# NEW DEVELOPMENT OF UNDULATOR VESSELS AT E.S.R.F

N.Rouvière, I.P.N, R&D-Accelerators, Orsay, France
On behalf of the Vacuum Group from ESRF


*Abstract*

Seventeen 15mm high 5 meter long Undulator Vessels without any distributed pumps have been installed on the ESRF Storage Ring.

Further requests by the Beamlines Users to increase the x-ray beam energy and brilliance resulted in a new design of a 10mm high vessel.

This paper describes the results obtained with several prototype chambers installed and tested on the Storage Ring:
-10mm high 2 meter long stainless steel
-10mm high 2 meter long copper plated stainless steel
-10mm high 5 meter long copper plated stainless steel

All of them gave very good results provided some precautions were taken.


## 1 INTRODUCTION

The European Synchrotron Radiation Facility produces x-rays beams essentially from Undulators.

In March 1995 a 15mm high 5 meter long stainless steel Undulator vessel without any distributed pump was produced and tested on the Storage Ring.

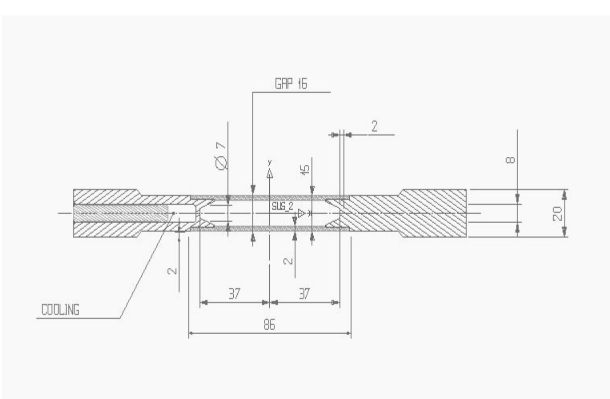


Fig.1

Since then, 17 such chambers have been mounted on the Storage Ring. The pressure measured at each extremity of the chamber is $5.0E^{-9}$ mbar for a stored beam of 200 mA.

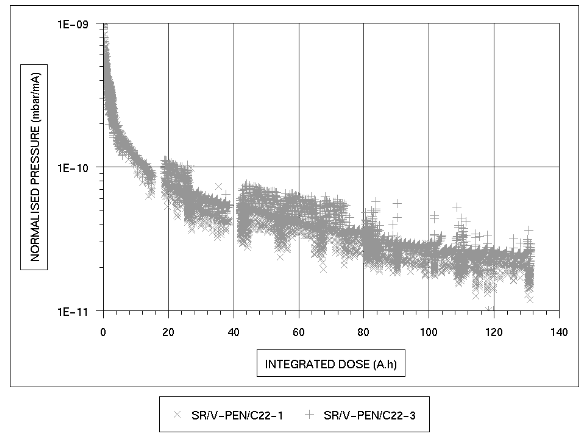


Fig.2

Recent requirements for further reducing the Undulator gap led to the study of a new design of Undulator chambers with reduced height.

## 2 10mm HIGH 2 METER LONG PROTOTYPE CHAMBER

The prototype is made of two 316 LN lateral bars, one of which includes the cooling circuit. Two 1mm thick 316LN sheets are electron beam welded to the bars in order to close the vacuum volume that will be inserted into the Undulator gap.

The necessary mechanical stiffness of the chamber is provided by a stainless steel **U** structure welded to the chamber outside the Undulator section. This **U** piece is also used to align the chamber.

However, the stainless steel material used for the construction has a too high resistivity for an acceptable value of the chamber impedance, therefore a second prototype has been fabricated using 60µ copper plated stainless steel sheets.

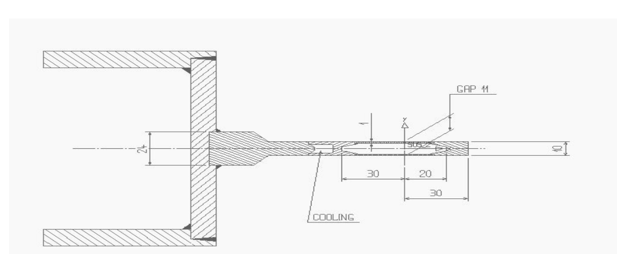


Fig.3

## 3 PREPARATION OF THE CHAMBER IN THE LABORATORY

Cleaning process: according to the CERN procedure.

Vacuum firing: Vacuum firing at 950°C for 2 hours at $1.0E^{-6}$ mbar is made at CERN either on the finished stainless steel chamber or on the raw material in the case of the copper plated chamber.

Bake out in the laboratory: bake out at 400°C for 2 weeks for the Undulator vessel, the Upstream and downstream vessels are baked at 300°C.

In situ bake out: after installation on the Storage Ring, the chamber is baked at 150°C for one week.

