

Vacuum Conditioning of the ESRF Storage Ring

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Abstract

Commissioning of the 850m ESRF storage ring started in February 1992. Since then a dose of 400A x h has been accumulated, correspondingly, the dynamic average pressure measured at 100mA stored beam decreased from 3.0E-8mbar to 3.0E-9mbar. In the multi bunch mode the lifetime has increased from eight to fifty six hours, further improvements are expected. In the 16 bunch mode, the stored beam lifetime is no longer limited by dynamic pressure but by Touschek effect. For this mode, the temperature of the RF fingers increases significantly. We have experienced problems of pollution from magnetic dust in our insertion device vacuum vessels.

1. DESCRIPTION OF THE VACUUM SYSTEM

The vacuum system of the 850m ESRF storage ring is made of 32 cells, isolated by all metal valves. Each cell is composed of 17 stainless steel vessels connected by flanges. Copper absorbers are brazed onto the vessels to collect photons, while two glidcop crotch absorbers collect the highest density part of the photons produced by the dipoles.

Each cell receives nine bellows to compensate for thermal expansion during bakeout. The beam stay clear cross-section is maintained unchanged in the bellow by means of an RF finger/sleeve set up.

Pumping in each cell is provided by ion pumps and NEG pumps. Each cell includes a 5.4m straight section to receive a five metre long insertion device vessel.

Vacuum monitoring uses cold cathode inverted magnetron gauges. Interlocks protect the system against pressure incidents, including those originating from the beamlines.

The vacuum system has been designed to reach a 10^{-9} mbar pressure for a 100mA stored electron beam.

2. STORAGE RING VACUUM CONDITIONING

The first stored beam was obtained in February 1992. Since then a dose of over 400 Ampere x hours has been accumulated. The figure of merit for vacuum conditioning is the stored beam lifetime. The evolution of lifetime τ for a multibunch mode of filling the storage ring is shown on figure 1.

The lifetime improvement obtained with the increase of the integrated dose in ampere x hours can also be expressed in terms of the evolution of the number of molecules emitted per photon impinging on the vessel absorber. The density of photons received on absorbers varies with the position of the absorber in the cell. The crotch absorbers in vessels CV6 and CV13 receive much a higher density than the flat absorbers brazed on the stainless steel walls of the vessels. The number of molecules emitted per photon is 1000 times lower for crotch absorbers than for flat absorbers (see Figure 2).

Therefore one can expect further vacuum conditioning of the flat absorbers, the present dynamic pressure of 3×10^{-9} mbars measured for a 100mA stored beam should reach the design value of 1×10^{-9} mbars after further conditioning.

Consequently, the present value of 56 hours of lifetime for a 100mA stored beam should increase to a value greater than 100 hours.

Figure 1: Lifetime evolution

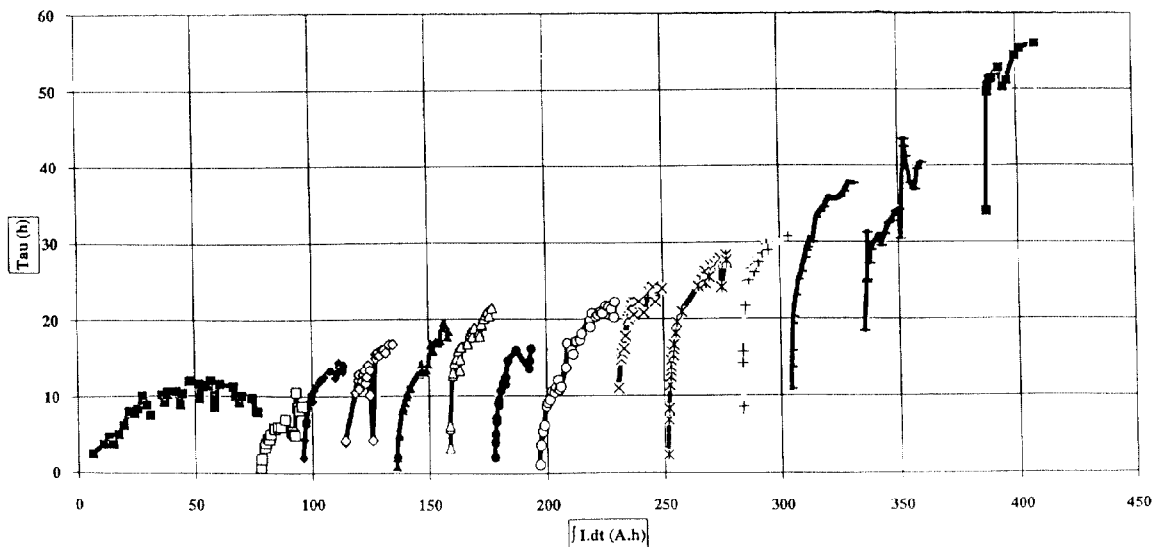
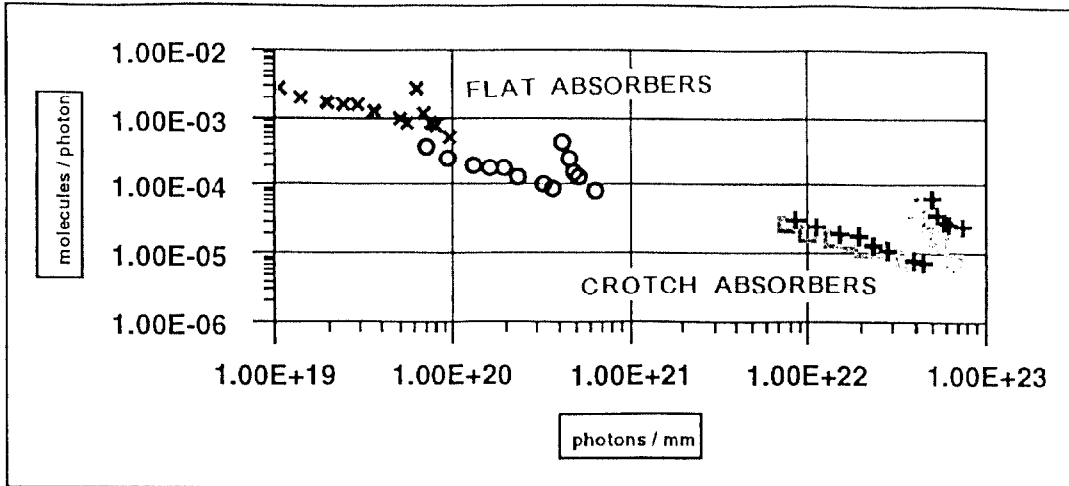


