# AN ANCILLARY PUMPING SYSTEM FOR THE APS VACUUM SYSTEM

D. Walters, J. Noonan, J. Gagliano, G. Harris, V. Svirtun
Argonne National Laboratory, Advanced Photon Source
9700 South Cass Avenue, Argonne, Illinois 60439 USA

*Abstract*

An ancillary pumping system has been designed and installed in the Advanced Photon Source (APS) storage ring. This vacuum system has the ability to pump sectors of the storage ring down from room pressure to ultra-high vacuum (UHV). The ancillary system is a "dry" system that uses a combination of turbomolecular pumps and oil-free roughing pumps. The benefits of this system are the reduction of equipment needed for in-tunnel maintenance, essential for the operation of a UHV storage ring; rapid response to vacuum emergencies; and a guard to accidental exposures to hydrocarbon contamination. The operational logic and the pump interlock and controls are described.

## 1 INTRODUCTION

The Advanced Photon Source is a facility for material science research. It provides users with a source of x-rays at an energy of 7 GeV. The main positron beam is contained within the storage ring that is two-thirds of a mile in circumference. The storage ring is divided into 40 sectors with isolation valves between each sector.

## 2 APS VACUUM SYSTEM

To achieve an average pressure of $10^{-11}$ Torr without beam and $10^{-9}$ Torr with beam, the main vacuum system uses a combination of ion and non-evaporable getter (NEG) pumps. The NEG pumps handle the majority of the gas load within the system. One characteristic of the NEG pumps that mandates the use of ion pumps is their ability to only pump active gases, such as water, oxygen, carbon dioxide, carbon monoxide, and hydrogen. However, the NEG pumps do not pump inert gases such as helium, neon, and argon, and are poor pumps for stable gases like methane and nitrogen. Ion pumps can, to a much greater extent, pump these inert and stable gases.

An additional technique used to achieve UHV in the storage ring is to bake it. This is done at 150°C where pressurized, heated water flows through the water cooling channels in the storage ring vacuum chamber. At this temperature the pressure is very high and would constitute a high gas load to the NEG pumps. For this reason, external pumps are attached to the system during the bake to remove gas from the system, and the ion and NEG pumps are not started until the system has started cooling down after the bake. This is done to preserve the life of both the NEG and ion pumps. Before this system was put into place the external pumps were in the form of movable carts at each end of the sector. The permanently installed ancillary pumping system is located at one end of the sector.

## 3 DESCRIPTION OF THE ANCILLARY VACUUM SYSTEM

### *3.1 System Overview*

The ancillary vacuum system is organized into 20 subsystems for each pair of sectors in the storage ring (see Fig. 1). Sectors 1 and 2 make up the first installation, sectors 3 and 4 make up the next, and so on around the 40 sectors of the ring. Each installation is made up of two turbo pumps, a dry roughing pump, interconnecting vacuum lines, and controls. Each sector has its own turbo pump

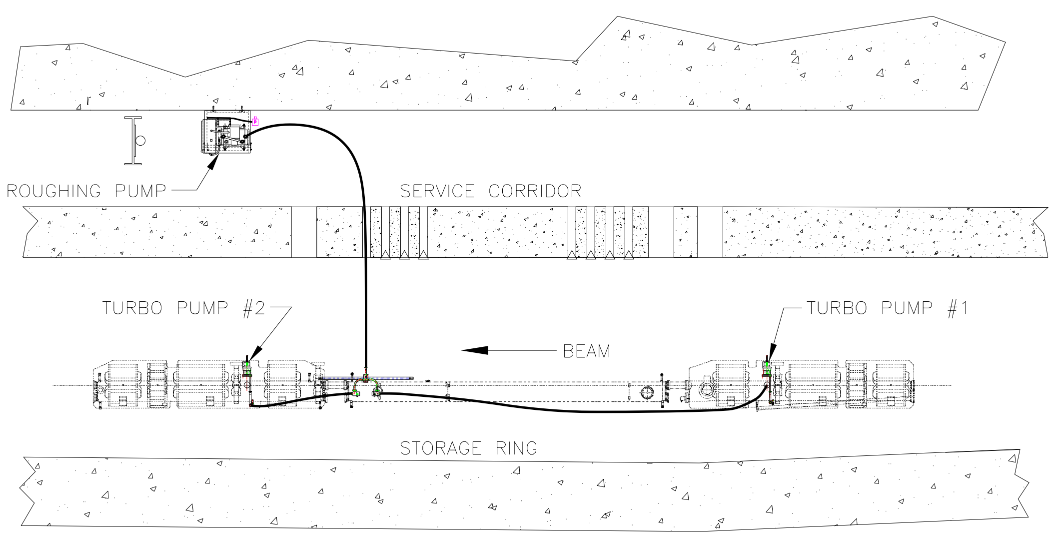


Figure 1: APS storage ring with ancillary pumping system.

attached to an all-metal valve on the storage ring chamber.

