Distributed Non-evaporable Getter Pumps for the Storage Ring of the APS*

R. Dortwegt and R. Benaroya
Argonne National Laboratory
Advanced Photon Source
9700 South Cass Avenue
Argonne, IL 60439

Abstract

A pair of distributed Non-evaporable Getter (NeG) strip assemblies is installed in each of 236 aluminum vacuum chambers of the 1104-m storage ring of the Advanced Photon Source. Distributed pumping is provided to remove most of the gas resulting from photon-stimulated desorption occurring along the outer walls of the chambers. This is an efficient way of pumping because conductance is limited along the beam axis. The St-707 NeG strips are conditioned at 450°C for 45 min. with 42 A. Base pressures obtained are as low as 4 x 10^{-11} Torr. The NeG strip assemblies are supported by a series of electrically isolated, 125-mm-long, interlocking stainless steel carriers. These unique interlocking carrier elements provide flexibility along the vacuum chamber curvature (r=38.96 m) and permit removal and installation of assemblies with as little as 150 mm external clearance between adjacent chambers.

I. INTRODUCTION

The Advanced Photon Source (APS), currently under construction at Argonne National Laboratory, is a synchrotron radiation research facility. It incorporates a 7-GeV positron storage ring (SR) designed to maintain a pressure less than 1 nTorr with a circulating current of 300 mA. The low pressure is critical to enabling the machine to deliver long beam lifetimes. The SR has 240 chambers over its 1104-m circumference. Each one of 236 aluminum chambers contains a pair of St-707 Non-evaporable Getter (NeG) [1, 2] strips, allowing for distributed pumping. This is an ideally suited pumping method over conductance limited chambers whose cross section is shown in Fig. 1. Test results indicate that the combination of sputter ion pumps and NeG strips achieve the desired chamber pressure. The NeG strips are designed to be effective over a 20-year period. However, should one or more of the strips require replacement (e.g., due to greater than anticipated exposure to gases while in a pumping mode or accidental damage), it would be desirable to accomplish the task without removing chambers. Therefore, unique interlocking stainless steel (SS) carriers for the NeG strips were designed and built to allow removal and installation of NeG assemblies between two adjacent chambers.

II. NEG PUMP TEST

Tests were made [3] to determine the effectiveness of the NeG strips even before the novel replacement design, using the interlocking carriers, had been incorporated. A 10-ft-long

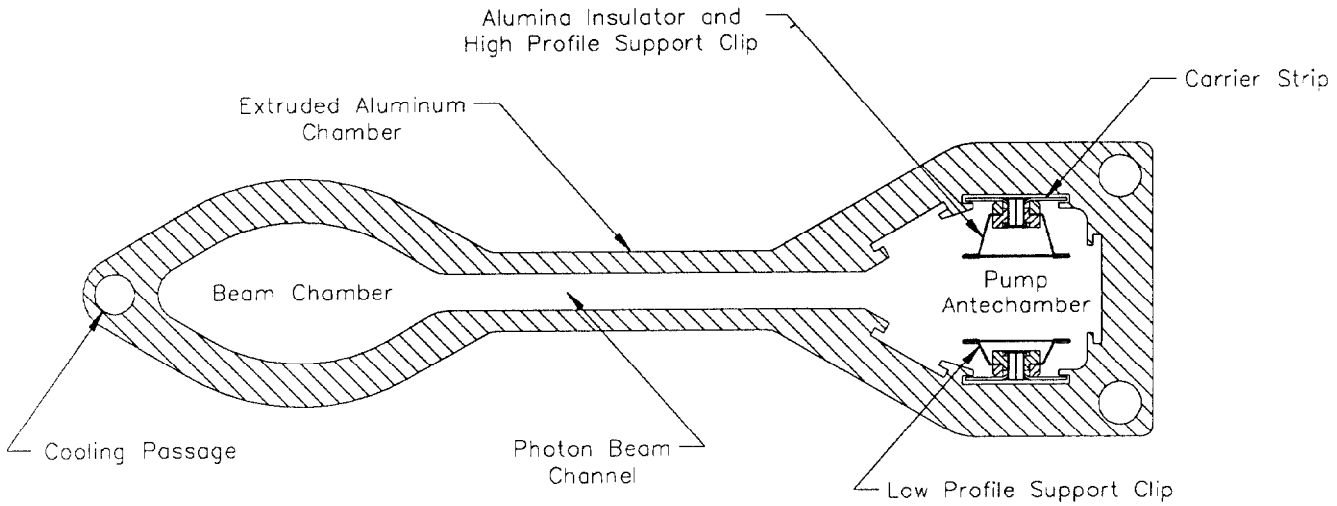

Figure 1. Storage Ring Vacuum Chamber Cross Section.

