COMPARISON OF ESRF AND ELETTRA VACUUM EVOLUTION, TROUBLESHOOTING AND SUCCESS

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Abstract

A comparison of the performance of some key components of the vacuum systems of the third generation synchrotron radiation (SR) light sources ESRF and Elettra is made. It is shown that, following routine vacuum interventions, both accelerators reach suitably high gas-scattering beam lifetimes in a matter of few tens of ampere·hours of integrated beam doses. The impact of the installation of narrow-gap vacuum chambers is discussed. Some failures and their impact on the operation of the accelerators are described in detail.

1 VACUUM SYSTEM

1.1 General Layout

The vacuum systems of ESRF and Elettra share some common features, such as the material chosen for fabricating the vacuum chambers, austenitic stainless steel (SS) of the AISI 300 series, the absence of an ante-chamber, the utilization of ion-pumps (IPs). The possibility of carrying out *in-situ* bake-outs is also noticed, although this feature has been lost at Elettra.

The ESRF is divided into 32 cells, each approximately 26.4 meters in length, while Elettra has 12 cells of 21.6 meters. Each cell at the ESRF is pumped by 11 IPs of various sizes, and 11 non-evaporable getter (NEG) pumps (cartridges). At Elettra, cells are pumped by 12 IPs of various sizes and NEG modules. For the same beam current, each meter of horizontal bending magnet trajectory at Elettra generates 1.42 times the photon flux of the ESRF's.

1.2 Insertion Device Vacuum Chambers

At Elettra and the ESRF, the straight sections devoted to the installation of insertion devices (IDs) have approximately the same length, 5 metres or so. As the vertical size of such chambers has become smaller and smaller, their specific conductance has decreased ([1, 2] and sec. 3.3). This feature, combined with the lack of distributed pumping along their length, has made an impact on the overall availability of photon beams to the experimenters. The ESRF has already installed a total of 7 narrow-gap ID chambers with NEG-coating [4]. At this time, 6 are still installed in the ring, four being made out of SS and two of extruded aluminum (Al). Elettra has installed four extruded aluminum chambers which have been affected by vacuum problems and long conditioning times [2]. Taking advantage of the extensive studies on NEG-coated chambers carried out at the ESRF, Elettra will install soon the first NEG-coated ID chamber.

1.3 Bremsstrahlung Measurements

The high energy bremsstrahlung (BS) is an effect which is very sensitive to the local vacuum conditions, particularly in the straight sections. An updated review of the BS measurements carried out at the ESRF is given in fig.1 (see ref. [1] for further details).

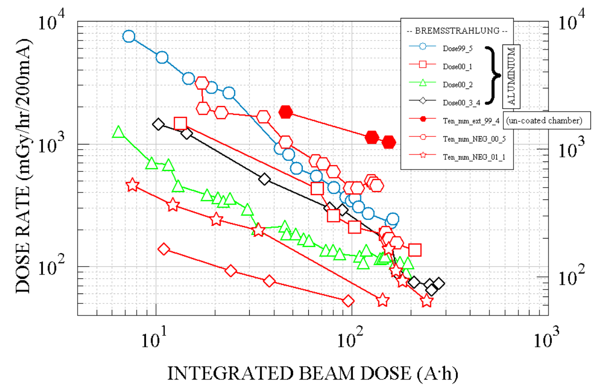

Figure 1: Bremsstrahlung measurements at the ESRF.

Elettra's measurements, not shown here, indicate a minimum BS emission in a conditioned Al vessel to be about 1250-220 times higher than that of a SS one with same geometry. Part of this difference could be explained by different pressure profiles due to the higher SR-induced desorption yield of Al with respect to that of SS. For ID vessels, the local pressure and BS rates remain higher for Al vs SS even after much larger doses.

2 BEAM LIFETIME ISSUES

2.1 ESRF

The impact of the installation of new vacuum chambers on the ESRF storage ring can be seen in figure 2. The fifth and last experimental run of the year 2000 has been chosen as an example, as it involved many different

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filling modes [5], one vacuum failure (a leak caused by corrosion of the SS wall), and an out-of-ordinary delivery of photons to the experimenters at 5 GeV electron beam energy.

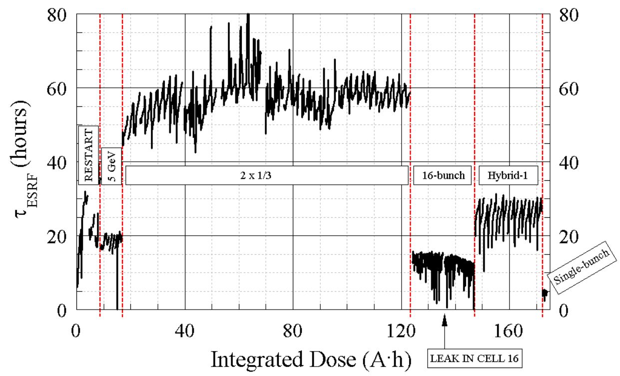

Figure 2: ESRF: beam lifetime evolution for Run 00-5.

