DEVELOPMENT OF NEW TRANSPORT LINE (TL-1) FOR INDUS FACILITY

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Abstract

Transport Line–1 (TL-1) is a part of pre-injector system of Synchrotron Radiation Sources Indus-1 and Indus-2. In order to insert more number of diagnostic devices, especially Beam Slit Monitors for observing the beam position at various locations on TL-1, and to study the angular divergence etc., one new UHV system for TL-1 was designed and developed.

Total length of TL-1 is ~13.6 metres. This line transports the electron beam from the Microtron to the Booster Synchrotron. TL-1 comprises of Stainless Steel (SS grade: AISI 316) chambers, with ports for pumps, gauges, bellows for mechanical flexibility, isolation valves, and different Beam Diagnostic Devices like Beam Slit Monitors (BSM), Beam Profile Monitors (BPM), Secondary Emission Wire Monitors (SEWM) and Fast Current Transformers (FCT).

All the associated UHV components were fabricated and qualified for UHV, individually in the UHV Lab. Vacuum in the range of 10^{-9}-10^{-8} mbar was achieved. Ultimately all the components, (including the Beam Diagnostic Devices), are assembled in a mock assembly as per their original positions and tested. The aim of this exercise is to resolve the various unforeseen minor problems, in assembly, well in advance, so that the final assembly in actual position can be completed within minimum time period, (minimum down period of Indus facility), with more efficiency.

This paper describes the testing procedures and the results of this exercise.

INTRODUCTION

To improve the electron beam current in the Booster, it was decided to “qualify” the electron beam, before getting injected into the Booster. For this purpose, it was decided to insert more number of diagnostic devices, especially BSM-s, in TL-1. Since the modifications had to be done at various locations, vacuum system of TL-1 was redesigned and developed. The vacuum chambers, pumps and gauges were developed in UHVT Division and the Beam Diagnostic (BD) devices, in Beam Diagnostic Section and IMA Section. All the components were made of SS grade: AISI 316/304, except for one diagnostic device, Fast Current Transformer (FCT) which was made of high quality Alumina. All the components were tested individually for the vacuum performance, at various levels of fabrication. After ‘vacuum-qualifying’ the components individually, they were assembled in a mock assembly line as per actual positions in TL-1 and were evacuated. New TL-1 is ready to be installed in place of old TL-1.

One pressure profile curve was plotted, considering the pump positions, and approximating the gas loads at various locations.

PARTS OF TL-1

TL-1 comprises of ~13.6 m of nearly straight length (except for a 15° bending chamber), connecting the Microtron to the Booster, and a branching at 45° for using the electron beam in Field Electron Laser (FEL) experiments, which will be assembled at a later stage. This straight part consists of a number of BD Devices, UHV chambers, pumps, gauges, valves, and bellows. The details of the components are listed below.

Beam Diagnostic Components

BSM, BPM, SEWM and FCT are the diagnostic devices used in TL-1. All of these, except FCT are made of SS grade: AISI 316/304, and FCT is made of high purity Alumina.

Vacuum components

Sputter Ion Pumps (SIP) (7 no, total, including one for FEL line), are the main vacuum pumps and Penning Ionisation Gauges (PIG) (2 no) are the vacuum gauges.

Three ports (including one for FEL Line) are provided for roughing, leak detection, and pumping during baking. Turbo Molecular pumps (TMP), through UHV isolation valves, are used for roughing and pumping during baking. Helium Mass Spectrometer Leak Detector was used for leak detection.

Table 1: Main Components in TL-1

Component	**Quantity**
BSM	5+1 (FEL)
BPM	4
FCT	2
SEWM	2
Bellows	11
Gate valves	4
SIP	1 (140 l/s -FEL) + 4(70 l/s) + 1(35 l/s)
PIG	2
SS pipes	11 + 2 (15 ° and 45 ° bent-chambers)

EXPERIMENTAL DETAILS

Construction specifications vary from component to component and so the baking restrictions also change. In BSM-s, diaphragm-bellows are used for actuating the

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linear-motion-feedthrough-s for the slit-blade movements. These bellows restrict the baking at those parts. Similarly, FCT-s are made of high purity Alumina, with brazing to the SS flanges, and so these parts should be baked at low and uniform temperature with extreme care. They were not baked, during these vacuum tests. All the SIP-s, vacuum chambers and other SS parts were baked at ~200 - 250 °C for ~24 hrs.

