THE VACUUM PERFORMANCE OF THE LEP CU RADIOFREQUENCY CAVITY ASSEMBLIES

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Abstract: Each of the 128 Cu cavity assemblies (accelerating and storage) of the LEP radiofrequency (RF) accelerating system along with all pumps and components is baked for 24 hours. The cavity assembly is then conditioned up to a maximum RF power of 140 kW over a period of up to two weeks. Starting with a base pressure in the low 10^{-10} Torr after bake-out, the introduction of RF power causes the desorption of H_2, CH_4, CO, H_2O and CO_2 with, in some cavity assemblies, heavier gases with masses around 55 and 75. The cavity assemblies were installed in the LEP machine, but not rebaked, and results are given of the gas composition and total pressure after the first few months of LEP operation.

Introduction

In mid July 1989, the CERN large Electron Positron Collider (LEP) started operation with the injection of positrons at 20 GeV and obtained a stored beam of 0.25 mA two weeks later.

The radiofrequency (RF) accelerating system, which consists of 128 OFHC Cu accelerating and OFHC Cu + 0.1% Ag storage cavities, provides an accelerating field of 3.1 MV m^{-1} at a nominal maximum input power of 125 kW per cavity assembly.

A cavity assembly consists of one accelerating cavity and one storage cavity and these 128 cavity assemblies enable up to 3 mA of electrons and 3 mA of positrons to be stored at energies up to 51 GeV.

As part of the acceptance tests and before installation in the LEP tunnel, each cavity assembly (Fig. 1) was subjected to a 150°C bake-out then conditioned by running up slowly to full RF power over a period of some days followed by continuous running at full power for about one week. The details and results of this vacuum and RF conditioning have been fully described in a previous publication [1].

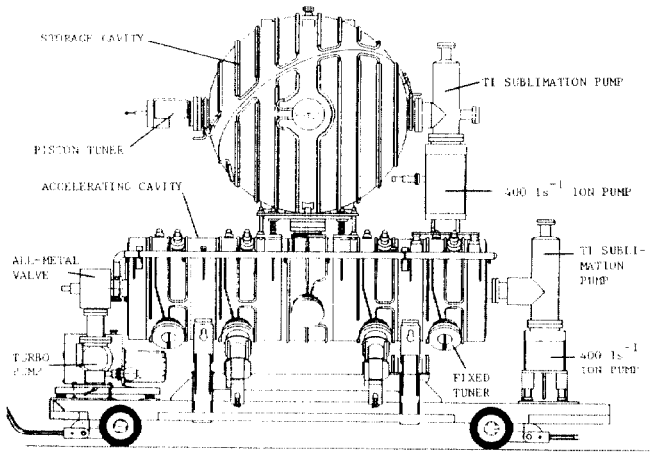

Fig. 1 : An RF cavity assembly on its conditioning stand.

In this report we shall describe how the cavity assemblies were stored after conditioning and the behaviour of the vacuum during the first few months of operation of the LEP machine.

Cavity Unit Storage and Installation

After each cavity assembly had been RF conditioned to full power, it was let up to atmospheric pressure with bottled N_2 (99.995%). For preparation for storage, the Ti sublimation pump along with the sputter ion pumps and the turbomolecular pump on the accelerating cavity had to be removed. Also a small all-metal valve for the introduction of the N_2 was removed once the cavity assembly was at atmospheric pressure. These three flanges were quickly sealed with blank flanges before the assembly was stored. All cavity assemblies were stored in a heated hall for periods up to 3 years before installation in the LEP machine.

Groups of 8 cavity assemblies, with a sputter ion pump plus Ti sublimation pump assembly between each, are separated by all-metal sector valves. Installation and alignment of 8 cavity assemblies took about one week. The pumping from atmospheric pressure was carried out immediately with 5 mobile turbomolecular pumping stations and pressures in the low 10^{-5} Torr range were obtained after about 2 hours of pumping. After about 48 hours when the pressure was in the low 10^{-7} Torr range, the Ti sublimation pump filaments were degassed for 4 hours then the sputter ion pumps started.

Results

After 3 weeks all pressures were in the 10^{-9} Torr range and after 2 months the low to middle 10^{-10} Torr range was reached without RF. However, during this time the cavities were operated at various power levels thus the pump-down process had superimposed on it from time to time the gas desorption induced by the RF.

