DEGASSING OF THE AGS EXTRACTION MAGNETS WITH UV LIGHT*

H.C. Hseuh, J.E. Tuozzolo and C. Trabocchi
AGS Department, Brookhaven National Laboratory
Associated Universities, Inc., Upton, New York 11973 USA

Introduction

In the vacuum system of particle accelerators most injection and extraction equipment, such as bump magnets, inflectors, kickers and septums, is located inside the vacuum system. This equipment is made of various materials with high outgassing rates which becomes the major sources of gases in the vacuum system. This is the case for Brookhaven's AGS ring where the kicker magnets and the extraction septums, due to their size and construction, usually have the highest outgassing, and have been the cause of several major vacuum failures during AGS operation.

Several approaches can be taken to reduce the outgassing of these magnets:

(1) redesign and construct the new ones using UHV standards and practices, which will be costly and time-consuming;
(2) modify the existing magnets, which will increase the radiation exposure to personnel because the beam loss around these magnets is usually high;
(3) install special degassing equipment in the existing magnets.

We have investigated the third approach by testing two types of degassing sources, a UV lamp and in Infrared (IR) radiant heat lamp, in spare AGS kicker magnets and septum magnets. This paper reports our study of the degassing treatment during pumpdowns of two kicker magnets.

Description of Test Setup

The UV lamp is a commercially available mercury arc lamp[1] in a quartz tube powered by a constant voltage high reactance supply. The lamp produces 7 watts ultraviolet (UV) light with major wave lengths of 254 nm and 185 nm. No measurable temperature rise was detected on the vacuum box when the lamp was on, therefore, it is ideal for a system which is not bakeable. The Infrared (IR) heat lamp is a high power quartz radiant lamp[2] with maximum heat output of 600 watts. It does raise the temperature of the vacuum box and the equipment within it.

To evaluate the effectiveness of these two degassing sources, several pumpdown runs were carried out on two spare kicker magnets which were made available to us. One is used for slow extracted beam (SEB) operation and the other for fast extracted beam (FEB).

The SEB kicker magnet has a solid steel core with a water cooled copper septum and backleg. The steel core, which has a surface area of 2,100 cm^2, has been nickel plated to reduce outgassing. The magnet is mounted in an aluminum vacuum chamber with external welds which has been alternately used in the ring or stored in air for more than ten years. Total surface area of the vacuum chamber and the aluminum magnet support hardware is approximately 11,000 cm^2. After roughing, vacuum is maintained in the chamber by a 60 l/s ion pump. The FEB kicker magnet has a solid ferrite core assembled in two halves with a total surface area of 3,500 cm^2. The ferrite was fired in air at 600°C before assembly. The vacuum chamber and support hardware is all stainless steel with a total surface area of 22,000 cm^2. Vacuum is maintained in this chamber by a single 220 l/s ion pump. When installed in the ring, neither magnet operates on its own ion pump; instead, they depend on the ring vacuum system for maintaining vacuum. The SEB kicker usually operates in mid 10^{-6} Torr vacuum and the FEB kicker in 10^{-7} Torr vacuum.

The test setup is shown schematically in Figure 1. Both lamps were mounted through Conflat feedthroughs on one side of the vacuum box. Less than half of the inner surface area was directly exposed to the UV or IR light, which reduced the effectiveness of these degassing treatments. Both total and partial pressure gauges were installed in the vacuum boxes to monitor the pressure change during pumpdown and degassing. The total pressure gauges are a Pirani gauge and either a Bayard-Alpert ion gauge or a cold cathode gauge. An UTI C100 residual gas analyzer (RGA) was used to measure the gas composition during pumpdown and degassing. A Leybolt-Hereaus turbomolecular pump station was used during initial roughing and degassing and the ion pump was used to hold the vacuum after degassing.

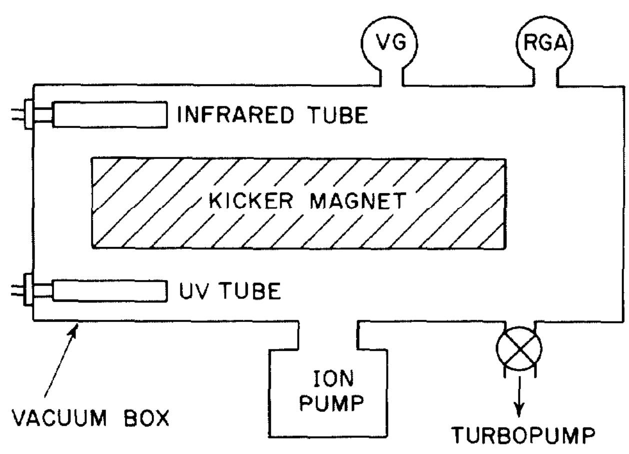

Fig. 1. The degassing test setup for AGS kicker magnets.

