NEG-COATED VACUUM CHAMBERS AT THE ESRF: PRESENT STATUS AND FUTURE PLANS

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Abstract

The problem of reducing the amount of bremsstrahlung radiation generated by the interaction of the 6 GeV electron beam passing inside the 5 metre-long narrow gap vacuum chambers of the ESRF has been solved by applying thin-films of Non-Evaporable Getter (NEG) materials. A status report on such chambers presently installed at the ESRF is given, together with details of the R&D program being pursued. A new NEG-coating facility under completion is described, and future plans discussed.

1 STRAIGHT SECTIONS AND BEAMLINES

Figure 1 shows the status of all straight sections and beamlines of the ESRF, as of Run 02-2 ending on 22 May 2002. "CV" stands for "chambre á vide". "CV5000-15" identifies a 15 mm chamber (external vertical dimension), approximately 5000 mm long. "INVAC" stands for "in-vacuum undulator". The straight sections of cell 4, 5, 7, 23 and 25 are taken by RF cavities or machine diagnostics. "BM#" identifies the experimental beamlines making use of the synchrotron radiation (SR) generated inside the dipole magnets (critical energy 20.5 keV), while "ID#" those utilizing undulator and/or wigglers. Few ID beamlines are splitted into several sub-stations. Additional details about the ESRF vacuum system can be found in ref.[1].

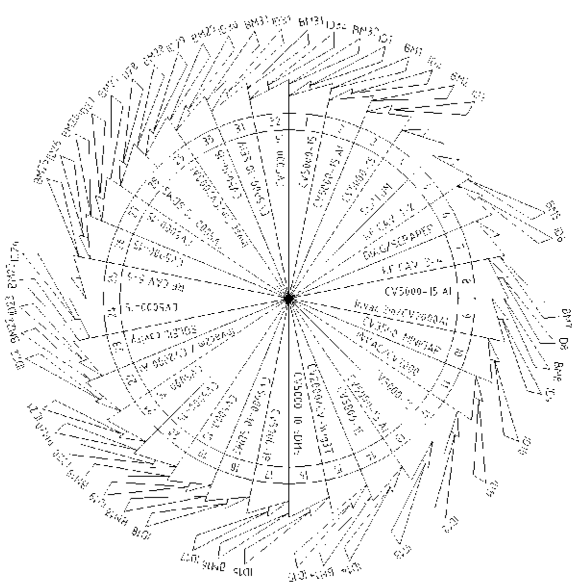

Figure 1: Narrow-gap vacuum chambers, type and location, and beamlines.

2 NEG-COATED VACUUM CHAMBERS

2.2 Location and Inventory

Table 1 gives some details concerning the NEG-coated vacuum chambers which are installed in the storage ring

Table 1: List of NEG-coated vacuum chambers. Material 1 is extruded-aluminium, 6060 T6. Material 2 is 316 LN stainless steel, with 50 µm of electro-deposited copper.

Material	Section (HxV) mm^2	Length (mm)	Installation Time/Location
1	74x11	5073	May 2000/ID8
1	74x11	5073	Aug 2000/ID13
1	74x11	5073	March 2002/ID2
1	74x11	2093	Aug 2001/ID22
1	74x11	2093	Jan 2002/ID9
1	74x11	2093	Jan 2002/ID29
2	57x8	5175	Aug 2001/ID16
2	57x8	5175	May 2001/ID18
2	57x8	5175	Jan 2001/ID28
2	50x8	5175	Oct 2001/ID31 (a)
1	57x8	5073	May 2002/ID6 (b)

(a) ID31 used to be the test section for Machine/Safety/Vacuum studies, now moved to ID6;
(b) This chamber is NOT NEG-coated yet, will be used as reference for future studies.

2.2 Description of the Chambers

The three different cross-sections listed in tab.1 are shown below, in fig.2a, 2b and 2c. For all coated chambers, the NEG material has been chosen to be the ternary alloy Ti-Zr-V, as it has been found to be the one with the lowest activation temperature [5]. All coatings have been performed at CERN by EST-SM staff.

The NEG-coatings have been activated during bake-out. The bake-out temperatures are 180 degrees C for those made out of aluminium, and between 200 and 250 C for the stainless steel ones. The aluminium chambers have elliptical beam apertures, while the stainless steel ones

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have polygonal apertures.

