NEON VENTING OF ACTIVATED NEG BEAM PIPES IN THE CERN LHC LONG STRAIGHT SECTIONS WITHOUT LOSING VACUUM PERFORMANCE

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Abstract

In the CERN Large Hadron Collider (LHC), about 6 km of the UHV Long Straight Section beam pipe (LSS) are at room temperature and serve as experimental or utility insertions. The vacuum of these sectors rely on TiZrV non-evaporable getter (NEG) coating to achieve very low pressure.

In the case of venting to atmosphere, the use of NEG coating implies the bake-out of the vacuum sector to recover the low pressure and reactivate the NEG coating.

A new method to vent a vacuum sector to atmosphere allows performing short interventions without losing completely the performance of the already activated NEG coating. The principle is to over-pressurize the vacuum sector with Ne gas which is not pumped by the NEG coating, remove the faulty component and then pump down the sector again. The injection of such a gas in the vacuum sector aims at preventing the saturation of the NEG coating during the exchange of the component.

A detailed description of this new venting system will be presented and discussed. Preliminary results obtained from a laboratory venting system and its evaluation in the LHC tunnel to replace existing components will be presented.

INTRODUCTION

In the 6 km of the LSS beam vacuum pipes a large use of TiZrV non-evaporable getter coating (NEG) [1] is employed in order to satisfy the vacuum requirements. The final performance of the LSS sectors relies on the activated NEG coating capable to pump most of the gas present in UHV system, *i.e.* H_2, CO, CO_2 and H_2O. The NEG does not pump noble gas and methane; therefore 780 ion pumps uniformly distributed over the entire length of the LSS sectors are used to remove non-getterable gas and prevent pressure instability. In all the LSS sectors, the pressure is monitored by 170 Bayard-Alpert (BA), 442 Pirani and 642 cold cathode Penning gauges [2].

In several occasions, *i.e.* exchange of a leaking stainless steel interconnecting bellow module, damaged RF-shielding (Fig.1) or broken vacuum gauge, it is necessary to perform short mechanical interventions on a sector already activated. Moreover, any of these interventions require the bake-out and the activation of the NEG coating. For any LSS sector an intervention time (mechanical interventions, bake-out equipments installation and NEG activation) of at least 10 days is needed to achieve a pressure lower than 10^{-9} Pa.

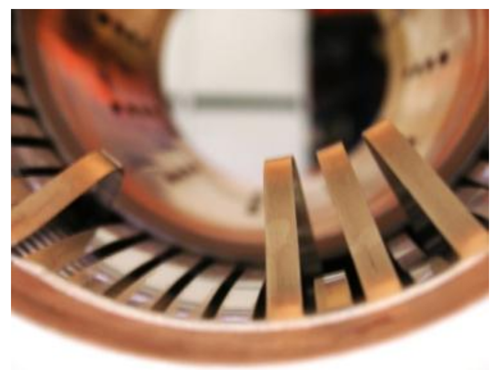

Figure 1: Damaged RF-shielding fingers found on a bellow module installed on a LSS sector.

PRINCIPLE

The developed Ne venting system allows to perform short interventions in less than 5 days on all the LSS sectors, without losing the performance of the already activated NEG coating. The principle is to over-pressurize the vacuum sector with a gas which is not pumped by the NEG, remove the faulty component and then pump down the sector again. The over-pressurisation of such a gas in the vacuum sector preserves the NEG from saturation during the exchange of the faulty component avoiding air back streaming through the beam pipe aperture.

A noble gas, which as mentioned before is not pumped by the NEG, is used for the injection. However, the impurities (~10 ppm) contained in the gas available on the market are already enough to partially saturate the activated NEG, when the injection is carried out at atmospheric pressure. Therefore a purifying stage is used

