VACUUM CHAMBER DEVELOPMENT FOR THE SYNCHROTRON X-RAY SOURCE AT ARGONNE*

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A vacuum test chamber 1.6 meters in length for the synchrotron X-ray source has been completed and tested for the evaluation of welding, sealing and ultra high vacuum (UHV) applications. A base pressure of 6.5×10^{-11} Torr (nitrogen equivalent) has been achieved. The pumping system consists of non-evaporable getter (NeG) strips. The pumpdown procedure, NeG characteristics and results are discussed.

Introduction

A 1.6-m-long aluminum test chamber has been constructed and has provided a means for testing the feasibility of using NeG strips as the primary pumping mechanism for the Argonne Advanced Photon Source (APS). The test chamber has also provided a facility for evaluating the problems associated with the welding of aluminum for ultra high vacuum applications as well as a means of testing sealing methods at the chamber end flanges.

Test Chamber

The aluminum test chamber was constructed from two 6061-T6 aluminum plates 0.635-cm thick that were formed into two symmetrical halves which were welded together on two sides along the 1.6-m length. A cross section of the chamber is shown in Fig. 1, clarifying the weld locations as well as showing the antechamber and the placement of the NeG pumping strips. Full penetration welds were used to minimize virtual leaks and chill bars were used on the inside surfaces of the chamber but they failed to prevent raised surfaces from forming along the welds.

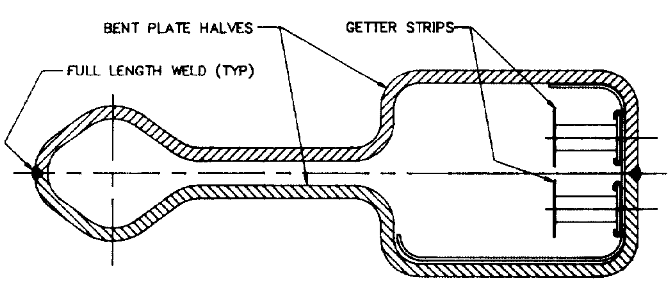

Fig. 1. Test chamber cross section.

Seven ports were welded to the chamber for instrumentation and feedthroughs. These ports are 304 stainless steel to aluminum transitions which allowed welding aluminum ports to the aluminum chamber but having stainless steel conflat flanges at the connection ends. Several welding attempts were made before vacuum integrity was realized. Since the chamber length welds were quite "rough", they are a "worst case" scenario since the final APS vacuum chambers will be extruded thus eliminating the chamber length welds on each side. During the initial vacuum tests, the end flanges were sealed using 0.040-inch gold wire seals. Vacuum integrity was maintained during heat cycles by loading the stainless steel bolts to the upper end of their elastic limit.

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NeG Strips

Pumping of the system was done using a 350-ℓ/s turbo pump backed by a 140-ℓ/s turbo pump. This method maintains a low foreline pressure on the chamber turbo pump thus providing higher hydrogen pumping speed. A liquid nitrogen trap was installed between the chamber and the 350-ℓ/s pump to insure chamber cleanliness.

The NeG strips used are the ST-707 variety consisting of a nonmagnetic constantan strip coated on each side with a 0.07-mm-thick layer of 70% Zr, 24.6% V, and 5.4% Fe. This alloy forms thermally stable chemical compounds with gasses (O_2, CO, N_2, CO_2) while the adsorption of H_2 is thermally reversible. To become effective as a pump, the strip must be activated after pumpdown from atmosphere. This procedure consists of heating the strip to 450°C for 45 min and results in diffusion of the saturated surface layer into the bulk of the material. The heating also reduces the H_2 content in the getter whenever the H_2 dissociation pressure of the getter exceeds the H_2 pressure in the vacuum system. After activation, the strength of the gettering action depends on the temperature of the getter and on the amounts and molecular species of the gasses which have been pumped.[1] The pumping speeds immediately after activation are high, but decrease as the getter surfaces saturate. Before saturation, the NeG strip is heated again to restore pumping speed. Three or four of these conditionings may be necessary before reaching the desired pressure. Several hundred conditionings are possible, as the total capacity of the NeG strips is higher than the lifetime gas load of the synchrotron storage ring. When the system is vented, dry N_2 gas is used to cover the NeG strip surfaces to prevent other gasses from being absorbed until the NeG strip is activated. The ST-707 getter material was chosen because of its low (450°C) activation temperature and its pumping speed for H_2 of ~300 ℓ/s/m.

Two such strips were installed along the length of the chamber and insulated from the chamber with ceramic blocks. The strips are connected to high current feedthroughs at each end of the chamber to allow the passage of high current through the strips for activation and conditioning. The open end of the chamber can be seen in the photograph (Fig. 2) taken in the vacuum laboratory.

Two-inch-wide heating tapes are spirally wrapped around the chamber for baking purposes. The chamber is also wrapped in aluminum foil to reflect the heat back into the chamber. Temperature controllers are used to maintain an even 150°C bakeout of the chamber. Cooling coils are installed to allow cooling of the chamber when the NeG strips are heated to 450°C.

