spectrum of the vacuum to document the quality of the bake. The RGA spectrum that was obtained just after the initial bakeout of the Illinois/CEBAF gun is attached to this note as an example of what to expect. There are four things to watch for in the RGA spectrum:

    (a) The peak at mass 14 should be 25-30% smaller than the peak at mass 12 after baking. The peak at mass 12 is carbon from cracking of CO (mass 28) or CH_4 (mass 16). In a "clean" system the peak at mass 14 will include CH_2 (from cracking of CH_4); the presence of some is ok as some methane is "made" in the ion pump. However, if there is a leak in the system there will be a much larger component at mass 14 from cracked N_2 (from air that enters via the leak). This peak is almost as sensitive as the helium peak for leak detection.

    (b) The peak at mass 32 (corresponding to O_2) that was present in the "pre-bake" RGA spectrum should be missing. Oxygen "sticks" to clean surfaces; if the surfaces are clean, there won't be any showing up at the location of the RGA head as it will have stuck to the walls of the system.

    (c) The peak at mass 40 (corresponding to argon) should be very small or undetectable. Argon is pumped by the DI style pump we are using, and should disappear after the system has been pumped on for a while.

    (d) The peaks at mass 44 (corresponding to CO_2) and at mass 18 (corresponding to water) should disappear with baking.

22. Before the source can be used it will be necessary to bring the cesiator into operation. See technical notes # 90-5 and 90-9 for details.

23. Replace all non-bakeable items (such as the corona shields, the guide rods in the cesiator and stalk bellows guide assemblies, and the cesiator and stalk actuator mechanisms); then clean up any fiberfrax dust.

THERMOCOUPLE PLACEMENT FOR THE INITIAL BAKEOUT

NPL 2772-4

ADDITIONAL THERMOCOUPLES (NOT SHOWN)