### *3.2 Turbo Pump*

A turbomolecular pump was chosen because it represents a good balance of features and capabilities, and can be obtained for a reasonable price. The turbo pump is a throughput type pump that moves gas through it rather than storing the gas on the pump walls like an ion pump does. It is very useful on systems that are being baked out or for a second pumping stage after initial pump out.

The turbo pumps used at the APS are called hybrid turbo pumps because they have an additional drag pump stage that expands the capability of the pump. A standard turbo pump has a roughing pump in series with it to take in the turbo pump's exhaust. This exhaust line, called a foreline, needs to be at $10^{-2}$ Torr in the standard pump; in the hybrid pump, the foreline is now 20 Torr. The pressure difference that the pump can hold off has been greatly expanded by the drag stage. Since the hybrid pump can have a roughing pump with a much higher base pressure (a potential cost savings), it can use several types of dry pumps that have high base pressures. In the case of this system which has a roughing pump with a base pressure of $10^{-2}$ Torr, the turbo pump can reach base pressures of $10^{-10}$ Torr. Turbo pumps are very low in vibration and have a relatively high natural frequency. Given that the reaction mass of the storage ring is very high, the turbo pumps can be run under regular conditions. In the early conditioning of the storage ring this in fact did happen on one or two occasions.

We use an Alcatel ATS 100 hybrid turbo pump. With a 6" vacuum flange, the pump is rated to 125 liters/second. The drag stage is very effective because it has a tolerable foreline pressure of 20 Torr. This has two primary ramifications for this installation: the pump can be started at a higher pressure, and in the event the roughing pump becomes inoperative, the turbo pump can still run (~ 3 hours) while the roughing pump is replaced. In this application the converter in on top of the tunnel shielded from the radiation in the storage ring.

### *3.3 Roughing Pump*

One roughing pump services two turbo pumps in this system. When the pressure in the storage ring is down to $10^{-4}$ Torr the amount of gas flowing out of two turbo pumps is small enough that it can easily be handled by one roughing pump. We considered a number of pumps from various manufacturers, all having a minimum speed of 9 cfm of speed and base pressure lower than 50 mTorr. All the pumps were some sort of dry pump, with no oil or grease lubricants exposed to the vacuum. We chose a Vacuum Research $2 \times 9$ dry piston pump with a pumping speed of 9 cfm at room pressure and a base pressure of approximately 30 mTorr. This two-piston pump has one piston in series with the other to produce the low base pressures, and can rough the 360-liter volume of the sector in 35 minutes to a pressure where the turbo pump can take over. In spite of the approximately 40 feet of hose that connects the roughing pump to the turbo, this has become a useful part of the system.

## 4 DETAILS OF THE ANCILLARY SYSTEM

### *4.1 Turbo Pump Subsystem*

Shown in Fig. 2 is the turbo pump subsystem. In each installation there is a manual all-metal valve connected to the storage ring vacuum chamber. Between the turbo pump and the valve is a double-sided flange where a small all-metal valve is attached. This valve allows the sector to be pumped down with the flow going around the pump. After some in-house testing it was determined that there is a very large penalty for roughing the sector down through the turbo, and even a small valve can make a large difference. The valve and the turbo are joined together in a common manifold that is then connected to the main roughing hose.

### *4.2 Roughing Pump Connection*

The hose connecting the turbo to the Y manifold mounted on the ceiling is made by Swaglok™. The hose connector is modified by welding an NW-25 long flange onto it. All the connections are standard NW-25 where the O-ring is silicone rubber rather than Viton. The silicone has better radiation resistance than Viton. The Y manifold contains two aluminum right angle valves with silicone vacuum O-rings. The valves allow pump-down of each sector separately. The hose extends outside the tunnel to the rough pump platform.

### *4.3 Roughing Pump Subsystem*

The platform is made up of three main subassemblies: the pump itself, the remote relay box, and the pneumatic box piggy-backed onto the remote relay box (see Fig. 2). On the pump is a manifold elbow on which is mounted the main valve, the vent valve, and the low vacuum gauge. The gauge and the vent valve are between the pump and the main valve. The remote relay box houses the motor starter and a number of control logic relays. Mounted on the remote relay box are external lights to indicate power and faults and an elapse time meter to show the hours on the roughing pump. The 208-V disconnect is part of this box. If an emergency occurs, the roughing pump can be turned off without having to go to the local control box on top of the tunnel. The pneumatics are in an external box on the back of the remote relay box; also on the platform is the delay volume. The two needle valves together with the volume establish a circuit that delays the opening of the vent valve for a period of 3 to 6 seconds. Part of the operation of this system is that the vent valve opens after the main valve closes. This allows ample time for the main valve to shut before the vent valve opens.