The stainless steel chambers make extensive use of electron-beam (EB) welding. There are 6 EB welds running along the 5 m long chamber profile, 3 on the upper face and 3 on the bottom face. For all chambers, a total power of approximately 550 W at 200 mA is dissipated along the external wall.

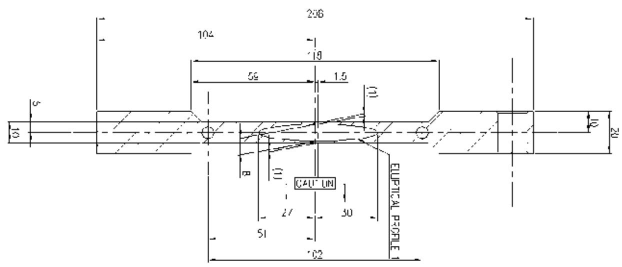

Figure 2a: 10 mm, extruded-aluminium vacuum chamber.

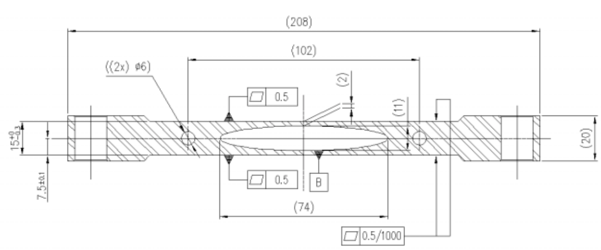

Figure 2b: 15 mm, extruded-aluminium vacuum chamber.

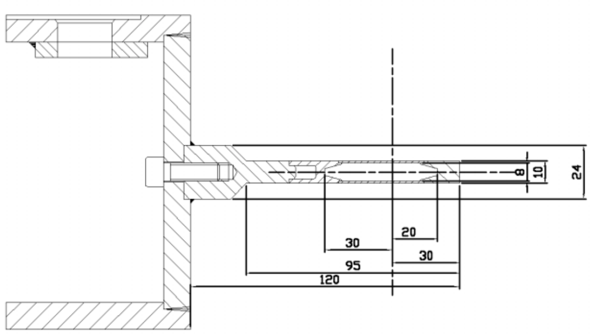

Figure 2c: 10 mm, stainless steel vacuum chamber. Two versions exist, with 50 and 57 mm horizontal apertures, respectively.

Fig.2d shows the chamber of fig.2a installed on the new straight section which will be used for machine, safety and vacuum studies, beginning June 2002. The planarity of the chamber's flat surfaces (after bake-out at 180 C for 24 hours) has been measured to be within +/- 0.3 mm in the area where the insertion-device will be installed. A gate valve, used to isolate the straight section from the achromat part of the machine, is partially visible on the left. A short chamber with bellows, SR absorber, beam-position pick-up electrodes, ion-pump and a vacuum gauge is installed between the two. The front-end of the preceding beamline, BM5, is visible in the background.

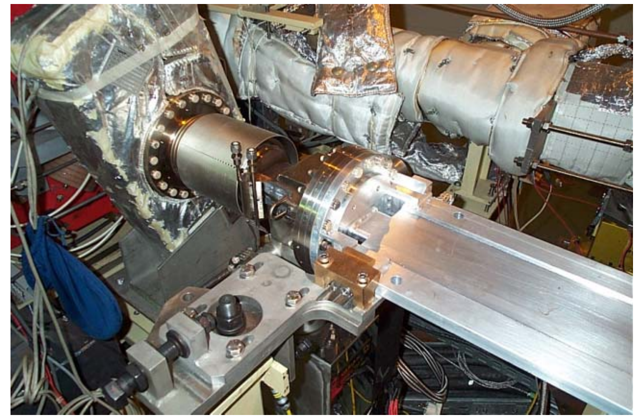

Figure 2d: Close-range view of the "10 mm", extruded-aluminium CV5073 installed on ID6 (right).

3 MACHINE PHYSICS AND VACUUM ISSUES

Remarks of general interest are the following:

- The prototype "15 mm" extruded aluminium chamber (tested between Oct 1999 and Oct 2000 on ID31), had been activated 6 times and vented 5 times, without noticeable degradation of its performances [2,3].
- Two "15 mm", extruded-aluminium chambers (installed on ID8 and ID13 since May/Aug 2000) have never been in need of a re-activation of the NEG coating. The dynamic pressures measured on the chambers immediately before and after these two chambers have reached the 1.0E-12 mbar/mA range after one machine run (tipically around 150 A·hour), and have since remained at that level [3,6].
- No occurrences of peeling-off , or release of dusts from the NEG-coated chambers have ever been recorded in the form of sudden beam losses.
- No adverse effect on the impedance of the machine caused by the electric conductivity of the NEG coatings has been noticed [4]. One of our colleagues, --E. Plouviez of the Diagnostic Group, Machine Division-- has measured the surface resistance of sample kapton foils which had been coated by us (thicknesses measured: 0.6 and 2 μm). At the chosen frequency of 14 GHz a resistivity of 5.0E-6 Ω/m has been measured. This means that the skin-depth at 14 GHz is greater than the NEG-coating thickness [7].

