RE-COMMISSIONING OF THE ESRF STORAGE RING VACUUM SYSTEM

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Abstract

A long accelerator shutdown to allow the construction of new buildings marked the phase one of the ESRF upgrade program. A number of vacuum sectors have been modified during this time for repair and maintenance but mainly to increase the brilliance of the synchrotron radiation beams by installing longer insertion device (ID) vessels with non-evaporable getter (NEG) coating and a new In Vacuum Undulator. The paper gives an overview of the modified machine and reports experience with its re-conditioning.

ACCELERATOR UPGRADE AND BUILDING CONSTRUCTION ACTIVITY

In December 2011, the user operation of the ESRF accelerators was stopped for five months to start the construction of new buildings around the experimental hall which will house new longer synchrotron radiation experimental stations (beamlines) and additional laboratory and office space. About 25000 tons of soil have been removed which created a considerable misalignment of the storage ring. A slab of roller compacted concrete and poured concrete (the so-called "golden slab") has been installed to serve as vibration-damping support for the new experiment stations. These construction activities were incompatible with the operation of the accelerators, also a part of the required services (electricity, cooling water...) were not available. Many of the scheduled vacuum interventions for the storage ring upgrade were scheduled to take place during the long shutdown to profit from the downtime as much as possible [1], [2].

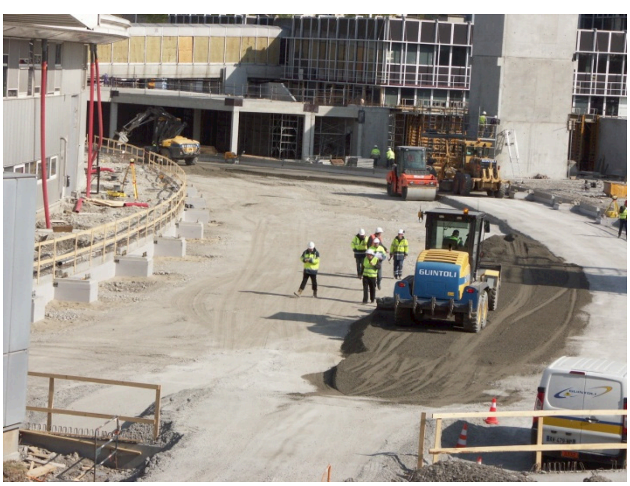

Figure 1: Installation of roll concrete for low vibration floor of synchrotron radiation beamlines end-stations.

LENTHENING OF FOUR INSERTION DEVICE VACUUM SECTIONS

For the lengthening of four ID sections twelve vacuum sectors had to be vented and reconditioned in total: To obtain the additional ID length one magnet of the preceding and of the subsequent sector are suppressed and a shorter vacuum chamber is installed [3], [4].

The four six meter long low gap aluminium vacuum chambers [5] have been coated with NEG in the ESRF coating facility [6]. Each of them had been pre-conditioned already on the storage ring and measured in terms of Bremsstrahlung during one machine run on the dedicated test sector [7].

The additional six meter sectors bring the total number installed to eight. Most of them will remain with the low gap extruded aluminium vacuum chamber to be equipped with up to four in-air insertion devices; few will be modified again by installation of an adapted model of In Vacuum Undulator [8]. Table 1 informs about the principal layout of the 28 ID sectors which are available for the production of synchrotron light.

Table 1: ESRF Insertion Device Sections May 2012

Layout	number
5m narrow gap Al ID chamber	12
6m narrow gap Al ID chamber	8
5m - One In Vacuum Undulator	5
5m – Two In Vacuum Undulators	3

REPAIR AND MAINTENANCE INTERVENTIONS, PROCEDURES

Exchange of Varnished Components

The remaining vacuum chambers which had developed leaks during operation and were temporarily fixed with varnish have been exchanged in the long shutdown. The venting of many of the vacuum sectors has also been used to replace faulty residual gas analyzer heads or cold cathode gauges sensitive to humidity.

Working Procedures

To avoid water vapour condensation on the vacuum surfaces boil-off nitrogen from a Dewar has been used systematically to vent the vacuum sectors. During the work the system is kept under a slight N2 overpressure. All new vacuum chambers have been pre-baked and controlled in terms of residual gas spectrum in laboratory.

For the activation of the NEG-coated chambers and surrounding chambers without coating a sequence oriented on the one used by CERN for the LHC warm sections has been used [9], the objective is to avoid gas load from connected chambers under heating as much as possible for the freshly activated film to obtain a high gettering speed and capacity. As compared to the CERN procedure the proposed activation temperature has been lowered to 190˚C to be compatible with the construction material of the vacuum chamber (aluminium alloy).

VACUUM CONDITIONING

The long accelerator shutdown was divided by the intermediate restart in March into two working periods, as the majority of vacuum interventions took place in the first period the intermediate restart in March was expected to be the more difficult one in terms of initial high dynamic outgassing.

Within three hours of careful ramping of the electron filling of the storage ring while verifying that the observed maximal pressures stayed in the low 10^{-07} mbar range and vacuum conditioning started in all places of interventions it was possible to come very close to the nominal filling of the storage ring in multibunch mode (200mA). At around 190mA one of the five-cell copper RF cavities which had been vented for the exchange of a varnished coupler had a strong resonance producing outgassing, so some time was invested to condition the cavity around this working point.

