# UNDULATOR VESSELS DEVOID OF DISTRIBUTED PUMPS

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## ABSTRACT

Following problems due to dust produced by the distributed NEG pumps introduced in the first generation of ESRF five meter long ID vessels, a new design for a 15mm high five meter long stainless steel ID vessel devoid of distributed NEG was produced. This prototype was carefully prepared by heat treatment, then installed on the storage ring in March 1995. Results have been excellent. Since then twelve identical units have been installed on the Machine.

## 1 INTRODUCTION

The ESRF is a synchrotron radiation machine, one of its major targets is to increase the brilliance of the X ray beams. One of the parameters allowing for higher brilliance is the gap of the undulators. The FPR "Foundation Phase Report" foresaw an undulator with a 20mm gap. Five meter long and 19mm high undulator vessels were designed in this respect. - ***Figure 1***. The distributed pumping was provided by NEG strips to obtain a pressure of $10^{-9}$ mbar with 100mA stored beam.

However, these NEG strips led to the production of dust particles, in particular magnetic dust. This dust formed filaments of magnetic dipoles under the influence of the undulator field, resulting in partial loss of the electron beam and loss of lifetime. Removal of dust sources and reduction of gaps from 20mm to 16mm led us to design stainless steel vacuum vessels 5 meters in length and 15mm in height devoid of pumping.

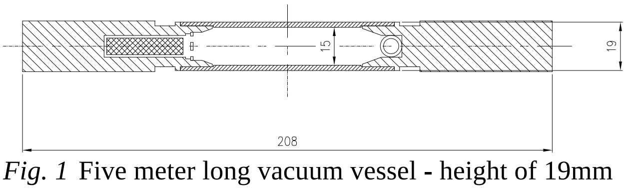



*Fig. 1* Five meter long vacuum vessel - height of 19mm

## 2 DESCRIPTION OF AN INSERTION DEVICE VESSEL

A first prototype vessel was designed at the beginning of 1995 and installed on the machine in March 1995.

*Synchrotron radiation power distribution received by the ID vessel*

E = 6 GeV
I = 200mA
B dipole = 0.86T
Number of photons received by the chamber = $1.7.10^{17}$ ph/s
Critical energy $E_{ph}c$ = 20.52keV
Total photon power received by the 5m long vessel = 560W

*Characteristics of the geometry of the vessel*

The vessel is made of 316LN stainless steel, 5 meters long 65mm wide and 15mm in height - ***Figure 2***. The cooling system is inserted inside one of the two bars which compose the vacuum vessel. Two sheets, 2mm thick are electron beam welded to the side profiles.
To minimise the desorption compared to a 19mm vessel with distributed pumping it was necessary to have a very simple geometry.

i.e.
- elimination of the NEG ante-chamber,
- moving the cooling system to the outside,
- reducing the overlaps for welding.

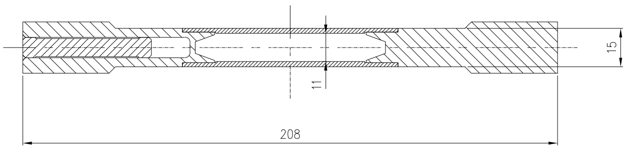



*Fig. 2* Insertion device vessel - height of 15mm

## 3 CLEANING PROCESS

### 3.1 Cleaning

At the ESRF, we apply the CERN cleaning procedure for stainless steel.

### 3.2 Vacuum firing - **Figure 3**

The vacuum firing of the chamber was carried out at CERN applying their bakeout techniques. This firing effectively removed most of hydrogen from the metal and partly CO and $CO_2$.

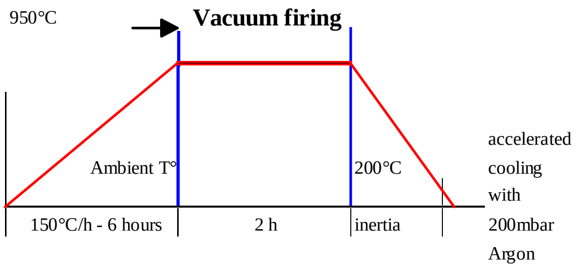



*Fig. 3* Vacuum firing cycle

## *3.3 Laboratory bakeout at 400°C - **Figure 4***

Bellows and connecting chambers are baked at 300°C while the ID chamber is baked at 400°C. The ion pumps situated at the extremities of the chamber are also conditioned.