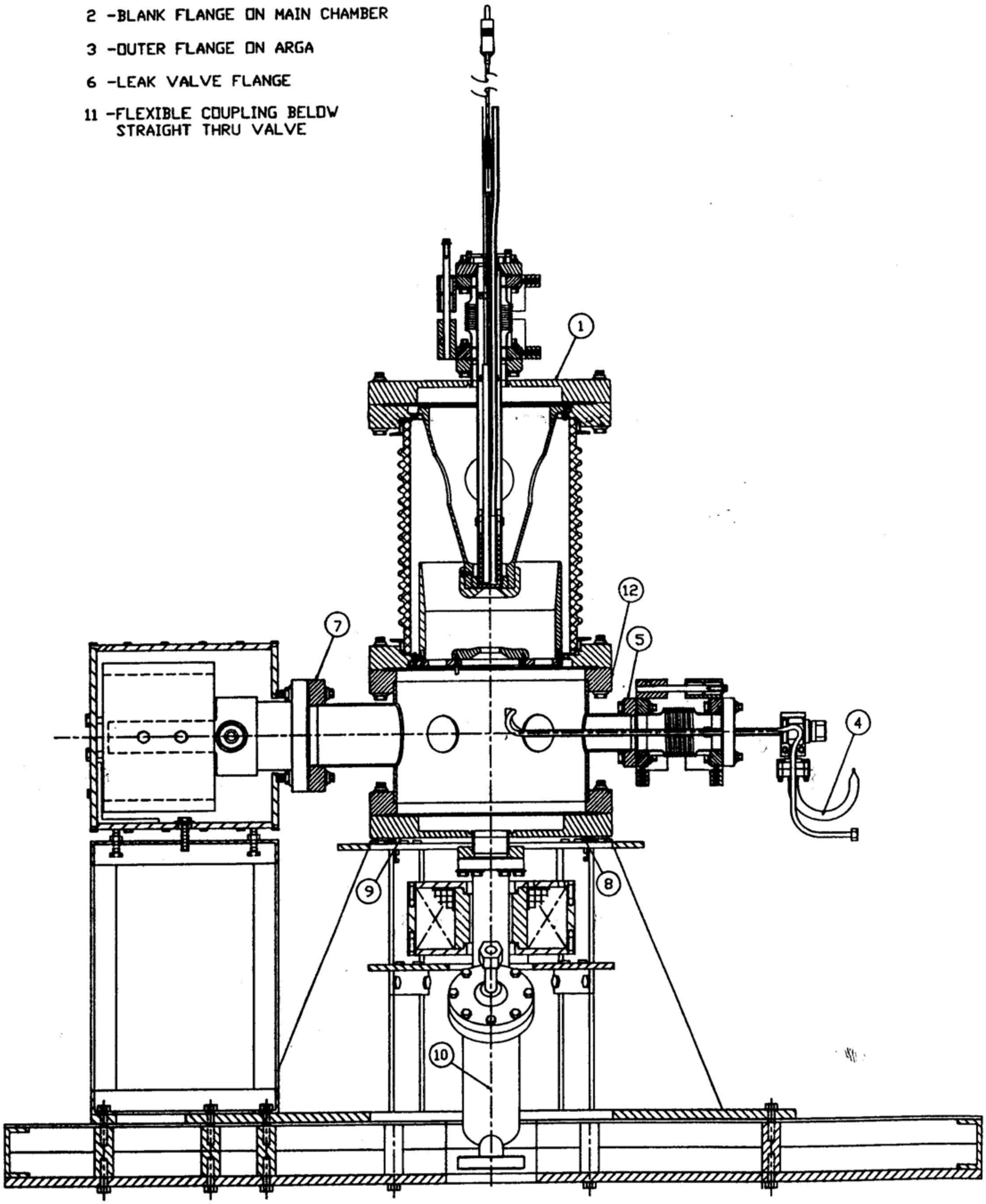
CONTROL-WINDOW

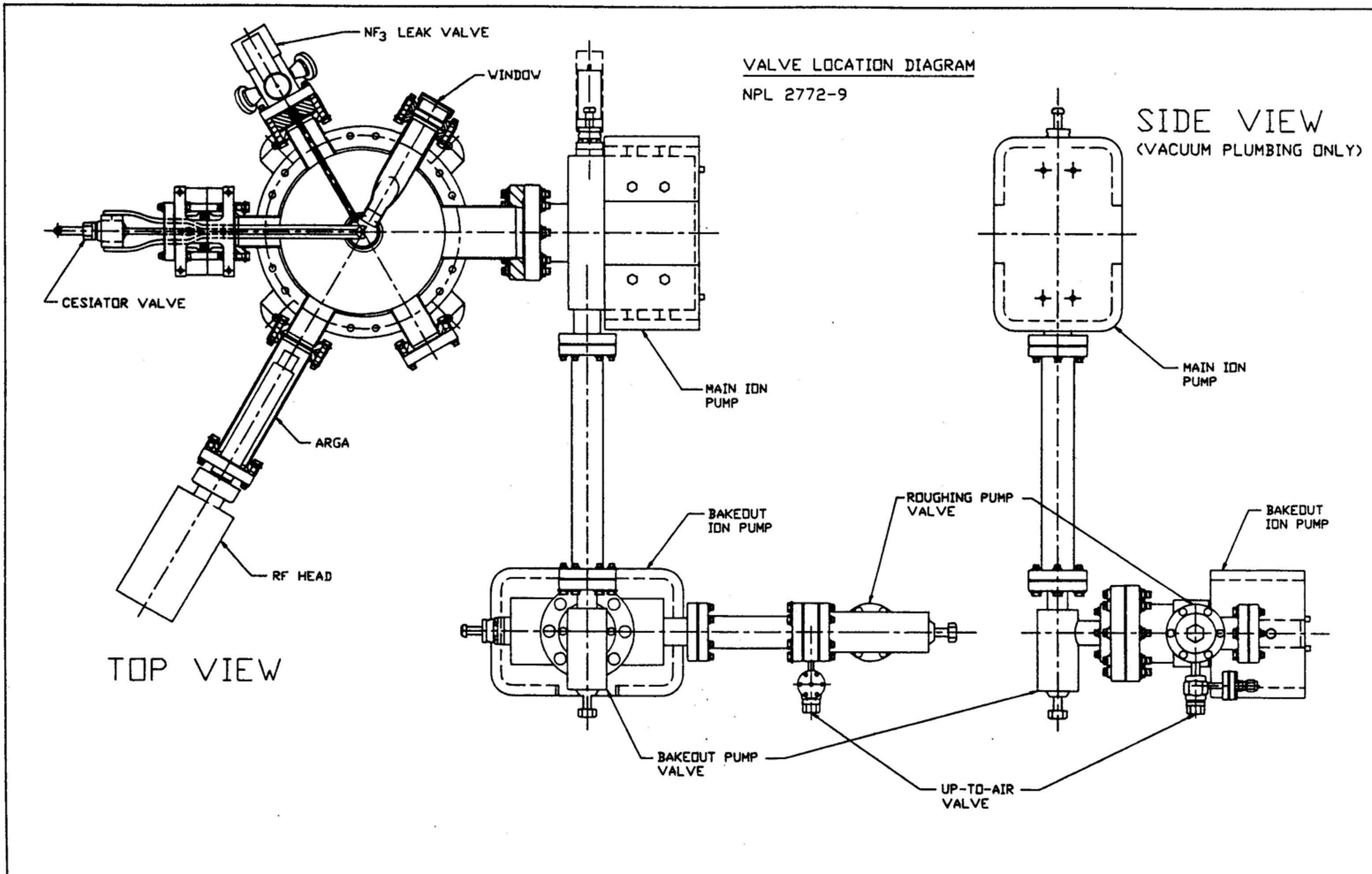
2 -BLANK FLANGE ON MAIN CHAMBER

3 -OUTER FLANGE ON ARGA

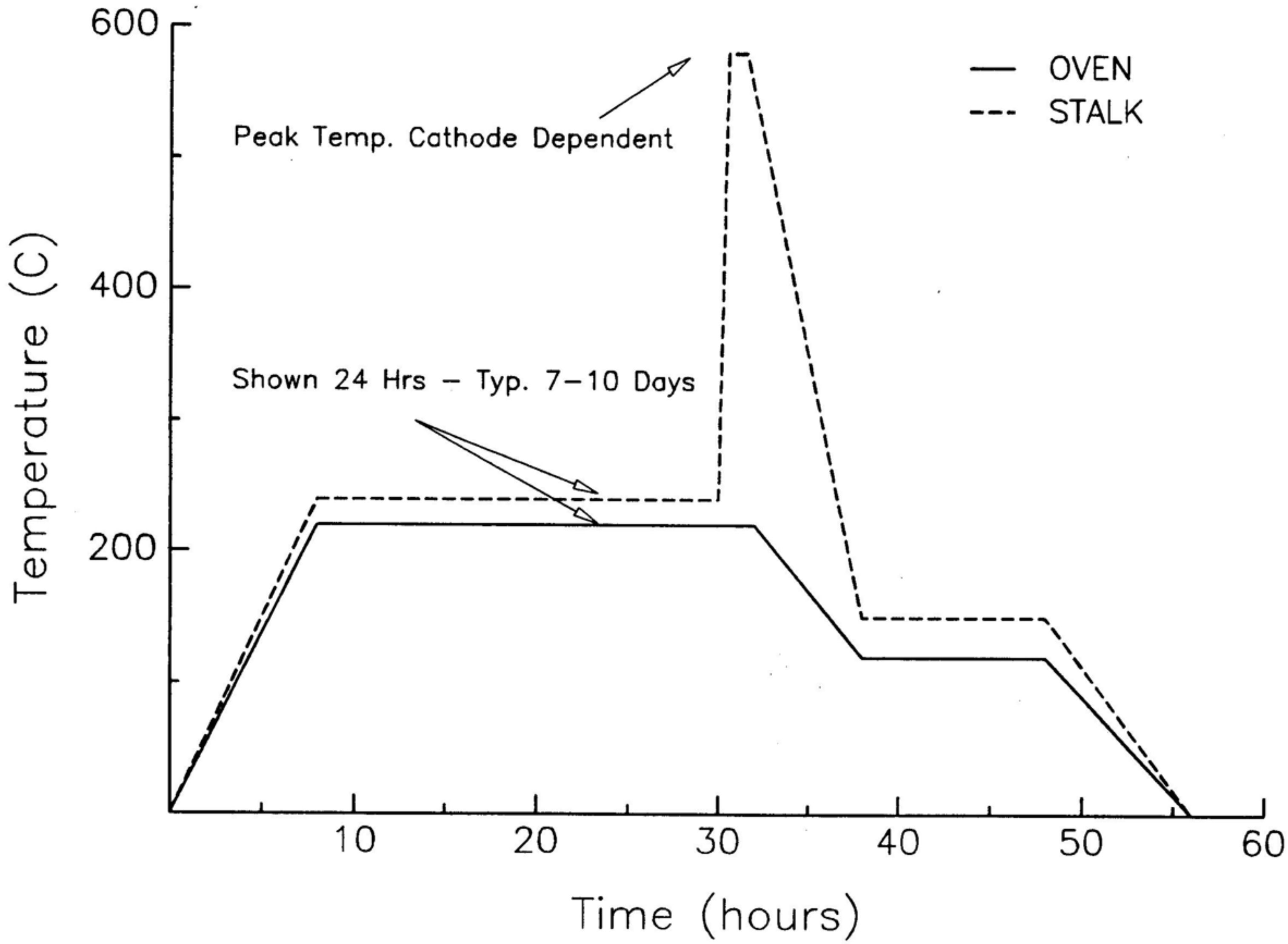