It should be mentioned that low pressures as such are not necessary for operation of the RF system but in the LEP machine the RF accelerating system is close to the experimental areas and off momentum e^+ and e^- produced by beam-gas Bremsstrahlung creates a background at the interaction point. Thus, it is for this reason that as low a pressure as possible is required in the RF accelerating system when it is in operation.

After some months of LEP machine operation at energies ranging from 20 GeV (injection) to 46 GeV (Z_0 production) the base pressure without RF of almost all the cavity assemblies was in the 10^{-10} Torr range. In Fig. 2 is shown a typical pressure profile from one set of 8 unpowered RF cavity assemblies. The corresponding residual gas spectrum is shown in Fig. 3.

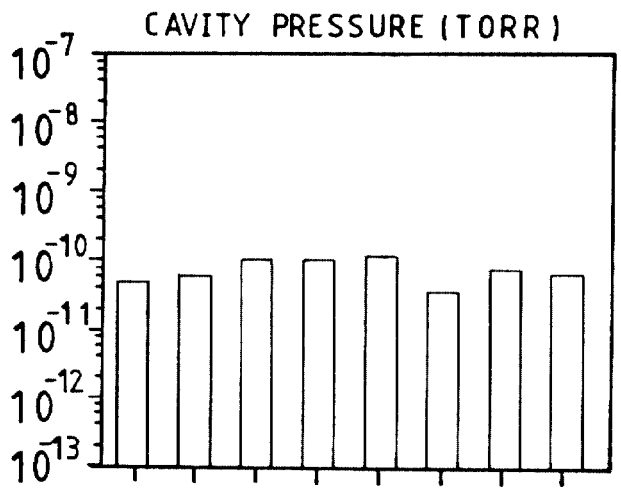

Fig. 2 : A pressure profile from a set of 8 unpowered cavity assemblies.

At the gas analyser the total pressure (without RF) was 1.6×10^{-10} Torr and the residual gas consisted of 64.3% H_2, 1.8% CH_4, 22.9% H_2O, 4.5% CO and 6.5% CO_2.

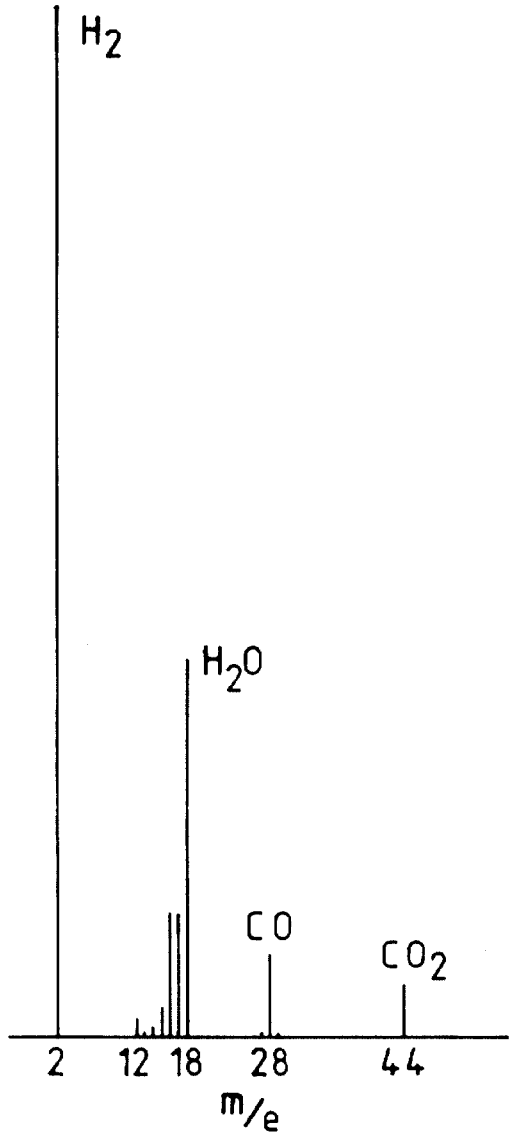

Fig. 3 : The residual gas spectrum in an unpowered cavity assembly.

