Contamination Free Helium Leak Detection of Sensitive Systems

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Introduction

High Technology Systems (HTS) with sensitive surfaces, such as Superconducting Radio Frequency (SRF) Accelerating Cavities[1], Polarized Electron Sources[2] (PES) for accelerators and many others, are prone to degradation when subjected to particulate or hydrocarbon contaminants. Particulate contamination control of SRF cavity surfaces and vacuum components have been discussed by several authors at this contamination workshop. Hydrocarbon contamination mainly results from prolonged evacuation with conventional oil lubricated pumping systems and/or prolonged leak detection with conventional leak detectors.

The sensitivity of the conventional leak detectors suffers due to the back-streaming of atmospheric helium (5×10^{-1} Pa) through the pumping systems and/or the trapping of helium in the O-rings and oils of the pumping systems[3]. This reduced sensitivity leads to the use of the leak detectors over a long periods of time for detecting small (1×10^{-10} atm. cc s^{-1}) leaks in HTS thereby exposing the sensitive surfaces to contamination. In this paper, a review of the work in progress, at Thomas Jefferson Accelerator Facility (Jefferson Lab), in reducing the contamination of sensitive surfaces is presented.

Results and Discussions

Present Status:

A helium adsorption-desorption leak detection method was developed and effectively used to achieve high confidence level in the vacuum integrity of 3000 UHV seals operating in CEBAF's linacs at 2K. This technique was further translated into a commercially viable leak detector system, Figure 1, using a Cooperative Research and Development Agreement (CRADA) with MKS Instruments Inc.,[5]. This leak detector consists of a 6.5 K closed cycle helium refrigerator (APD Cryogenics, Inc.) to maintain the vacuum in the leak detector chamber and facilitate the adsorption-desorption of helium. A specially developed high helium sensitivity RGA (MKS Instruments) served as the sensor of the leak detector. The dynamic sensitivity of this leak detector was determined to be better than 2.5×10^{-13} atm cc s^{-1}. The integrated leak sensitivity of the leak detector is mainly limited by the time one has to wait to collect small amount of helium over prolonged periods of time and the helium diffusivity through the materials used.

Pfeiffer wide range turbo pumps also have high compression ratios for the light gases helium (10^7) and hydrogen (10^5). Further they are backed by dry diaphragm pumps and found to offer hydrocarbon free operation for more than three years of continuous use. In addition the dry diaphragm pumps were found to be free from particulate dust both in the inlet and exhaust lines and are being used in the Jefferson lab's clean rooms with out any special precautions. In recent studies, at Jefferson Lab, Stanford Research Systems (SRS) RGA's have been found to be highly reliable, have good linearity for helium and relatively in expensive[6]. The combination of these two products formed a very effective hydrocarbon free and sensitive helium detection system. The dynamic helium sensitivity of this system is found to be in the 10^{-11} atm. cc s^{-1} in the absence of O-rings. In the presence of O-rings the system requires a few hours of evacuation for reducing the helium background and to obtain 10^{-10} atm cc s^{-1} dynamic sensitivity.

In addition, extractor gauges have been found to work reliably at liquid helium temperatures. They are able to measure pressures down to 10^{-12} Pa at 2 K and hence can detect small leaks in cryogenic vacuum systems[7].

Future Developments:

Hot filament ion gauges and RGA's are known to change the residual gas composition due to some unknown chemistry. This may be of concern in some of the applications involving sensitive surfaces. In such a case the RGA and the ion gauge may be isolated by a turbopump, which in turn is backed by another small turbopump. All the instrumentation is mounted at the inlet of this second pump, Figure 2. For sensitive leak checking applications the backing dry diaphragm pump may be isolated to improve the sensitivity. Such a system is presently being assembled together. Further we are also looking into developing vacuum instrumentation without hot filaments.

Many applications require the use of helium leak detectors in high helium back ground environments. The present day leak detector technology does not satisfy the requirements for even less sensitive applications under high helium back ground conditions. The main difficulty is again the trapping of helium in the elastomers and/or oils of the pumping system. Jefferson Lab has proposed several simple and effective solutions in limiting the effects of trapping and back streaming of helium in vacuum systems[3]. A CRADA is being finalized between Varian Associates and Jefferson Lab to improve the Varian leak detectors helium sensitivity under high helium back ground environments.

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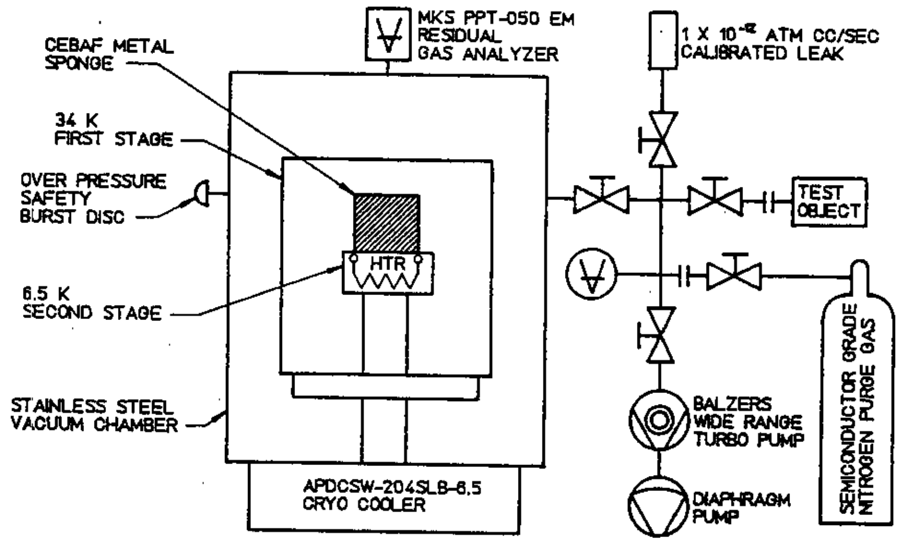

FIG. 1 SCHEMATIC OF THE EXTREME SENSITIVITY He LEAK DETECTOR

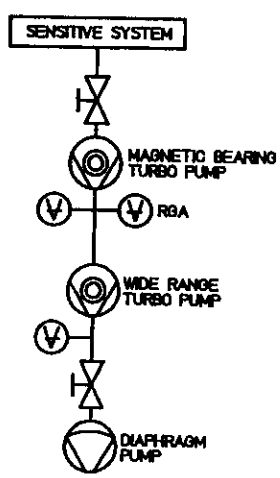

FIGURE 2 - CONTAMINATION FREE LEAK DETECTION SYSTEM