PLS VACUUM CHAMBER

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Abstract

The PLS vacuum chambers consist of 12 times of two sector chambers and one straight section. The chamber material is Al 5083-H321. Each chamber consists of a top and a bottom piece, which are machined separately and welded together. The pumping system to reduce the average operating pressure up to a nano Torr has three nine sets of lumped NEGs in tandem with ion pumps installed beneath photon stops, and six ion pumps per superperiod. Helicoflex seals are used to connect all vacuum components onto the vacuum chamber. A prototype chamber will be machined by February 1992.

Introduction

For an electron storage ring, a good vacuum is essential to reduce the rate of electron beam collisions with residual gas molecules in the vacuum chamber, and hence to increase the beam lifetime. The vacuum system for the PLS storage ring is designed to maintain a beam-on operating pressure in the nano-torr range in order to achieve a beam lifetime of 5 hours or more.

Vacuum Chamber Design

A small vacuum chamber aperture in the PLS ring has a very low pumping conductance. If lumped pumping is employed along the vacuum aperture, the number of pumps required is enormous, and this is an expensive approach. The solution adopted in the PLS is to divide the vacuum chamber into two regions, a beam channel and an antechamber. The beam environment is separated from the antechamber[1-3] where the gas load due to synchrotron radiation is dealt with. The desorbing surfaces in the antechamber can be far away from the beam such that the beam channel is not affected by the local pressure increase. Furthermore, the antechamber can be designed large enough to accommodate large pumps at proper locations.

The PLS storage ring consists of twelve superperiods. Each superperiod has two sector chambers (7m and 10m long) and one long straight section. Sector chambers in one superperiod are shown in Figure 1. Three beam lines per superperiod are provided: one from an insertion device and two beam lines from a middle bending magnet.

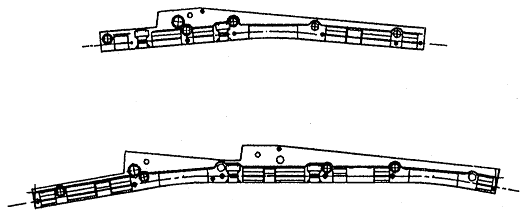

Figure 1: Sector chambers in one superperiod.

Each sector chamber consists of a top and a bottom piece. The two pieces are machined separately and welded together. Each piece has a thin welding lip on its perimeter (see Figure 2) along which welding is done. The chamber fabrication procedure is similar to that of ALS[4]. Aluminum alloy 5083-H321 is chosen as the vacuum chamber material because of good weldability, good mechanical properties, and good machinability.

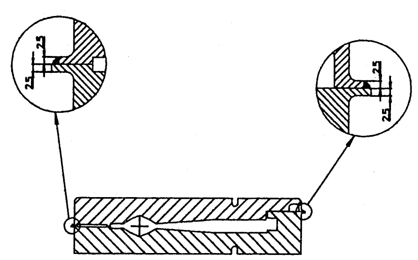

Figure 2: Welding lips.

When the electron beam circulates in the ring, the synchrotron radiation originating from the beam strikes the vacuum components and subsequently induces desorption of adsorbed gas molecules. Desorption is expected to dominate the pressure in the chamber. In the PLS vacuum system, synchrotron radiation is dealt with only by photon stops. This means that synchrotron radiation does not strike any portion of the chamber directly. Water-cooled photon stops block all synchrotron radiation except that radiation going to beam lines, as shown in Figure 3. OFHC copper is used for the photon stop material. The surface of the photon stop will be shaped with a grazing angle such that as many gas molecules and photons as possible go directly into the pump.

Magnets are installed close to the chamber aperture. Thus, magnet pockets have to be prepared on the chambers to avoid interference between chambers and magnets. The chamber cross-sectional shapes with various magnets set on

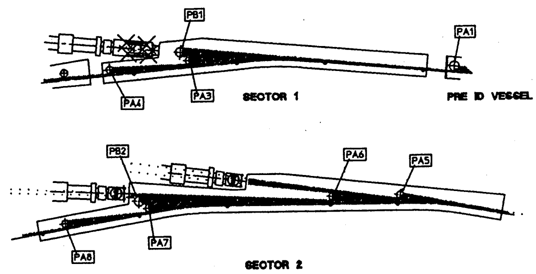

Figure 3: Photon fan and photon stop distribution.

the chambers are shown in Figure 4.