6 -LEAK VALVE FLANGE

11 -FLEXIBLE COUPLING BELOW STRAIGHT THRU VALVE

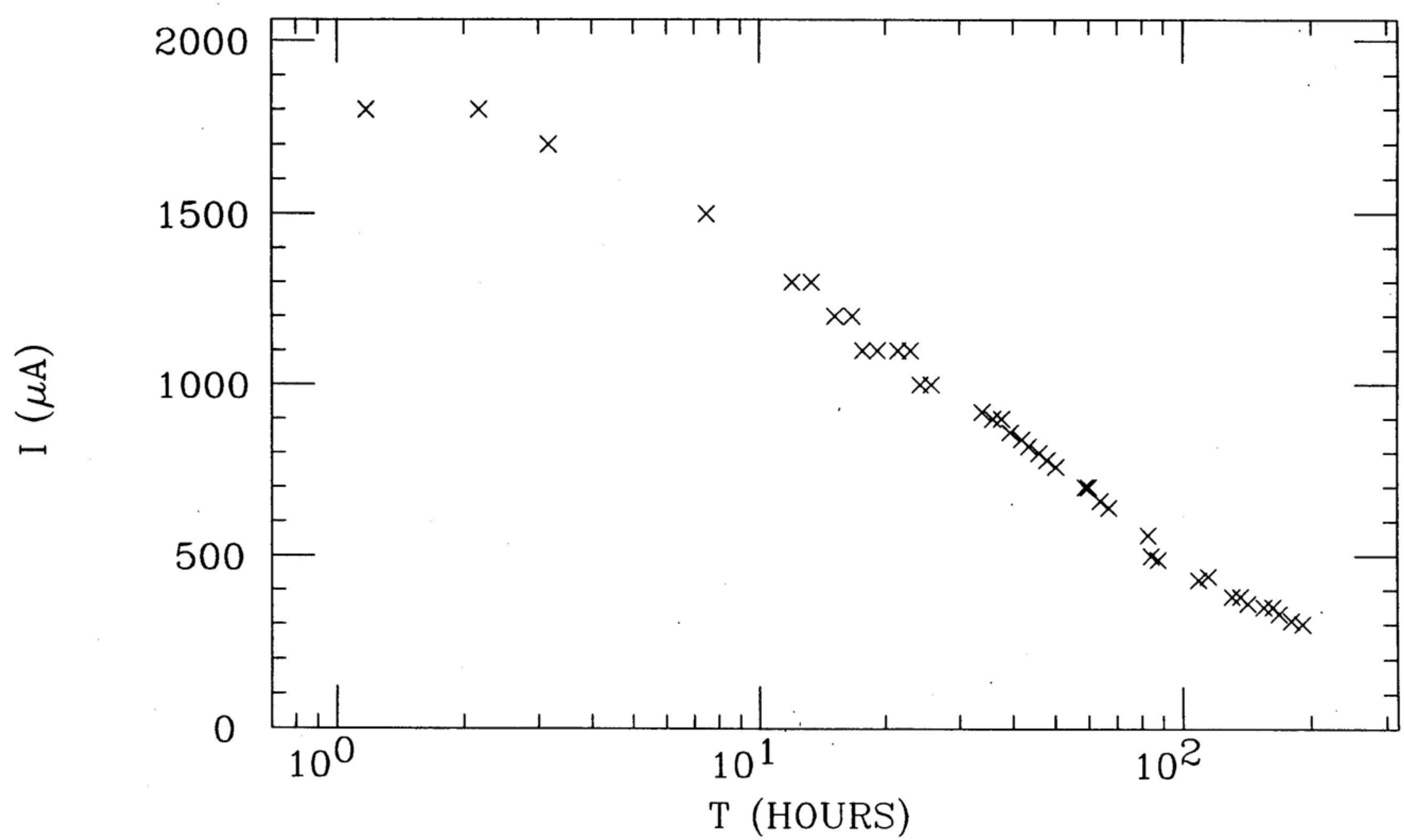



VALVE LOCATION DIAGRAM
NPL 2772-9
NF3 LEAK VALVE
WINDOW
CESIATOR VALVE
ARGA
RF HEAD
TOP VIEW
MAIN ION PUMP
BAKEOUT ION PUMP
BAKEOUT PUMP VALVE
ROUGHING PUMP VALVE
UP-TO-AIR VALVE
SIDE VIEW
(VACUUM PLUMBING ONLY)
MAIN ION PUMP
BAKEOUT ION PUMP

