

## A STUDY OF VACUUM PRESSURE IN TPS CELLS

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### Abstract

TPS cells have been recently installed and pumped into a vacuum status. The pumping down curves of the unit cells, including R01 (type 1); R07, R10, R11, R14, R15, R18, R19 (types 2 and 3); R04 (type 4), were recorded individually on site after welding on site and after assembly without leakage. For the R01 cell the pumping down curve after assembly without leakage is a little below that after welding on site, but the pumping curve of other cells after assembly without leakage is a little above that after welding on site. In those cells except R01, the pumping down curves after assembly of all vacuum components and pumps are similar. The slope of the pumping curve near 1 h in the R01 cell is -1.98, whereas about -1.39 on average for the other cells. The vacuum in the R01 cell is hence apparently improved. The aluminum vacuum chambers were proved to be cleaned with the same process and the assembly of components was similar. The photon stopper chambers were all pre-baked to 300 °C for the same duration. For the superior performance of vacuum in the R01 cell, we infer that one of the bending chambers was pre-baked at 150 °C for 24 h and the photon stopper chambers were cleaned with ozonized water.

### INTRODUCTION

In this report about the evacuated cells of the electron-storage ring of Taiwan Photon Source (TPS), the vacuum system of TPS of circumference 518.4 m is designed on consideration of these four factors: 1) Two aluminum (Al) bending chambers and two straight Al chamber are connected to a 14- m cell to simplify the ultrahigh vacuum (UHV) structure. 2) Vacuum pumps of great speed are assembled in the antechamber and near the absorbers to increase the pumping efficiency. 3) Absorbers are located optimally remote from the light source to diminish the heat load and the photon-stimulated desorption. 4) The flanges and bellows are optimally few to diminish the impedance of the beam duct [1]. In TPS cells, the chamber is made of aluminum alloy because of its properties of large thermal conductivity, absence of magnetism, small residual radioactivity, and ease of machining [2]. For the cell vacuum system of TPS, our group members [3] simulated the pressure distribution based on consideration of two major gas loads -- thermal desorption and photon- stimulated desorption [4-5]. Taiwan Photon Source (TPS) consists of 24 cells, of types 1, 2, 3 and 4. The design of types 2 and 3 is the same. The cells of four types are assembled with aluminum vacuum chambers, beam-position monitors,

gate valves, photon stopper chambers, ion pumps, NEG pumps etc. Despite unit cells of varied type, varied chamber length and slightly varied design, the chamber manufacture and assembly of components is almost the same. The pumping down curves after assembly without leakage are hence comparable for these cells.

### EXPERIMENTS

One cell chamber includes two straight chambers (S3, S4) and two bending chambers (B1, B2). The straight chamber is made of extruded aluminum alloy and subjected to a serial process of chemical cleaning. After the bending chamber is shaped by CNC machining and cleaned with ozonized water, it is welded from two halves of Al plates by the TIG method. According to preceding work [6], ozonized water effectively removes residual carbon on the surface of aluminum alloys, and the rate of thermal outgassing decreases to  $\sim 5 \times 10^{-15}$  Torr L s<sup>-1</sup> cm<sup>-2</sup> after baking. Before the four Al chambers are welded on site to compose a unit cell, the deformation and the alignment of the chamber are checked to be less than 0.3 μm. After one cell is welded on site, the vacuum components and pumps are installed in the clean room to control the dust and the humidity to diminish the rate of outgassing from the surface in the chamber. The photon stopper chambers are all pre-baked to 300 °C for the same duration before assembly to a unit cell. Four sets of turbomolecular pumps (70 L.s<sup>-1</sup>, Varian, V70) and dry pumps (Adixen, Drytel 1025) were installed for evacuation. A pumping cart, equipped with a residual gas analysis (RGA) to record the spectrum and a gauge of wide range to record the pressure, was additionally attached to a unit cell. In this paper, the pressure, recorded as the pumping down curve, is from the wide range gauge.

