Vacuum Technology
Room 303D - Session VT-WeA

Vacuum Measurement, Sensors and Control

Moderator: T. Gessert, National Renewable Energy Laboratory

2:00pm **VT-WeA1 An Overview of Particle and Field Instruments to Measure Solar System Plasma*, M. Wüest,*** Astroglobo, Switzerland

For almost 50 years solar system plasma has been studied by in-situ as well as remote sensing instruments. These instruments include particle instruments such as different kinds of mass spectrometers, solid state detectors or neutral atom imagers as well as electromagnetic field measuring instruments such as magnetometers and electric field instruments. In this presentation I will give an overview of the different types of instruments used in space research to better understand the plasma environment of the solar wind and the planetary magnetospheres.

2:20pm **VT-WeA2 An Overview of the Spallation Neutron Source Vacuum Systems*, P. Ladd,*** Oak Ridge National Laboratory **INVITED**

The Spallation Neutron Source (SNS) is an accelerator-based neutron source being built in Oak Ridge, Tennessee funded by the U.S. Department of Energy (DOE) Office of Science. The SNS will provide the most intense pulsed neutron beams in the world for scientific research and industrial development. At a total cost of $1.4 billion, construction which began in 1999 and will be completed in 2006 the culmination of the collaborative efforts of six National Laboratories (Argonne, Brookhaven, Jefferson, Lawrence Berkeley, Los Alamos, and Oak Ridge). Powerful neutron beams will be produced in the SNS facility by bombarding a mercury target with energetic protons from a large accelerator complex. A UHV environment is needed in the accelerator to minimize beam losses as the beam is accelerated from the ion source, where low energy particles are produced, through a series of accelerating cavities eventually accelerating the beam to 88% the speed of light with a capable of depositing 1.4 MW on the target at a beam energy of 1 GeV. The component parts of the accelerator will be briefly described specifically addressing the design and construction of the numerous vacuum systems that support accelerator operations. In conclusion the current status of the installation and commissioning of the various vacuum systems will be presented.

3:00pm **VT-WeA4 Interactions of Various Vacuum Gauge Sensor Technologies with their Measurement Environment*, P.M. Rutt,*** Helix Technology Corporation

The effects of industrial processing atmospheres on the operating components of a number of vacuum gauge sensor technologies are presented. Each common type of vacuum gauge sensor is evaluated with respect to its functional components. The gauges considered are hot cathode ionization gauges, cold cathode ionization gauges, various material diaphragm gauges, and thermal conductivity gauges. The mechanisms evaluated with respect to the gauge internal electrodes/sensors are erosion, chemical interaction, metallurgical interactions, and deposits. Some of these component problems will be addressed with possible solutions.

3:20pm **VT-WeA5 Modulated Bayard-Alpert Gauges in a Calibration Laboratory*, B.R.F. Kendall,*** Elvac Laboratories*; E. Drubetsky,* The Fredericks Company

Bayard-Alpert (BA) gauges may have large errors at pressures below about 10@super -9@ Torr because of x-ray and other unwanted effects. One of the simplest ways to overcome these problems is to add a modulator electrode, as described by P.A. Redhead in 1960. At least a factor of ten improvement in minimum detectable pressure is possible. We describe operational experience with both nude and metal-envelope modulated BA gauges on two UHV systems operating in the 10@super -11@ Torr range. In addition to eliminating x-ray errors, these gauges proved to have numerous other advantages which have not been generally recognized. They are unaffected by electrometer zero drift and are capable of discriminating against spurious currents caused by electron-stimulated ion desorption. Standard commercial ion gauge controllers can be used, with the addition of simple external adapters. These can range from elementary manually-operated switches giving single readings of true pressure, up to programmable devices capable of giving continuous readouts of true pressure and the magnitudes of the various error signals. A gauge tube with a modulator electrode can also be used, if necessary, as a conventional BA gauge with a standard controller simply by connecting the modulator to the electron collector (i.e. to the grid). We are replacing most of the conventional BA gauges on our UHV systems with modulated gauges. This has eliminated over-readings which sometimes approached 300 percent of true pressures in the mid 10@super -11@ Torr range.

3:40pm **VT-WeA6 Considerations for Selection of Ion Collector Diameter in Hot Cathode Ionization Gauges*, P. Arnold,*** Helix Technology Corporation

Characteristics of large diameter vs small diameter ion collectors in Bayard-Alpert type hot cathode ionization gauges are evaluated. Experimental data are shown for high pressure linearity, high pressure stability, and multi-second pumpdowns from the millitorr range to the high vacuum range. These pumpdowns were conducted with both argon and nitrogen as functions of time, pressure, and electron emission current in the millitorr range. Computer simulations and mathematical calculations are related to the test data to arrive at an explanation of the observed results. This evaluation is extended to miniature hot cathode gauges.

