# PERFORMANCE OF A NARROW-GAP, NEG-COATED, EXTRUDED-ALUMINIUM VACUUM CHAMBER AT THE ESRF

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*Abstract*

When a new narrow-gap insertion device (ID) vacuum chamber is installed in a straight section of the ESRF, its conditioning time is found to affect the operation of the storage ring mainly in two ways. The first one is the effect of the local pressure bump on the global average pressure seen by the 6 GeV electron beam. The second one is the local amount of bremsstrahlung (BS) radiation generated along the chamber and deposited on the first elements of the experimental hutch. The former leads to a reduction of the lifetime of the beam, the latter to the need of installing additional shielding materials in the hutch, thus reducing the availability of the beamline to the users. Based on measurements made at CERN and on a dedicated photodesorption beamline at the ESRF, it has been determined that a NEG-coated, extruded aluminium vacuum chamber would solve the problem, as it would have a reduced synchrotron radiation-induced outgassing yield and distributed pumping. This paper describes with different degree of detail how such a chamber has been conceived, designed, fabricated, coated and tested on a dedicated straight section of the ESRF. It is shown that, compared to similar chambers without NEG coating, the BS radiation has been reduced. No adverse effect on the impedance of the machine in various filling modes has been observed.

## 1 VACUUM CHAMBER GEOMETRY AND MATERIALS

### *1.1 Historical Background*

The vast majority of the ID vacuum chambers installed at the ESRF have been made out of stainless steel (SS), eventually copper-coated on the upper and lower faces in order to decrease their contribution to the resistive-wall impedance of the machine [1,2]. The welding technique employed was electron-beam welding (EBW) and tungsten-inert gas (TIG). Due to their overall length of approximately 5 m, and the relative scarcity of suppliers capable of performing the EBW under ultra-high-vacuum (UHV) conditions, the production of this kind of chambers has always taken long times and considerable financial resources. As they are devoid of any distributed pumping, their vacuum performance has always been characterised by a relatively long conditioning time and high BS levels, despite high temperature in-situ bake-outs. In 1998 and 1999 a prototype chamber made of extruded-aluminium has been installed on ID31, a straight section dedicated to vacuum pre-conditioning and radiation background measurements. It had been fabricated by the Advanced Photon Source with minor modifications for us. It became immediately clear that its vacuum and BS performance was superior to the standard ESRF design, mainly due to its chamber-antechamber design, distributed NEG pumping and localised photon absorber [4]. For a number of reasons beyond the scope of this paper, we could not adapt its design to our ring, and therefore a collaboration with CERN for depositing a NEG coating inside a single-chambered vacuum chamber nmwas started [3]. To this aim, we designed an aluminium-extruded chamber capable of replacing the most common type installed at the ESRF, the so-called "15 mm chamber" (16 mm, that is 15+1, is the minimum theoretical gap to which the ID poles can be closed to, where a tolerance of ± 0.5 mm is usually applied). At the same time, tests on NEG-coated SS and aluminium chambers were performed on a dedicated beamline. Their photodesorption yields had been measured to be lower than those of similar un-coated chambers [3].

### *1.2 Chamber Fabrication*

The chamber is shown in figure 1. The material is aluminium 6060 T6. Externally it has a rectangular cross-section of 208 mm by 20 mm. Internally it has an elliptical cross-section of 74 mm by 11 mm (where the NEG coating is deposited), and two cooling holes of 6 mm diameter each. The total SR power to be dissipated, from the dipole upstream of it, is of the order of 600 W at 200 mA, with a critical energy of 20.5 KeV. After extrusion, the upper and lower faces of the chamber are machined down to an overall vertical size of 15 mm.

The wall thickness and chamber straightness are carefully checked before shipping to CERN for coating.

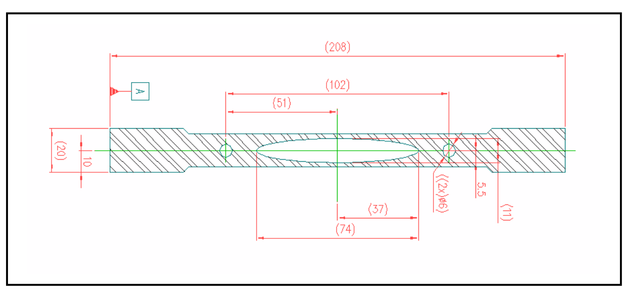


Figure 1: Cross-section of the chamber after machining.

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Al-to-SS, explosion-bonding, bi-metal flanges have been TIG welded to the machined extrusion.

Coating was performed by the SM group of the EST Division of CERN [5].

## 2 INSTALLATION

The chamber was installed on the straight section ID31 of the ESRF Storage Ring during the October 99 shutdown. It was baked-out at 120 °C for 2 days, during which time it was pumped by two turbo pumps connected upstream (UPS) and downstream (DWS) of it. After most of the water had been removed, the chamber's temperature was raised to 200 °C for 24 hours, in order to achieve the activation of the NEG. It must be mentioned here, that pre-qualification measurements carried out in our laboratory had indicated that the mechanical stress and deformation due to a 200 °C bake were well within acceptable limits, contrary to what finite-element calculations based on widely accepted yield stress data had suggested. After the activation and bake-out, with the chamber at room temperature, the UPS and DWS pressure - on top of two 120 l/s ion-pumps- reached the low 1.0E-10 mbar range, as measured by two inverted-magnetron Penning gauges, PEN1 and PEN3.

