CONSTRUCTION STATUS OF THE TPS VACUUM SYSTEMS

G. Y. Hsiung#, H. P. Hsueh, Y. T. Huang, C. M. Cheng, Y. C. Yang, C. K. Chan, L. H. Wu, C. H. Chang, C. S. Huang, S. W. Chang, T. Y. Lee, Y. P. Chang, Z. W. Chen, Y. T. Cheng, S. N. Hsu, C. C. Chang, C. L. Chen, NSRRC, Hsinchu, Taiwan
J. R. Chen, NSRRC & National Tsing Hua University, Hsinchu, Taiwan

Abstract

The vacuum systems for the 3 GeV Taiwan Photon Source (TPS) have been constructed since 2010. Most of the vacuum components and equipment have been manufactured and delivered. For the electron storage ring (SR), all the 24 cells of 14 m aluminium vacuum systems have been welded and assembled. The vacuum baking for the cells in the laboratory was undergoing to achieve the ultrahigh vacuum pressure below 1×10^{-8} Pa. The vacuum systems accommodated with the insertion devices in the long straight sections have been designed and under manufacturing. For the booster (BR), all the stainless steel chambers including the 0.7 mm elliptical chambers, BPM ducts, and the pumping chambers, have been manufactured. The two transport lines: LTB for Linac to BR and BTS for BR to SR were manufactured. Vacuum chambers for BTS adopt the similar chambers for BR but will be baked to ultrahigh vacuum for connecting with SR without injection window. The beam ducts for LTB will be made of aluminium alloys. The construction works for TPS vacuum systems will be completed in 2013 while the installation of the systems in the TPS tunnel will be started immediately.

INTRODUCTION

The concept of the vacuum design for the 3 GeV Taiwan Photon Source (TPS) is to achieve the lower impedance of mechanical structure as well as the lower surface outgassing rate for the beam ducts and vacuum components [1]. A prototype of one unit cell of 14 m vacuum system for TPS had been manufactured and tested [2] which proved the technical specifications of most of the critical components. And the construction of the vacuum systems has started since 2010 [3]. Most of the vacuum components and equipment have been manufactured and delivered. For the electron storage ring (SR), all the 24 cells of 14 m aluminum vacuum systems have been welded and assembled. The ex-situ vacuum baking for the cells in the laboratory is ongoing for inspecting if the ultrahigh vacuum pressure less than 3×10^{-8} Pa without leakage is achievable. The vacuum systems accommodated with the insertion devices in the long straight sections have been designed and under manufacturing. For the booster (BR), a section of prototype vacuum system has been assembled and baking tested. All the vacuum chambers and vacuum equipments have been delivered. The status of the construction works for TPS vacuum systems will be described.

#hsiung@nsrrc.org.tw

MANUFACTURING FOR THE 14 M CELL VACUUM SYSTEMS

Manufacturing for the 24 sets 14 m arc-cell vacuum systems has been completed in the period of June 2010 ~ Oct. 2012. All the aluminium bending chambers including 3 types (24×B1;18×B2,6×B8) each have completed the oil-free CNC machining in clean room, ozonized water cleaning, TIG welding via hand and automatic control in clean room. The short aluminium straight chambers two types (24×S3; 24×S4) made from the aluminium extrusion, each have completed the chemical cleaning and the TIG welding in clean room. Afterwards, a unit cell of vacuum system composed of S3-B1-S4-B2 chambers is installed on the pre-aligned girder supports and welded on-site to form one piece of vacuum segment. Each step of welding has passed the leak-checked. Then assemble the cell with the BPM flanges, valves, pumps, gauges, et al, and then pump down, leak-check, and vacuum-sealed. The assembly work for the cell vacuum systems in clean room is shown in Fig. 1. Each of the cell vacuum systems were lifted with a carrier hanging system moved to the pre-aligned supports in the storage area, as shown in Fig.2.

