# VACUUM CONDITIONING OF THE SOLEIL STORAGE RING WITH EXTENSIVE USE OF NEG COATING

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*Abstract*

The vacuum system of the SOLEIL storage ring makes use of standard pumps, like Sputter Ion Pumps (SIP) and Titanium Sublimation Pumps (TSP) combined with Non Evaporable Getter (NEG) coated vacuum vessels. Following the ESRF results on low gap insertion device (ID) chambers, it was decided to use, in addition to the traditional pumps, NEG coating deposited by magnetron sputtering on extruded aluminium vessels. This has been applied in an extensive way to all the straight vessels of the storage ring that means quadrupole/sextupole vessels and ID vessels, which represent about 56% of the ring circumference. The starting configuration of the SOLEIL vacuum system included all the NEG coated low gap ID chambers among which a 10.5 m long chamber.

Conditioning of the vacuum system over an integrated beam dose of 900 A.h will be presented. The periodical re-activations of the TSP performed since the beginning of 2007 improved significantly the conditioning rate. A comparison of the vacuum behaviour of two similar cells one with NEG coating and traditional pumping versus one with only NEG coating demonstrates the ability of the NEG coating to keep alone the pressure at low level.

## INTRODUCTION

The vacuum system of the SOLEIL synchrotron storage ring has been designed using in an extensive way the NEG coating of the vacuum vessels. The TiZrV NEG coating developed at CERN [1] had been already used for the insertion device vacuum vessels at some synchrotron facilities [2]. It was decided at SOLEIL to extend the NEG coating to all the straight vessels of the storage ring, including the quadrupole/sextupole type vacuum vessels.

## PUMPING SYSTEM

The vacuum system of the SOLEIL storage ring had been initially designed using standard pumps like Sputter Ion Pumps and Titanium Sublimation Pumps. Following the results observed at ESRF and other synchrotron facilities, it was decided to use Non Evaporable Getter (NEG) coating in addition to the foreseen traditional pumps.

***Conventional pumping:*** The SIP's have been distributed around the storage depending on the local outgassing. 150 $l.s^{-1}$ SIP's have been placed at pumping ports of the quadrupole vacuum vessels and close to the absorbers of the tapering vessels located upstream and downstream the ID small gap vessels. 400 $l.s^{-1}$ SIP's have been also placed close to the crotch absorbers where the outgassing induced by the PSD, was expected to be the highest. The pressure profile along the cells is deduced from the pressure reading on the SIP controllers.

In addition to the SIP's, Titanium Sublimation Pumps, 250 $l.s^{-1}$, have been placed at pumping ports of the quadrupole vacuum vessels and at the upstream pumping port of the dipole vessel.

In total the conventional pumps provide a 60.000 $l.s^{-1}$ nominal pumping speed distributed along the circumference of the ring corresponding to an effective pumping speed of about 20.000$l.s^{-1}$ on the beam channel.

***NEG coating:*** The NEG coating technology, developed at CERN [1], consist on a deposition by magnetron sputtering of a layer of ternary alloy of titanium, zirconium and vanadium (30%, 30% and 40% respectively). It has been shown that after activation, the NEG coating can reduce drastically the Photon Stimulated Desorption (PSD) effect [3], hence the conditioning time.

At SOLEIL, in addition to the standard pumps, the use of NEG coating has been implemented in an extensive way to all the aluminium straight vacuum vessels of the storage ring that means quadrupole/sextupole type and insertion device (ID) vacuum vessels which represent a total length of 200 m that is about 56% of the circumference [4] (see figure 1)

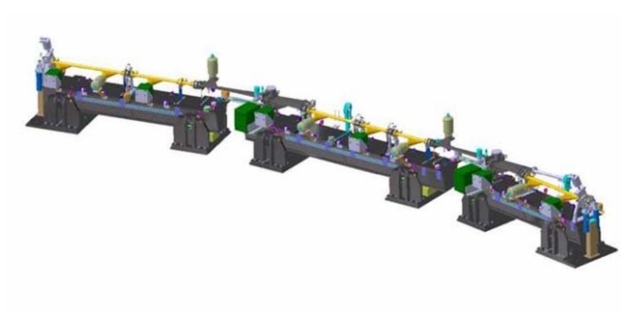

Figure 1 : One typical cell of the storage ring (In yellow the NEG coated quadrupole vacuum vessels).

To assess and compare the beneficial vacuum properties of the NEG coating, one cell of the ring was equipped with special quadrupole vacuum vessels without pumping ports that is to say without traditional pumping means.

### CONDITIONING

The average static pressure in the storage ring before injecting the first beam was 4. $10^{-10}$ mbar after having baked and activated the NEG of the whole ring (except the injection straight section), and after having activated all Titanium Sublimation pumps (TSP), using local controllers.

