A review of safety considerations in the design and operation of vacuum systems

Dr Andrew Chew*, Edwards, UK*

The Vacuum industry is, characteristically, comprised of an extremely wide spectrum of applications, techniques and equipment requirements. The assurance of safe operating conditions is a common and unifying factor. This paper will describe challenges and requirements for the safe operation of vacuum systems with respect to pumps, gauges and exhaust gas abatement.

This will include examples for the processing of hazardous materials (for example, flammable gases, pyrophorics, dust, oxidants and toxic materials etc.) as well as potentially corrosive materials and over-pressure hazards. Approaches for Hazard Analysis (including understanding reaction products) will be discussed as will wider concerns such as operating in high electrostatic and magnetic fields, radiation environments and mechanical fixtures.

“Challenging tasks in modern vacuum technology applications”

K. Kirsch[1], S. Kiesel[1], A. Trützschler[1], C. Worsch[1], Michael Flämmich[1] and K. Bergner[1]

[1] VACOM Vakuum Komponenten & Messtechnik GmbH, Großloebichau 07751, Germany.

Cutting-edge technology from the field of particle accelerators, quantum technology applications and lithography is pushing the limits of vacuum technology. Along with this, the desired setups and specifications are becoming more and more demanding. The challenging task of vacuum technology is to fulfil these ambitious and complex technical requirements with a compact, miniaturized, and robust solution, which is capable of operating in a standardized and industrial environment. In general, off-the-self" products are not sufficient for that. In this context, product developers and scientists need to find a joint language to deal with this task. That is the only way to realize high technical goals and keep them on schedule.

The focus of this talk is to explain needs and challenges of today's cutting edge technology applications related to vacuum requirements. Therefore, we address different state-of-the-art applications. One focus is the fundamental difficulty to fulfill demanding vacuum conditions in one system, either to achieve very low ultimate pressure or to guarantee extremely low residual gas proportions of certain compounds as well as high cleanliness of surfaces in contact with vacuum. On the other hand, we address the complex and demanding task of isolating quantum objects within a quantum application like quantum computing, quantum gravimetry, and quantum metrology. Based on this, benefits and drawbacks of different vacuum technology solutions to all of these requirements are shown within the transition from customized single components to standardized and industrial ready serial components.

"Control and mitigation of particulate transfer within UHV systems"

O. Poynton[1], S. Wilde[1], K. Middleman[1]

[1]STFC Daresbury Laboratory, Vacuum Solutions Group (United Kingdom)

Particulate levels and contamination are a critical risk influencing the performance and qualification of superconducting cavities for particle accelerators, where high levels of particulate can result in high levels of radiation under Radio Frequency (RF) power. Mitigation and control of particulate migration is key to protecting both the cavities and the Ultra High Vacuum (UHV) systems. To achieve this, a number of techniques can be used in conjunction to achieve ISO 4 standards of cleanliness and minimise the risk of particulate migration.

This talk will introduce:

- The UHV system implemented on our novel vertical test stand, used to qualify high beta cavities for the European Spallation Source.
- The fundamental principles for why, and how, particulate contamination effects the performance of superconducting accelerating cavities.
- How we have designed the vacuum system, procedures and cleanroom solutions to control particulate transfer.
- Corrective actions we take for cavities that fail due to particulate levels.

Helium permeation through zerodur glass

Sefer Avdiaj[1], Ardita Kurtishaj[1]
[1]Department of Physics, University of Prishtina, Prishtina, 10000, Kosovo.

In the new optical pressure standard Ultra-Low Expansion glass (ULE) cavities were proposed to measure helium refractivity for a new realisation of the unit of pressure, pascal. However, it was noticed that the use of this type of material causes some difficulties. One of the main problems of ULE glass is the pumping effect for Helium [1]. Therefore, instead of ULE, Zerodur glass was proposed as a material for the cavity. In order to calculate the flow of helium gas through Zerodur glass one has to know the permeation constant K. Moreover, the modelling of time dependency of the flow requires the knowledge of diffusion constant D as well. The relation between them is given by $K = S \cdot D$, where S is solubility of Helium in glass. In our research work we measured permeation of helium gas in Zerodur. The measurements were performed in the temperature range 27 – 120 °C. Based on our results, we consider that the Zerodur material has the potential to be used as cavity material for the new quantum standard of pressure.

References:

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