### RESULTS AND DISCUSSION

Figure 1 indicates the pumping down curves of the unit cells, including R01 (type 1); R07, R10, R11, R14, R15, R18, R19 (types 2 and 3); R04 (type 4), are recorded individually after assembly without leakage. In those cells except R01, the pumping down curve after assembly of all vacuum components and pumps is similar. For R01 cell, the pumping curve after assembly without leakage was observed to be a little below that after welding on site, but for other cells, the pumping down curve after assembly without leakage is a little above that after welding on site. The superior performance of the pressure in the R01 cell was observed.

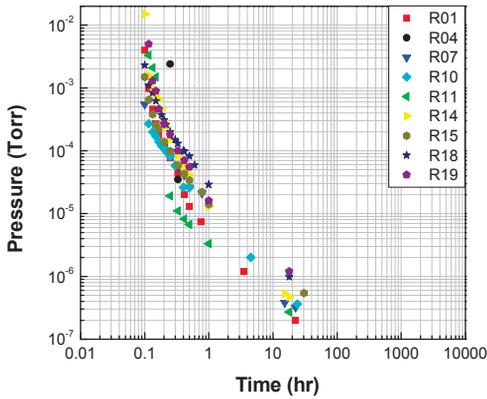


Figure 1: Pumping curves of unit cells.

The slope of the pumping down curve near 1 h and the pressure after pumping for 10 h in those cells are listed in Table 1. The slope of the pumping down curve near 1 h in the R01 cell is -1.98, whereas that for other cells is -1.39 on average. The pressure after pumping for 10 h in R01 cell is less than those in almost all other cells. Hence the vacuum pressure in the R01 cell is apparently improved.

As the pressure in the R01 cell is obviously better than for other cells, we investigated the reasons. First, Al chambers are known to have been cleaned with the same process and the assembly components are similar. Second, the photon stopper chambers were all pre-baked to 300 °C for the same time. Third, the assembly sequence and methods all followed the same standard operational procedure and verification lists. Of some different points for the R01 cell, one bending chambers (B1) was pre-baked at 150 °C for 24 hour before welding the exit ports for electron and photon. The pressure of this B1 chamber at 25 °C achieved  $\sim 4 \times 10^{-10}$  torr after baking. Cleaning with ozonized water effectively decreases the outgassing rate and improves the final pressure for the stainless-steel chamber. The photon stopper chamber, made of stainless steel, was cleaned with ozonized water, followed by the original cleaning process. After this overall cleaning, the photon stopper chambers were promptly installed in the R01 cell. Next, we analyzed the RGA spectra of the R01 and other cells.

Figure 2 shows the RGA spectrum of the R01 cell. Comparison with the spectra of other cells indicated that there were no obviously disparate signals. We guess that the RGA, equipped in the pumping cart, was not directly attached to the port in the unit cell, and the pressure is about  $\sim 1 \times 10^{-5}$  torr before the end of the pumping system, read from the extractor gauge in the unit cell. The RGA spectrum is too insensitive to diagnose the dissimilarity.

Table 1: Slope of the Pumping Curve near 1 h and the Pressure/torr in Unit Cells after Pumping for 10 h

Unit Cell	Slope	Pressure
R01	-1.98	$3 \times 10^{-7}$
R04	-1.40	$2 \times 10^{-7}$
R07	-1.40	$7 \times 10^{-7}$
R10	-1.39	$7 \times 10^{-7}$
R11	-1.52	$5 \times 10^{-7}$
R14	-1.44	$8 \times 10^{-7}$
R15	-1.33	$8 \times 10^{-7}$
R18	-1.33	$2 \times 10^{-6}$
R19	-1.27	$2 \times 10^{-6}$

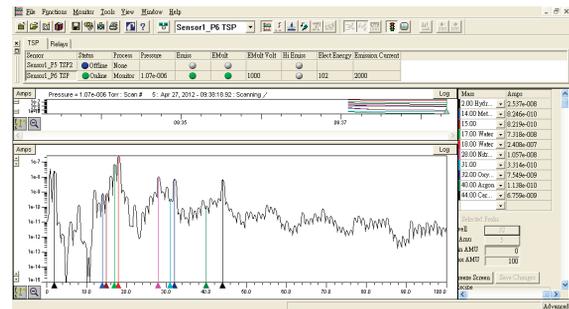


Figure 2: RGA spectrum in cell R01.

