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Ultra High Vacuum Systems for Accelerators

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ABSTRACT

In order to perform controlled, stable, and reproducible experiments, several research areas today require very low pressures. Maybe the most important example is the research that is performed in storage rings and accelerators where the lifetime and stability of particle beams depends critically on the vacuum conditions. Although the vacuum requirements ultimately depends on the kind of experiments that is performed, the studies of more and more rare and exotic species in storage rings and accelerators today pushes the demands on the vacuum conditions towards lower and lower pressures. The final pressure obtained in the vacuum system can often be the key factor for the outcome of an experiment. Pioneering work in vacuum technology has therefore often been performed at storage rings and accelerator facilities around the world.

In order to reach pressures in the low UHV regime and lower (below 10^{-11} mbar), several aspects have to be considered which implies choosing the proper materials, pumps and vacuum gauges. In the absence of gases inleaking from the outside, the rate of gas entering a vacuum system is determined by the release of molecules adsorbed on the surfaces and the outgassing from the bulk of the vacuum chamber walls. This means that the choice of material and, equally important, the pre treatment of the material, must be such that these rates are minimised. Today the most widely used material for vacuum applications are stainless steal. Besides its many mechanical advantages, it is resistant to corrosion and oxidation. If treated correctly the major gas source in a stainless steal chamber is hydrogen outgassing from the chamber walls. The hydrogen outgassing can be decreased by vacuum firing at 950°C under vacuum. In addition to choosing the right materials the choice of vacuum pumps are important for the final pressure. Since no vacuum pump is capable of taking care of all kinds of gases found in the rest gas at pressures below 10^{-11} mbar, a combination of pumps is needed. At these low pressures there are, however, some pumps that are disqualified, such as pumps which not are bakable (some cryopumps) and pumps that are using organic fluids for pumping (diffusion pumps) or as lubricants (turbopumps). Instead a combination of pumps like sputter-ion pumps, getter pumps and cryo pumps are routinely used today at accelerator facilities to reach this extreme vacuum regime. In addition to pumping efficiency aspects like operation stability and costs have to be considered when choosing the appropriate pumps for the vacuum system.

Even if quite a lot of work has been devoted to develop vacuum gauges for measuring pressures below 10^{-11} mbar, only a few commercial gauges are available. It is of great importance that the gauge is capable of measuring without influencing the pressure to be measured, which often is the case. Most gauges used today in this pressure range are improved versions of the old Bayard-Alpert type developed in 1950.

Using the storage ring, CRYRING, at the Manne Siegbahn Laboratory in Stockholm Sweden as an example it will be shown how it, with the right combination of vacuum pumps and materials, is possible to reach and keep the pressure below 10^{-11} mbar over a long time during an experiment.

Since a vacuum system of this type consists of more than just the chamber walls, pumps and gauges there are several other aspects that have to be considered in order to maintain low pressures. Detectors, electric wiring and all kinds of feedthroughs are just a few examples of weak links in the vacuum system. Other issues that will discussed are how to measure pressure when commercial gauges fail and how it is possible to use the background gas in a more constructive way instead of just considering it as a problem.