With the first stored beam (I=0.8 mA), the maximum pressure rise was 2 $10^{-8}$ mbar.

The conditioning effect progressed smoothly and by the end of May 2008, after having accumulated an integrated dose of 890 A.h, the average dynamic pressure is now 1.2 $10^{-9}$ mbar with I=300 mA in multibunch mode. The corresponding 16 h beam lifetime $\tau$ is still essentially limited by the residual pressure.

The plot of figure 2 presents the evolution of the product I.$\tau$ as a function of the integrated beam dose. One can observe the conditioning effect which is still improving with the accumulated beam dose.

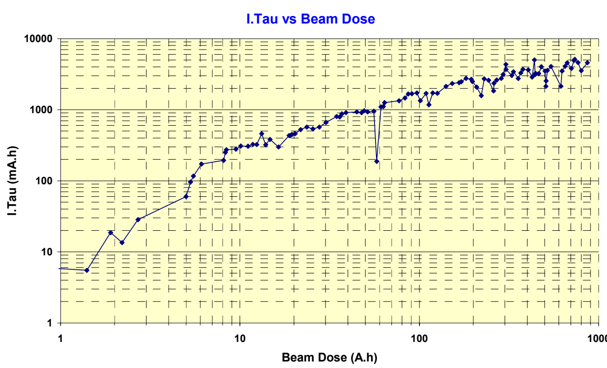


Figure 2: Evolution of the I.$\tau$ vs integrated beam dose.

The initial target value for the beam lifetime in the multibunch mode, was $\tau$=10 h @100 mA and for an average pressure of 1.$10^{-9}$ mbar. This value was reached after 45 A.h of conditioning less than 5 months after the first beam.

Figure 3 presents, for a typical cell, the average pressure normalized to beam current versus the integrated current dose.

This Log-Log plot illustrates the conditioning with beam of the vacuum vessel walls. Initially, this variation conforms to the usual measurements made in other synchrotron facilities with a negative slope of about 0.6.

From January 2007 onwards, remote control of the TSP was made available and all TSP are re-activated after every shutdown. As a result, the conditioning slope was increased from 0.6 to 0.8. This effect shows that the secondary photons which impinge the pumping ports, contribute to the global PSD outgassing.

Figure 4 presents for the same cell, the relative behaviours of the pressures measured in the NEG coated Aluminium vessels and in the Stainless Steel vessels (dipole vessels). One can observe that the pressure is lower in the coated vessels and that the conditioning slopes are similar.

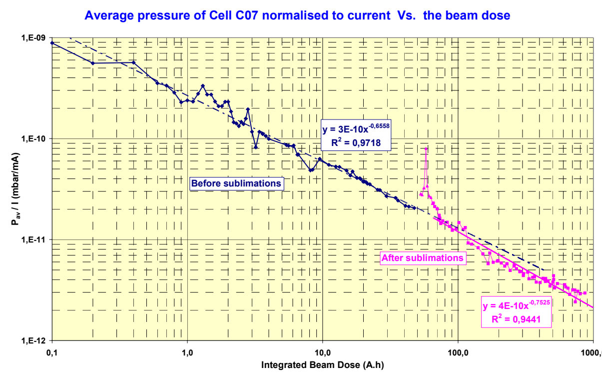


Figure 3: Vacuum conditioning of a typical cell.

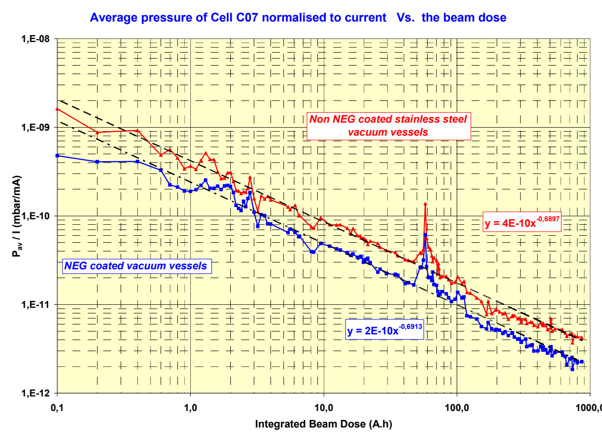


Figure 4: Comparison of the vacuum conditioning of NEG coated and stainless steel vessels.

## PHOTON STIMULATED DESORPTION

Figure 5 presents the evolution of the estimated photon stimulated desorption (PSD) yield $\eta$ as a function of the integrated photon dose per unit length. The PSD yield has been calculated from the pressure measurements on the NEG coated part and from the estimated pumping speed installed there. The slope of the conditioning is 0.69.

