Test of the Vacuum Chamber with NEG Strip for the ATF Damping Ring

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Abstract

Design study on the vacuum system for the damping ring of the Accelerator Test Facility (ATF) is in progress. This ring has eight wiggler magnets. The vertical gap between poles is 20 mm. We are going to install NEG strip on both side of a beam duct in this narrow gap. In the activation of the NEG strip, heating problem for the chamber wall will be considered. We design the support of the NEG strip and test the vacuum performance of the chamber with NEG strip.

I. INTRODUCTION

The damping ring in ATF is an electron ring (1.54 GeV, 600 mA) to achieve a low emittance beam using wiggler magnets. There are two wiggler sections in the ring and each section has four wiggler magnets. Hard intense synchrotron radiation (SR) will be generated by wiggler magnets. The maximum power density of it at the beam-duct wall will reach 1.44 kW/m, and the photon density will become 1.9×10^{19} photons/m/s.

An aimed average pressure of the ring is below 5×10^{-8} Torr with beam. To realize this pressure, we must achieve the pumping speed of 140 l/s/m along the duct. The distributed pump along the beam duct is essential to get this pumping speed. We are planning to install Zr-V-Fe (St707) non evaporable getter (NEG) strips [1] as a main pump for the wiggler chamber.

All vacuum chambers are made by aluminum alloy (A6063) and they are extruded in atmosphere of Ar + O_2. The aperture of the beam duct is a race-track of 15 mm high × 47 mm wide and its length is 2.1 meter for one wiggler magnet. The cross sectional view of the chamber is shown in figure 1. Along the beam duct, two side channels for NEG strips will be installed.

In this paper we briefly report the first result of the test of the installation of strip into a vacuum chamber simulating the pumping channel.

II. SUPPORT OF THE NEG STRIP

Activation of the NEG strip is performed by direct current heating. In this process, the strip is heated at 450 °C for 50 minutes. Therefore, the strip must be isolated from the chamber wall to avoid the over-heating of the chamber and that of wiggler magnets. Cross sectional view of the chamber and the support without the strip is shown in figure 2.

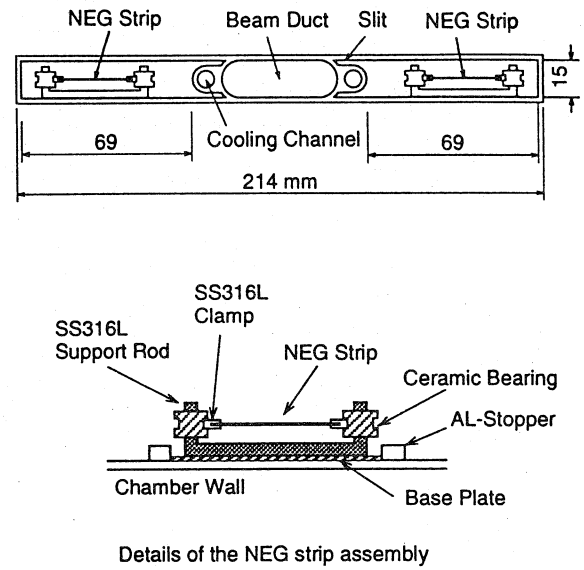

Figure 1. Cross sectional view of the wiggler chamber.

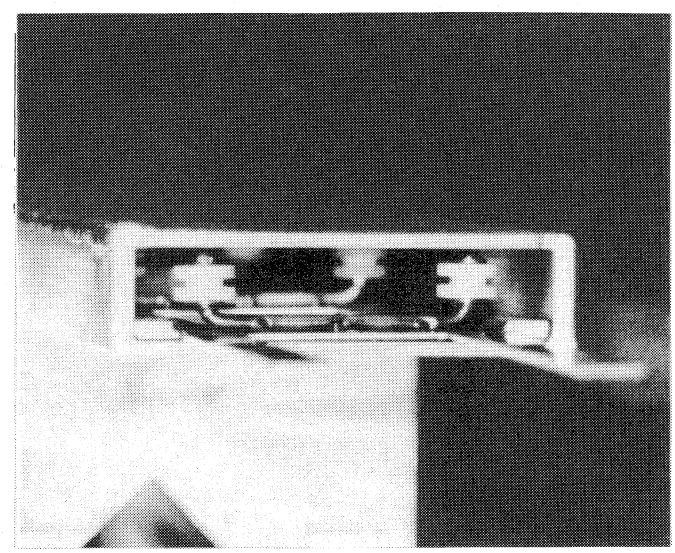

Figure 2. Cross sectional view of the chamber and the NEG support.

