NPL Polarized Source Group
Technical Note # 90-7

Evacuation and Bakeout of the Illinois/CEBAF Polarized Electron Source After Minor Changes

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We present here the procedure to follow for evacuation and bakeout of the Illinois/CEBAF polarized gun after minor changes such as the replacment of the cathode crystal, the replacment of the cesium capsule, or similar modifications that involve replacment of only a small fraction of the cleaned and baked vacuum components. A separate procedure is presented in source note # 90-4 for bakeouts after major changes.

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 stalk and the cesiator 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 millitor 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. A sure 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.

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 before a typical 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.

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 below. The attached figure documents the cycle graphically.

    (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 programmed 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 any 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 at about 70 C. These problems are discussed in detail in Polarized Source Tech. Note #90-4. If only minor parts of the gun have been changed it is unlikely that similar problems will occur during a bakeout. If you note a significant pressure rise at about 70 C, refer to that note for the appropriate "evasive action."

As the temperature approaches the flat-top value (220 C), it is necessary, in general, to watch carefully for overshoot and oscillation. However, after the controller has been "tweeked" for the time constants of the gun, this will no longer be necessary.

(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 pumps 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. For bakeouts after minor changes in a system that has been baked previously, the "flat top" will typically last only about 24 hours. 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 0.4%/hour (corresponding to less 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 the oven temperature down to 120 C and the stalk temperature down to 150 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 the oven temperature at 120 C and the stalk temperature at 150 C for 10 hours.

This gives the internal parts that are well connected to the outside time to stabilize in temperature. 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 both the oven and the stalk back down to room temperature over 8 hours.

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) and leak check the system using the RGA. This step will typically be required after three or four bakeouts, and should be done with particular care in stressed areas (e.g. the stalk and cesiator).

21. Take an RGA spectrum of the vacuum to document the quality of the bake. The RGA spectrum that was obtained just after a typical bakeout of the Illinois/CEBAF gun following a cathode change 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. 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 BAKEOUTS

