

IUVSTA WORKSHOP WS-63  
Surface Phenomena Limiting Pressure in Vacuum Systems

REPORT TO IUVSTA

prepared by  
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on behalf of the  
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**INTRODUCTION**

It is well known that walls are active due to the amount of gases adsorbed. All of these gases are in thermal equilibrium between the intake and desorbed gases at the wall temperature. This equilibrium can be altered either by temperature changes or particle interactions with the surface, yielding neutrals, ions and photons. In addition many processes need foreign gases that are deliberately introduced into the system, which can react with hot surfaces e.g. filaments, or surfaces changing the gas composition of the vacuum. So, knowledge of the surface effects limiting pressure in vacuum systems is a matter of great importance.

This topic is of great importance for most of the vacuum systems users and this was the main aim to propose IUVSTA to support this workshop and it was very well considered by the IUVSTA Scientific and Technical Directorate, STD. So, we expect a significant attendance from the involved Divisions. Unfortunately this was not the case and most of participants were out of the IUVSTA frame.

Even though we consider that the workshops completely fulfil the programme of the WS-63 with participants from significant Laboratories involved in performance of vacuum systems and gas composition from surface effects.

**CONTEXT of the WS-63**

The context of the WS-63 was prepared and developed according to the IUVSTA regulations. There were up to 12 invited lecturers to present the updated state of the art in one of the specific topics of the

WS, followed by one and a half hour of discussions or short presentations of questions or matter of interest for the discussions. In this sense and according to comments received, the WS was entirely satisfactory and completely fulfilling the expected goals.

Initially were up to 35 participants but finally 5 of the regret to attend for several reasons.

Final duration of the WS was four days with a total of 29 hours because the four day participants asked to intensify the morning session to have the afternoon of Saturday free.

It is interesting to point out that up to eight participants were also attending the European Vacuum Conference in Salamanca. At this respect the Organisation set up a Bus to move they to Salamanca on the morning of Sunday

## **DEVELOPMENT**

The final programme was presented in 12 sessions devoted to the following topics and days:

### **WEDNESDAY, September 15**

SESSION 1: General introduction to the WS by R. Reid

Two aspects were considered, in the first part the context of the IUVSTA and the STD programme of workshops were developed. In the second part the context of the WS was analysed and the goals of the WS were presented.

Discussion and short presentations:

There was a wide discussions and interventions about the problems related with the surface phenomena in vacuum systems and limitations in experiments and processes.

SESSION 2 The influence of several methods of pumping affects the composition of the gas in vacuum systems presented by J.M. Jimenez of CERN.

He presented the main limitation on the residual gases that can be expected from the available commercial pumps through his experience in the vacuum systems at CERN.

Discussion and short presentations:

A wide discussion related with performance of several types of pumps was set up by several participants. Problems related with

turbomolecular pumps and gas contamination. Main questions were promoted by R. Reid, M. Leisch, Cox and Valizadeh among others. There was also a short presentation on Outgassing from Sputter ion pumps by A. Bonucci, SAES Getters. Italy.

**SESSION 3:** This was a session presenting a novelty regarding outgassing in vacuum systems by mutual friction by moving parts by R. Nevshupa of ICMM-CSIC.

This was a very interesting presentation about the influence of outgassing by moving parts in vacuum systems, especially in spatial research, processed in vacuum such as nanotechnology, microelectronics and in the field of hard coatings.

Discussion and short presentations:

Several questions about this matter were set up with some more interest in the possible uses of the friction as a tool to measure the absorbed gases in solid and thin films. With respect to this E. Barriozabal from TEKNIKER, an industrial association in Spain, presented problems related with systems for vacuum deposition.

**FINAL PANEL**

At the end of the day the Chairpersons of the sessions J. L. de Segovia, E. Berriozabal, V. Baglin and L-H Wu summarised the main points of the lecturer and session's discussion

**THURSDAY, September 16**

**SESSION 4** This session was focused on the surface treatments to reduce outgassing rates in vacuum systems. A lecture by I. Arakawa, Japan, was presented. He presented the ozonate water process as a cleaning process to reduce outgassing and electron stimulated desorption yields in large vacuum systems, especially those devoted to large accelerators.

