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TITANIUM VACUUM CHAMBER LINERS IN THE CORNELL ELECTRON SYNCHROTRON*

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Summary

A method is described for constructing and installing solid metal liners inside epoxy filled synchrotron magnets.

Introduction

The Cornell Electron Synchrotron has been in operation since 1967. It has a bending radius of 100 meters and consists of 192 ten foot long magnets. This was the first synchrotron to be built which places the entire magnets and coils inside the vacuum chamber. The system is pumped by three inch oil-diffusion pumps which are placed every two magnets apart. The system normally operates at a vacuum of a few times 10^{-6} torr (measured at the pumps) which is more than adequate at the operating energies.[1, 2, 3]

Originally the RF cavity structures were pumped with similar pumps with water cooled baffles. Over a period of time this led to RF breakdown in the cavities. Ion pumps were added to the cavities and finally the oil diffusion pumps adjacent to the RF stations were removed and liquid nitrogen cold traps were installed. This system was entirely satisfactory except for (a) the radiation damage and deterioration of the super-insulation used on the cold traps and (b) the 1/2 hour per day of machine down time required for filling the cold trap reservoirs. A system has been partially installed which eliminates the cold traps by lining the magnets immediately adjacent to each RF cavity with a solid metal liner. The RF cavities are thus kept clean by virtue of the pressure gradient established across the relatively low pumping speed of the liner tubes.

System Requirements

The magnet consists of wide gap and narrow gap magnets, both of which have a conductance value of approximately 31 liters/sec per magnet. The outgassing rate per magnet has been measured to be 0.3 micron liters/sec. The calculated pressure as a function of length over a two magnet section is shown in Figure 1. This curve assumes the same pumping speed at the cavity end as is found elsewhere.

Liner Description

The liner consists of a thin metal sleeve placed in the magnets adjacent to the RF cavities. The sleeve is open at the far end but a seal is made between it and the existing vacuum wall at the end near the RF cavities. The magnet as a gas source is then isolated from the RF fields by the clean low conductance path of the liner.

The circumference of the sleeve is 7 inches and is manufactured from 0.001 inch thick titanium alloy foil. The alloy chosen was Ti-13V-11Cr-3Al which has a yield strength of 160,000 psi, a resistivity of 150 microohm cm, and which is available in thin sheet form. The foil is wrapped on a copper mandrel with 1/2 inch of overlap and spot welded to itself with a double row of weld spots. Each row of welds has 40 welds per inch. The gas leakage through the welded seam has been calculated to be negligible. The sleeve is inserted in the magnet as shown in Figure 2 and the gas seal at the cavity end is accomplished as shown.

The far end of the liner is held centered in the aperture with a thin stainless steel spider which allows the region outside the liner to be pumped. There has been no difficulty with liners being crushed due to differential pressure nor with the liner shifting in the aperture during use.

Electrical Properties

Eddy currents induced in the liners due to the 60 Hz magnetic field variation can cause overheating and/or time varying field distortions. It is for this reason that the material has been kept as thin as possible and has been made from a material with a high resistivity.

At 10 GeV magnet excitation level the average power per liner due to eddy currents is 20 watts which gives rise to very small temperature rises.

The fields produced by the eddy currents cause time varying field errors in the guide field. The worst case occurs at the time in the cycle when $\dot{B}/B$ = max. This occurs several hundred microseconds after injection time. The peak to peak closed orbit distortions caused by these field errors have been calculated and found to be acceptable. The peak to peak distortion for one RF station with liners is .11 inches. For the case when all RF stations have liners, the quantity is .22 inches.

Operation

When in place, the conductance of one of the liners is 4.5 liters/sec. The conductance of the region outside the sleeve is 17.2 liters/sec. The calculated pressure distribution with a liner is shown in Fig. 3. The pressure at the cavity is shown to be 0.5 x 10^{-6} torr which is approximately the measured value. The pressure at the cavity without the liner and without the cold trap would be 2 x 10^{-6} torr.