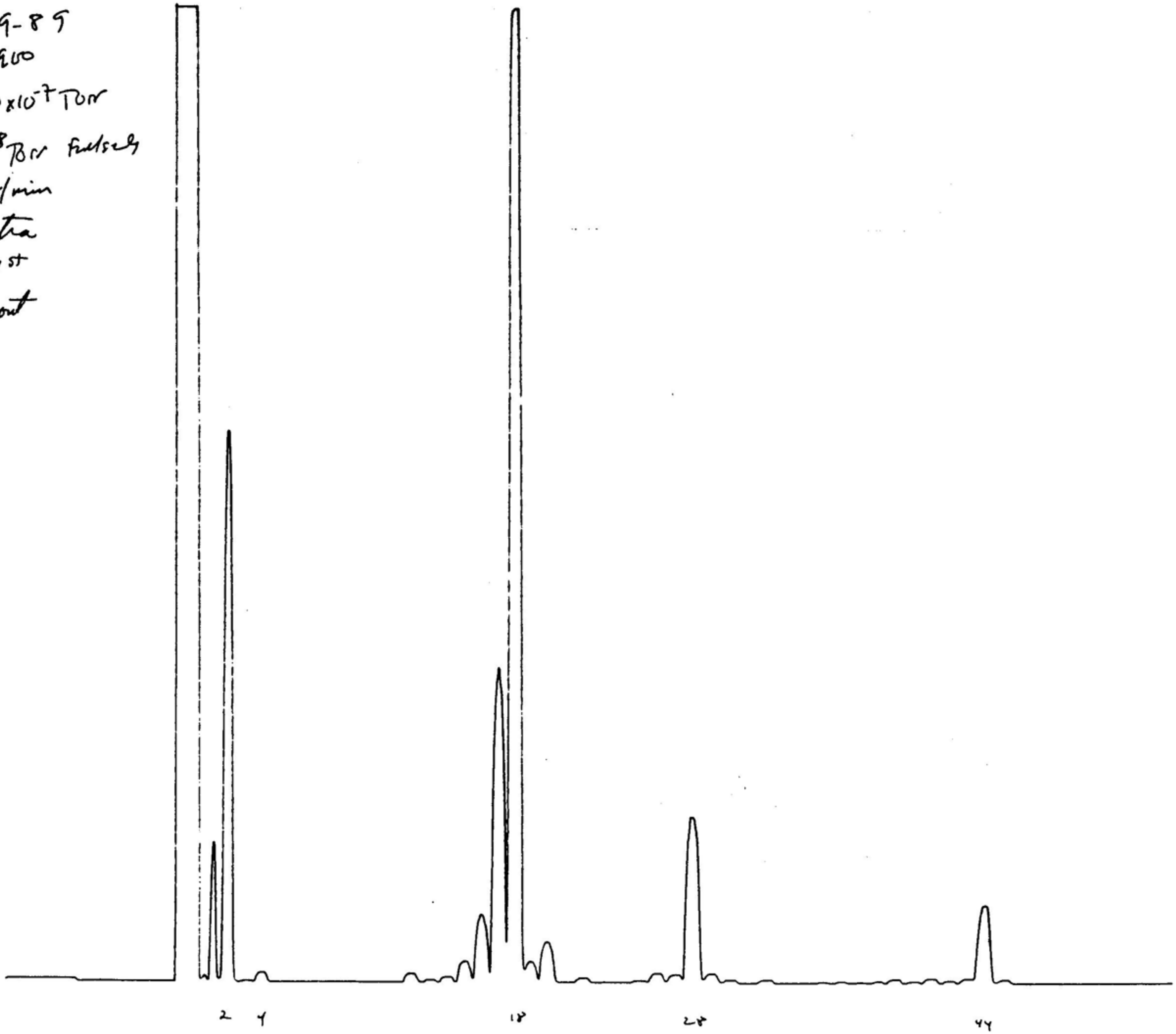
TEMPERATURE CYCLE FOR INITIAL BAKEOUT

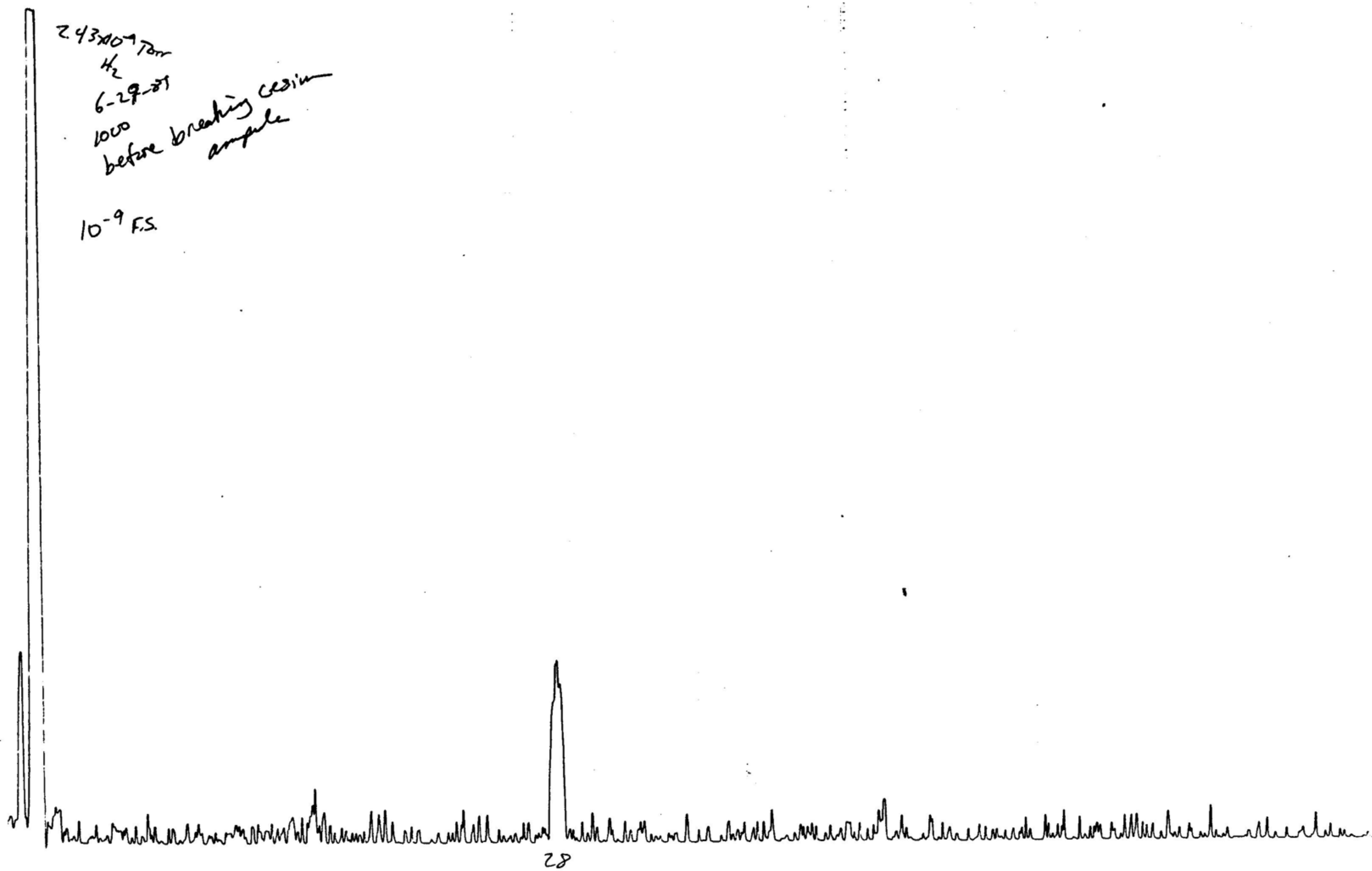


ION PUMP CURRENT VS TIME



6-9-89
0900
1.60×10^{-7} Torr
10^{-8} Torr fullscale
25 amu/min
Spectra before 1st bakeout





2.43x10-9 Torr
H_2
6-29-83
1000
before breaking cesium ampule
10-9 F.S.
28