UPGRADE OF THE ESRF VACUUM SYSTEM

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Abstract

In respect of the accelerator vacuum system the upgrade program of the ESRF concerns in terms mainly the insertion device (ID) sectors. Here the available length for the production of synchrotron light is being increased from five to six or even seven meters. The presence of canted ID sectors where two independent synchrotron light beams will be produced in the same straight section requires new quadrupole chambers compatible with the new geometry. A number of long insertion device vacuum chambers for the new ID sectors has already been produced by ESRF and coated with non-evaporable getter (NEG) material, a new generation in-vacuum undulators for the extended ID sections are under preparation.

This paper outlines the status of the vacuum system upgrade and the ESRF NEG coating activities. Recent improvements of the vacuum measurement and control system are also reported.

SCOPE OF THE UPGRADE

In 2008 the ESRF Council approved the launching of phase 1 of an upgrade program for the years 2009 to 2015. The program mainly consists of construction of new experimental stations (beamlines) as well as the refurbishing of some existing beamlines. In order to increase photon flux and brilliance for these upgrade beamline projects, or to allow the creation of a second source point of synchrotron radiation (SR) from a single ID sector, some of these sectors need to be lengthened [1,2]. New Radio Frequency (RF) cavities and transmitters will be installed; an overview of the light source upgrade is given in [3]. Due to budget constraints appearing in 2010 the foreseen number of ID sector modifications was reduced due to the cancellation or postponing of some of the envisaged beamline upgrade projects.

STATUS OF ID SECTION MODIFICATIONS

For the ESRF Vacuum Group (VG) the main challenge lies in the production, qualification and installation of low gap ID vacuum chambers with a Non-evaporable Getter (NEG) coating [4,5]. The initial intervention to modify the sector includes the installation of new chambers for the shorter focussing / defocusing sectors up- and downstream the low gap chamber and a coated 6.2m long conductance-limited ID chamber. For the final configuration the long ID chambers will be replaced by In Vacuum Undulators (IVU)[6] and shorter ID chambers in some of the straight sections. A part of the projected modifications of the concerned vacuum sectors has been already completed; Table1 shows the status of summer 2011 in a simplified list.

Table 1: ESRF source points for Insertion Device SR

Type	Summer 2011	Planning 2015
5m ID sectors	24	17
6m narrow gap	4	8
6m with IVU	0	2
7m straight	0	1

The projected 7m straight section will receive at the same time source points for two SR beamlines by means of canted IDs and a set of RF cavities

VACUUM UPGRADE PROGRAM

Chambers for longer straight sections

As described in [7] the removal of the focusing quadrupole magnets next to the ID chamber (up- and downstream) from the original lattice design enables the use of a longer ID chamber as the focusing/defocusing sectors will become shorter. The vacuum chambers in these sectors, identified as CV3 and CV15 have a specific conductance of 15.9 l·m/s [8] and are equipped with lumped pumping (2 × 200 l/s SAES St 707 NEG cartridge and 1 × 45 l/s VARIAN Triode Sputtering Ion Pump (SIP) each). In 2009, for a first installation of a lengthened straight section CV3 and CV15 made from extruded aluminium have been used. The lumped pumping was replaced by a TiZrV NEG coating produced at ESRF in DC-Magnetron enhanced Physical Vapour Deposition (PVD). Design considerations like transparency of the chamber for magnetic fields, the availability of a SIP as additional vacuum gauge and speeding up of the conditioning of a modified sector gave priority to the use of chambers made from stainless steel with lumped pumping (1 × 200 l/s St-707 NEG, 1 × 55 l/s SIP) for all 6m extensions. For the 7m straight section NEG-coated CV3 and CV15 stainless steel vacuum vessels without lumped pumping will be used.

Low gap 6m chambers

One of the two NEG coating benches at ESRF [8] has been modified to accommodate chambers up to 6.2m long as needed for the upgrade sections. Eight of these chambers have already been coated at ESRF, one at SAES-Getters Spa, Italy. Starting in 2009, prototypes were tested in the storage ring beam path on the dedicated sector ID30. By looking at the Bremsstrahlung (BS) conditioning which relates to the chamber pressure and photodesorption yield, it was found that for the in-house coating at ESRF improvements were necessary in terms of deposit homogeneity and post-deposition quality control to reach the required level of reproducibility of the chamber quality.