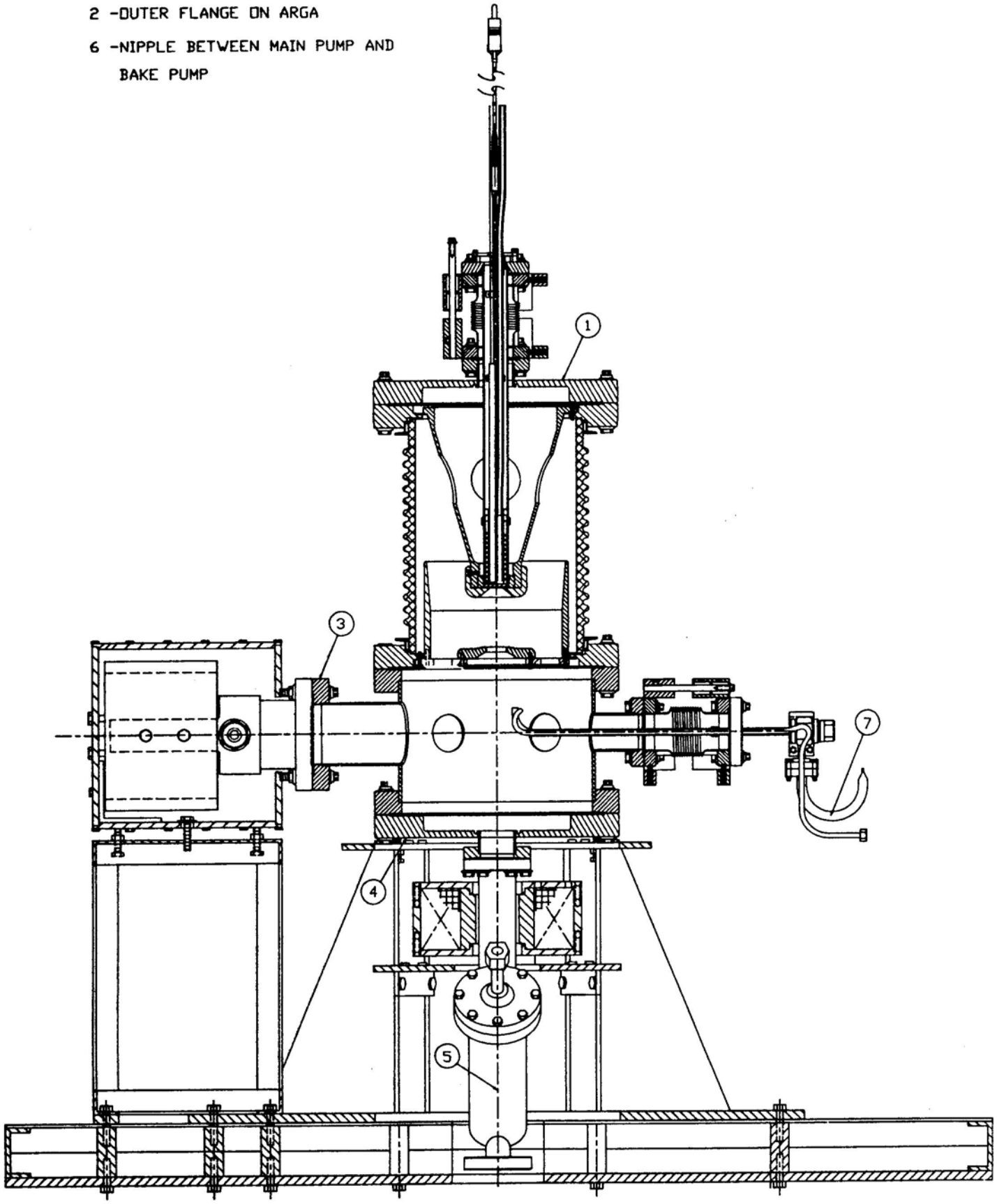
NPL 2772-5

ADDITIONAL THERMOCOUPLES (NOT SHOWN)