## 4 BEAM CONDITIONING OF THE 10mm HIGH 2 METER LONG STAINLESS STEEL PROTOTYPE

Fig.4 shows beam conditioning obtained on the stainless steel vessel:

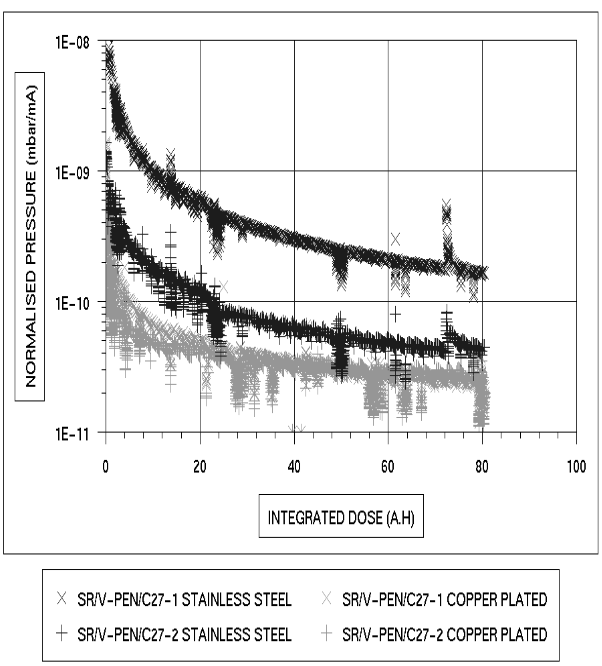


Fig.4

After 30 A.hours of beam conditioning the total normalised pressure is $9.0E^{-11}$ mbar/mA.
The gas analysis shows:

| | | |
|---|---|---|
| $H_2$ | = | 67.7% |
| $CH_4$ | = | 5% |
| $H_2O$ | = | 1% |
| CO | = | 19.3% |
| $CO_2$ | = | 7% |

## 5 BEAM CONDITIONING OF THE 10mm HIGH 2 METER LONG COPPER PLATED STAINLESS STEEL PROTOTYPE

Fig.4 also shows beam conditioning obtained with the copper plated stainless steel vessel. The vacuum conditioning is more rapid than with the stainless steel prototype. After 30 A.hours of beam conditioning the total normalised pressure is $3.4E^{-11}$ mbar/mA.
The gas analysis shows:

| | | |
|---|---|---|
| $H_2$ | = | 91% |
| $CH_4$ | = | 0.7% |
| $H_2O$ | = | 0.1% |
| CO | = | 8% |
| $CO_2$ | = | 0.2% |

The copper plated layer has a pumping effect on $CH_4$, CO, $CO_2$.

## 6 BEAM CONDITIONING OF THE 10mm HIGH 5 METER LONG COPPER PLATED STAINLESS STEEL PROTOTYPE

Fig.5 shows beam conditioning obtained with a 200 mA stored beam.

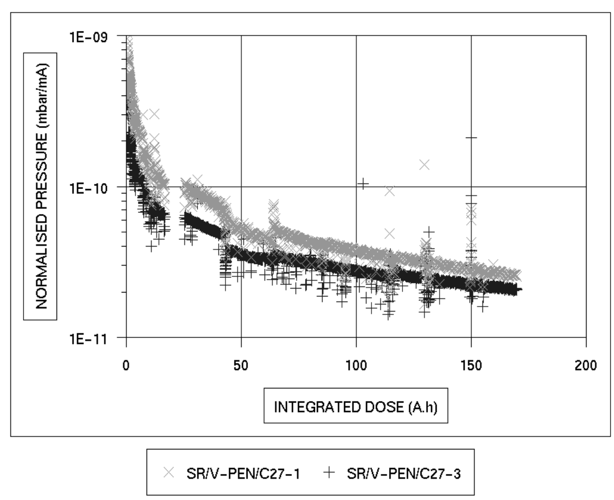


Fig.5

After 30 A.hours of beam conditioning the total normalised pressure is $7.0E^{-11}$ mbar/mA.
The gas analysis shows:

| | | |
|---|---|---|
| $H_2$ | = | 89% |
| $CH_4$ | = | 0.8% |
| $H_2O$ | = | 0.6% |
| CO | = | 9.4% |
| $CO_2$ | = | 0.2% |

In addition, on this 5 meter copper plated vessel the reduction of CO and $CO_2$ partial pressure is confirmed.

## 7 DISCUSSION

Although the Undulator chamber height has been reduced from 15mm to 10mm the vacuum performances are equivalent. Since July 1997, four of these 10mm vessels have been installed on the Storage Ring. The conditioning at 400°C in the laboratory is, for the time, being indispensable.