The aluminum vacuum chamber has 150°C bakeout capability. Chamber bakeout is performed using hot water of 150°C supplied from a hot water pumping system. Hot water bakeout is safer than electrical heater bakeout in that the maximum temperature in the chamber cannot be higher than the water temperature. The chamber material has high thermal conductivity, and the area across which heat flows is relatively large. Therefore, heat is transferred quickly, and bakeout can be done effectively. Two water tubes of 1cm I.D. are installed on the top and the bottom chamber surface, as shown in Figure 5. The tubes for bakeout are used for chamber temperature stabilization during the ring operation. In this case, chilled water will circulate in the tube to stabilize the chamber temperature.

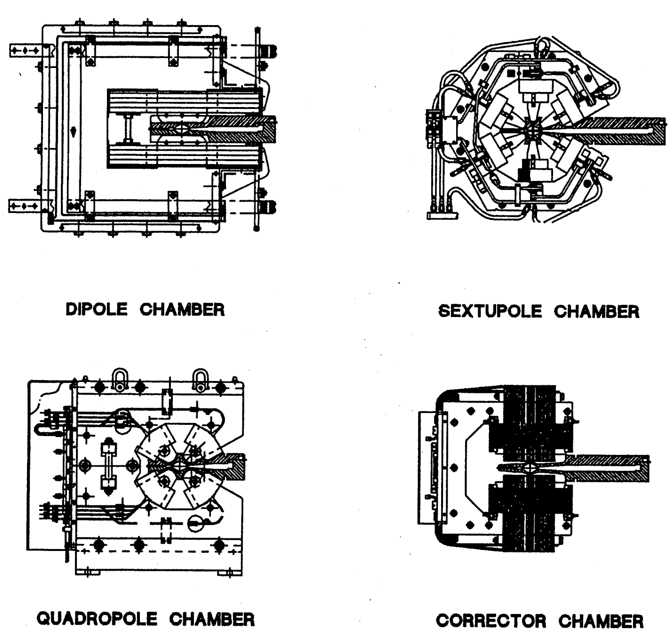

Figure 4: Chamber cross-sections with magnets.

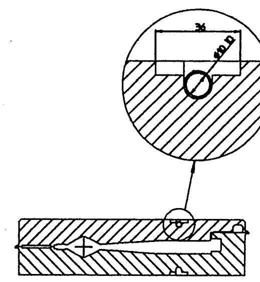

Figure 5: Water tubes on chamber surfaces.

The photon beam from an insertion device will have a high intensity. If the electron beam motion is not controlled correctly, high power radiation may strike the chamber neck, melting the chamber in a short time. In order to prevent such a disaster, the locations which can be struck by radiation should be closely monitored to check if the beam mis-steering happens. In the PLS, a vacuum gauge is installed to sense a sudden pressure rise, which will be caused by severe gas desorption due to the mis-steered radiation.

Pumping System

The pumping system of the ring is designed so that the pressure is kept below a certain level throughout the chamber. Figure 6 shows the vacuum pump diagram for one superperiod of the storage ring. The storage ring vacuum system is pumped by lumped non-evaporable getter pumps (NEGs) in tandem with ion pumps, and sputter ion pumps (SIPs). The combination pumps are installed under the photon stop where high synchrotron radiation induced gas loads are present. They offer 9,000 liter/sec per superperiod. Further, six SIPs per superperiod will also be installed to provide distributed pumping. Their nominal pumping speed is 360 liter/sec per superperiod, and a pump current can be used to give an indication of a local pressure. Combining NEG pumping with ion pumping is an effective means of pumping all the common residual gases and results in an enhanced pumping of certain gases such as argon, methane and water vapor.

Roughing from atmospheric pressure down to the ion pump start-up pressure is done by four mobile turbo-molecular pumping units per superperiod. They are also used for sector chamber bakeout. The ion pumps are started after bakeout and just prior to isolation of the turbo molecular pumps as the activated NEG begins to dominate the pumping.