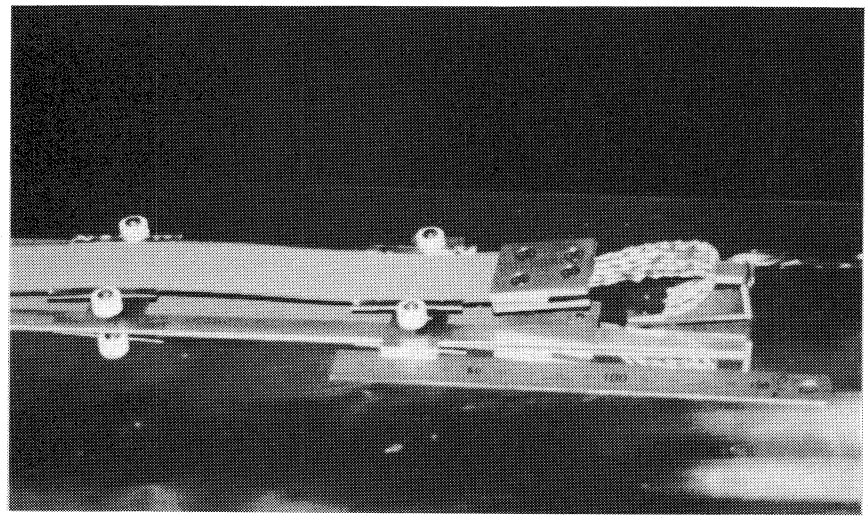

Figure 3. NEG strip with supprts and a copper braid.

Aperture of the test chamber is a rectangular of 15 mm high × 70 mm wide. It is the same as that of the side channel for the wiggler chamber. The NEG strip is 800 mm long and 30 mm wide. Its expansion length to the direction of the strip becomes about 6 mm in the activation.

At a half height of the chamber, ceramic bearings are settled on the support rods. Rods are made of stainless steel (SS316L) and they are arranged every 110 mm along the chamber. Ceramics isolates the strip from the chamber wall to avoid over-heating of the wall and electric short between the strip and the wall. One edge of the NEG strip was fixed with the copper clamp to connect an electrical power feed-through. Other edge was not fixed and it was connected to the chamber with a copper braid and clamps. Ceramic bearings rotate smoothly against the expansion of the strip. Therefore, the NEG strip can move toward to the copper braid without touching the chamber wall. Figure 3 shows the photograph of the NEG strip with supports and the copper braid.

III. ACTIVATION TEST

A. Set up and pre-bakeout

Figure 4 shows the schematic diagram of the experimental set up. Test chamber is 1.7 meter long and it includes two NEG strips. We attached the thermocouple on the NEG strip to measure temperature. The chamber was evacuated by a turbo-molecular pump (TMP, 300 *l*/s) and an ion pump (IP, 30 *l*/s). One B-A gauge measured the total pressure in the head of the pumping port.

At first we had baked the vacuum chamber to 150 °C for 24 hours. About 20 hours evacuation after the bake-out, the total pressure became 1.0×10^{-9} Torr with TMP.

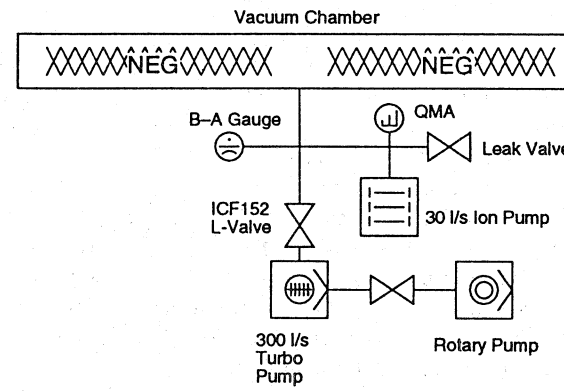

Figure 4. Schematic of the experimental set up.

Before the activation of the NEG strip, we had purged the chamber with pure N_2 gas and had connected the ion pump. It was a same sequence of the ring construction. Chambers will be baked before assembly at the beam line, but will not be baked *in situ*. An hour evacuation from the N_2 purge, the pressure becomes 1.6×10^{-7} Torr with TMP.

B. Activation of the NEG strip

The NEG strip was activated at 450 °C for 50 minutes by fedding the current of 50 A. About 18 hours evacuation after the activation, the total pressure becomes 2.7×10^{-9} Torr with TMP and IP.