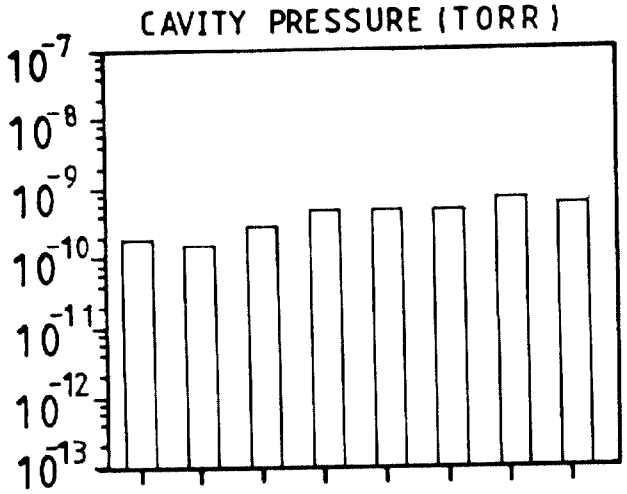

Fig. 4 : A pressure profile from a set of 8 powered cavity assemblies.

With the LEP machine operating at 46 GeV, the overall average pressure in the RF cavities is 7.2 x 10^{-10} Torr and in Fig. 4 is shown a pressure profile from a set of 8 powered cavities. The residual gas spectrum is shown in Fig. 5 and there it can be seen that the effect of the RF is to desorb mostly H_2 such that the gas composition becomes 90.1% H_2, 1.1% CH_4, 3.5% H_2O, 2.5% CO and 2.9% CO_2. Such a gas composition rich in H_2 is, of course, desirable since the Bremsstrahlung interaction rate depends directly on the molecular weight and universely on the radiation length. Since the radiation lengths for H_2,CH_4, H_2O, CO and CO_2 do not vary greatly, the molecular weight is the determining factor.

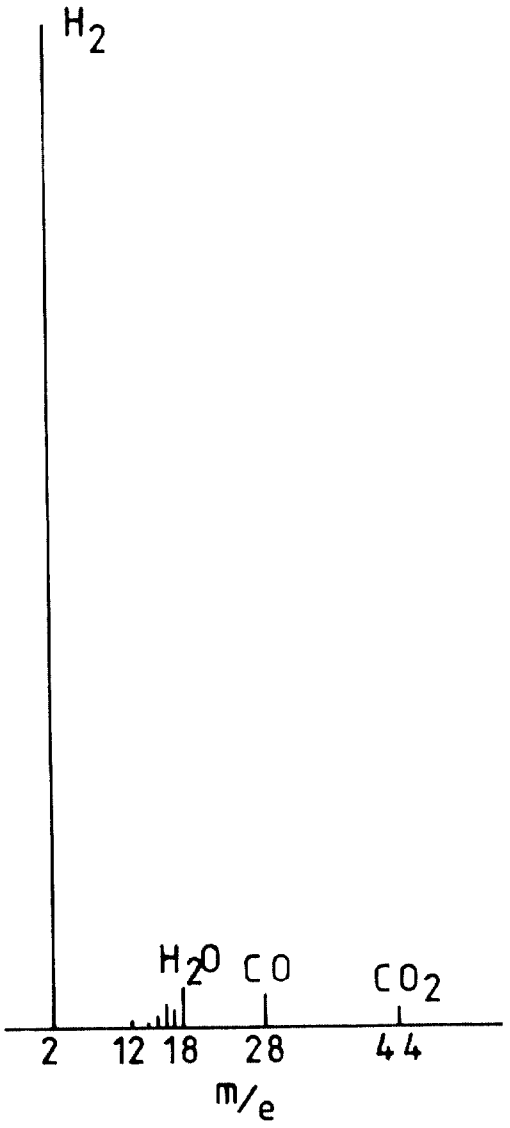

Fig. 5 : The residual gas spectrum in a powered cavity assembly.

Conclusions

After installation in the LEP machine without bake-out and after some months of operation, the base pressure in the 128 RF cavity assemblies without RF power is in the 10^{-10} Torr range with a residual gas spectrum relatively rich in H_2 (~ 64%). Operation of the cavity assemblies to give a beam energy of 46 GeV resulted in

an increase in average pressure to around 7.2×10^{-10} Torr and a gas composition containing 90.1% H_2.

References

[1] A.G. Mathewson and Liu Zhiman, "Vacuum Conditioning of the LEP Radiofrequency Cavity Units", in American Institute of Physics Conference Proceedings No. 171, New York, pp 186-192.