The general procedure of vacuum tests was:

- After fabrication, the parts were cleaned chemically and ultrasonically.
- Then they were subjected to the leak testing of the welds. (≤10-^{10} mbar l/s).
- After qualifying the leak-test, the components were assembled in the UHV test set-up, which consists of an SIP, Bayard Alpert Gauge (BAG), and a TMP through a UHV isolation valve.
- The set up was tested for leaks of the demountable joints.
- After qualifying the leak-test, the system was pumped by TMP for ~8 hrs.
- Baking was done using flexible heating tapes. At first, Aluminium foils were wrapped over the system, uniformly. Heaters were wound over that. Again Aluminium foil was wrapped over these heaters. These processes were done to make the baking as uniform as possible. The heating was done through variac-s, to control the temperatures at various components, individually. The temperature was ramped at a rate of ~50 °C per hour.
- Baking was done for ~24 hours. During the cooling cycle, SIP was flashed, and BAG was degassed. After the SIP running at full voltage (~6 kV), and the UHV isolation valve getting sufficiently cooled, the system was left on SIP pumping for ~48 hrs and the ultimate vacuum was noted down.

Vacuum simulation of TL-1.

An approximate vacuum profile in TL-1, was computed by approximating the outgassing rates of various components and the effective pumping speeds at various positions. Specific outgassing rate of 10^{-11} (mbar-l/s-cm^2) was assumed for the SS parts.

RESULTS AND DISCUSSION

In the mock assembly, an ultimate vacuum ~4 *10^{-8} mbar was achieved without baking. To avoid the repeated bakings of critical diagnostic components, it was decided not to bake the lines, at present, but to keep them under vacuum, on SIP-s. These will be kept under vacuum till the final assembly in the actual position of TL-1, is permitted.

In the pressure profile simulated, the maximum pressure was 4 x 10^{-8} mbar, and it was on the BSM near the Booster. This was due to the dimensional restrictions.

The components are vacuum qualified, and the final assembly is over. FCT chambers are not connected in the mock-up assembly, due to its delicate construction (ceramic part).

Table 2: Vacuum test results

Component	Temp. constraints	Vacuum (mbar)
BSM	80 °C (bellows)	(4-7) x 10^{-9}
BPM	150 °C (Al screen)	(4-7) x 10^{-10}
FCT	Unbaked (Ceramic)	~1 x 10^{-9}
SEWM	90 °C (Epoxy)	~3 x 10^{-8}
Chambers	200 °C	(3-6) x 10^{-9}

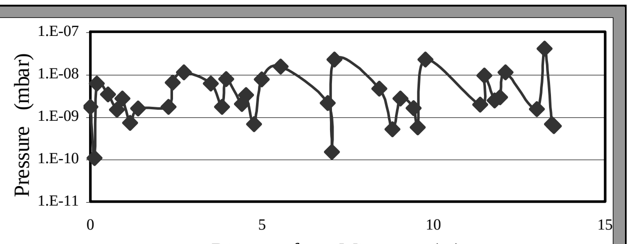

Fig-1. Pressure simulation of new TL-1

Fig -2. Mock assembly of new TL-1.

CONCLUSIONS

There were many modifications/ changes incorporated in the new TL-1, by adding more diagnostic devices. Since the physical length had to be kept the same as the existing TL-1, lot of stringent conditions had to be applied. The number of pumps, gauges and valves, and their positions are kept almost the same. Thorough vacuum qualification, and the mock assembly of the total line was mandatory, before setting it in actual position. The mock-up assembly is over, and we have solved the problems, well in advance. Now the final assembly in actual position can be done, systematically, more efficiently, with minimum time period, resulting in minimum off-period of Indus-1 and Indus-2.

ACKNOWLEDGEMENTS

The authors are thankful to all the colleagues in UHVTD, RRCAT, specially Sri. Netram, Sri. Paramsivam and Sri. Kulkarni, for their respective contributions. Special thanks are due to our colleagues in Beam Diagnostics Section and IMA Section, RRCAT, for their efforts and co-operation in assembling and testing the diagnostic devices.