Chamber Pumpdown

The following pumpdown procedure is used when starting from atmospheric pressure. The chamber is roughed out using an oil free mechanical pump and sorption pumps for contaminant free pumping to the low micron range. The turbo pumps are valved off from the chamber and brought up to speed while the chamber is

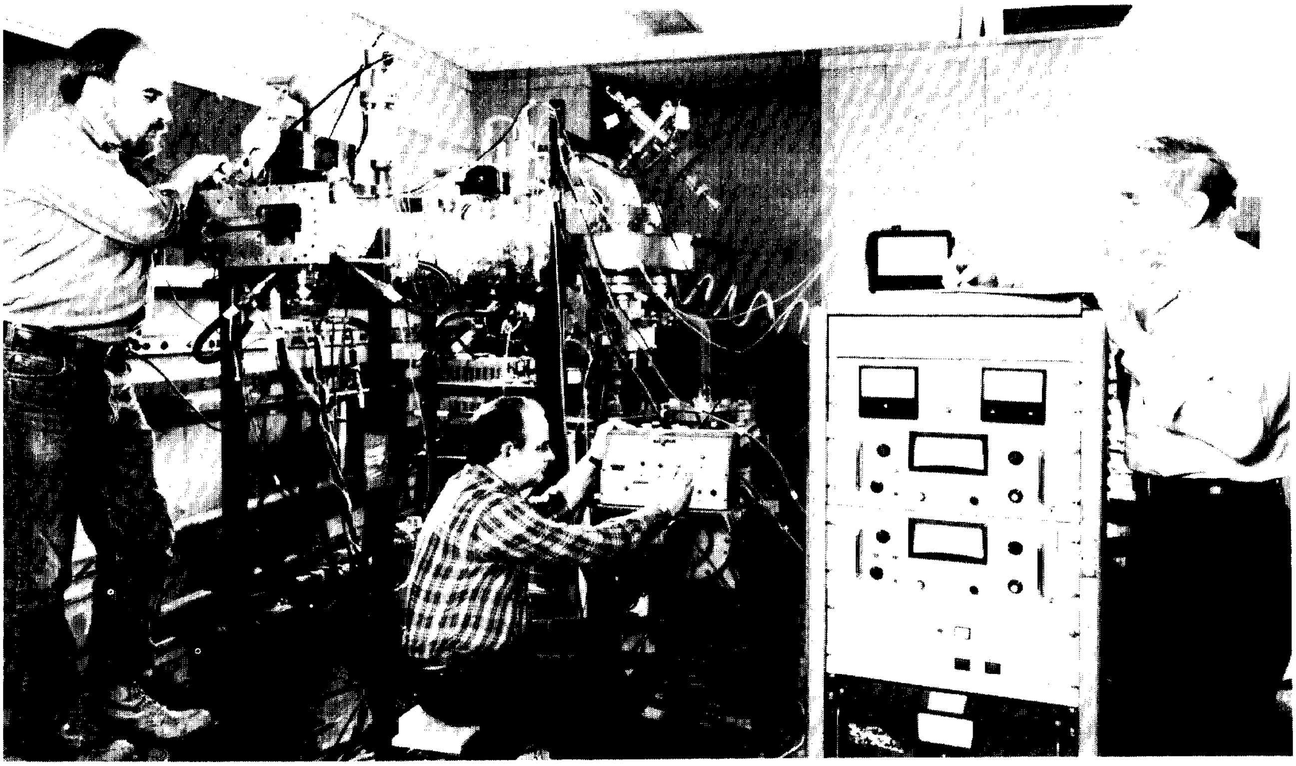

Fig. 2. APS Test chamber assembly.

being roughed by the sorption pumps. When the low micron range is reached, the turbo isolation valve is opened and the system allowed to pump to the low 10^{-6} Torr range. At this time the heater tapes are energized and the system baked for from 24 to 48 hours at 150°C with the turbo pumps pumping on the chamber. When the bakeout is completed, and the chamber cooled to ambient temperature, the NeG strips are activated at 450°C for 45 minutes. When activation is completed, and the NeG strips begin cooling, the chamber pressure begins to drop. At a pressure of about 6×10^{-8} Torr the turbo isolation valve is closed and a small 20-ℓ/s ion pump on the chamber is energized. The ion pump is necessary because the NeG strips will not pump noble gasses or methane. After about 4 days the chamber pressure reached 9.5×10^{-11} Torr and 10 days later the pressure had dropped to 6.5×10^{-11} Torr. It was necessary to condition the NeG strips (heat them to 450°C for 5 to 10 minutes) three times before reaching 6.5×10^{-11} Torr.

Sector Prototype

The second generation APS test facility is now underway.[2] This facility will consist of a full size sector (26.5 m in length) of the APS storage ring complete with all vacuum hardware, diagnostic equipment and full size models of the magnets. This facility will provide a means of testing fabrication methods, assembly methods and vacuum performance at full scale. The vacuum chamber extrusions are completed and are now being prepared for shipment to Argonne. The bending magnet chambers are scheduled for bending on a ~40-m radius. A vigorous welding development program is underway using the expertise of a highly recognized welding company working together with a robotic manufacturer to devise the best possible automated welding methods to insure repeatable leak tight welds. All necessary vacuum pumps, vacuum monitoring equipment and aluminum vacuum hardware has been purchased with much of it now in hand. A target date for completion of the sector is September 1987.

Conclusions

The final pressure of 6.5×10^{-11} Torr has been very encouraging and confirms the feasibility of using NeG strips for primary pumping of the APS vacuum chambers. Many problems were encountered with the test chamber but were due to weld porosity and leaks which will be minimized in the extruded APS chambers. The fact that this low pressure was obtained in a chamber manufactured in this manner is a further testimonial to the capabilities of the NeG strips.

Future plans include attempts to seal the end flanges with spring energized aluminum seals rather than gold wire. This has been unsuccessfully attempted in the past but new flanges have been designed and new seals from a different manufacturer have been obtained. Glow discharge cleaning tests will also be done with argon as well as hydrogen as the gas atmosphere. This chamber will continue to be used as a test facility for seal, surface and NeG strip pump tests during the early stages of the APS development.

Acknowledgments

The majority of the assembly and pumpdown exercises were done by Ed Wallace, a senior technician at Argonne National Laboratory. His patience, technique and years of experience were instrumental in making this endeavor successful.

References

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