The aim is to eliminate as much of the occluded gases (CO and $CO_2$) as possible from the first layers of the metal to minimise desorption when the chamber is bombarded with photons.

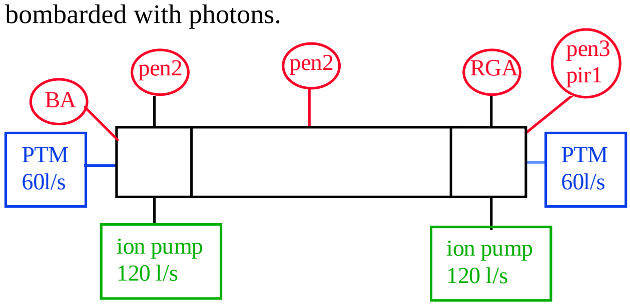



*Fig. 4* Laboratory bakeout at 400°C

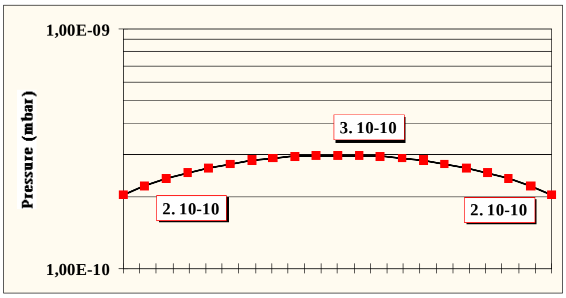
## *3.4 In situ bakeout at 400°C*

A last phase of conditioning at 400°C of the vessel was carried out after mounting the vessel on the storage ring. The aim was to obtain the same pressure distribution as in the laboratory. It is necessary to bake the upstream and downstream vessels at 300°C to minimise desorption which could lead to the contamination of the specially treated undulator vessel. To prevent this, a 120 l/s ion pump was added as a barrier at each end of the undulator vessel.

# 4 EVALUATION OF THE PRESSURE DISTRIBUTION

## *4.1 Evaluation in the static range*

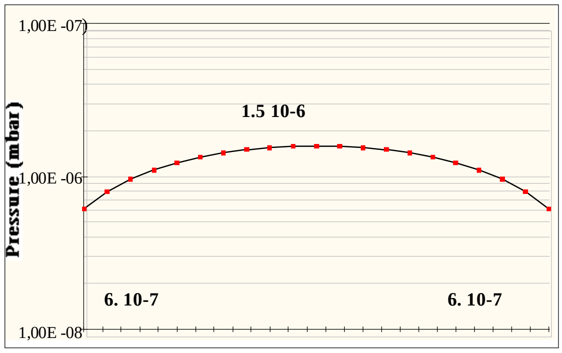
$\alpha = 1.10^{-10}$ Pams$^{-1}$ = $1.10^{-13}$ mbar.l.s$^{-1}$ cm$^{-2}$




## *4.2 Evaluation in the dynamic range*

Number of photon on the chamber : $1.7.10^{17}$ ph/s

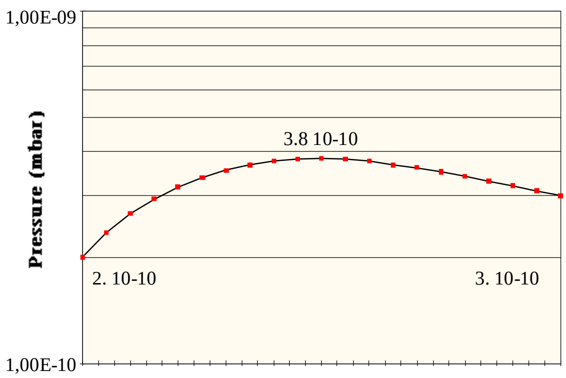
H2 = $1.5.10^{-3}$ mol/ph
CO = $5.10^{-4}$ mol/ph
$CO_2$ = $1.5.10^{-4}$ mol/ph
Ch4 = $7.10^{-4}$ mol/ph
Total gas flow $1.8.10^{-5}$ mbar.l.s$^{-1}$
Therefore $\alpha = 2.3.10^{-9}$ mbar.l.s$^{-1}$