Discussion and short presentations:

Interesting questions were discussed by those participants in the field of large vacuum systems. J. Jimenez, CERN, P. Strubing, CERN, J. A. Ferreira, CIEMAT, Spain, Fusion systems, and C. Baglin, among others participants.

SESSION 5      A lecture on “gas reduction arising from particle interactions in Large Collider” was presented by V. Baglin, CERN.

He focused the lecture on the interaction of beam particles with vacuum systems as a point of the challenging interest to reduce gas load and to avoid particle stimulated molecular desorption as well as secondary electron emission yield.

Discussion and short presentations:

Several questions were introduced by M. Cox in his short presentation about the source of gases in storage rings. He pointed out the importance of the materials and components thermal treatments in or ex situ to reduce outgassing.

Other important observations were set up by M. Leisch. R. Reid and Ch. Cheng

A short presentation on Effects of Electrical and Electromagnetical perturbations on pressure measurements in particle accelerators was presented by P. Strubin, CERN, CH.

SESSION 6      This session was devoted to the Measurement of total and partial pressures in vacuum systems. A lecture on problems related with the calibration of gauges for ultra high vacuum was presented by L. Peksa, Chalmers University of Prague.

He discussed the several methods to calibrate gauges at very low pressure: Orifice flow and dynamic extension.

Discussion and short presentations:

P. Hedbany, Carles University Prague, presented short contribution on “Dybnamic extension” a new method to calibrate gauges in the UHV range.

and Accurtely Vacuum measurement in different regimes J. Sobrado, INTA, Spain

An intense discussion was started with this matter. Many interventions related with the measurement of pressure either by gauges or mass spectrometers in research laboratory and industries were discussed. The lack of reproducibility of measurements due to the fact that laboratories do not calibrate their gauges and spectrometers was the main criticism.

## FINAL PANEL

Sessions Chairmen, J. Sobrado, INTA, Spain, J. Gómez-Goñi, Polytechnical University of

Madrid, Spain, summarised the main points of the discussion:

What the uncertainty at  $10^{-10}$  mbar?

What has for calibration  $N_2$  versus  $H_2$ ?

What would be the demand of calibration at UHV?

What about pressure fluctuations at low pressures?

The final conclusion was: to encourage IUVSTA-STD to recommend research laboratories to calibrate gauges and other instrument to avoid the lack of reproducibility in measurements.

## FRIDAY, September 17

SESSION 7 This session was related with "Gassing in Vacuum Systems". M. Leish, Graz Technical University, presented a lecture on "Hydrogen outgassing".

He focused on stainless steel because of the main construction material in vacuum systems. He discussed about the two method of outgassing rates: Diffusion limited model (DLM) and the recombination limited Model (RLM). The main conclusion is that the recombination strongly depends on the atomic structure of the surface. AFM and STM techniques has been used to study the phenomena.

Discussion and short presentations:

A wide discussion was started mainly by those attendees related with the large vacuum systems: V. Baglin, CERN, P. Strubin, CERN. M. Cox, Diamond, UK. Several suggestions were discussed about how  $H_2$  can be reduced. In this line there was a short contribution by L-H Wu, National Synchrotron Research Centre, Taiwan, on the use of "ceramic Chambers with TiN coatings

A sort presentation by J. Sobrado, INTA. Spain on Accurately Vacuum measurement in different regimes was discussed.

SESSION 8 This was a continuation of session 7 on Gassing in Vacuum Systems focussed on "Hydrogen in Vacuum

Sysystems” lecture presented by T. Tanabe, NUCL. Kyushu-U, Japan. He discussed the influence of surface contamination on the system surfaces yielding other products such as CH<sub>4</sub> and H<sub>2</sub>O. He pointed out that at present time not too many studies has been related with hydrogen at practical surfaces jointly with subsurface regions.

Discussion and short presentations:

Discussions were continued with many questions related with what kind of materials and how new materials can benefit the hydrogen reduction.

