Fermilab

TM-789
0549.000

Outgassing Tests of Magnet Lamination

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Introduction

As part of the current interest in improving the main ring vacuum system, the pressure peaks at the main ring extraction Lambertson magnets must be considered. Some simple but time consuming pump down tests were made on four samples of Lambertson magnet laminations. A qualitative comparison of the curves shows relative effectiveness of the different samples in decreasing the gas load.

The Problem

The vacuum peaks in the main ring are caused by the need to put stacked metal laminations inside the vacuum system. A large virtual leak is created by the surface gas trapped in the compressed lamination stack. Normally a clean metal surface has a gassing rate that starts at approximately 10^{-8}torr liter/per cm^2 sec and drops rapidly as the gas is pumped to about 10^{-10} Tl/cm^3 sec in a time of the order of days. In this case as in the normal virtual leak problem there is a conductance limit that does not allow the gas to be pumped away. Since a normal metal surface has a large quantity of gas absorbed on the surface a lamination stack has a very large supply of gas.

Vacuum Tests

To test several recent suggestions of ways to reduce the gas load, two inch welded stacks of laminations were pumped down in a small test chamber. The pump down curves show the time scale involved in reaching a given pressure and the base pressure reached show the relative effectiveness of reducing the gas load. Four samples were tried; first a normal stack (bare); second an epoxy impregnated stack, third a high temperature vacuum degassed stack, and finally a metal plated one.

Results

The results are shown in the figure. A disclaimer must be made because of the limited number of samples (i.e. one of each) and the limited time available (i.e. days instead of months or years in the main ring). The test chamber has a 30 ℓ/s main ring style triode ion pump and as such has about three times as much pumping speed per linear inch of lamination stack as those in the main ring. However, because of the different time scale involved, comparison of these pressures to main ring values are difficult.

The plated lamination was not different than the bare one. A visual inspection seemed to indicate that the plating did not cover the cracks. Both samples required a couple days of roughing before the ion pump could be started. The remaining two did not.

A comparison of the curves for the others speak for themselves. Notice that a low temperature in situ bake (~190°C for 24 hours) improved only the bare set but enabled the bare one to go lower than the epoxy impregnated one. It is interesting that a high temperature in situ bake

($400^{o}C$ for 24 hours) was required to lower the pressure of the high temperature degassed one. Though it was not tried, it seems reasonable to guess that a high temperature in situ bake of the bare one would show another improvement in the gassing rate.

The high temperature degassing treatment means in this case the standard oven treatment of the commercial metal treatment company involved. It is $1000^{o}C$ until the pressure is below 10^{-5}torr. One probably does not need to go quite that high in temperature but it should be above $800^{o}C$. After the treatment the stack was shipped and stored in a plastic bag for a couple of weeks before the vacuum tests and handled with white gloves. Magnetic properties of the metal before or after the high temperature degassing were not checked.

Conclusion

Provided the magnetic properties did not suffer in the high temperature degassing, this treatment would appear superior. Unlike the epoxy impregnated sample there is no question of radiation damage.