Figure 2: Desorption rate of absorbers



3. VACUUM BEHAVIOUR IN THE MULTIBUNCH MODE VERSUS THE SINGLE BUNCH MODE.

The most stable mode of operation of the storage ring is the so-called multi bunch mode where one third of the 1000 available RF buckets are filled with beam. Currents up to 175mA have been stored in this mode, which means a population of 0.5mA per bunch.

Synchrotron radiation Users also require an operation mode where only a few bunches are filled with beam. One such typical mode of operation at ESRF is the so-called multi-single bunch with 16 bunches filled with 5mA, or an 80mA total current.

Vacuum behaviour is considerably different between the multi bunch mode and the multi single bunch mode.

Figure 3 shows the average pressure versus stored beam intensity in multi bunch and in 16 bunch mode. In the multi bunch mode, the average pressure increases linearly with current while in the 16 bunch mode, the relation is $P=10^4 I^2$.

The difference of pressure behaviour in the 16 bunch mode is attributed to the return current flowing in the vacuum vessel walls, corresponding to a circulating current of 5mA/bunch to be compared with 0.5mA in the multi bunch mode.

The effect of this return current can be seen easily in the RF finger shielding the bellow corrugation. Figure 4 shows the temperature on these RF fingers versus stored beam in the multi bunch and 16 bunch modes.

Our experience is that the quality of the contact of the RF fingers is important: loose contacts will produce pressure bursts in the 16 bunch mode.

Effects of pressure on lifetime (see figure 5)

In the multi bunch mode the product lifetime x pressure is a constant, independent of the intensity, for this mode lifetime is still pressure limited.

In the 16 bunch mode the produced lifetime x pressure is no longer a constant, due to the non linearity $P=f(I)$. For this mode, lifetime is Touschek limited.

Figure 3: Storage ring average pressure behaviour in different machine operation modes