However, the in-situ bake out at 400°C on the Storage Ring produces unacceptable mechanical deformation, therefore the in-situ bake out temperature is limited at 150°C to remove water pressure. The difference on conditioning at 150°C compared with 400°C in situ bakeout is shown on figure 6.

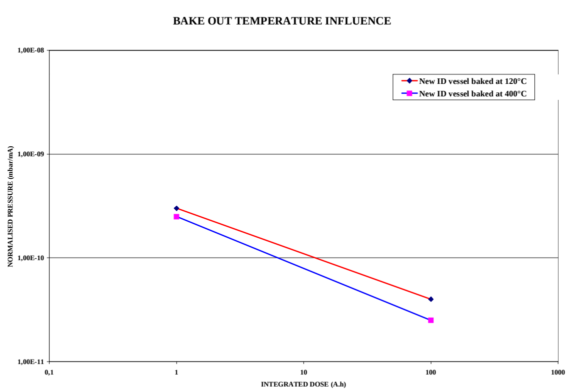


Fig. 6

Beam conditioning has a memory effect: after venting, a beam conditioned chamber will condition faster than a new chamber: see figure 7.

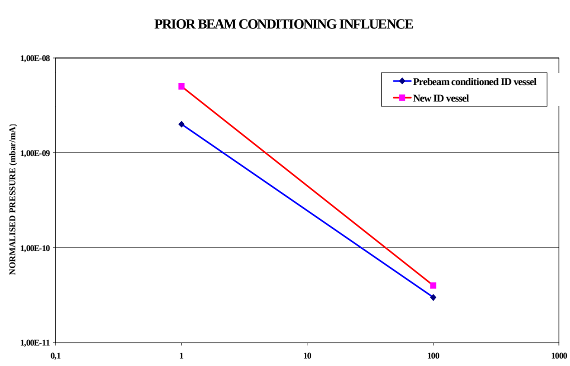


Fig. 7

## 8 PHOTO DESORPTION EXPERIMENT

At the E.S.R.F an experimental set-up has just been commissioned in order to measure $\eta$, the number of molecules produced per photon:

### 8.1 In static

Calculation of the distributed pressure [1]:

$P_l = P_o + 7.97E^{-4}.\alpha.(l^2.L^2/K'.\sigma^2)$ ($N_2$ equivalent)

With $P_l$=limit pressure; $P_o$=Pump pressure; $\alpha$=outgasing rate ($Pa.m.s^{-1}$); $Q=3.04E^{-10}$ $Pa.m^3.s^{-1}$; L=length; K'=1.29; $\sigma$=section ($m^2$); $P_l=P_o+3.74E^{-7}$ Pa; l=perimeter; $\sigma$=section ($m^2$)

$Pl=Po+3.74E^{-7}$ Pa

$Q = 3.04E^{-10}$ $Pa.m^3.s^{-1}$

$\alpha = 1.65E^{-9}$ $Pa.m.s^{-1}$

### 8.2 In dynamic with the first beam (80 mA) [2]

$\eta = (\Delta P.C)/N$ With $\Delta P$= (mbar)

C = conductance (l/s)

$N = 2.5E^{16}$ Photons

$\eta = 5.7E^{-5}$ mol/photon

$\eta$ $H_2$ = $5.4E^{-5}$ mol/photon

$\eta$ CO = $2.8E^{-6}$ mol/photon

$\eta$ $CH_4$= $1.0E^{-6}$ mol/photon

$\eta$ $H_2O$= $1.0E^{-8}$ mol/photon

$\eta$ $CO_2$= $1.3E^{-8}$ mol/photon

## 9 CONCLUSION

A conditioning with several A.h has to be performed on this chamber (photo desorption experiment).

The 10mm high 5 meter long Undulator vessel has a more difficult technology than the 15mm high chamber: this is due to the **U** reinforcing structure which makes the chamber cross-section strongly asymmetrical.

The electron beam welding of the copper plated sheets on the lateral bars require precautions.

The copper plated layer however present important advantages:

- low resistivity and good heat transfer for R.F.currents,
- integrated pumping.

The systematic decreasing of the chamber material outgassing is a key goal.

Our goal is to optimise the chamber preparation operation and possibility reduce the bake out temperature in the laboratory, while obtaining reduced partial pressures of CO and $CO_2$.

## ACKNOWLEDGEMENTS

With special thanks to the CERN/Vacuum Group, the ESRF Drafting office and the ESRF/Vacuum Group.

## REFERENCES

[1] "Répartition de la pression dans une canalisation désorbante, en régime moléculaire", C. Henriot / CEA / LNS / 91191-Gif sur Yvette, France.

[2] "Studies of photon induced gas desorption using Synchrotron Radiation", O. Gröbner, A. Mathewson, H. Störi, P. Strubin / CERN / 1211-Geneva 23-Switzerland.