A typical pumpdown run would be started after venting the vacuum box to room air for several days. When degassing with the UV light, the UV lamp was turned on for a period of 4 hours, which is a compromise between the effectiveness of degassing and the convenience of operation. To reach a stable bake

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temperature, the IR light was usually powered for overnight. The use of indium coated C-ring in the kicker vacuum box has limited the maximum power and temperature to 250 watts and 100°C. The temperature around the seal during IR degassing was about 70°C.

Measurement and Result

The outgassing rate of the kicker magnets was calculated by Q = P × S, using the measured total pressure P and the estimated pumping speeds S of either the turbopump or the ion pumps. The effective pumping speed of the turbopump and the manifold was about 10 l/s as calculated by the molecular conductance equations. The nominal pumping speed of the ion pumps was used in our calculation. When the partial pressure of the system was monitored by the RGA, the changes in relative peak heights were used without correcting for the variations in sensitivity of the RGA due to pressure change. The total pressure during initial phase of degassing was usually in the micron range which prevented operation of the RGA. Typical RGA spectra during pumpdown of the kicker magnet are shown in Figure 2.

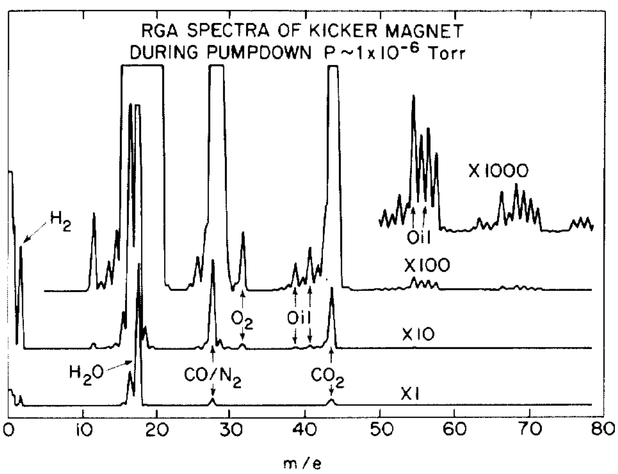

Fig. 2. The RGA spectra of the FEB kicker magnet during pumpdown.

The Pumpdown of the SEB Kicker Magnet

The pumpdown curves of this magnet are shown in Figure 3. After one month of operation with its ion pump and without degassing, the magnet had achieved a low 10^{-6} Torr vacuum. The UV lamp was then energized for 4 hours and the pressure and total outgassing rate was reduced by a factor of three. The second pumpdown with 4 hours of degassing during roughing gave a similar improvement in outgassing, and a mid 10^{-7} Torr vacuum was reached in a week.

The Pumpdown of the FEB Kicker Magnet

Five different runs were carried out on this magnet with venting to room air between the runs. The pumpdown curves of these runs are summarized in Figure 4.

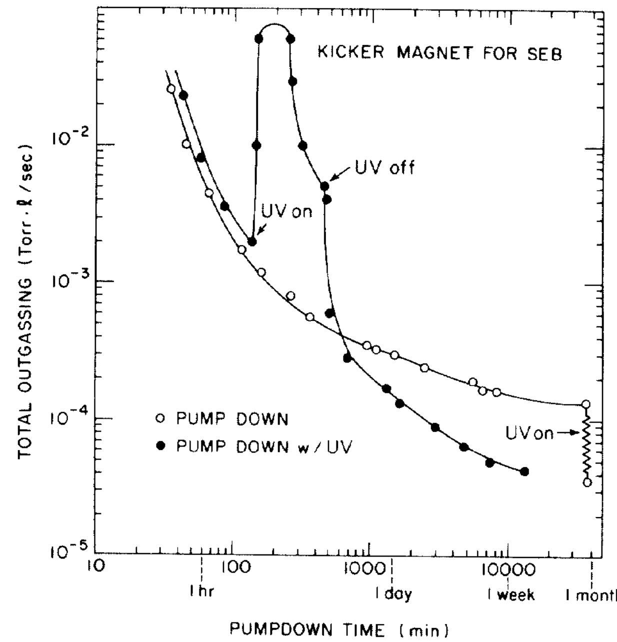

Fig. 3. The pumpdown of the SEB kicker magnet with and without UV degassing.