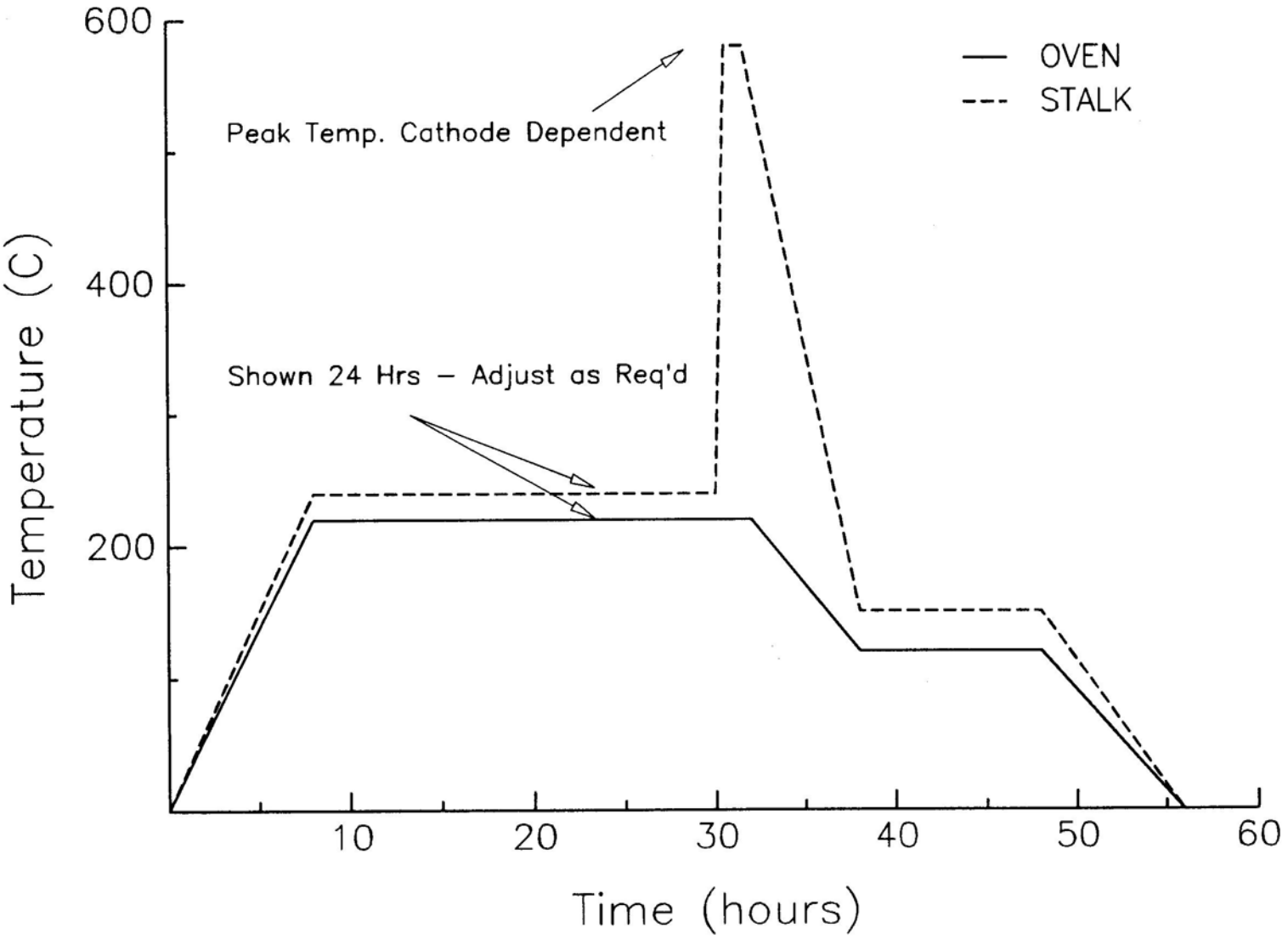
CONTROL-WINDOW

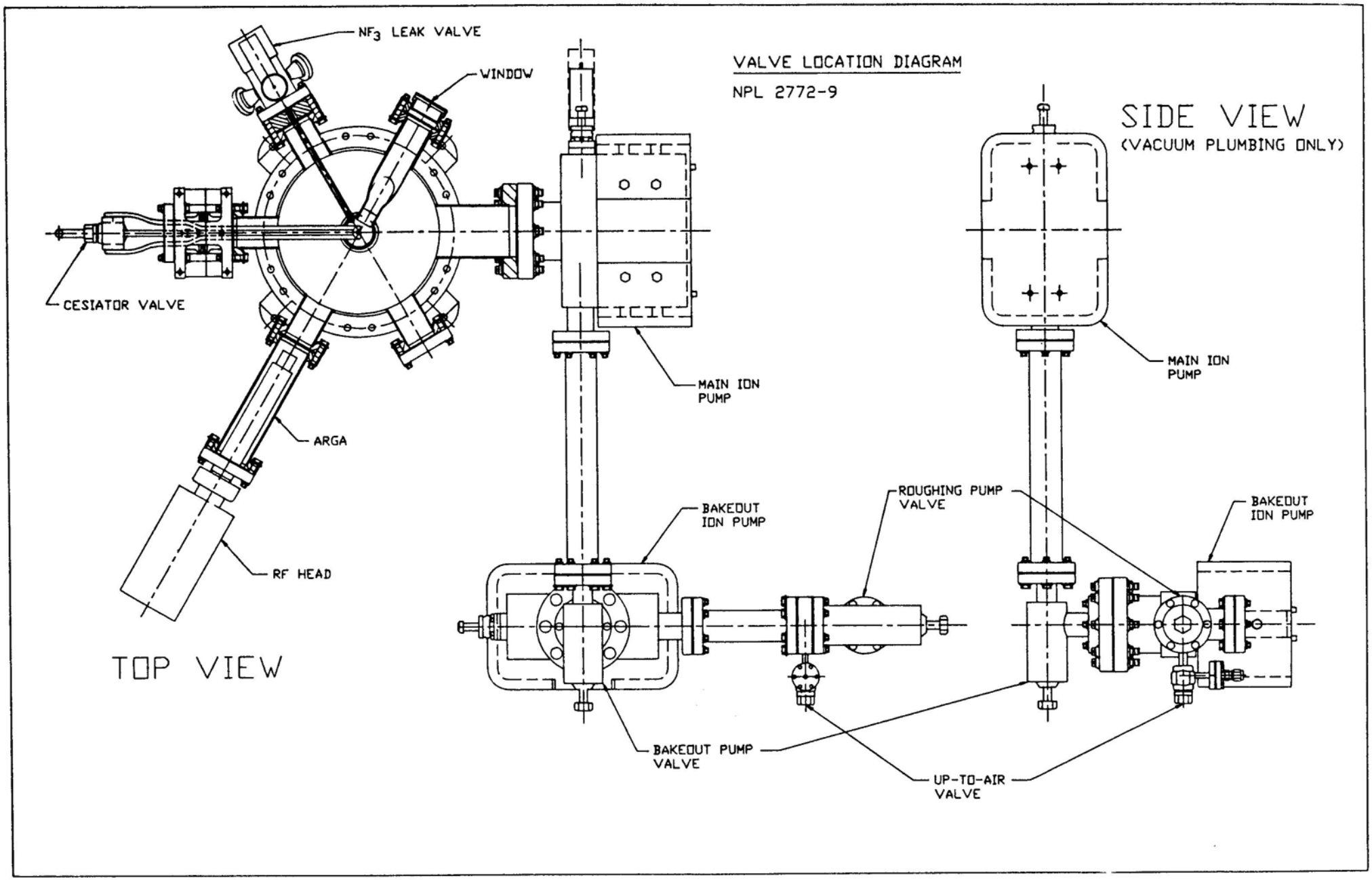