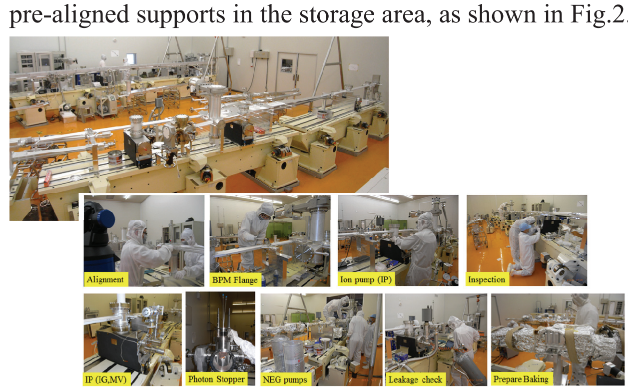


Figure 1: Assembly work for the cell vacuum systems.

Figure 2: Storage of the cell vacuum systems.

VACUUM BAKING FOR 24 CELLS VACUUM SYSTEMS

The ex-situ baking for the 24 cells were performed mostly in the storage area rather than on the girders. The preparations of the baking and the results after baking are described in the following sections.

Preparations of the Baking

Prior to the vacuum baking, each cell has to install the crotch absorbers, photon stoppers, BPM flanges, and the rf-bridge between the flanges of the sector gate valve (SGV) and the beam duct, as illustrated in Fig. 3. The whole system is wrapped with the heating tapes uniformly distributed and covered with the aluminum foils and the kapton foils for uniform baking at 150 °C for 24 hours, as the assembly shown in Fig. 4. The system were cooled down after fully degassing all the extractor ionization gauges, ion pumps, residual gas analyser, and activating all the non-evaporable getter pumps.

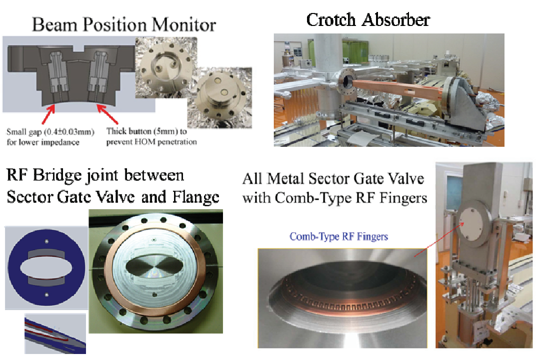


Figure 3: Installation of the critical parts for the cells prior to vacuum baking.

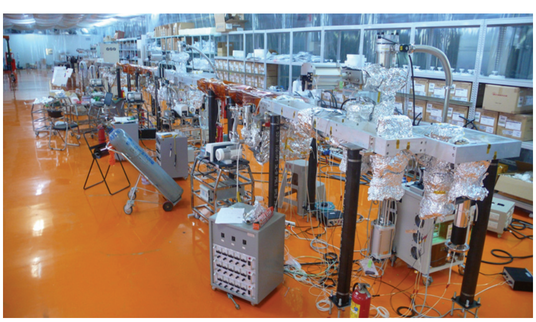


Figure 4: Preparation of the vacuum baking for one cell.

Results after Baking

Vacuum baking for more than 75% of the cells have been completed. Most of the cells have reached to the ultimate pressure less than 5×10^{-9} Pa after baking. The typical pumping down curve is shown in Fig. 5, denoted the pressure changes (a) before baking, (b) during baking, (c) degas and activation, (d) after baking. When the cell passed the leak-check after baking, all the ion pumps were turned off and the mechanical pumps were isolated with the valves. The whole cell vacuum system was sealed in vacuum. The pressure in the valve-sealed system arose to about 4×10^{-7} Pa typically over a weekend. It is noted that only the NEG pumps are functioned for pumping the H_2 and CO in the sealed vacuum system. Then the remaining residual gases in the system contain the argon (Ar^+:[40],[36]) dominantly following by the methane (CH_4^+:[16],[15],[14]) as shown in Fig. 6.