Normal operation of the vacuum system for the damping ring will be performed with IPs and NEG strips. Therefore we closed the valve and separated TMP from the

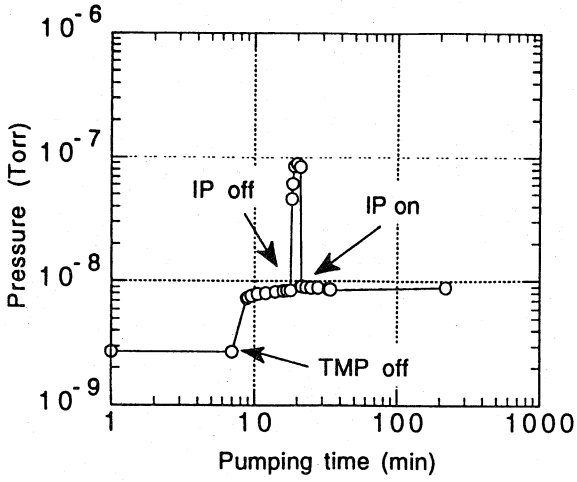

Figure 5. Pressure variation vs pumping time.

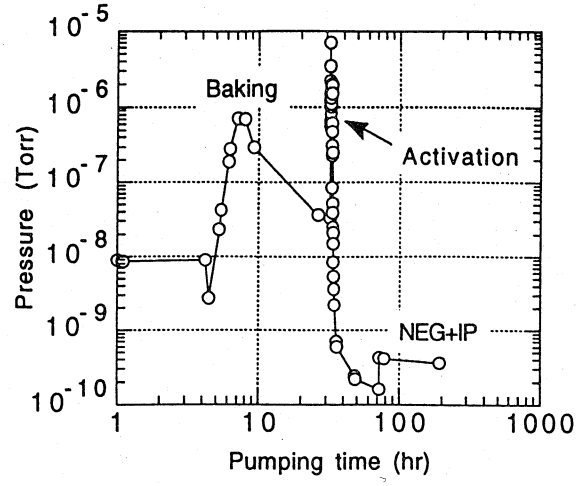

Figure 6. Pressure variation vs pumping time for the ultimate pressure measurement.

chamber to study this situation. After 10 minutes from it, the total pressure became 8.4×10^{-9} Torr. However, the pressure with only NEG strip was increased up to 9.0×10^{-8} Torr as shown in figure 5. It was a build-up of CH_4 because the NEG strip had very low pumping efficiency against CH_4.

Four hours later, the total pressure became 8.9×10^{-9} Torr with a combination of the NEG strip and IP.

C. Heating of the chamber wall

During the activation, we had been checked the temperature of the outer wall of the chamber, because the distance between the wall and the heated NEG strip was only 7 mm. We expected the over-heating problem for the chamber. Before the activation, the temperature of the chamber was equal to the room temperature ~25 °C. At the end of the activation, the temperature of the wall ranged from 30 to 75 °C. The maximum one was obtained at a position correspond to a half length of the NEG strip. The heat isolation was successful and we can allow this order of the over heating for vacuum chambers and magnets.

D. Ultimate pressure of the chamber

We measured the ultimate pressure of the vacuum chamber with the NEG strip. After the above test, we carried out a bakeout of the chamber as shown in figure 6. At the end of the bakeout, we performed the activation for the NEG strip and the conditioning for IP. After 40 hours evacuation we obtained the pressure of 1.6×10^{-10} Torr with the NEG strip, IP and TMP.

After 90 hours evacuation the ultimate pressure for the system with a combination of the NEG strip and IP was obtained as 3.6×10^{-10} Torr.

IV. SUMMARY

The vacuum test of the chamber with NEG strips for the ATF damping ring was performed. Aperture of the test chamber is a rectangular of 15 mm high × 70 mm wide and it included two NEG strips with supports.

The over-heating of the chamber wall was checked during the activation of the NEG strip (450 °C). The maximun temperature of the wall reached 75 °C near the center position of the strip. It was found that the design of the NEG supprt were acceptable.

Before the activation of the NEG strip, we baked the chamber, purged it with pure N_2 gas and connected the ion pump to simulate the ring construction in near future. About a day evacuation after the activation, the total pressure of the chamber with the NEG strip and IP was obtained as 8.9×10^{-9} Torr.

Finally, the ultimate pressure of the chamber was measured. Chamber baking and NEG activation was continuously performed without vacuum breaks. After 90 hours evacuation, the ultimate pressure was 3.6×10^{-10} Torr with a combination of the NEG strip and IP.

REFERENCES

[1] manufactured by SAES GETTERS S.p.A., *Itally.*