2 -OUTER FLANGE ON ARGA

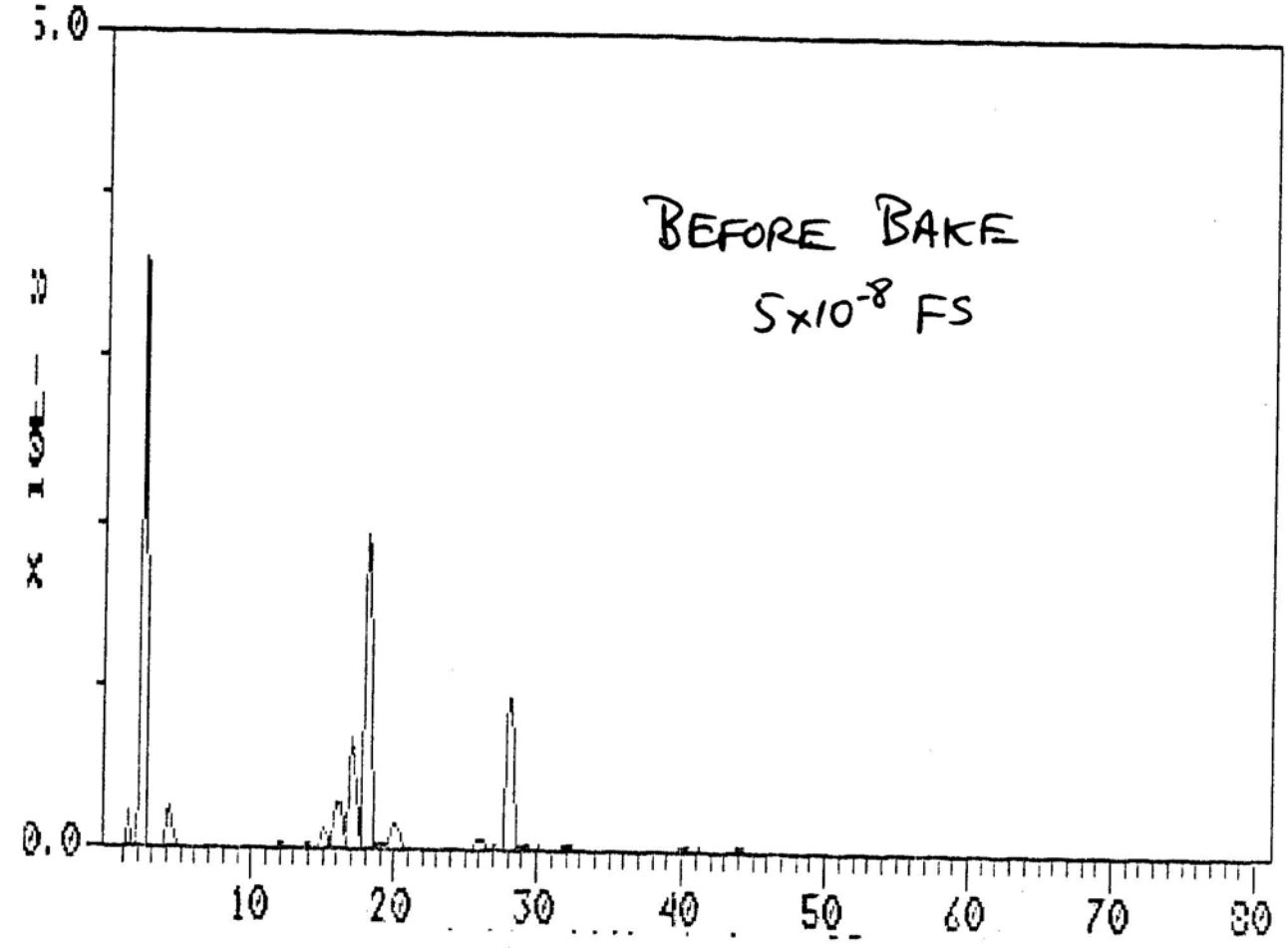
6 -NIPPLE BETWEEN MAIN PUMP AND BAKE PUMP