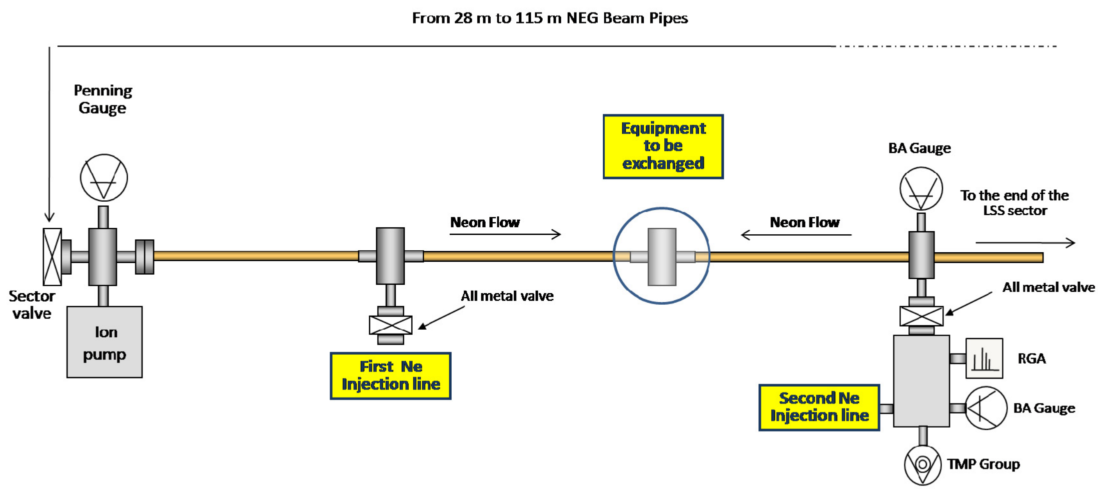

Figure 2: Schematic of a standard configuration with the two Ne injection lines.

to remove the impurities present on the gas prior to over-pressurization of the beam pipes.

Neon as Injected Gas

Among the possible noble gas species that can be employed, Ne is the choice of preference because it has a low mass and does not affect leak detection. The others noble gas could not be used for different reasons. In the cases of He and Ar, a small amount may be left after the pump down which would reduce the sensitivity of the leak detection. Finally, Kr and Xe have a high mass, and therefore a high cross-section for beam-gas interactions, so that even small traces would lead to an increase of the background to the LHC experiments.

THE NEON INJECTION SYSTEM

During the intervention two injection lines are used, in order to inject the gas from both sides of the equipment to be exchanged. Figure 2 shows a typical configuration in the case of an exchange of an interconnecting module or a vacuum gauge. Generally one of the two systems is always installed directly on a stainless steel dome where a BA gauge and a residual gas analyser (RGA) are installed for qualification purposes.

A schematic drawing of the Ne injection line is shown in Figure 3. Both Ne venting systems are equipped with a NEG filter gas purifier. A high pressure reading gauge is used in order to keep a fixed over pressure in the beam pipes during the intervention. A full compact range gauge is also installed on each turbo molecular pumping group (TMP) of the injection line.

Filtering Stage

The Ne venting system is a UHV system and is therefore baked up to 250°C. The Ne gas bottle contains always a certain amount of impurities, approximately 4 ppm of N_2, 2 ppm of H_2 and H_2O, 1 ppm of O_2 and 0.2 ppm of CO and CO_2. All these contaminants in the Ne bottle are removed by a NEG filter cartridge (MicroTorr® from SAES getter). The activation of the filter is achieved by heating the purifier at 400°C for 3 hours and, after having carried out the activation, the NEG filter could be used at room temperature or at the activation temperature (higher pumping capacity for CO, CO_2 and H_2O). In this latter case a second purifying stage operating at room temperature should be used in order to remove the H_2 desorbed directly from the NEG cartridge. Indeed, for the NEG, the H_2 equilibrium pressure is strongly related to its temperature following the Sievert's law [3]. This level of equilibrium pressure is not negligible in this application.

Injection and Pump Down

The Ne venting system is used to inject the gas in the beam vacuum pipes of generally 80 mm diameter, from each side of the faulty component. When the pressure in the sector is higher than 1200 mbar, the mechanical intervention can be carried out. An intervention time of 15 minutes is generally large enough to exchange any kind of small components. After the intervention, the pump down of the Ne injected is done with the two TMP groups installed in the Ne venting system. The ultimate pressure reached in the beam vacuum pipes before restarting the ion pumps should be lower than 10^{-7} Pa. The quality of the intervention is done by the pressure reading of the BA gauge located in the LSS sector after 1 night of pumping with the ion pumps switched-on.

