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MPS/SR/Note 73-12
27.2.1973

# NOTE ON VACUUM PUMPDOWN TESTS OF A FAK MAGNET MODULE

# AND ITS TEST TANK

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## 1. Introduction

The poor pumpdown and ultimate pressure characteristics of previous FAK model, prototype and production type magnet modules, owing presumably to high water content in the ferrite structure, have led us to a certain systematic ferrite treatment. This treatment, applied to the ferrite after machining but before vacuum tests, allowed a much faster pumpdown and a significant decrease in ultimate pressure.

In this note we describe the history and the subsequent treatment of the ferrite together with some pumpdown curves for certain prepump starting conditions.

## 2. History of the Ferrite Treatment

The ferrites used for this particular test happened to be the prototype ferrites but are nominally identical to the production ferrites. They were premachined by the manufacturer Indiana General with an E55 cutting agent (main constituents: sodiumcarbonate $Na_2CO_3$, sodiumchromate $Na_2SO_4$, quartz

$SiO_2$ and sodiumcloride NaCl). The ferrite machining was finished off in CERN by Atelier West with Helvetoc cooling agent (consisting mainly of sodiumnitrite $NaNO_2$).

When the first magnet was built up it was noticed that a few ferrite pieces, after lying around for months in humid air, showed a very slight white or yellow deposit on part of the surface. This powder could easily be wiped off with Kleenex and water. Thus a magnet was built using this ferrite cleaning procedure. This magnet was pumped down in its test tank with great difficulty and only a relatively high ultimate pressure was reached, just good enough to pulse the magnet 35 million times at its design current.

We began to realize the depth of the problem when we saw the 11-turn ejection magnets, which were due for modification in summer 1972. These magnets were built partly with identical ferrite to the above mentioned. They went into the PS apparently clean and they came out of the machine clean. After a long weekend in humid air however, the ferrites showed a thick (2-3 mm) powdery deposit, mushrooming on the surface, the colour of which was whitish-yellow.

This powder was scraped off and analysed as mainly sodiumsulphate $Na_2SO_4$, chrom Cr and sodiumchloride NaCl. This was partly expected, knowing the cutting fluid used by the manufacturer. The cutting fluid does not explain the existance of the sodiumsulphate, however. It is still a mystery how this salt got into the ferrite, if not during manufacture.

It was recognized that hygroscopic salts were present in the ferrites. These salts prevent a rapid pumpdown and thus tend to keep the pressure up because of the high water content. The water may be pumped out eventually, but as soon as the ferrite is exposed to humid air again, the salts suck up all the moisture they can get. The only solution to the problem is getting rid of these hygroscopic salts. To do just this, we employed the following procedure.

## 3. Ferrite Cleaning Procedure

The ferrites were soaked in cold static tap water for about one month. Frequent water changes were necessary because of the leaching out of the dissolved salts, witnessed by the yellow colour of the water due to sodium-chromate.

After this followed a 24 hours boiling in demineralized water. Because the water was still discoloured at the end of this treatment, it was decided to continue with a 70 hours boiling period using tap water. There was no demineralized water available to us then. It was found out that boiling ferrite in the tap water was not advisable because it left hard mineral deposits on the ferrit surface. In order to remove these deposits the ferrites had to be wire-brushed.

After this, the ferrites were subjected to a 24 hours cold tap water wash for control purposes. Then followed a bake-out at 175$^{o}$C in a Heraeus oven for about 5 days, after which the ferrites received the "Waddup-treatment" (bake-out at 250$^{o}$C under vacuum for about 7 days). Only after this procedure was the magnet module built up.

## 4. Magnet Module

A FAK magnet module contains about 10,4 dm$^{3}$ of ferrite material, weighing ca. 57 kp. The total ferrite surface is approx. 1,43 m$^{2}$. However, most of this surface (~ 80%) is tightly sandwiched between the high voltage capacitor plates; thus the pumping conductance is judged to be poor.

## 5. FAK Test Tank

This tank is an upright cylinder with VacIon pumps mounted directly onto the top and bottom faces. For vacuum purposes the tank was equipped with the following items :

1 Pfeiffer turbomolecular pump with prepump 400 $m^3/h$
2 VacIon pumps of 400 l/s each
5 Ionization gauge heads in 3 strategic positions
2 Ionization gauge control units IMG 2

To allow electrical measurements, the following equipment was also installed throughout the test :

2 ceramic to metal seal high voltage feedthroughs
1 oscilloscope screen
1 electron gun with araldite feedthrough and bellow.

Rubber was used for most of the vacuum seals; 7,5 metres in all.