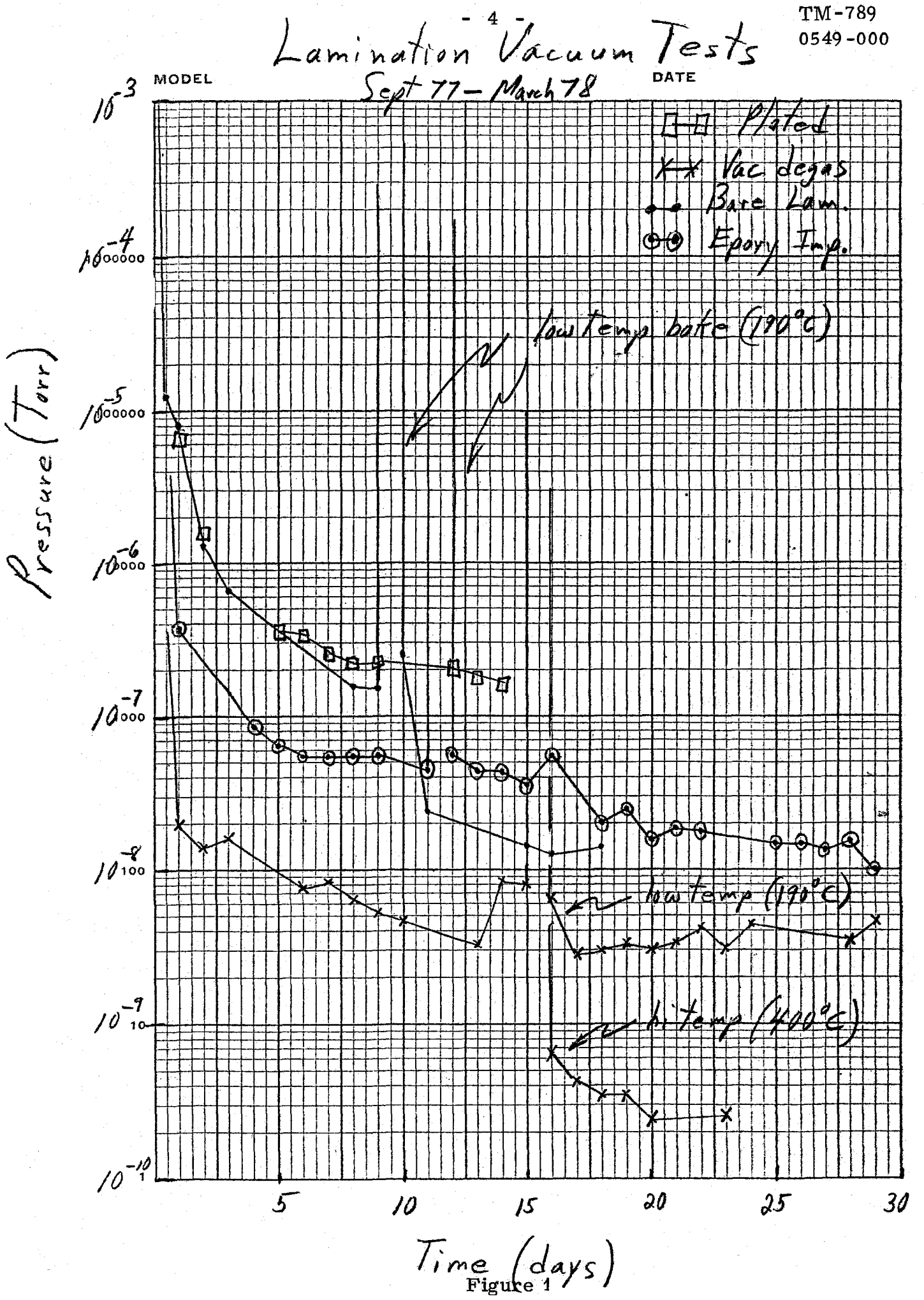
Lamination Vacuum Tests
Sept 77 – March 78
MODEL
DATE
Plated
Vac degas
Bare Lam.
Epoxy Imp.
low temp bake (190°C)
low temp (190°C)
hi temp (400°C)
Pressure (Torr)
Time (days)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9
10^-10
5
10
15
20
25
30

Figure 1

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Addendum to TM-789(A)
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Because of worries about high temperature degassing effects on the mechanical alignment of stacked septum laminations, a suggestion was made to try the bake before stacking the laminations. One would not expect a bake before assembly to decrease the gassing rate as much as a bake afterwards, however, as the figure* shows a 2" stack made from pre-baked laminations was surprisingly low (only the "after assembly" baked one being lower). Obviously this method requires clean handling of the baked laminations during stacking and welding.

*See attached.