NEG coating and quality control

The production parameters and the quality control for the NEG coating were reviewed and optimized. A semi-automatic winding machine for the production of the intertwisted wire cathodes has been developed. The cathodes are now systematically pre-conditioned in a dedicated preparation vessel by sputtering on Krypton diode plasma. After removal of the oxide layer the cathodes can be installed into the chamber to be coated. The cathodes positioning inside the chamber has been optimized through the use of guiding ceramic spacers. The use of spacers originates an uncoated area due to shadowing and requires that the cathodes are displaced during the PVD process. In addition to an activation test to verify the static limit pressure achieved a systematic X-Ray fluorescence (XRF) scan is done for each chamber. The XRF analysis verifies the presence of the coating by looking at the Zr signal. The procedures of in-situ activation of the installed chamber on the storage ring and initial exposure of the new chamber to the beam have been improved. The systematic pre-qualification of the chambers takes place always in the same sector of the storage ring (ID30). In the connected beamline a special ionisation chamber prepared and operated by the ESRF Safety Group measures the BS data relevant for the approval of the chamber[9]. Figure1 shows the BS conditioning plots for some 6m low gap chambers produced in 2010. The BS generated by the last 6m chambers was lower than the one of the best 5m chambers before the upgrade[10].

In parallel to this reference detector a plastic scintillator has been installed in the ID30 beamline hutch for comparison. By means of a Hamamatsu photosensor module H5784 the fluorescence generates a voltage which indicates the Bremsstrahlung level. As identical detectors can also be installed in a Front End flange as shown in Figure 2 it becomes possible to follow the electron loss / BS data also when the Front End shutter is closed. As these devices can be installed in any sector of the ESRF ring, it allows the follow-up of a chamber after removal from the ID30 pre-conditioning sector and installation on the final destination for a beamline upgrade. Here it gives meaningful results in the first two weeks after the installation of a new chamber, later losses other than BS dominate the signal. In addition to the described measures which are directly linked with the preparation and qualification of low gap chambers for the upgrade the ESRF VG runs a R&D program on the photodesorption bench D31. New coatings or vacuum chamber materials can be tested here without impact on the ESRF stored beam quality [11].

Vacuum control and instrumentation

The upgrade concentrates on the straight sections around the IDs so the large majority of vacuum chambers of the storage ring will remain in place. The chambers made of stainless steel with brazed copper absorbers are especially subject to ageing, so an early detection of vacuum failures is essential.