## 6. Test Sequence Description

The pump down curves (Fig. 1) show the results of the various tests performed on the tank and FAK module. The test conditions were as follows :

Tank + Magnet :

1. Ferrites as received from Waddup, then exposed 10 hours to air during magnet assembly
   Tank 5 mins $N_2$, 1 hour air during mounting of module

2. 2 hours $N_2$ at atmospheric pressure

3. 1 hour $N_2$ at atmospheric pressure + 1 hour air, side-cover off

4. 5 mins $N_2$ at atmospheric pressure + 1 hour air, side-cover off

5. 1 hour air at atmospheric pressure

Tank only :

6. 5 mins $N_2$ at atmospheric pressure + 1 hour air, lid off to take out module

7. 5 mins $N_2$ at atmospheric pressure

## 7. Results

The experimental results may be studied from the accompanying graph (Fig. 1). The numerical values of each pressure plotted is the average value of two gauge readings. In short, firstly, the ultimate pressure of the tank alone is of the order of $2 \times 10^{-7}$ Torr. Secondly, it is possible to pump down the module in the test tank to a pressure of $4 \times 10^{-7}$ Torr in 24 hours.

It is also evident from pumpdown curves 3 and 4 that the duration of a nitrogen inlet to impregnate the ferrite before exposure to air is not critical, provided it is longer than 5 minutes. There is no noticeable difference in magnet pumpdown time after 5 mins or 1 hour exposure to dry nitrogen.

Further, comparison of curves 3,4 and 5 shows little difference in the pressure reached after 24 hours pumping, which suggests that the hygroscopic salts previously present in the ferrites have been effectively removed.

Distribution:

FAK section

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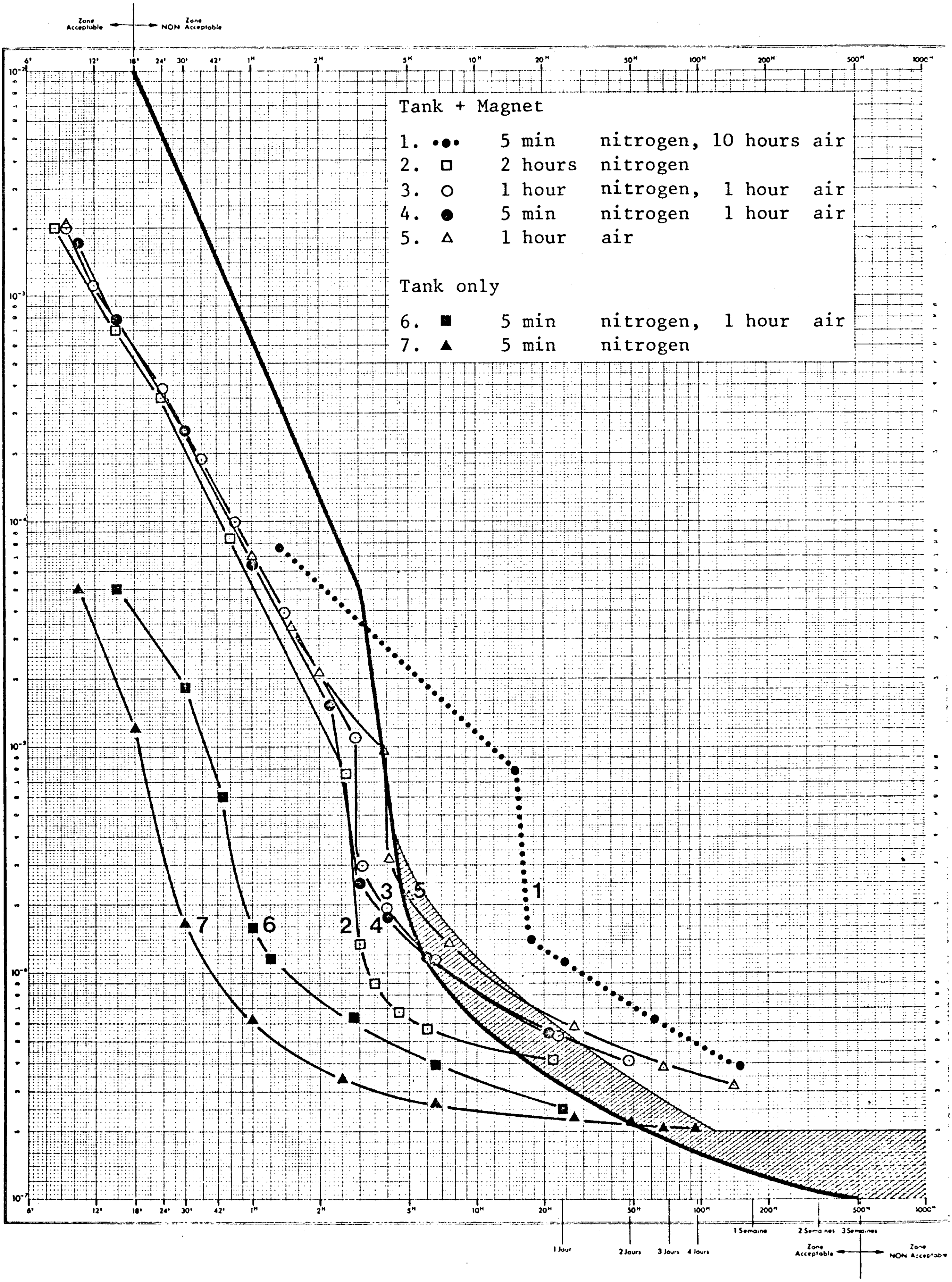


FIG. 1: Pumpdown curves for various prepump starting conditions