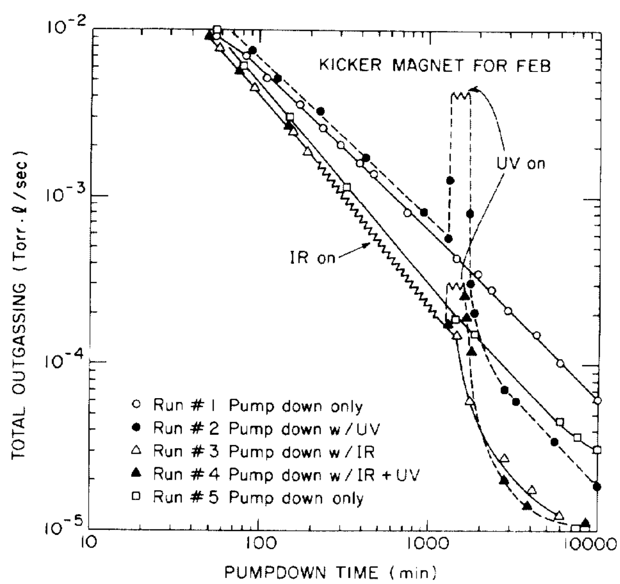

Fig. 4. The pumpdown of the FEB kicker magnet:
#1: without degassing;
#2: with UV degassing;
#3: with IR degassing;
#4: with IR and UV degassings;
#5: after the above degassings.

Run #1 was without degassing. A pressure of low 10^{-7} Torr was achieved with the 200 l/s ion pump one week after starting, with H_2O, H_2, CO and CO_2 the major outgassed species. Four hours of UV degassing was applied after overnight roughing in Run #2; immediately pressure and outgassing were reduced by a factor of three. Further reduction in outgassing was observed when IR degassing was used alone or with UV degassing as demonstrated in Runs #3 and #4. The IR degassing was more effective in lowering the outgassing than the UV degassing, though it needed longer time to reach the equilibrium temperature and would require a bakeable system. Run #5 was a repeat of Run #1; however, the outgassing was only half of that of Run #1, which suggests a memory effect after UV and/or IR degassing. Either some contaminants were permanently removed from the surface by the light or the weakly bonded molecules were not readsorbed on the surface when vented to room air. The integrated gas flow during the 4 hours of UV degassing equals several hundred Torr.l of gas and corresponds to 10^3 monolayers of molecules removed from the surface.

The composition of the residual gases during and after degassing is summarized in Figure 5 for a typical UV degassing run on FEB kicker. The partial pressures of H_2O (m/e=18), CO (m/e=28), CO_2 (m/e=44) and oil (m/e=41) increased by several decades when the UV light was on. Very little change in the hydrogen peak (m/e=2) was observed, which is understandable, since the source of hydrogen is mainly from bulk diffusion instead of surface desorption.

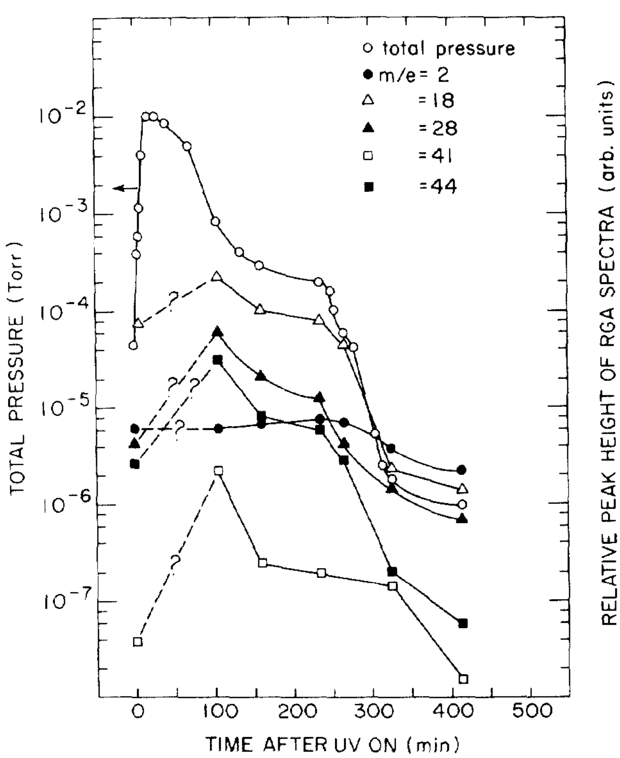

Fig. 5. The changes in total and partial pressures during and after UV degassing of the FEB kicker magnet.

Conclusion

The merits of using UV and IR light lamps as degassing sources for AGS extraction magnets have been demonstrated in our studies. A factor of three to five improvement in outgassing rate and pressure was obtained with several hours' degassing treatment. These lamps are compact and simple to operate, and can be installed in the existing magnets in the AGS ring without major modifications. If all the inner surface area of the magnet chamber is directly exposed to the degassing light by the installation of multiple lights, an improvement of one decade in outgassing is feasible. Certainly, the durability of these lamps under intense radiation has to be studied.

References

1. Phototron, Danielson Associates, Inc., Lisle, IL 60532.

2. Vacuum Research Manufacturing Co., San Ramon, CA 94583.