**SESSION 9** This session continued with problems related with outgassing in vacuum systems. A lecture on “Nonthermal desorption process in the experimental study of physisorption systems: effects and applications” was presented by I. Arakawa, Gakushuin University, Japan. He focused the presentation on pumping characteristics of cryopumps. Studied the layer growth and the structure of rare gas films physisorbed on metal surfaces. Isothermal adsorption of physisorbed hydrogen. Adsorption of Helium on porous adsorbents.

Discussion and short presentations:

There was a interesting discussion about the cryosurfaces and its behaviour for evaporable materials.

There was also a short presentation on Achieving Ultra-high Vacuum without Bakeout. By M. Cox , Harwell Science and Innovation Campus. UK

## **FINAL PANEL**

Sessions Chairmen T. Tanabe, Japan, P. Strubin, CH, M. Leisch, Austria and M. Cox, UK, chaired the panel for final discussion of the Friday sessions. The main conclusion hydrogen was that can be reduced by the development of new surface treatments and the use of evaporation of active materials such as getters but this topic will be discussed in the Saturday session. The role of cryosurfaces was also discussed.

## **SATURDAY, September 18**

Saturday sessions were devoted to “Getters in Vacuum Systems” with the following presentations.

**SESSION 10** A lecture was presented on “Optimization of non evaporable getter coating and surface conditioning for accelerator beam pipe” by O. Malyshev from STFC Daresbury Laboratory. UK. He discussed the role of non-evaporable getter (NEG) coating related with the lower activation temperature lower desorption yield in combination with higher sticking probability and pumping capacity would be very beneficial. Thin NEG films of various single element Ti, V, Zr and Hf to quaternary alloy were investigated in terms of thermal activation temperatures.

**SESSION 11** A lecture on the “Impact of first wall conditioning methods on vacuum aspects in fusion devices” was presented by Jose A. Ferreira, CIEMAT, Spain. He discussed the advances in the plasma generator TJ-II, where several kinds of wall conditioning techniques have been traditionally used, including He Glow discharges under metallic walls, boronization and, recently, lithiation. All these techniques produced some impact on residual gas composition and outgassing rates. In this presentation these changes will be documented and discussed in the frame of physical and chemical elemental processes limiting the ultimate level of vacuum that can be achieved under hot plasma operation.

**SESSION 12** The last lecture was devoted to NEG with a presentation on Outgas of Methane from NEG coating, by Chia-Mu Cheng, from the National Synchrotron Radiation Research Center (NSRRC), Taiwan. He presented quantitative measurements of gas evolution from Zr-V NEG. The main gas evolution contain Methane and Krypton, depending on coating conditions and history. He gives evidence that the main source of methane is in the NEG.

Discussion and short presentations:

The main conclusion in these sessions is that in large vacuum systems the use of "in situ" NEG are the most useful technique to reduce hydrogen pressure in the system.

## **CONCLUSIONS**

### FINAL CLOSING REMARKS

This session was chaired by R. Reid, IUVSTA General Secretary, and M. Leisch, Graz Technical University and IUVSTA-VS Division Chairman. They summarized the main discussions and new knowledge in the discussion and presentations on surface phenomena related with the nature of the residual vacuum and limiting ultimate pressure.

Problems of outgassing of H<sub>2</sub> were very well presented and the concentration in vacuum systems was focused on the wall treatments, including NEG, presence of foreign elements and structure of the material.

The measurements of vacuum and gauges calibration were well presented and uncertainties in the UHV region were shown to be in 10% of measurements. It was pointed out the lack of reproducibility of measurements in research laboratories and industries. It is recommending to the IUVSTA-STD and Divisions the convenience of calibration of the instruments, especially vacuum gauges and mass spectrometers.

It is noticeable the increasing studies on gas evolution by mutual friction of moving parts in vacuum as a positive source of gas. At this respect, the presentation of a new non destructive method to determine gas contains in solids and thin films by friction was very interesting.

The behaviour of NEG and its uses in vacuum systems was also a very interesting contribution to the knowledge of the state of the art.

A final conclusion was that the presentations will be in the ASEVA web page accessible.

# PICTURES