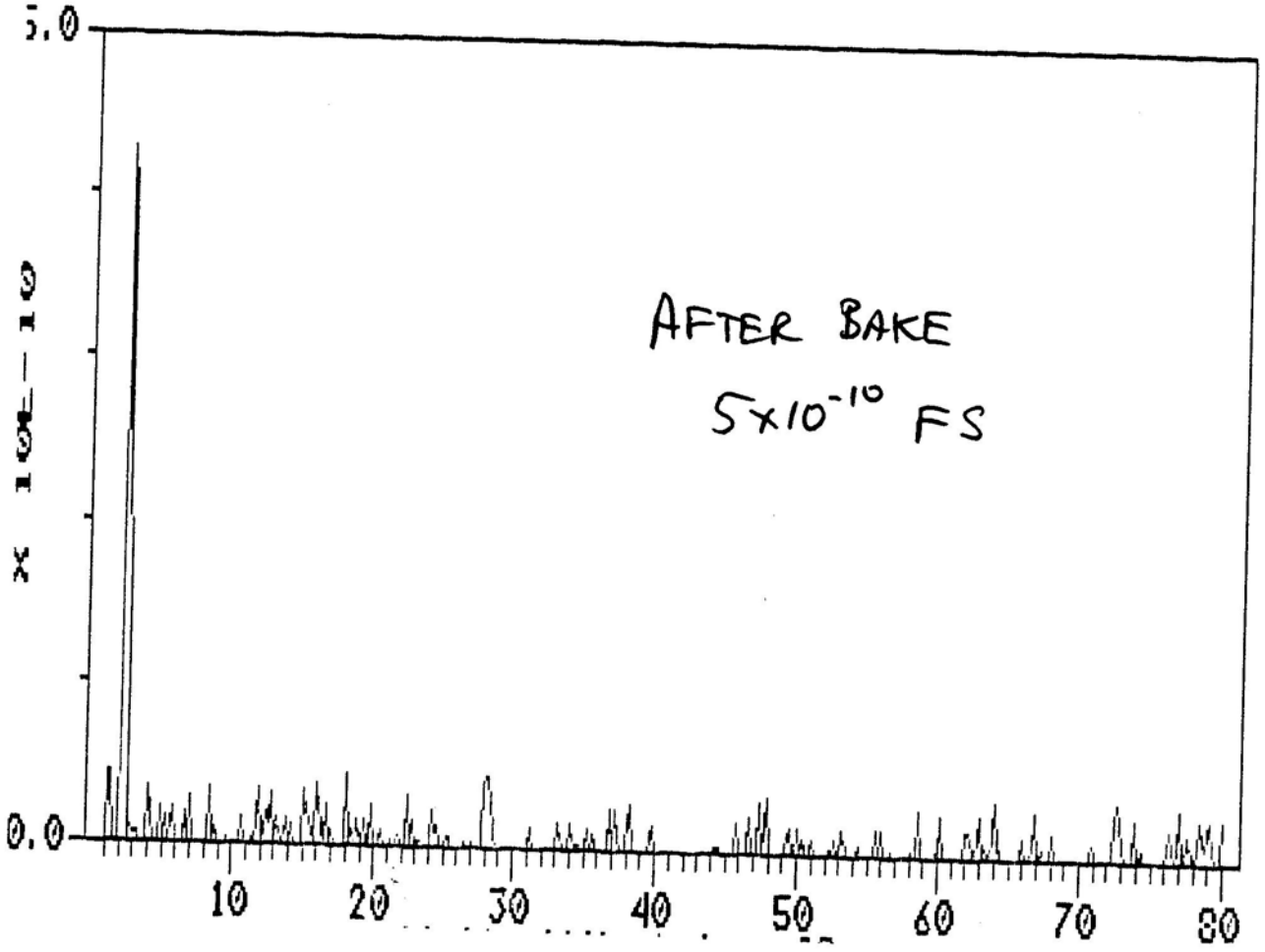


TEMPERATURE CYCLE FOR ROUTINE BAKEOUT




VALVE LOCATION DIAGRAM
NPL 2772-9
NF_3 LEAK VALVE
WINDOW
CESIATOR VALVE
ARGA
RF HEAD
TOP VIEW
MAIN ION PUMP
BAKEOUT ION PUMP
ROUGHING PUMP VALVE
BAKEOUT PUMP VALVE
SIDE VIEW
(VACUUM PLUMBING ONLY)
MAIN ION PUMP
BAKEOUT ION PUMP
UP-TO-AIR VALVE


5.0
0.0
10
20
30
40
50
60
70
80
BEFORE BAKE
5x10⁻⁸ FS


5.0
0.0
10
20
30
40
50
60
70
80
AFTER BAKE
5x10⁻¹⁰ FS