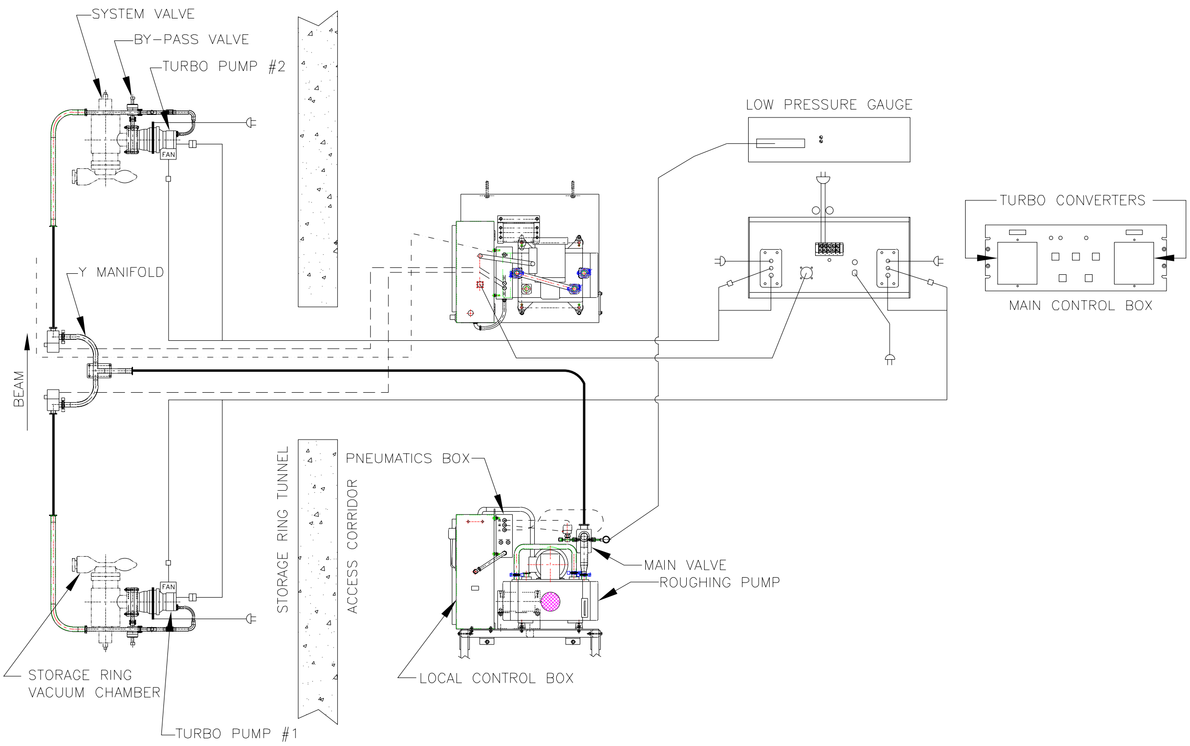


Figure 2: Ancillary pumping system.

### *4.4 System Controls*

The main control box is in the rack on top of the tunnel. The relays are part of a logic control whereby if the main control box, connecting cable, remote relay box, or roughing pump should become inoperative, the main valve will close and protect the turbo pump. Part of the logic behind this is the assumption that the roughing pump is able to generate a pressure lower than the setpoint on the low-vacuum gauge, thus guaranteeing that the pump is working. As described above, if the roughing pump becomes inoperative, the main valve will close and the vent valve will automatically vent the pump and gauge. When the pump begins to operate again, the main valve will only open after the gauge has reached its setpoint. The gauge will latch a relay so that if it goes to high pressure later the main valve will not close. The two turbo controllers (converters) are in the main control box connected to the meters. The meters serve two functions: feedback to the operators that the turbo has started to spin up and information on the pumps spinning down. Only when the turbos are at a *complete* stop can the roughing pumps be valved out and turned off. The main control box has remote indicators for the main APS control room to monitor the turbo pump system for the following conditions: turbo pump on, turbo pump at full speed, roughing pump on, and the roughing pump pressure.

## 5 CONCLUSIONS

This system is currently installed at the Advanced Photon Source. It is used on a regular basis for system maintenance and system baking.

## 6 ACKNOWLEDGMENTS

This system was designed, assembled, and installed by a group larger than just the authors. Ron Kmak was instrumental in the design and documentation of this system. The mechanical engineering group provided support for the component installation in the storage ring. The vacuum group as a team provided the assembly, installation, and ongoing maintenance of this system that allows it to be used on the regular basis. This work was supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.