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straight chamber, similar to a section 1 type in a SR sector [4], was cleaned and installed with two 30-l/s sputter ion pumps, an angle valve for isolating the turbo molecular rough pumping complex, a nude ion gauge, and a residual gas analyzer. A pair of St-707 NeG strips was mounted on SS continuous carrier strips that were electrically isolated from the NeGs by means of ceramic insulators. The strips were constrained to the top and bottom antechamber walls within the grooved tracks that follow the straightness of the chamber. The NeGs were electrically joined in series at the end opposite to the entrance feedthroughs. The entrance junction was made with a banana jack-type connector, enclosed in a multicontact band, which solidly engaged the feedthrough with the Conflat seal closure action. The chamber was pumped with a turbomolecular pump. This was followed by a bakeout at 150°C which lasted until a stable pressure of 4 x 10^{-9} Torr was reached 36 hours later. The NeG strip was then activated at 450°C for 45 min. This was achieved with a current of 42 A through the NeGs. The expended power in the NeG strip was sufficient to retain the temperature of the insulated aluminum walls at 150°C without requiring additional baking power. During the initial phase of activation, the pressure increased to 1 x 10^{-5} Torr while the activation current was slowly raised towards its maximum. At the conclusion of the activation, the ion pumps were started. Finally, the turbo isolation valve was closed and, when the chamber walls cooled down to ambient temperature, the pressure stabilized at 4 x 10^{-11} Torr.

III. INTERLOCKING CARRIER SYSTEM

Mechanical support for the NeG strips is accomplished through the use of 0.75-mm-thick x 125-mm nominal length SS strips (which have been termed "links"). A typical installation of one of the NeG assemblies is shown in Fig. 2. The links are snapped together during installation of the NeG assembly and inserted into the corresponding 2.5 x 32-mm slots which run the length of the vacuum chamber. The links are provided with fastening support clips and 99.5% alumina insulators to support the NeG at regular intervals while maintaining electrical isolation from the vacuum chamber.

The use of an interlocking set of links for a carrier strip is found to have the following advantages: (1) When installed, the assembly has sufficient flexibility in the horizontal plane to follow the 39-m radius of curvature possessed by some of the vacuum chambers. (2) The required space between chambers during removal of an assembly is less than 150 mm. As the NeG assembly is removed, each carrier link is disengaged from its neighbor immediately upon exit from the chamber. This permits bending of the NeG strip by itself to a radius less than 150 mm in the vertical plane, avoiding any adjacent hardware (see Fig. 3). (3) The force required to pull the assembly through the slot in the vacuum chamber is reduced significantly compared to a continuous strip (from approximately 10 kg down to the order of 1 kg or less on prototype units).

A detail of one of the typical links with fastening clip and insulators is shown in Fig. 4. The SS link, including the curled pin at one end, is stamped from flat sheet material. A hole of corresponding diameter is punched in the other end of the link. During installation, the curled pin of one link is snapped into the hole of the adjacent link. The curled pin detail was required since approximately 33% of the vacuum chambers are curved in the horizontal plane. For applications where only straight chambers are employed, the curled pin can be replaced with a vertical tab and the mating hole replaced with a slot.