To this date, a record lifetime tau around 90 hours at 170 mA, in uniform-filling mode, has been recorded at the ESRF during the second run of 2001. Generally speaking, the lifetime goes down as the charge per bunch goes up, that is going from uniform filling to 2 times 1/3, hybrid, 16-bunch and finally single-bunch.

2.2 Elettra

Figure 3 shows the measured beam lifetimes following installations of several new vacuum chambers.

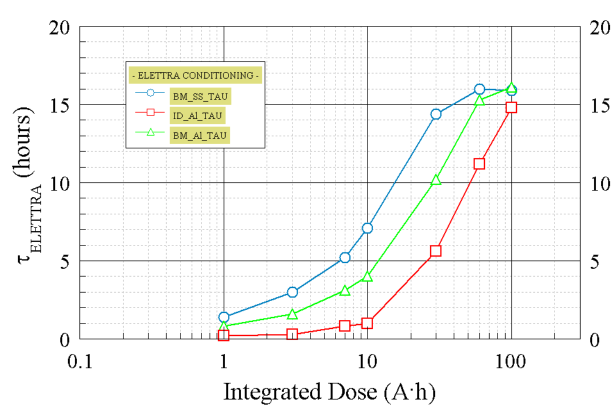

Figure 3: Elettra: tau versus integrated beam dose. BM_SS: bending magnet stainless steel chamber; ID_Al: ID aluminum chamber; BM_AL: bending magnet aluminum chamber.

It can be seen that in the case of the SS chamber, tau recovers the nominal lifetime value of 15 hours at 200 mA and 2 GeV after approximately 35 A·h, while it takes much longer for the Al chambers. The BM chambers are not irradiated directly by SR. When the pressure drops below 1.0E-8 mbar, the beam lifetime is not dictated by the residual gas density. In that case, it is generally Touschek-dominated, i.e. it strongly depends on dynamic parameters such as the cavities' temperature, gap voltage, machine files, etc… .

3 VACUUM CONDITIONING

3.1 ESRF

Immediately before or during the experimental run mentioned in sec 2.1, three major vacuum events happened: 1) installation of a new chamber equipped with a beam-position monitor in cell no.2; 2) a narrow-gap (10 mm vertically) SS ID chamber, NEG-coated, was installed in cell no.31; 3) A leak, caused by corrosion, developed in cell no.16, after approximately 135 A·h. Figure 4, 5 and 6 show the dynamic pressure rise vs integrated beam dose D as recorded by the inverted-magnetron Penning gauges of cell 2, 31 and 16, respectively. The bottom part of each figure shows the beam current at the same D.

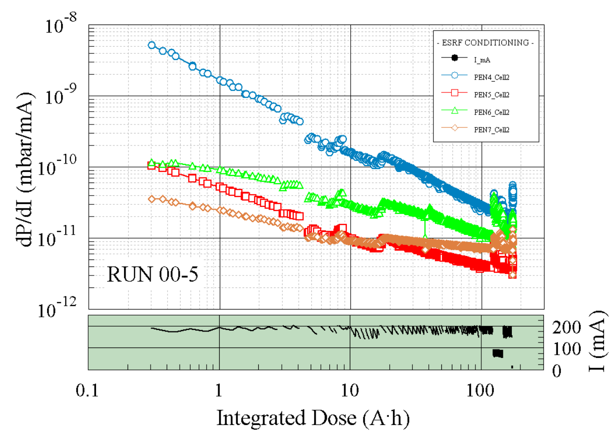

Figure 4: ESRF: Conditioning of cell 2. PEN4: entrance of dipole1, location of new BPM chamber; PEN5: on crotch 1; PEN6: entrance of dipole 2; PEN7: on crotch 2.

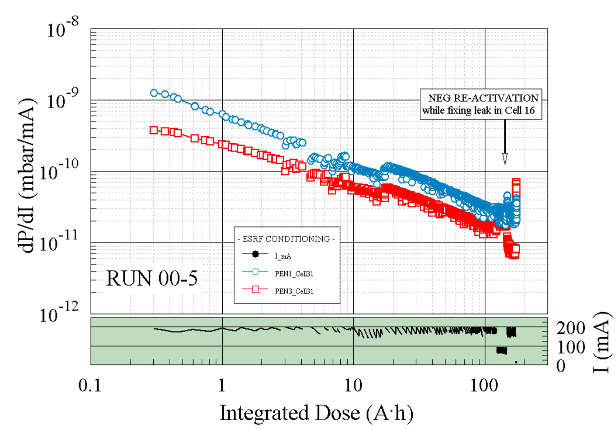

Figure 5: ESRF: Conditioning of cell 31's ID chamber. PEN1: entrance of ID chamber; PEN3: exit .