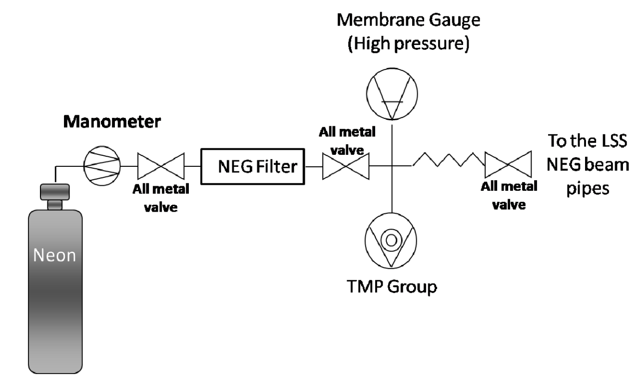

Figure 3: Schematic of the Ne injection line.

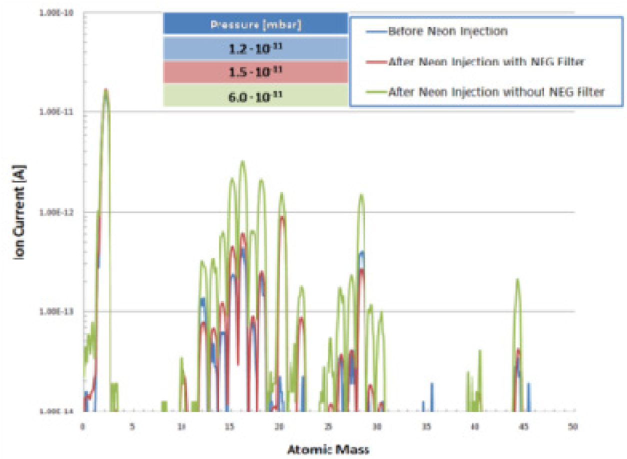

Figure 4: Spectra of the system before and after Ne injection with and without the NEG filter.

PURIFICATION EFFICIENCY TESTS

A mock-up (length: 32 m – volume: 160 l) made of NEG coated vacuum chambers (diameter 80 mm), one BA gauge and one RGA was used. Its purpose was to estimate the effect of the Ne bottle's impurities on the activated NEG coating and to verify the purification efficiency of the NEG filter cartridge. Following the bake-out and the activation of the NEG chambers, the purifier was activated at 400°C for 3 hours and then cooled down at room temperature. Ne was injected to a pressure of 1200 mbar and kept for 1 night. Afterward, the sector was pumped by a TMP group for three days. When the pressure reading by the BA gauge was lower than 10^{-7} Pa, the ion pumps were switched on and the TMP group isolated from the sector. The system was left in such configuration for one night, with the pumping relying on the NEG coated vacuum chambers and on the ion pumps. Figure 4 shows the mass spectra recorded by the RGA and the pressure read by the BA gauge (N_2 eq.) before the Ne injection and after Ne injection with and without the purification media, respectively. The results show clearly that with the use of the NEG filter the system after pump-down comes back to the original condition, except for a small amount of Ne left in the system. However, in the case Ne is injected without the NEG filter, impurities in the vacuum system such as CO, CO_2, H_2O and CH_4 could be detected. Furthermore, an increase of the pressure reading of the BA gauge of a factor 5 is also recorded.

CONCLUSIONS

A new Ne venting system is developed in order to perform fast mechanical interventions in all the LSS vacuum sectors of the LHC without losing much of the performance of the already activated NEG coating.

It is demonstrated that a noble gas purifier can be used in order to reach very high purification efficiency and remove all the possible contaminants present on the commercial Ne gas. During the intervention, the purified Ne must be injected from both sides of the component to be exchanged and by applying an overpressure, it is possible to prevent any saturation of the NEG coating due to air back streaming through the beam pipe aperture. Application of this Ne venting system on the exchange of a bellow module and a BA gauge of two different LSS sectors of the LHC have shown excellent results.

ACKNOWLEDGMENTS

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