# 5 RESULTS

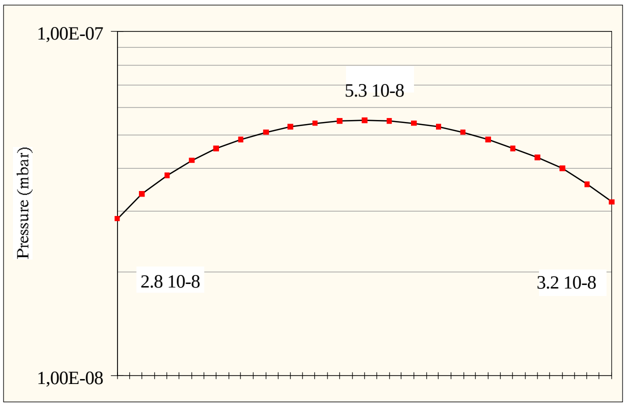
Pressure was measured at three points on the vessel prototype : two at each extremity and one in the middle of the vessel. For the standard vessels inserted in the magnets it is only possible to make measurements at the extremities.

## *5.1 Results in laboratory*




Results obtained in laboratory correspond to the evaluation made.

## *5.2 Results on the storage ring*




Measurements of pressure distributions are given without beam conditioning. ***Figure 5*** shows consequences of this conditioning. Results obtained with the above mentioned processes can certainly be improved, in this case, the oxygen and hydrogen levels in the metal have to be reduced.

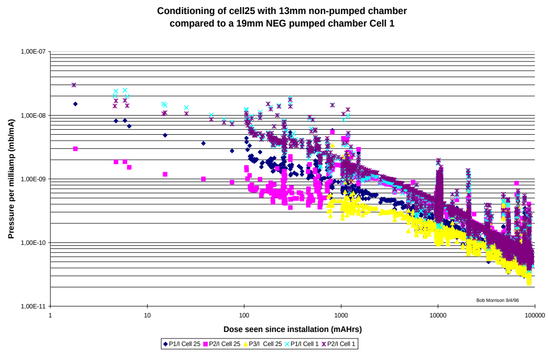



*Fig. 5* Conditioning on the ID vessels

## 6 COMPARATIVE STUDY BETWEEN A CHAMBER WITH DISTRIBUTED PUMPING, A CHAMBER WITHOUT PUMPING AND A CHAMBER WITH SEVERAL LUMPED PUMPS

The conditioning is very similar between these three chambers - ***Figure 6***.

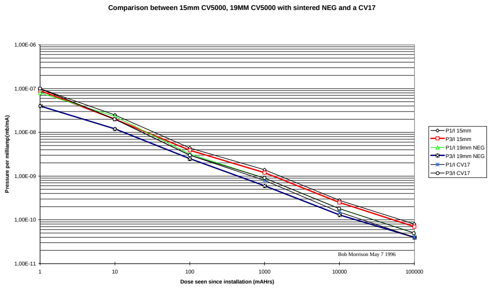



*Fig. 6* Pressures on 15mm and 19mm ID vessels

## 7 BREMSSTRAHLUNG

A gas analysis after one month of beam conditioning gave the following partial pressures with a total pressure of $3.7.10^{-9}$ mbar.

| | | |
|---|---|---|
| $H_2$ | = 94,9 % | ➩ $3.51.10^{-9}$ mbar |
| CH4 | = 1 % | ➩ $3.7.10^{-11}$ mbar |
| CO | = 4 | ➩ $1.48.10^{-10}$ mbar |
| $CO_2$ | = 0,1 % | ➩ $5.18.10^{-12}$ mbar |

A follow-up of the Bremsstrahlung dose produced by a newly installed 15mm ID vessel devoid of pumping was made in May 1996. The Bremsstrahlung measured dose follows very well the decay of the pressure measured at both extremities of the ID vessel corresponding to the conditioning of the vessel. On the first day, the Bremsstrahlung dose was 50msv/hr (measure taken in the beam axis behind a lead wall of a thickness of 15mm). In the hutch, the dose was 10msv/hr. After twenty days of conditioning, the dose was reduced to 4msv/hr. In the hutch, the dose was similar to the noise level.

This means that the integrated pressure between input and output of the 5 meter long vessel is indeed proportional to the pressure indicated by the vacuum gauges located at both extremities.

## 8 CONCLUSION

It is quite possible to place vacuum vessels without pumping on a machine at certain precise locations where it is not possible to fit pumps. It is a question of optimising the desorption of the vessel and to pay attention to the desorption the the neighbouring vessels. Soon the brilliance of the ESRF will be increased. The gaps of the undulator vessels will be reduced. Work is already going ahead on a prototype vessel with a height of 8mm and 5 meter in length. These new chambers will be without pumping.

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