Fermilab

TM-849
1600.000

PUMP DOWN TIME OF ENERGY DOUBLER MAGNETS

M. Kuchnir and J. Tague

January 1979

ABSTRACT

Reported here is a study made of the time needed to pump down the insulating vacuum space of ten Energy Doubler magnets. This pump down time was found to be a function of the superinsulation and its previous exposure history. A factor of 50 reduction in pump down time can be obtained by prepumping and keeping them evacuated prior to installation. Exposure to 1 atm of N_2 gas for a few hours does not significantly increase the reduced pump down time.

INTRODUCTION

The operational requirement of minimum down time for magnet replacement in the Energy Doubler introduced a novel compromise in the design of cryostats: Reduction of pump down time at some refrigeration cost. The large surface area involved in the multilayer insulation is the component responsible for the long degassing time. In industrial storage dewars this large surface area presents no major problem specially when compared with the dramatic reduction in infrared radiation heat load brought in by this kind of insulation. For the cylindrical geometry of the Energy Doubler dipoles, the infrared radiation load on the shield, $\dot{Q}$, with no multilayer insulation would be

$$\dot{Q} = \frac{1672.\ \varepsilon}{2.12 - 1.12\ \varepsilon} \text{ watts}$$

where ε is the emissivity of the surfaces. The thought of a gold plated cryostat (ε = .027) was entertained but the resultant 22. W would be too much. Of the 23 W shield load of the Energy Doubler dipoles, less than 10 W is estimated as due to infrared heat through the dimplar[1] (multilayer insulation now in use). In a couple dipoles (PAB-87 and PAB-119) a different multilayer insulation (MVE process)[2] was used and the data shows it (PAB-87 took five days instead of the typical 16 hours in its first pump down to 3 mTorr).

EXPERIMENTAL SET-UP

The measurements were carried out at room temperature with a thermocouple gauge[3] at the magnet end opposite to the vacuum pump. The plugging fixtures and pumping stations of the Energy Doubler Magnet Inspection Group were used. Only the insulating vacuum space was pumped down, the other spaces (1Ø, 2Ø, beam tube, N_2) were left with one atmosphere of air but temporarily pressurized with ~10 psig of helium for leak detection. Figure 1 is a schematic of the equipment, moved from magnet to magnet in the stockpile at the north end of Industrial #1.

DATA

From the measurement of the insulating vacuum pressure as a function of time for ten magnets during N_2 flushing operations, it became very clear that the time, t, needed to reach a pressure, p, much higher than the blanking pressure of the pumping system, depended on the multilayer insulation and its exposure history. As an example we discuss the data obtained with magnet PAE-96; see Fig. 2. The first pump down, during which a small leak was corrected, was carried out for 16.5 minutes reaching 280 mTorr. One atmosphere of N_2 was admitted and a second pump down started, which reached 240 mTorr in less than 11 minutes. Again one atmosphere of N_2 was admitted and the third pump down carried out, this time for 1000 minutes (16 hours, 40 minutes) reaching 1.7 mTorr. The blanking pressure of the pumping system is less than .4 mTorr. Again one atmosphere of N_2 was admitted, left soaking in for ten minutes and a fourth pump down restarted. After five minutes the pressure was 6.5 mTorr Based on the experience collected with other magnets one can extrapolate this pump down curve to reach 1.7 mTorr in less than ten minutes but requiring several hours to reach 1.0 mTorr. We did use this same magnet to get a first indication of the influence of the soaking time and the use of CO_2 instead of N_2 as soaking gas. Figure 3 is a superposition of chart recorder traces. No pressure scale correction is needed to infer from these curves that N_2 is superior to CO_2 as a soaking gas, for room temperature operations, in spite of improved initial pumping rate due to N_2 trap cryopumping action.