## 3 CONDITIONING

Since installation in October 1999, the chamber has been subjected to 4 "runs" (the last one being underway at time of writing). In between each run the chamber has been vented to air, and re-baked at 120 °C. Activation of the NEG-coating at 200 °C for 24 hours has been performed the first three times. During the shutdown between the first and second run, the chamber has been dismounted and sent back to the manufacturer, where a CF 16 flange for installing a third Penning gauge has been added in the centre of the chamber, PEN2. The four conditioning curves, in the form of dynamic pressure rise in mbar/mA versus beam dose in A·hour, are shown in figure 2, A through D.

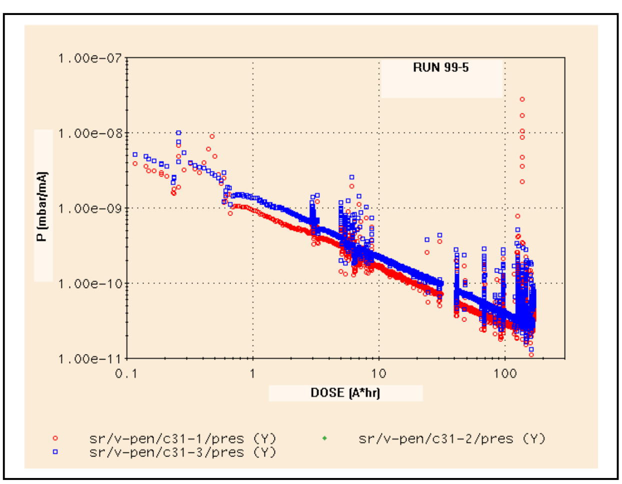


Figure 2 A: First conditioning of the chamber.

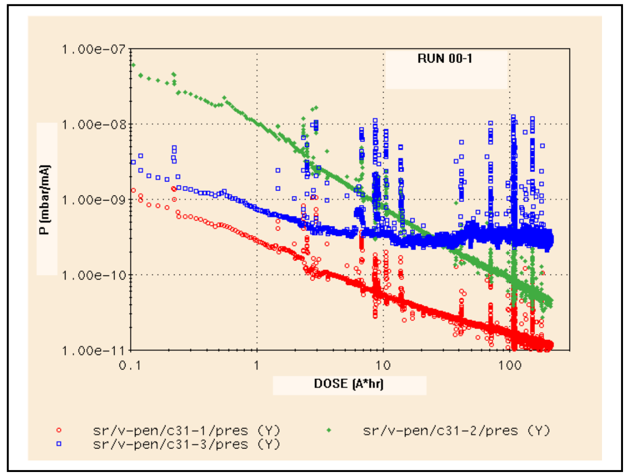


Figure 2 B: PEN2 has been added in the center of the chamber. The "flat" part of the curve for PEN3 is due to an abnormally high leakage current.

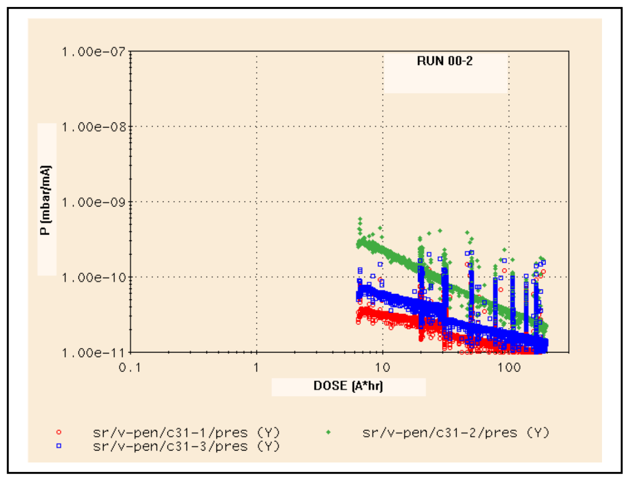


Figure 2 C: PEN 3 replaced, lost data for dose<6.4 A·hr.

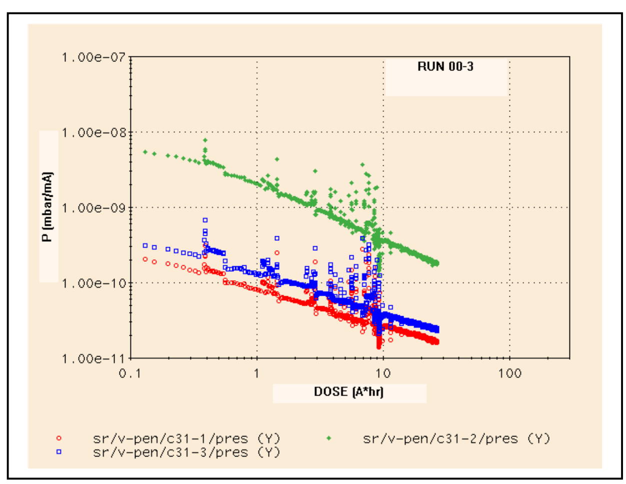


Figure 2 D: Last run, still underway. No NEG activation has been performed.