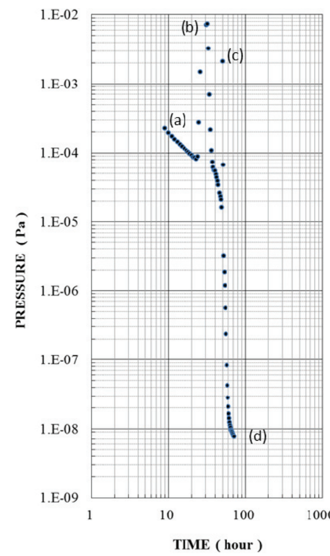


Figure 5: Typical pumping down curve for a cell through the vacuum baking.

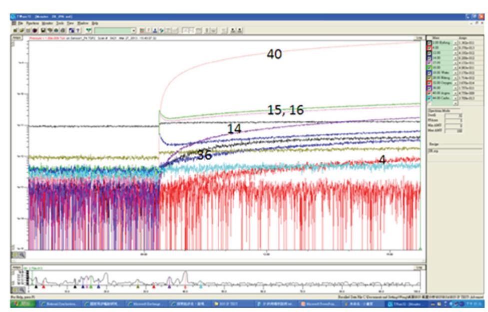


Figure 6: Pressure rise of the residual gas in a valve-sealed cell vacuum system after baking.

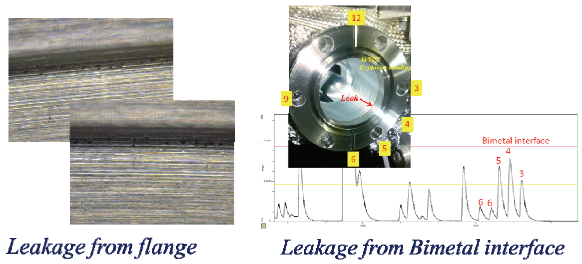
Though the ultimate pressure for most of the cells had reached to the ultra-high vacuum after baking, there were several kinds of problems major the leakage occurred on some vacuum components which should be replaced and the cell should be baked again. The identified leakages are categorized as follows:

- BPM: Brazing joint in feedthrough (6 events).
- BPM: Diamond edge shape gasket [4] (15 events).
- Al/SUS explosive bonding flanges: knife edge or bimetal interface (10 events).
- Ion Gauge: feedthrough (2 events).
- Metal angle valve: unsealed (2 events).
- Brazing joint of Crotch absorber [5]: (1 event).

There are about 40% of the baked cells had to solve the leakage problems and performed more baking for twice or

ISBN 978-3-95450-122-9

more than three times. Figure 7 illustrates (a) the example of the leakage from the small holes penetrated through the knife edge and (b) to identify the location of leak on the bimetal interface of the explosive bonded flange.



(a) (b)

Figure 7: Leakage finding on the bimetal flanges.

CONCLUSION

The 24 sets of 14 m arc-cell vacuum systems have been assembled. More than 75% of the cells were ex-situ baked to the ultrahigh vacuum at pressure less than 5×10^{-9} Pa. However, there are about 40% of cells have baked more than once due to leakages. The leakage problems are from the insufficient brazing joint on the feedthrough of BPM and Ion Gauge, and cooling tubes of Crotch absorber; potential defects or holes on the interface or knife edges of the Al/SUS explosive bonding flanges; and the loss of sealing on the metal angle valves. All the damaged parts were replaced. Manufacturing of the vacuum chambers for the long straight sections of storage ring and for the booster are on-going. The construction works for TPS vacuum systems will be completed in 2013 while the installation of the systems in the TPS tunnel will be started immediately.

ACKNOWLEDGMENT

The authors thank to the colleagues of TPS vacuum group for the great collaboration on the team works for the vacuum assembling and the preparation of vacuum baking.

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