A more complete study of the influence of N_2 soaking time on the pump down time was made with magnet RBB-72 and is shown in Fig. 4. It shows pump down times (from 1. Torr to 2. mTorr) of less than 30 minutes for soaking times of up to two days. The data points, however, show enough scatter to indicate that some parameter was not as closely controlled as it should. We suspect this parameter to be a combination of the N_2 soaking pressure, N_2 purity and perhaps temperature. Nevertheless the conclusion remains that N_2 exposure during the few hours needed to install a magnet in the tunnel does not appreciably increase the pump down time.

Figure 5 is the data for the non-typical magnet PAB-87, whose cryostat instead of dimplar uses a continuous ribbon of aluminized Mylar separated by fiberglass paper.[2]

Table I presents a summary of the pump down time needed to reach 3 mTorr for all magnets measured. Their scatter (except for PAB-87) can be attributed to the exposure history of their multilayer insulation.

TABLE I

Pump Down Time To Reach 3 mTorr

Magnet	Date	t_1 (1st time)	t_2 (2nd time)	t_1/t_2
PAC-135	781215	8 h	8.5 min	56.5
RDC-100	781218/19	11 h 30 min	-	
PAE-92	781219, 790108	10 h 20 min, 8 h 50 min	-	
PCA-120	781220/21	25 h	20.5 min	73.2
PAG-89	781227/28	15 h 20 min	-	
RAC-79	781228/790102	25 h 10 min	-	
PAB-87	790102/07	5 days 1 h 40 min	2 h 20 min	52.1
PAE-96	790109	13 h 20 min	-	
PAH-97	790110	11 h 20 min	-	
RBB-72	790111	14 h 10 min	-	

On magnet RAC-79 a second thermocouple gauge calibrated against the first and installed at one of the cryolab safety vent ports read the pressure near the pumping end of the magnet. So pressure drops across the magnet during pump down could be recorded. The pressure of the pumping end was at least one order of magnitude lower than at the closed end.

Some degassing study was also carried out on magnet RAC-79. After being pumped for three days and reaching the pumping system blank-off pressure of .35 mTorr, pumping was stopped and pressure rise monitored. It increased with a time constant of the order of 40 hours, reaching 42 mTorr after 33 hours.

CONCLUSIONS

The major conclusions have been summarized in the abstract above. It remains here to recommend the construction of plugging fixtures and pumping stations so that magnets ready to be installed are kept with their multilayer insulation in vacuum. Just prior to installation this vacuum should be broken with dry N_2 gas.

ACKNOWLEDGEMENTS

We want to thank J. Humbert for providing us with the equipment (plugging fixtures, pumping station, and leak detector) used in these measurements as well as the other members of Magnet Inspection Group for continuous support.

REFERENCES

[1] Dimplar specification: Nine layer pairs of .001" aluminized polyester over the N_2 shield; each pair consisting of a flat sheet and an embossed sheet with .040" high dimples. Plus three layers of flat sheet over the 2Ø tube covered by a non-aluminized layer of Mylar. Energy Doubler drawings: 1620-MB-106792-B, MB-97659, MA-96774, MA096775, MA-97992.

[2] A total of 40 two-ply layers of 1/2 lapped barber pole wrapping of 3" wide, 1/2 mil single aluminized Mylar over 3-1/2" wide, 1 mil, 1303 glass cloth. R.J.Stanczak, MVE file report of July 7, 1978.

[3]The Thermocouple gauge used, Teledyne's Hastings Raydist Model DV-6M with readout unit Model VT-6, was adapted with an output for a chart recorder (HP-7132A). The pressure signal calibration was carried out no further than relating the output voltage to the scale in the readout unit.

