STATUS REPORT OF THE SLS STORAGE RING VACUUM SYSTEM: EXPERIENCE AFTER TWO YEARS OF OPERATION

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The SLS vacuum system has accumulated a total beam dose of 2840 Ah during the first years of operation. The improvement of the dynamic pressure which was observed during the commissioning phase was continued.

INTRODUCTION

The SLS storage ring vacuum system consists of a 288 m long stainless steel UHV system with a full antechamber design. Synchrotron radiation hits only on discrete photon absorbers which are made of OFHC copper. In total 150 photon absorbers are distributed over the circumference of the ring. To achieve the required pressure of less than 10^{-9} mbar with full beam, sputter ion pumps with a total pumping speed of 42000 l/s are installed close to the photon absorbers, the main source of photon stimulated desorption.

For the vacuum conditioning of the vacuum vessels an external bake-out system was used. All vacuum chambers for the magnet sections were baked in a bake-out oven at a temperature of 250°C and installed afterwards into the storage ring under vacuum [1]. The adjacent straight sections were then evacuated and baked in the tunnel with a movable and modular bake-out oven.

DYNAMIC PRESSURE

The total vacuum pressure of the SSL storage ring is monitored with cold cathode gauges. Two gauges are installed in each vacuum section of the 12 magnet arcs. The 12 straight sections are equipped with one or two gauges. The readings of all gauges are used for the calculation of the average pressure [2].

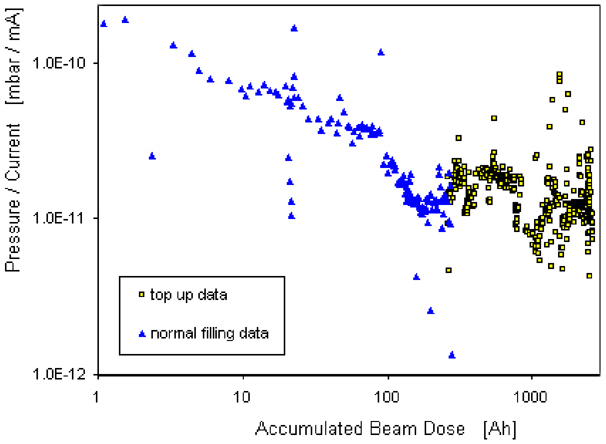

Fig. 1: Dynamic pressure p/t [mbar/mA] as a function of accumulated beam dose [Ah].

Fig. 1 shows the evolution of the dynamic pressure p/I as a function of the accumulated beam dose. The data are taken from the start of commissioning in 2001 to the end of 2003. During this time period a total beam dose of 2840 Ah was accumulated.

There is a little discontinuity in the graph which is caused by a different analysis of the data. The first data series (indicated with normal filling data) from 1 Ah to 240 Ah (taken in the year 2001) are calculated with a fit of the archived data. In this fit the gradient of the pressure versus beam current is calculated during the beam current decay where the machine was operated in the normal filling mode. During the second series from 240 Ah to 2840 Ah the machine was operated most of the time in the top-up mode. For that series the dynamic pressure was calculated by a division of the average pressure with the actual beam current during top-up. This calculation neglects the base pressure and leads to higher values.

The decrease of the dynamic pressure as a function of the accumulated beam dose which has the expected slope of -2/3 (in a plot with double logarithmic scale) observed during the commissioning phase was continued also for higher beam doses. The lowest values could be achieved at 1000 Ah with values of about 5.0 10^{-12} mbar/mA. These values correspond to a N_2 equivalent pressure of 4.5 10^{-10} mbar at 400 mA with a typical partial pressure composition of 70 % H_2 and 30 % CO.

However this low value could not be retained over a long period due to partial venting of the machine which was caused by interventions into the vacuum system. These interventions can be classified into two groups: planned interventions, for instance for the installation of new vacuum vessels or vacuum equipment and unplanned interventions caused by accidents.

After an intervention the improvement of the vacuum pressure is stopped and starts again with increasing beam dose from a higher value as before.

INSERTION DEVICES

Five insertion devices have been installed in the SLS by the end of 2003 [3].

Except for the in-vacuum undulator, all insertion device chambers have an antechamber design. The chambers for W61 and UE54 are equipped with NEG strips in the antechamber over the full chamber length and with one sputter ion pump and one NEG cartridge at each chamber end box.