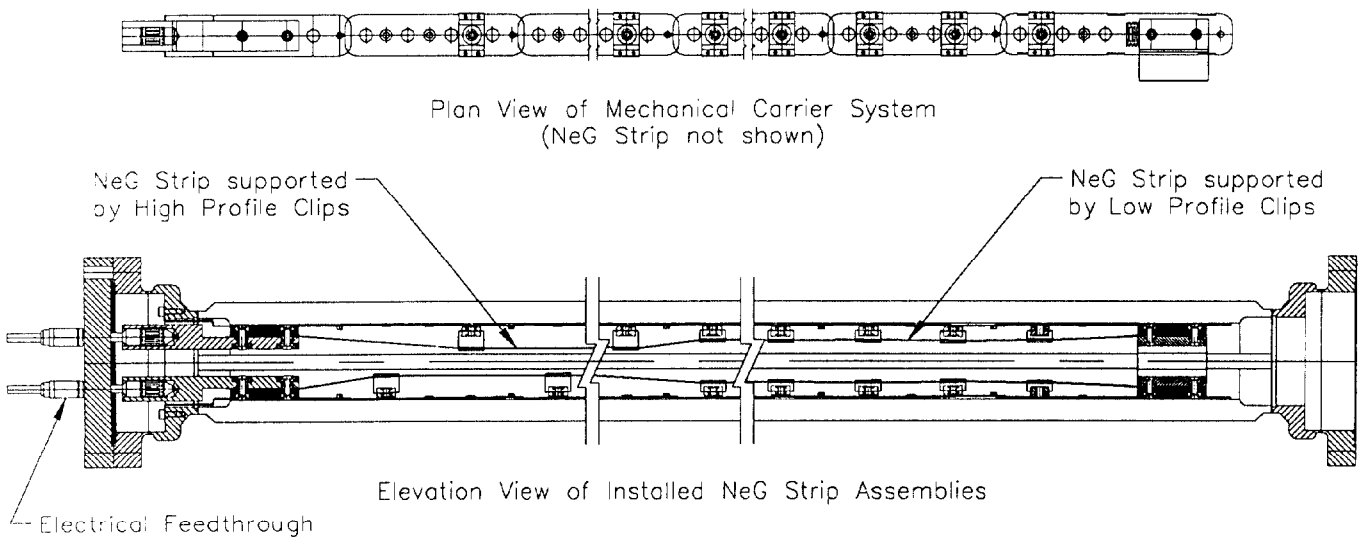

Figure 2. Typical Installation of NeG Assembly.

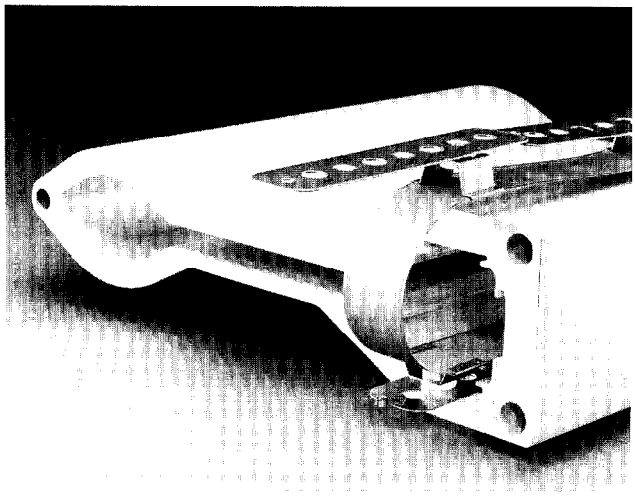

Figure 3. NeG Assembly Removal.

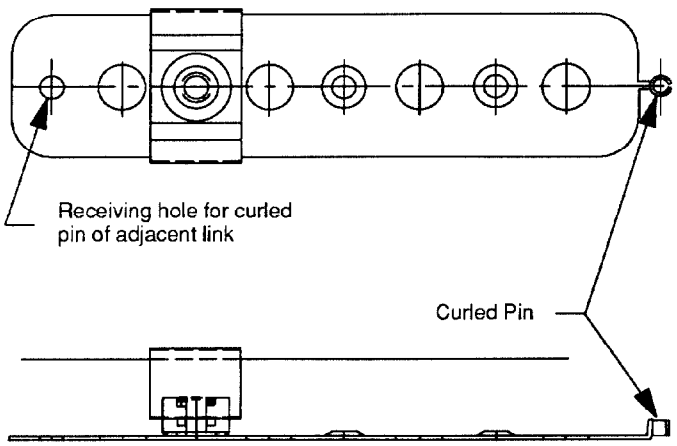

Figure 4. Typical Link.

Two types of fastening support clips (high and low profile types) are employed to support the NeG strip. As illustrated in Fig. 2, the low profile clips support the NeG strip further away from the beam axis than the high profile clips. The low profile clips are employed in regions where synchrotron radiation passes between the NeGs. In these regions, the NeG resides in the shadow of the vacuum chamber, preventing damage to the NeG in the event of beam missteering. The low profile clips are not used throughout since the force required to install the NeG assemblies increases significantly when the low profile clips are used. This is due to the reduced spacing between low profile clips (i.e., two clips per link). A reduced spacing between clips is required for the low profile supports so that the NeG is prevented from contacting the vacuum chamber during activation when the strip expands between clips due to differential thermal expansion (NeG at 450°C and carrier at 150°C).

When high profile clips are employed at the 125-mm interval (i.e., one clip per link), the system is assembled so that clips are staggered from top to bottom (see Fig. 2). This permits sagging of the top NeG strip without contacting the bottom strip which itself may coincidentally expand upwards.

Other manufacturing considerations include the use of 316 SS, which remains non-magnetic even when work hardened during forming and punching operations, and the removal of all burrs from carrier links prior to assembly.

IV. ACKNOWLEDGMENTS

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V. REFERENCES

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