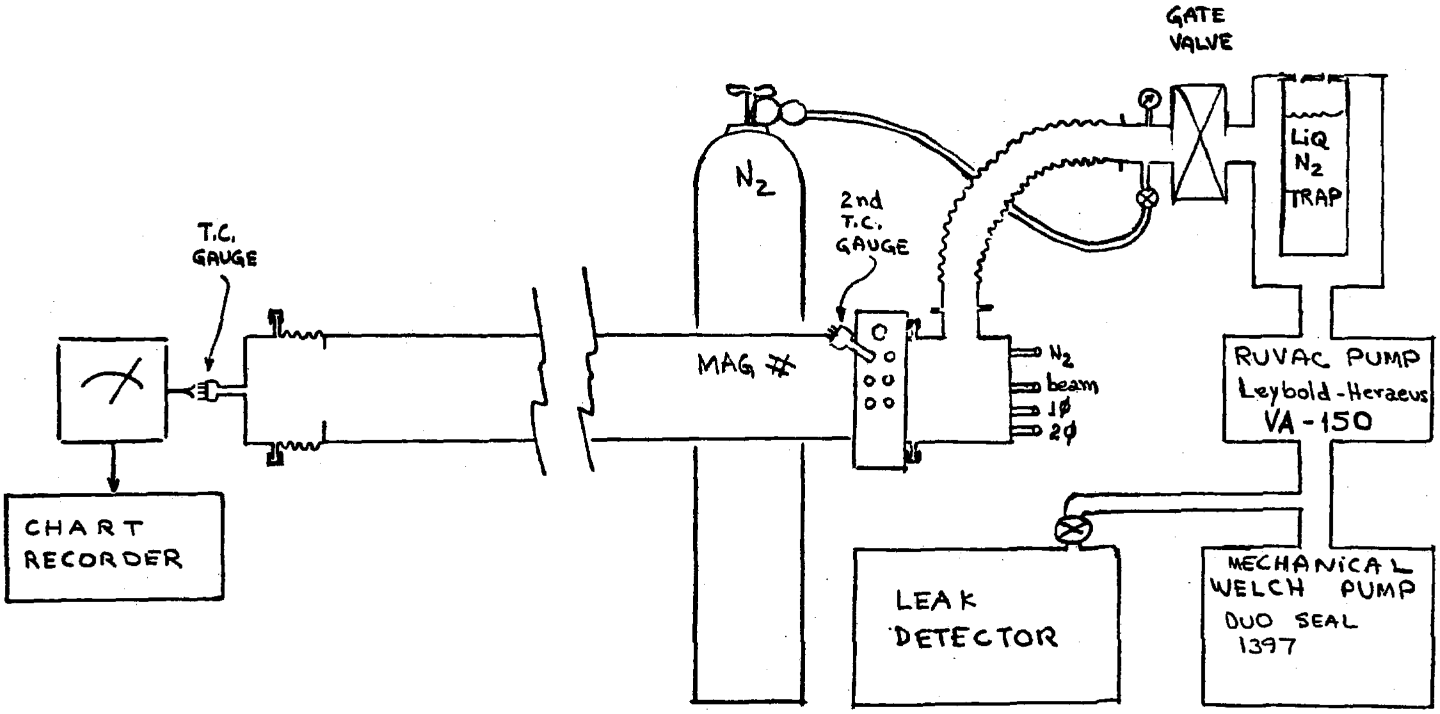


FIG. 1 EXPERIMENTAL SET-UP