4 NEG-COATING FACILITY

The longest chambers installed on the ESRF storage ring measure approximately 5.2 m. With the aim of performing the NEG-coating by ourselves, a new building allowing the set-up of chambers of that size in a vertical position has been built close to our laboratory. Fig.3a shows a cross-sectional view of the facility, scheduled to become operational in June 2002. A 5 metre-long chamber and the solenoid have been sketched for reference.

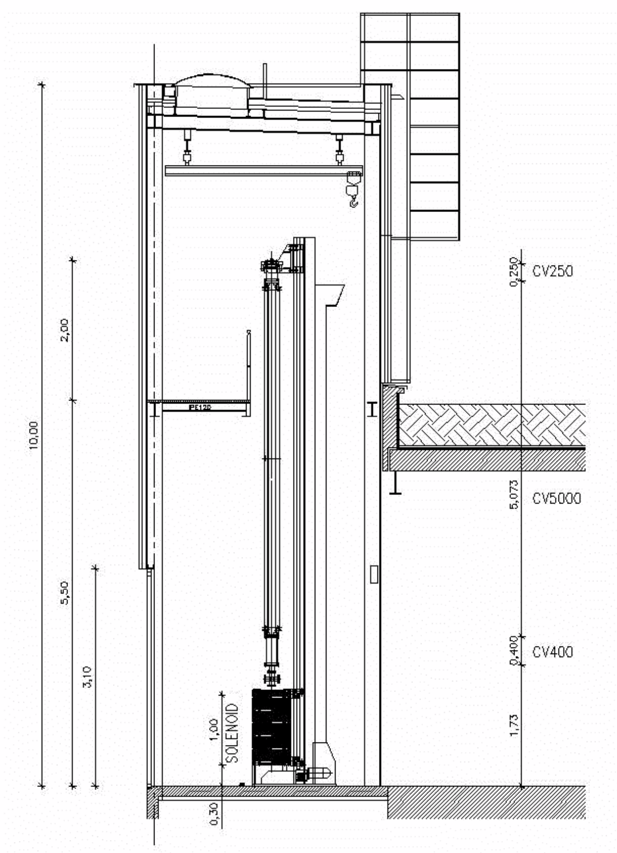

Figure 3a: Set-up for magnetron sputtering of a 5 metre long vacuum chamber.

Figure 3b: Air-cooled solenoid for magnetron sputtering

An air-cooled solenoid, 1 metre long, with an internal diameter of 320 mm --generating a magnetic field of approximately 500 G at a circulating current of around 100 A-- has been fabricated. It will be fixed to a motorized device which will move it up and down along the chamber to be coated so as to allow sputtering the NEG-materials under the more favorable "magnetron configuration" [5]. Fig.3b shows the solenoid under test in our lab. As it can be derived from fig. 3a, should the solenoid not be used ("diode configuration" for the NEG-sputtering), then longer chambers could be coated.

5 FUTURE PLANS

The main points of action for us in the near future are:

- Commissioning of the new NEG-coating facility.
- Coating of a 10 mm, extruded-aluminium, (57x8) mm^2 CV5073.
- Coating of a crotch-absorber.
- Coating of a “generic” achromat-profile chamber [1].

6 CONCLUSIONS

Narrow-gap vacuum chambers coated with a thin-film of NEG materials have proved to be a good solution for the reduction of bremsstrahlung radiation deposited in the experimental hutches of the ESRF. No limiting machine issues have been observed so far. The resistive-wall impedance seems to be very marginally affected by the NEG-coated chambers, and no generation of dust or peeling-off has been observed. The current program of R&D aims at coating 5 metre-long, 8 mm chambers (internal vertical dimension), made out of extruded aluminium. Coating of crotch-absorbers and achromat-type chambers could to be an interesting development.

7 ACKNOWLEDEGMENTS

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8 REFERENCES

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