All points rising high above the "straight" lines correspond to transient events and/or different filling patterns.

Each run is labelled by its name, 99-5, 00-1, 00-2, and 00-3 (i.e. "Year"-"RunNo". There are 5 runs each year at the ESRF). As can be seen in fig.2 A to D, the conditioning of the chamber has progressed as expected all four times, with slopes in the range of -0.45 to –1.1.

A memory effect, as identified by the initial values of the three Penning gauges being always lower than the initial value of the previous run is visible, except for the fourth run, when activation of the NEG has not been performed. This is proof that activation of the NEG coating is important and effective.

## 3 BREMSSTRAHLUNG RADIATION MEASUREMENTS

Figure 3 shows the conditioning of the 15 mm, NEG-coated aluminium chamber during the four runs, versus the integrated beam dose. Details about the different filling modes implemented at the ESRF and cited in figure 3 and below, can be found in [6].

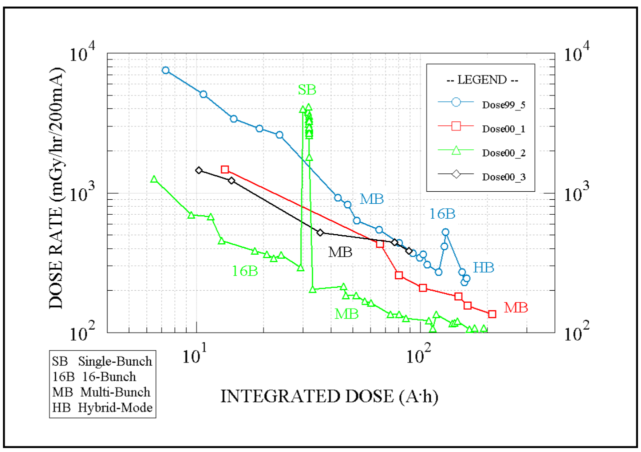


Figure 3: BS radiation dose rate vs integrated beam dose

It is reminded that the highest currents during operation in MB, HB, SB and 16B filling mode are 200 mA (MB and HB), 15 mA and 90 mA, respectively. All measurements have been normalised to 200 mA.

As can be argued from figure 3, the experimental points can be well fitted with straight lines in log-log scale, with each line lying below the one corresponding to the previous run, except for the last one corresponding to the non-activated-NEG case. Since the BS is generated by the beam interacting with the residual gas molecules along its straight path inside the chamber, this is another independent proof that the pressure profile when the NEG is not activated is higher than when it is activated. It has to be mentioned here that the residual-gas compositions in all four runs were essentially the same, as recorded by the RGA installed above the 120 l/s ion-pump downstream of the chamber.

## 4 CONCLUSIONS

The characterisation of a low-gap, NEG-coated, extruded-aluminium vacuum chamber suitable for installation in an ID has been discussed in terms of its reduced outgassing and related BS radiation contribution.

It has been demonstrated that compared to the technology employed by ESRF before its development, it is a relatively low-cost, effective solution to solving the problem of radiation background and long vacuum conditioning times, with possible adaptation to other existing or planned synchrotron radiation light sources and particle accelerators.

## ACKNOWLEDGEMENT


Work supported by the Machine and Operation Groups of the ESRF. The chamber and the ancillary equipment have been designed by B. Plan of the ESRF Drafting Office. P. Berkvens and P. Colomp of the ESRF Safety Group have kindly performed the BS radiation measurement and provided the data. Fruitful discussions with C. Benvenuti, P. Chiggiato, A. Escudeiro-Santana and V. Rouzinov of CERN SM/EST are acknowledged.


## REFERENCES


[1] N. Rouvière, "Undulator Vessels Devoid of Distributed Pumps", EPAC'96, Sitges, June 1996.

[2] R. Kersevan, "Status of the ESRF Vacuum System", EPAC'98, Stockholm, June 1998.

[3] P. Chiggiato, R Kersevan, "Synchrotron Radiation-Induced Desorption from a NEG-Coated Vacuum Chamber", EVC-6, Lyon, December 1999, to be published in *Vacuum.*

[4] R. Kersevan, "Vacuum System of the ESRF: Operational Experience and Status Report", EVC-6, Lyon, December 1999, to be published in *Vacuum*.

[5] The NEG coating is applied onto the chamber by sputtering a set of cathodes placed parallel to each other along the axis of the chamber. Each cathode is made up of three intertwisted thin wires of titanium, zirconium and vanadium. Sputtering, in diode configuration, is then obtained by using pure kripton gas and a suitable potential between the chamber's wall and the cathodes. The procedure is covered by a CERN patent; P. Chiggiato, private communication.

[6] http://www.esrf.fr/machine/myweb/MODES.html