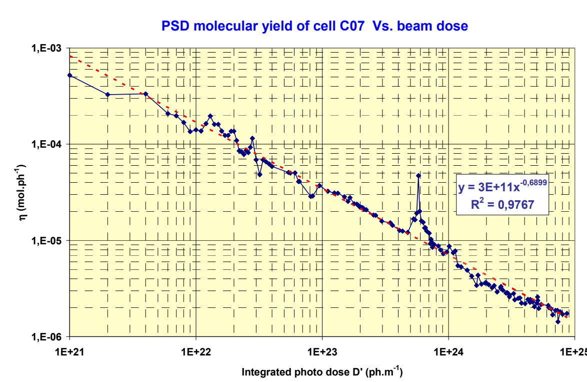


Figure 5: PSD yield estimated in the NEG coated vacuum vessels.

As expected, these values are better than the ones usually measured in previous PSD experiments [5,6]; about one order of magnitude for stainless steel and two order of magnitude for aluminium.

To evaluate the PSD behaviour of the NEG coating during the construction phase, PSD measurement had been performed at ESRF on a dedicated beamline D31 [7]. PSD measurements were made on two different test vacuum vessels of SOLEIL (figure 6) : one quadrupole type with pumping ports and no pump installed, and one quadrupole type without pumping ports.

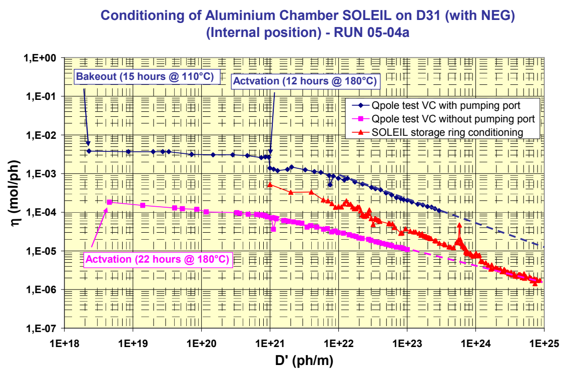


Figure 6**:** Experimental data of PSD yields on quadrupole type vacuum vessels measured at ESRF on D31 beamline. The red points correspond to the PSD yield estimated from the total pressure recording on the SOLEIL storage ring.

The PSD yield effectively measured on the ring during the conditioning was initially in between the two curves (see fig. 6). After the TSP's were activated the value became closer to the curve of the experimental results for the vessel without the pumping ports.

## PRESSURE PROFILE

Figure 7 presents the pressure distribution along one typical cell with a 300 mA current.

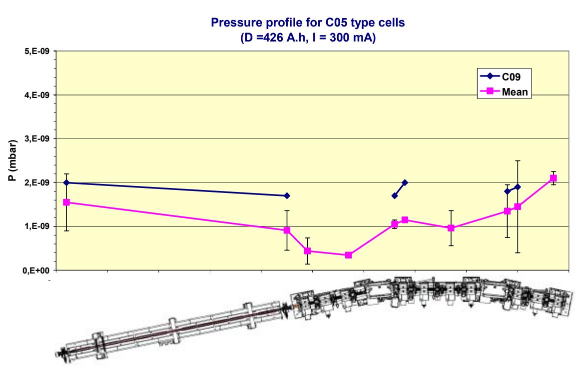


Figure 7: Pressure profile along one typical cell (in pink). The pressure in the test cell 9, which doesn't have additional pumping in the quadrupole vessels is shown in black

It shows that the pressure profile is quite flat, despite the high photon power deposited downstream the bending magnets, where the crotch absorber and the longitudinal absorber stop about 60% of the photons radiation generated in the bending magnet.

It also shows the pressures measured along the cell 9 without pumping ports (pumping provided only by the NEG coating).

One can observe that the pressures are not significantly different. This result would mean that there is no additional flux coming from the neighbouring quadrupole vessels. This demonstrates that the NEG coating alone enables to keep the pressure at low level.

The total beam lifetime is still dominated by the gas scattering effect and there is an excellent correlation between the value of this gas scattering lifetime derived from the average pressure and the measured lifetime (21 h at 250 mA) [8]. This demonstrates that the pressure along the ring is well represented by the measured pressures at the SIP's, hence that thanks to the NEG coating, there is no pressure bumps in between SIP's.

## CONCLUSION

The efficiency of the NEG coating used in an extensive way has been demonstrated by a rather fast conditioning of the storage ring. Nevertheless it seems that this conditioning has been limited by two contributions :

- The PSD in the dipole vacuum vessels which are not coated contributes significantly to the average pressure.
- The PSD in the non coated pumping ports of the quadrupole vessels due to secondary photons which is locally compensated by the lumped pumps (SIP or TSP)

The NEG coating is efficient enough to keep the low pressure required for good beam lifetime

## ACKNOWLEDGEMENTS

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