To assess the effect of cleaning with ozonized water on the photon stopper chamber, we compared the pumping down curves vs. time for pumping at 25 °C, 24 h baking at 300 °C, and after baking. Figure 3 shows the pumping down curves vs. time with the treatment of ozonized water cleaning. The gradient of the pressure versus pumping duration near 1 h is proportional to  $t^{-1.41}$  for the photon stopper chamber after cleaning treatment with ozonized water, steeper than without that treatment. Besides, the final pressure in the photon stopper chamber was  $1.78 \times 10^{-10}$  torr after cleaning with ozonized water, better than without that treatment. Cleaning the photon-stopper chamber with ozonized water indeed improves the outgassing rate of the chamber.

Finally, because the unit cell was transported to the safekeeping area after assembly without leakage, baking did not proceed. Only cell R03 had baking on the supports of the girders. Figure 4 indicates the pumping curve vs. time during pumping at 25 °C, 24 h baking at 150 °C, and after baking in the R03 cell. The slope of the pumping curve near 1 h for cell R03 is -1.36. The final pressure in cell R03 was about  $5 \times 10^{-11}$  torr.

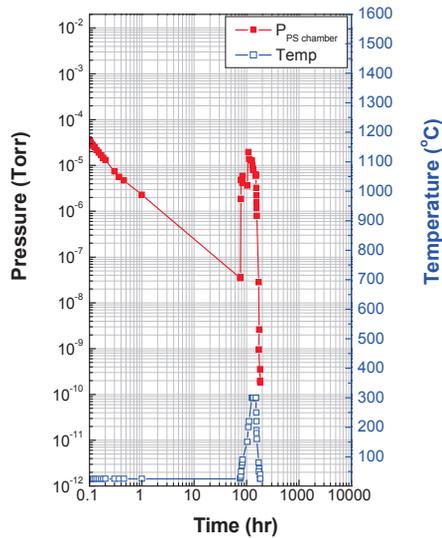


Figure 3: Photon stopper chamber pumping curves vs. time after cleaning with ozonized water.

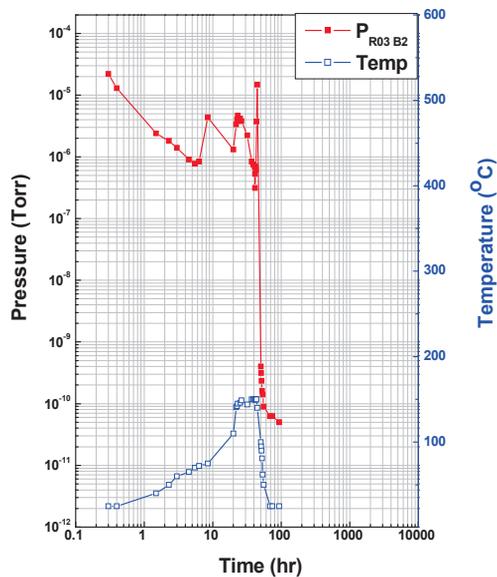


Figure 4: Pumping curves for cell R03 vs time.

## CONCLUSION

For the superior presentation of pressure in cell R01, we suggest that one of the bending chambers had been pre-baked at 150 °C for 24 h and the photon stopper chambers were cleaned with ozonized water. The knowledge of the pressure in TPS unit cells will help analysis and examination of the final pressure after baking in the future.

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