ID	Type of vacuum chamber	vertical aperture	chamber material	pumping system	chamber installed
U24	in vacuum undulator	7 mm	SST	SIP, NEG	Apr-01
UE54	ante chamber APS type	12 mm	AL	SIP, NEG	Jul-03
UE56	ante chamber BESSY type	11 mm	AL	SIP	Jul-01
UE212	antechamber	16 mm	SST	SIP	May-01
W61	ante chamber APS type	5 mm	AL	SIP, NEG	Sep-02

Tab. 1: Insertion device chambers at SLS.

The in-vacuum undulator has two sputter ion pumps with in total 300 l/s and four NEG cartridges with in total 4000 l/s pumping speed.

The vacuum chambers for UE56 and UE212 are equipped with sputter ion pumps at each end box and several sputter ion pumps which are distributed with a distance of about 50 cm along the vacuum chamber.

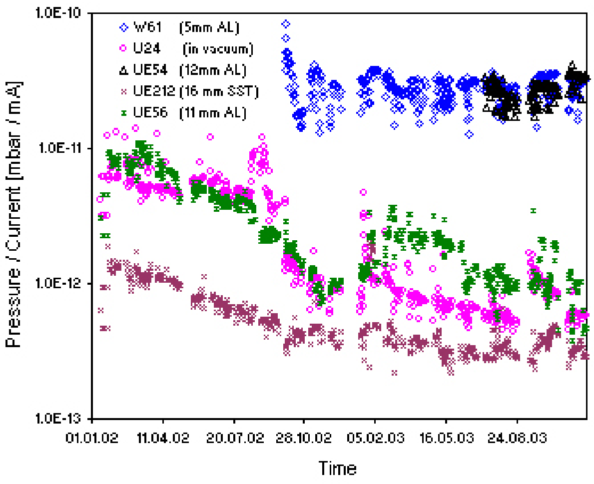

Fig. 2: Dynamic pressure in all five ID chambers during the last two years.

SLS VACUUM SYSTEM INTERVENTIONS

In the past three years we had several interventions with different influence on the average pressure. The interventions can be classified depending on the involved shut-down time into interventions with and without bake-out of the corresponding vacuum vessel.

Interventions without bake-out

When only small vacuum components such as pumps, gauges, valves, photon absorbers, or leaky flange gaskets have to be changed it was in general not necessary to remove the full vacuum sections from the magnet arcs. In those cases the appropriate vacuum section was vented with dry nitrogen which is boiled-off from liquid nitrogen [4].

The change of the vacuum component is then done under a nitrogen atmosphere. Before the corresponding flange connection is opened the area is covered with a plastic bag. Also the part which has to be changed and all tools, gaskets, and screws are placed inside the plastic bag. The bag is also equipped with two rubber gloves and one DN 20 KF port. All remaining openings at the plastic bag are closed with adhesive tape as tight as possible. The bag is then connected to a roughing pump, evacuated, and let up with nitrogen.

Now the screws of the flange connection can be opened, the vacuum component changed, and the flange connection closed again under the nitrogen atmosphere.

Typically one or two days are needed until machine operation can start again. Beam lifetimes of about 10 hours are back after one week of operation.

Interventions with bake-out

When complete vacuum chambers had to be changed on a vacuum section in general the whole vacuum section was usually removed from the corresponding magnet arc. The vacuum section was then transported into the vacuum hutch. After finishing modifications the vacuum section was baked at 250°C in the bake-out oven and installed into the ring under evacuated conditions. The adjacent straight sections were afterwards connected to the gate valve at each end of the vacuum section. The straights were then evacuated and baked in situ with the mobile oven system.

The total time which is involved in that procedure including the opening and closing of the magnets is typically seven to ten days.

CONCLUSIONS

The concept of working without an in situ bake-out system for the SLS vacuum system was successful. The exchange of vacuum components under a nitrogen atmosphere can save shut-down time. In the future it is also planned to test the replacement of vacuum chambers in an arc section under nitrogen atmosphere without removing the full section.

REFERENCES

[1] L. Schulz et al., *SLS Vacuum System*, PSI Scientific Report 2000, VII

[2] L. Schulz, A. Streun, *Vacuum Conditioning and Lifetime Improvement,* PSI Scientific Report 2001, VII

[3] G. Ingold, T. Schmidt, *Insertion Devices: First Experiences,* PSI Scientific Report 2001, VII

[4] R. Reid, *Procedures for Venting and Pumping down Vacuum Systems on the SRS Machine Complex,* CLRC Daresbury Laboratory DL/UHV/05/95 Aug. 1995