The leak in cell 16 has been fixed by putting varnish on the spot. Location of the Penning gauges as per fig.4. A persistent instability in the read-out of PEN7, caused by humidity in the ceramic feed-through, is visible. The leaky chamber has been replaced during the following shutdown.

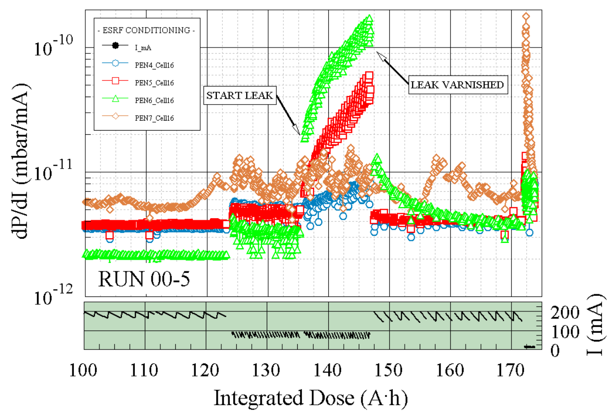

Figure 6: ESRF: corrosion leak, developing in cell 16.

3.2 Elettra

The conditioning of the dynamic pressure rise versus integrated beam dose for four different chambers installed in Elettra is visible in fig.7. All data refer to the standard mode of operation at 2 GeV. As can be seen, after more than 100 A·h of beam conditioning, dP/dI for the Al ID vessel is still higher than that of the SS ID one [7].

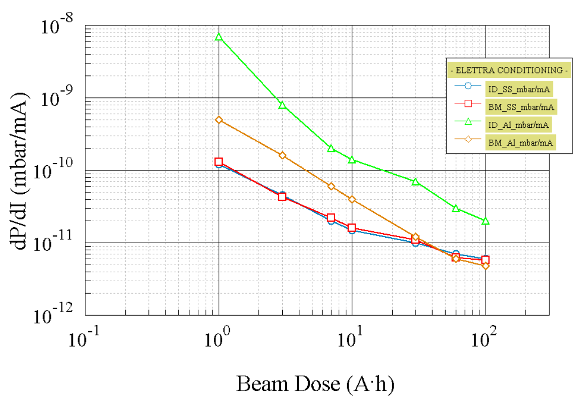

Figure 7: The Al ID chamber, void of distributed pumping and without NEG-coating, shows the longest conditioning time.

3.3 Comparison

Figure 8 plots the conditioning curves for two ID chambers of Elettra (Al and SS, open markers), alongside with two ESRF ID chambers (Al and SS, both NEG-coated, filled markers). It can be seen that, as already known from published literature [6], the Al chambers are characterized by higher SR-induced gas loads when compared to the SS ones. It should be noted that the dP/dI values shown here are not measured directly on the ID chambers, but rather on the pumping ports placed immediately upstream and/or downstream of them. At the ESRF, such chambers are equipped with SR absorbers, and therefore only part of the gas given-off during SR irradiation is coming from the ID chambers.

Detailed Monte-Carlo calculations, not shown here, indicate that when the NEG-coating is effective, this part should be very small, due to the small specific conductances involved, 3.75 l·m/s for Elettra's aluminum extrusion, and 2.28 l·m/s for ESRF's (0.94 l·m/s for the (8x50) mm SS chambers).

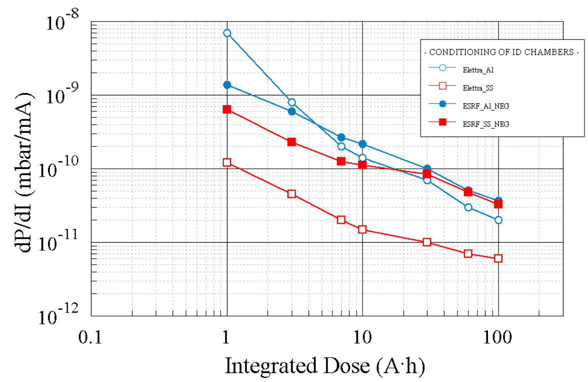

Figure 8: circles: Al chambers; squares: SS chambers

They are, clearly, conductance-limited systems. That is the reason why it is one of the authors' opinion (RK) that a better way of characterizing the pressure profile inside such ID chambers is to use BS data rather then pressure data measured outside of the chambers [1].

4 CONCLUSIONS

The vacuum systems of ESRF and Elettra have faced several failures and problems. In spite of that, beam lifetimes suitably long for the delivery of the photon beams to the users are routinely achieved after reasonably short times. One open issue at Elettra is the need for shortening the conditioning time of narrow-gap ID vacuum chambers. To this aim, the installation of a NEG-coated, extruded aluminum ID chamber is scheduled for the near future.

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