Vacuum monitoring is done by convectron- ion gauges, and SIP current measurements. Pressures in the ultra high vacuum are read with Bayard-Alpert ionization gauges.

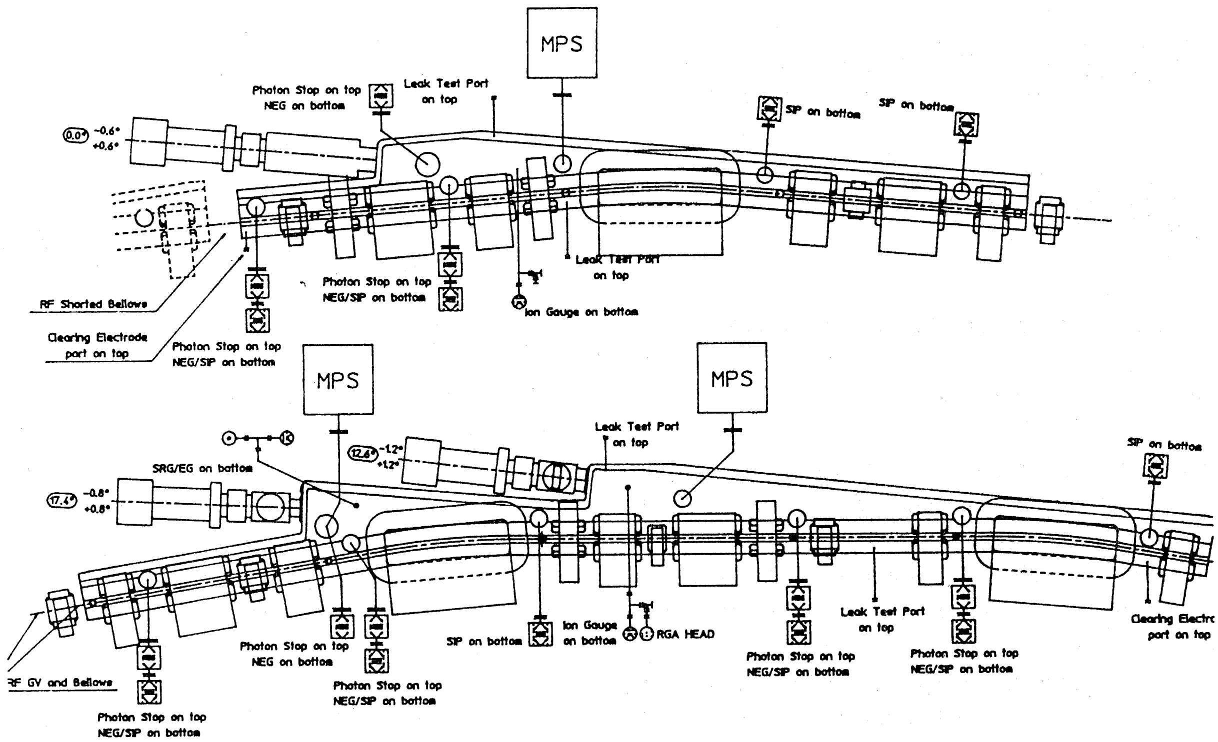

Figure 6: Diagram of vacuum pumps and gauges.

Partial pressures are continuously monitored with residual gas analyzer to check surface clean up and to detect leaks.

Vacuum components such as pumps and gauges are connected to the vacuum chamber using stainless steel spool pieces, i.e., conflat to helicoflex flange transitions, to allow for the use of industry standard components. The sealing effect of a helicoflex gasket depends only on the roughnesses of two joining surfaces.

Present Status

A 1.7 m long aluminum tube with an inside diameter of 6 inches has been pumped on using an ion pump and a titanium sublimation pump. Helicoflex seals were tried on Al alloy to Al alloy and Al alloy to stainless steel flange joints. A pressure of 6 x 10^{-11} Torr has been achieved. Another 1.5 m long aluminum test chamber with the internal geometry similar to that of the vacuum chamber is being tested. This allows us to test the chamber closure welding, to measure outgassing rates, and to measure the pumping speed of lumped NEG. Furthermore, a 10 m long prototype chamber consisting of vacuum system plus diagnostic equipment will be tested to check every aspect at full scale.

References

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