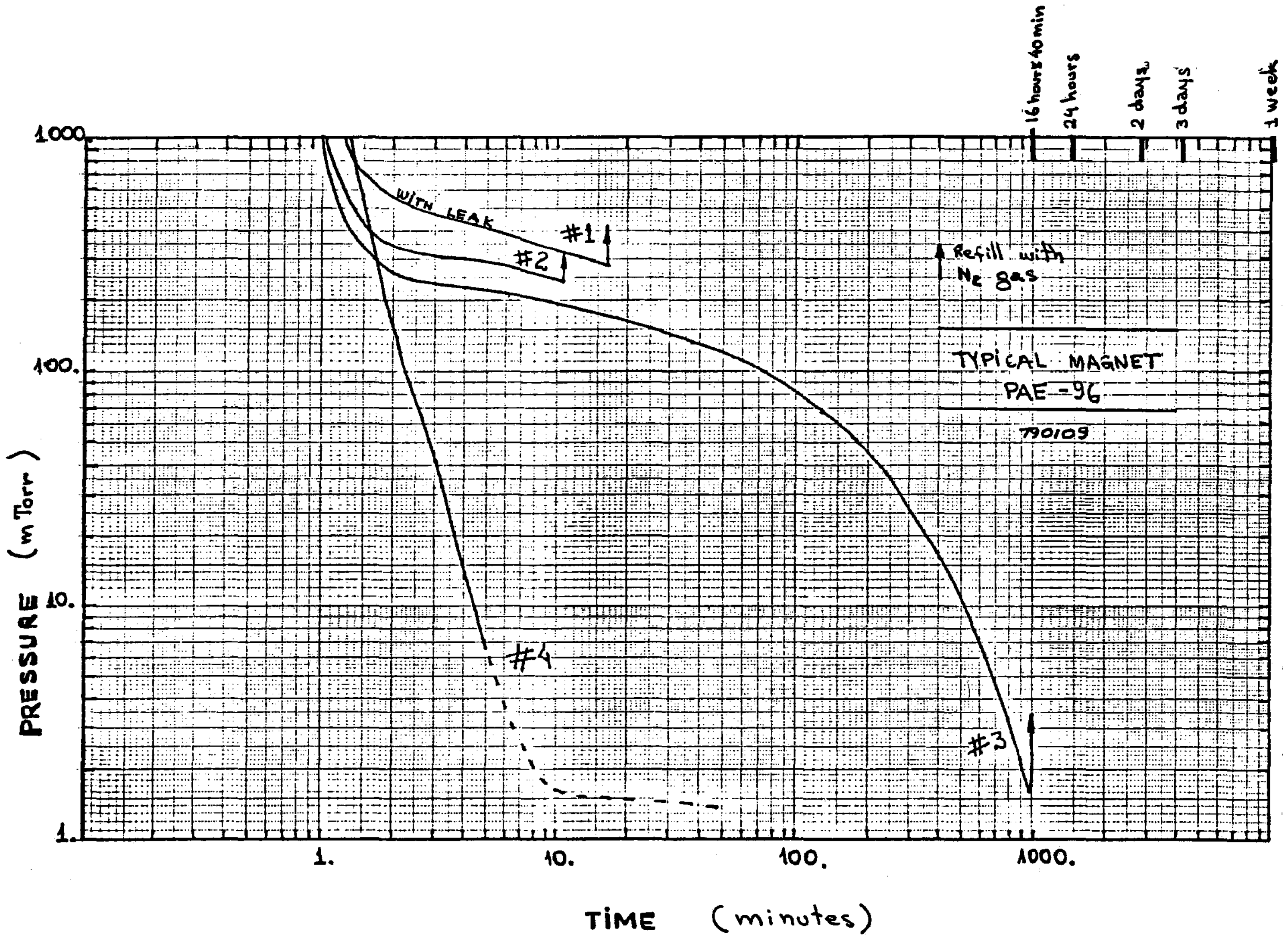


FIG. 2 TYPICAL PUMP DOWN CURVES

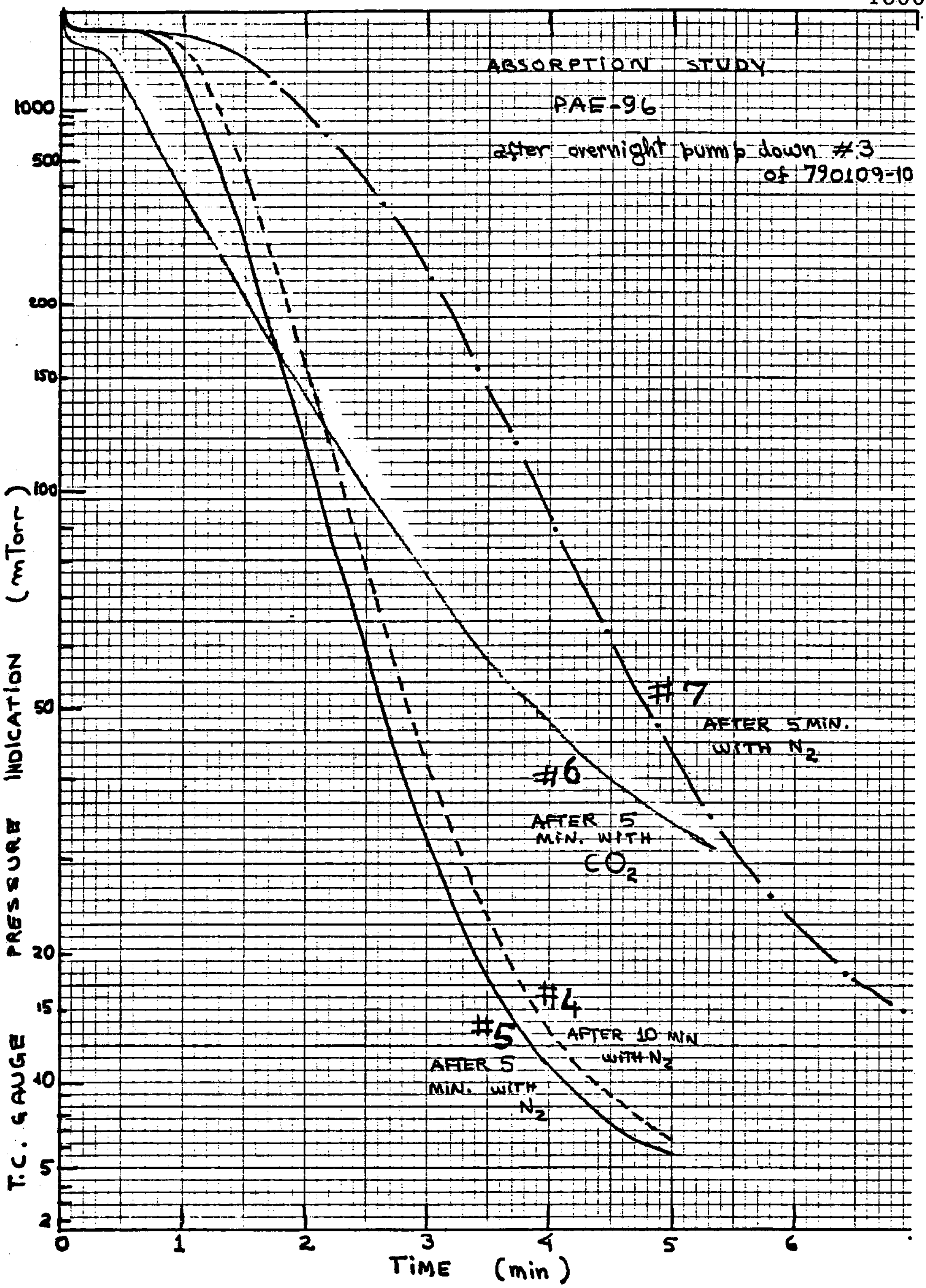