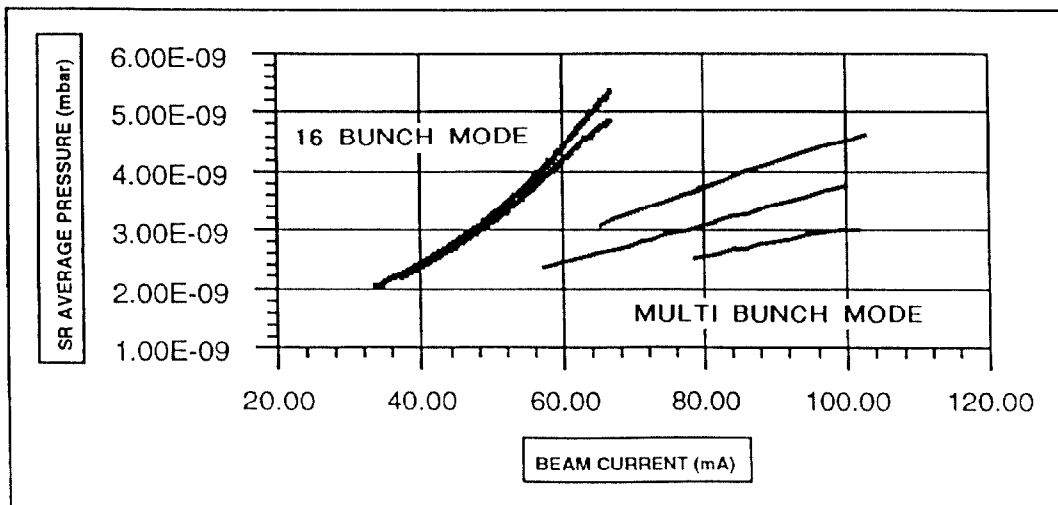


Figure 4: RF finger temperature in different operating modes

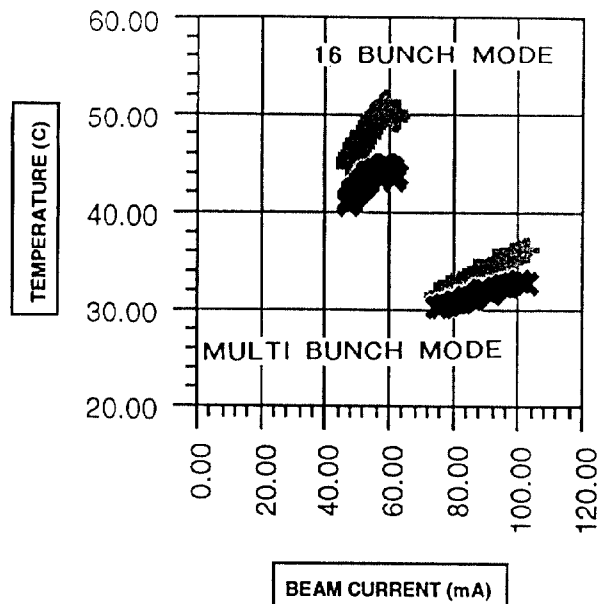
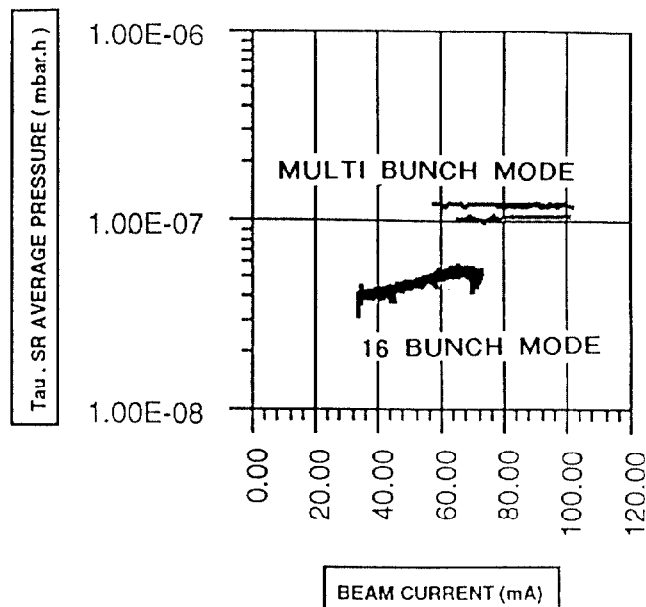


Figure 5: Pressure/lifetime behaviour in operation modes



4. DUST POLLUTION IN THE ID VESSELS

Each cell of the ESRF storage ring is equipped with five metre ID vessels installed in the gaps of the ID magnet assemblies supported by precision carriages. These carriages enable the changes of the gap to accommodate X-ray beam Users.

When we started to change these gaps at the end of 1992 we observed that gap changes on some ID vessels produced stored intensity losses. Several vessels were dismantled and examined with an endoscope equipped with a miniature camera. We discovered that the 707 NEG strips installed inside the vacuum vessels produce loose fine magnetic particles which can form a chain of small dipoles under the influence of the ID magnets, these chains could short circuit the ID vessel gap and interact with the stored beam.

Further investigation also showed that ID vessels are also sometimes contaminated by metallic debris produced during vessel manufacture. SAES the 707 NEG manufacture was alerted and soon discovered that the NEG magnetic dust are coming from the carbon steel tooling used to crush the Zr V Fe NEG alloy into powder.

SAES reacted positively to this problem and produced NEG blades made by sintering technique. This new type of NEG has recently been installed on two of our five metre ID vessels, results are satisfactory: no more beam loss can be observed when changing the gap of the undulator

Pollution from metallic chips introduced during manufacture seems more difficult to resolve. Some of these chips are likely to be pushed into the vessel during venting the electron beam welding tank to atmospheric pressure with dry nitrogen. We are trying to define a much more stringent Quality Assurance Plan to be applied throughout the manufacturing process.

5. CONCLUSION

The ESRF storage ring vacuum conditioning is progressing extremely well. Lifetimes of the order of 100 hours can be envisaged for 100mA beams stored in the multi bunch mode.

The dust pollution of the vacuum vessels is the most severe difficulty encountered with the vacuum system. This problem is crucial for insertion devices vessels and even more so for the development of the mini gap ID vessels.