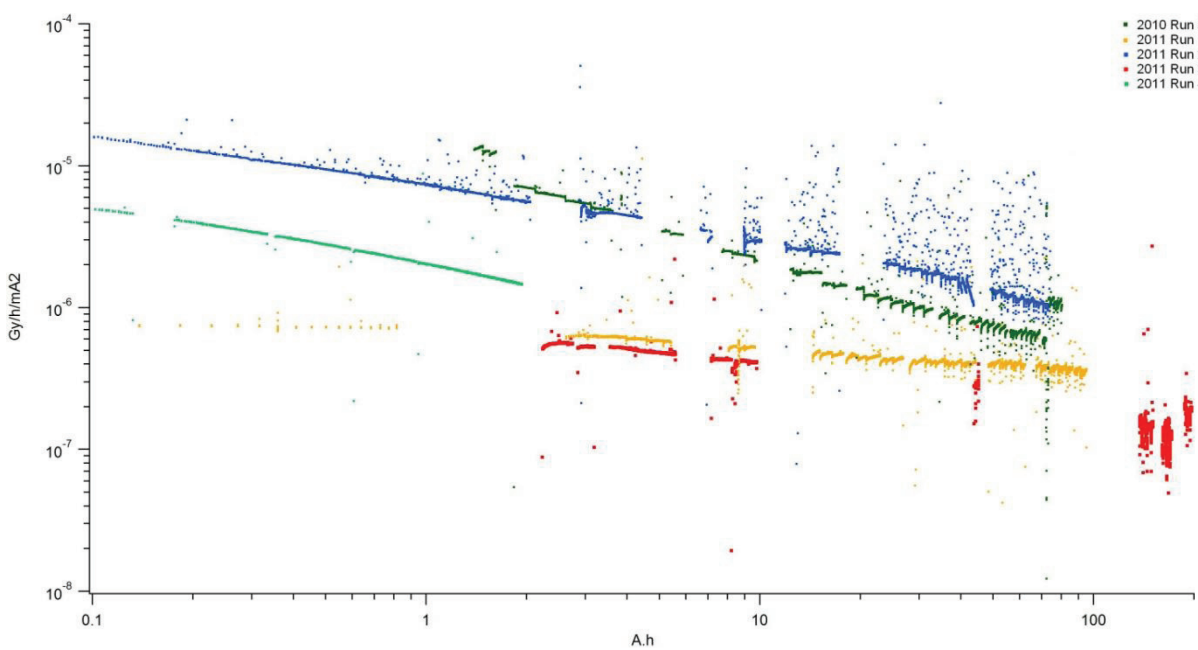

Figure 1: Bremsstrahlung conditioning curves for low gap 6m chambers

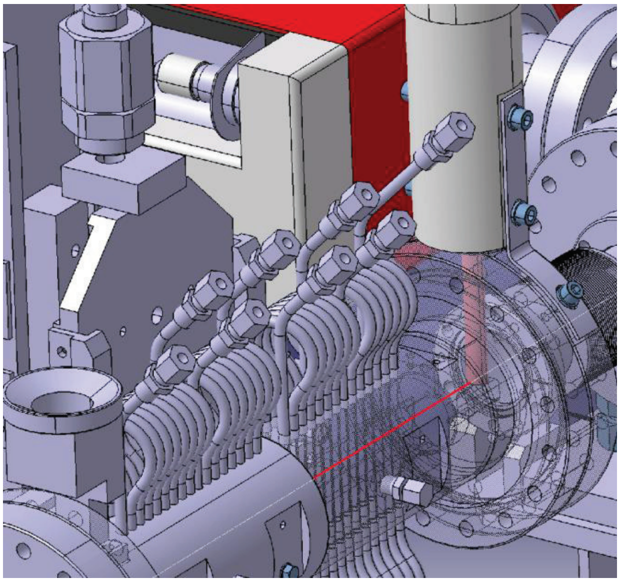

Figure 2: Scintillator inside Front End photon shutter flange

In addition to the existing acquisition and alarm tools for absolute storage ring pressures, temperatures and their derivatives ESRF is developing a Residual Gas Analyzer (RGA) based partial pressure information and alarm application. The RGA spectrum of a sector is compared in real time to the typical pressure signatures of events like air leaks, water leaks or a thermal problem. This application will further improve the preventive maintenance as detection and classification of vacuum problems can be one before they have dramatic consequences on the accelerator operation[12].

Assistance to beamline upgrade

A quality indicator of a synchrotron radiation facility is the availability of the source and the beamlines. The VG assists the beamline engineering teams and proposes to use hardware and software devices and solutions as used on the accelerators. This reduces the time for failure analysis, troubleshooting and maintenance of beamline vacuum. The extension of the Historical Data Acquisition to the beamline vacuum systems will help to trace a vacuum problem back to its origin. With the ESRF Upgrade this becomes more and more important as many beamlines go for the "window-less" design which means that the vacuum system communicates over the Front End with the one of the storage ring.

CONCLUSIONS

The upgrade of the ESRF storage ring vacuum system is in full swing. The technical solutions chosen for the longer low gap ID vacuum chambers and their surroundings have been optimized and successfully tested. The availability of total and partial pressure analysis tools with convenient user interfaces has triggered the development of semi-automatic vacuum acquisition and alarm tools with the objective to maintain the low level of down-time of the facility by early detection and qualification of potential vacuum problems.

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