FIG. 3 PUMP DOWN CHART RECORDER TRACES
AFTER DIFFERENT SOAKING TIMES

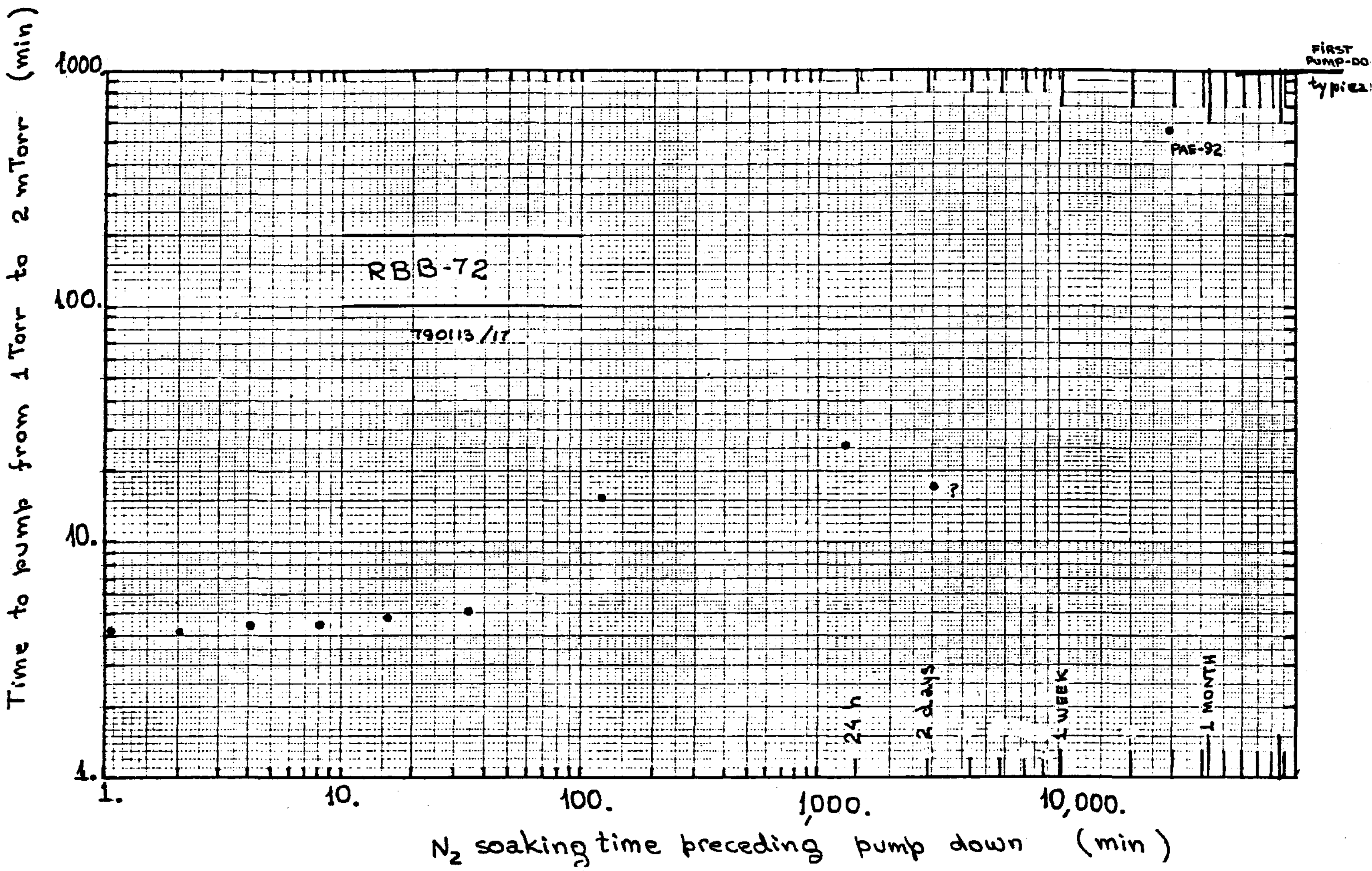


FIG. 4 N_2 EXPOSURE TIME STUDY