Summary

The liners described have been installed in the magnets adjacent to 4 of the 6 RF cavities. The system, while it gives no real improvement, does not appear to have any difficulties. In the near future we plan to install liners near the last two RF stations

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and also to install oil diffusion pumps at the open end of each sleeve. These additional pumps should lower the pressure at that point from 16 x 10^{-6} torr to 3 x 10^{-6} torr which should reduce the pressure in the cavity and the gas load on the ion pumps by a factor of five.

Acknowledgements

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References

1. R. Littauer, Internal Report CSDS-17, 9-64.
2. M. Tigner, Internal Report CSDS-7, 2-64.
3. R.R. Wilson, Internal Report CS-33, 5-67.

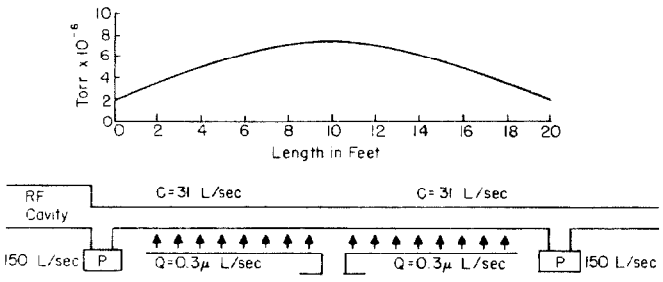


Fig.1. Pressure versus length in the region adjacent to an RF station without a titanium liner.

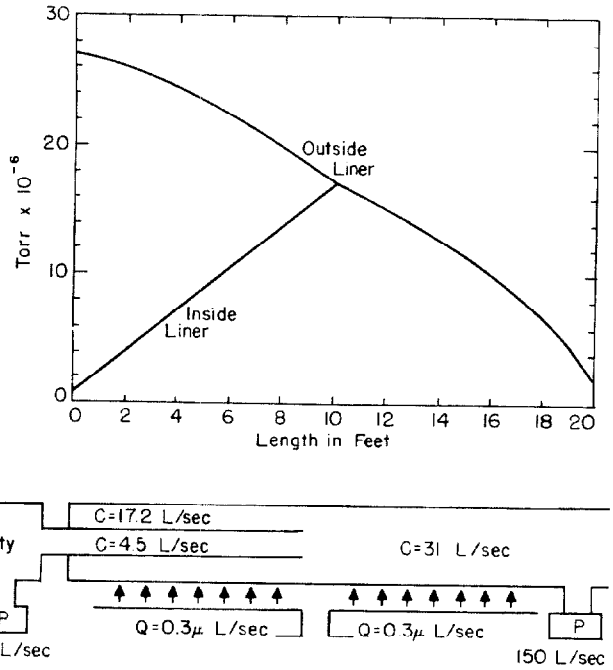


Fig.3. Pressure versus length in the region adjacent to an RF station with a titanium liner.

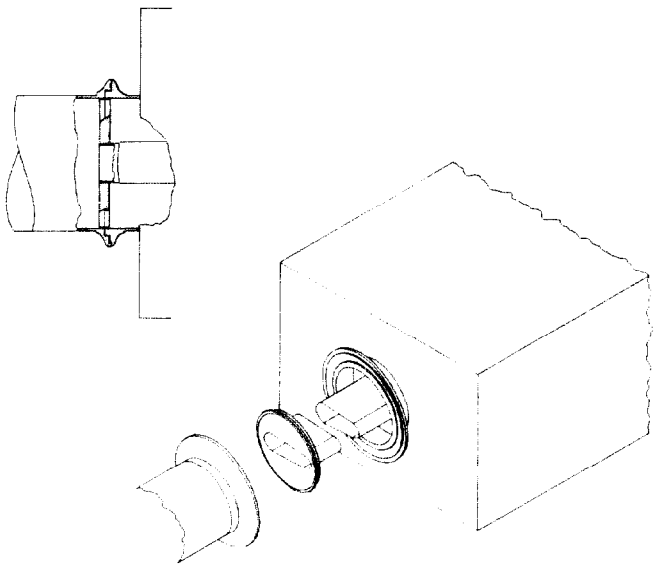


Fig.2. Isometric view showing liner insertion and sealing details.