Lamination Vacuum Tests

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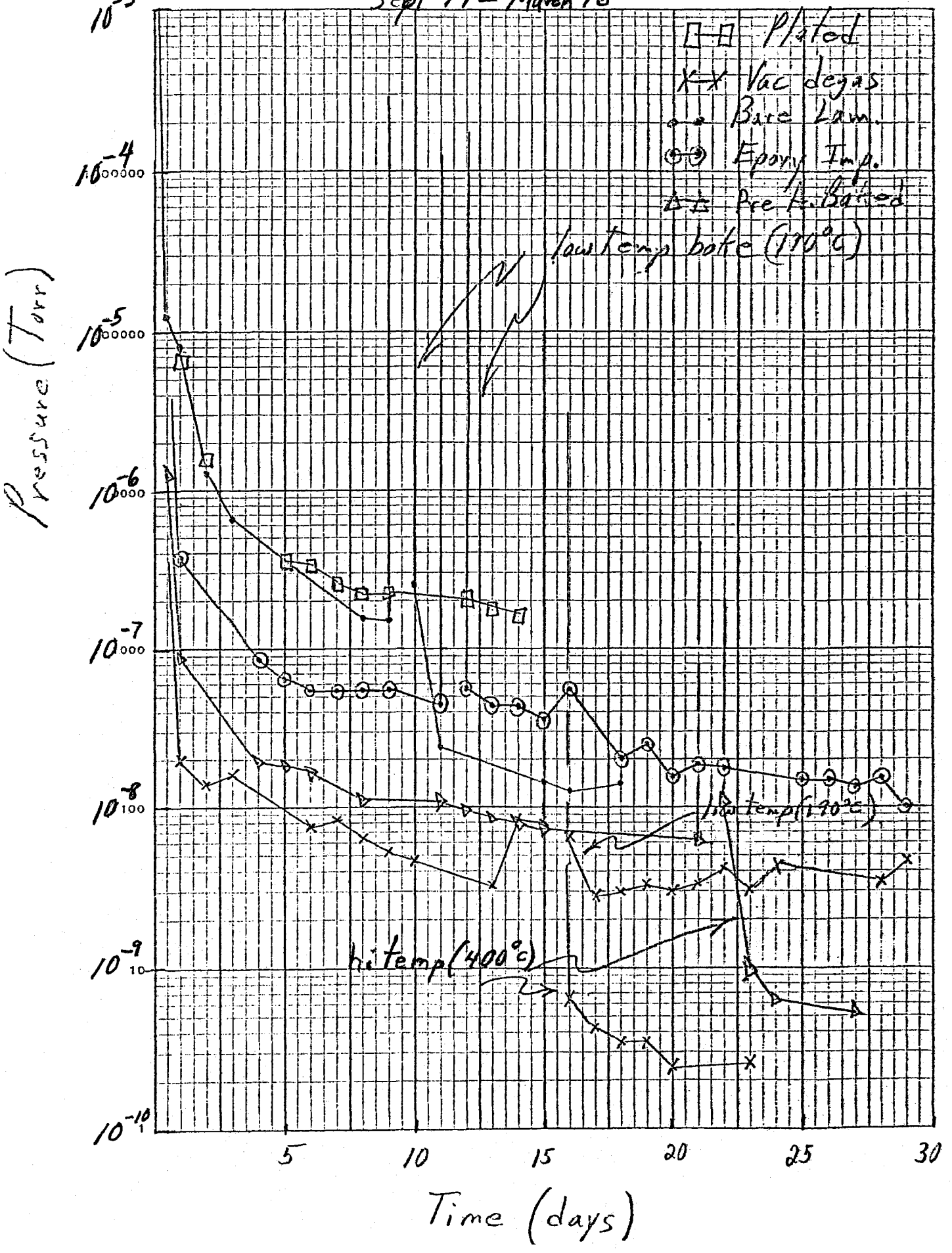
Sept 77 – March 78