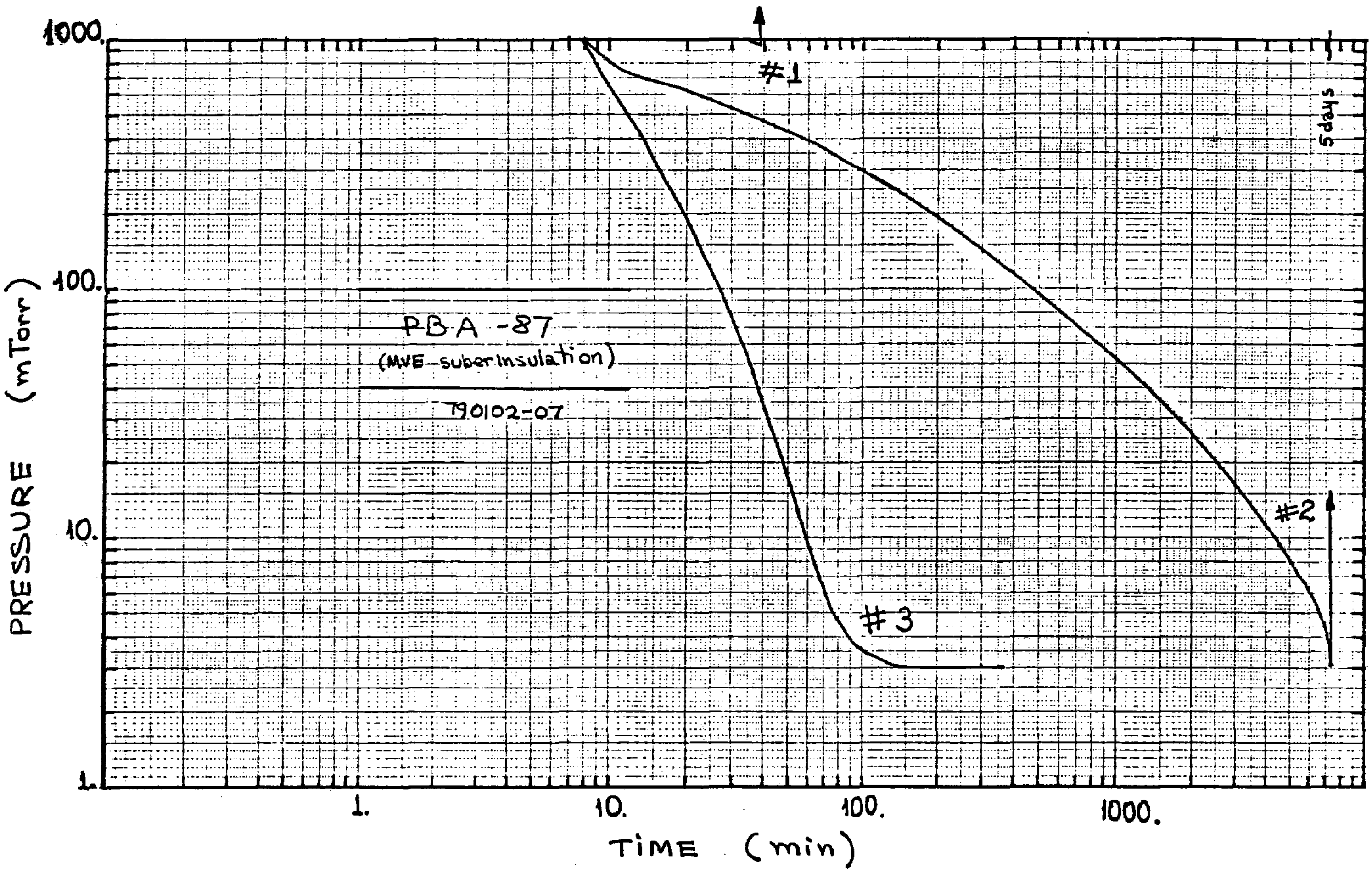
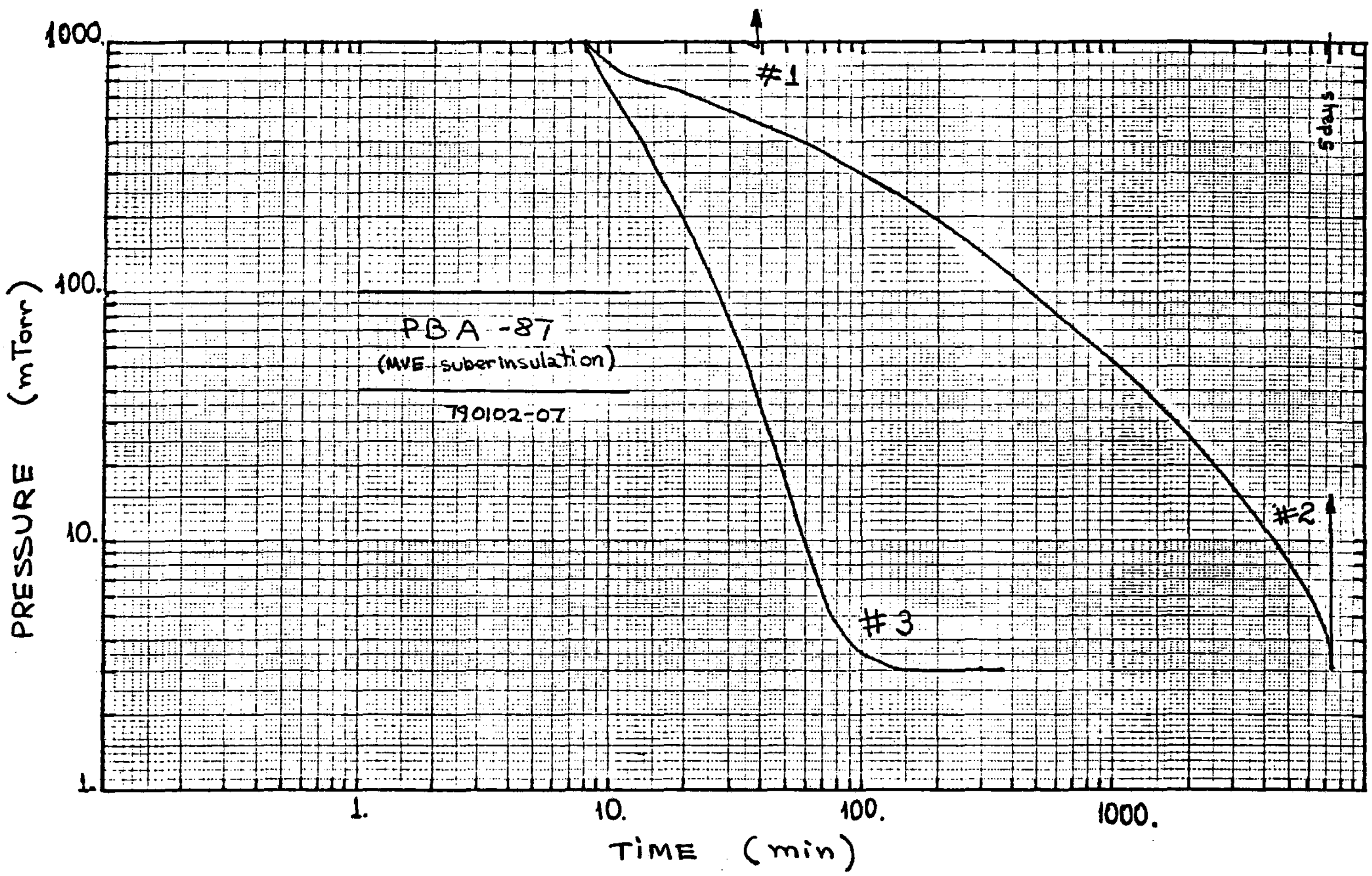


FIG. 5 PUMP DOWN CURVES FOR MVE SUPERINSULATED CRYOSTATS



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