The new cryogenically cooled In Vacuum Undulator could not be baked because the utilized AlNiCo magnet material is sensitive to demagnetization. All partial pressures of the device dropped quickly after switching on the cryogenic magnet cooling. There was however a remaining peak of H2O which decreased with the first accumulated beam dose during the restart. Eight Ampere-hours of accumulated beam which corresponds approximately to 48 hrs of storage ring operation in multibunch mode decreased the water residual pressure by 55% (measured with the residual gas analyser).

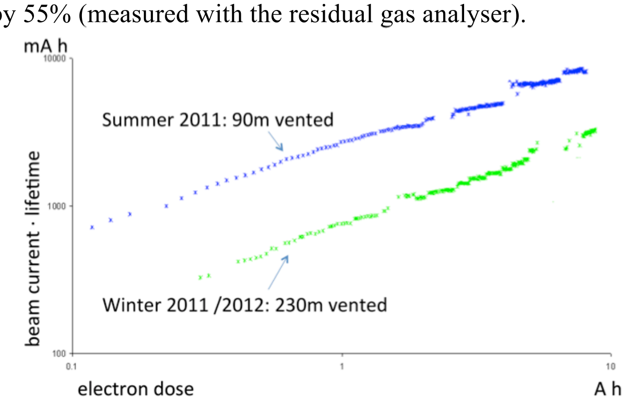

Figure 2: Comparison of the lifetime conditioning with the one observed after a conventional shutdown.

Figure 2 shows the conditioning of the product of electron beam current and beam lifetime after the first working period of the long shutdown where 230 meters had been vented and re-conditioned for interventions. As compared to a shorter usual shutdown where 90 meters have been vented the specific lifetime is lower by a factor 2.5 which correlates with the ratio in of vented accelerator vacuum system length.

CONCLUSIONS AND OUTLOOK

A shutdown of five months has been used intensively to lengthen insertion device sectors of the ESRF storage ring to six meters in order to increase the available length for the production of synchrotron radiation for the user communities. A number of maintenance and repair interventions for example on two of the LEP type RF cavities of the storage ring have been done as well. A second cryogenically cooled In Vacuum Undulator has been installed.

An intermediate restart of the accelerators took place in March 2012 to validate the new and modified installations and to do some beam scrubbing for vacuum conditioning. The restart for user operation in May 2012 after some additional vacuum interventions was smooth as seen from the vacuum. The conditioning of the beam lifetime and the average vacuum pressure followed the same slopes as observed after routine shutdowns.

Some of the longer straight sections will undergo additional modifications; the installation of permanent magnets for canting of the electron beam will allow to produce two independent synchrotron radiation beams from one ID sector. Depending on the canting angle it is necessary to install for two of these sectors new crotch absorbers. In order to avoid that the synchrotron radiation plane intersects cooling tubes of the absorbers which may lead to synchrotron radiation enhanced corrosion their design will be based on a horizontal two blade geometry as it has been successfully tested since few years on one vacuum sector of the storage ring.

A first HOM (High Order Mode) damped single cell cavity prototype [10] has been successfully tested. Two more prototypes will be qualified on the Storage Ring to install them in a later stage in the middle of a seven meter straight section between two canted insertion devices.

The preceding and subsequent focusing/defocusing magnets to go with the seven meter ID sector require a vacuum chamber with a smaller cross-section, there will be no place for lumped vacuum pumps. NEG coating will be deposited at ESRF to provide distributed pumping for these chambers. The assembly of girder, magnets and vacuum chamber will be magnetically measured prior to installation on the storage ring [11].

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REFERENCES

[1] P. Elleaume et al., “Upgrade of the ESRF Accelerator Complex”, EPAC08, Genoa, Italy, WEPC010.
[2] J.L. Revol et al., “Performance and Upgrade of the ESRF Light Source”, IPAC’11, San Sebastian, Spain, THCP009.
[3] M. Hahn et al., “Upgrade of the ESRF Vacuum System”, IPAC11, San Sebastian, Spain, TUPS001.
[4] A. Ropert et al., “Upgrade Plans for the ESRF Storage Ring Lattice”, EPAC’08, Genoa, Italy, WEPC051.
[5] R. Kersevan et al., “Status Report on the Performance of NEG-coated Chambers at ESRF”, EPAC06, Edinburgh, Scotland, TUPCH172.
[6] M. Hahn et al., “Status of NEG Coating at ESRF”, PAC’05, Knoxville, Tennessee, USA, ROAD005.
[7] P. Berkvens et al., “Calculation, Measurement and Analysis of Vacuum Pressure Data and related Bremsstrahlung Levels on Straight Sections of the ESRF”, EPAC’06, Edinburgh, Scotland, TUPCH171.
[8] J. Chavanne et al., “Upgrade of the Insertion Devices at the ESRF”, IPAC10, Kyoto, Japan, WEPD010.
[9] G. Bregliozzi et al., “Achievement and evaluation of the beam vacuum performance of the LHC long straight sections ”, EPAC08, Genoa, Italy, THPP138.
[10] N. Guillotin et al., “Development of HOM damped cavity for the ESRF”, EPAC06, Edinburgh, Scotland, TUPCH099.
[11] G. Lebec et al., “Stretched-wire Measurements of Small Bore Multipole Magnets”, this conference, THPPD001.

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