4:00pm **VT-WeA7 A Study of the Variation of Sensitivity of Hot Cathode Ionization Gauges as a Function of Gas Adsorption*, P.J. Abbott,*** National Institute of Standards and Technology*; P. Mohan,* National Physical Laboratory, India

Hot cathode ionization gauges of the Bayard - Alpert design are the most widely used gauges for pressure measurement in the high and ultra high vacuum range. The National Institute of Standards and Technology (NIST), has considerable experience in calibrating hot cathode ionization gauges of this type for customers and for its own use. Several different envelope geometries have been encountered for example, nude gauges, gauges with glass envelopes, and the more recent gauges having metal envelopes. The sensitivity of this particular type of metal envelope ion gauge is claimed to be highly repeatable, typically within a few percent over the period of one year. However, we have noticed much larger sensitivity shifts in these gauges during routine operation. We report the results of a systematic study of the change in sensitivity for two glass envelope ionization gauges, six metal envelope ionization gauges, and one extractor gauge over the pressure range 2x10@super -@@super6@ Pa to 7x10@super-@@super3@ Pa. An orifice flow (dynamic expansion) system generated the nitrogen and argon calibration pressures, and a spinning rotor gauge was used as a check standard for pressures above 10@super-@@super3@ Pa. For both argon and nitrogen, we found each gauge's sensitivity to be dependent on the quantity of gas the operating gauge was exposed to prior to calibration, i.e., the product of pressure and time. For argon gas, sensitivity shifts of up to 8 % were observed between an initial calibration and one performed after exposing the gauges to 0.028 Pa of argon for about five hours. For nitrogen, the shifts were as large as 14 %. Interestingly, for argon the sensitivity shifts occur towards the high-pressure end of the calibration range, while for nitrogen the shifts occur at the low pressure range. We believe that ionic pumping of gas and its subsequent release by the walls of the metal envelope is responsible for the observed sensitivity shifts.

4:20pm **VT-WeA8 A Study of Some Metrological Characteristics of Capacitance Diaphragm Gauges*, P. Mohan,*** National Physical Laboratory, India

The capacitance diaphragm gauges (CDGs) have been in use for a few decades and have been employed as transfer standards and reference standards. Despite their drawbacks, they continue to be used due to their ruggedness and UHV compatibility. A CDG consists of a sensor and an electronics control unit to display the pressure. To overcome the problem of ambient temperature variations, a heater is provided in the sensor to maintain it at nominally 45 °C. In a differential CDG, zeroing is done with both sides kept under vacuum. Afterwards, the system check (SC) is performed. This parameter is compared with the value given in the calibration sheet. A deviation between the two values is an indicator of the gauge needing re-calibration. A study has been performed to establish the link between the calibration factor (CF) and the SC, between the SC and the temperature of the CDG sensor and between the temperature and the shift in the sensor zero. A Resonant Silicone Gauge of 130 kPa f.s. range was used as a secondary standard for the calibration of the CDGs. The plots of CF against the pressure at different temperatures show that over a range of pressures, typically 100-1000 torr, the CF varies linearly with pressure and both the slope and the intercept values of this linear fit go on increasing as the temperature increases from about 290 - 318 K. Each temperature value corresponds to a different value of the SC. At 318 K, the CF tends to become a constant over the pressure range 100-1000 torr, meaning thereby that the slope becomes zero. Hence it can be said that the slope and intercept of the CF vs. pressure curve are a function the SC.

Plots of the different values of the slope and the intercepts against the SC values give linear fits from which we can calculate the slope and the intercept values for any particular SC value. Hence we can calculate the CF at any pressure in the range 100-1000 torr, for any temperature between 290-318 K.

4:40pm **VT-WeA9 Ultra-sensitive Leak Detection during UHV Evacuation by QMS under Accumulate Mode***, X. Chen, L. Wang,* ***T. Huang****, Q. Jin,* Tsinghua University, China*; L. Cha,* Tsinghua University, China, P. R. China

Tightness is extremely important to guarantee the longevity of the sealed vacuum devices with smaller volume, especially if it has to maintain high vacuum or even ultra high vacuum (UHV). As the structure of such minimized UHV devices is developed to be more complicated, it becomes a serious challenge to the leak detection technology. According to the basic concepts of the modern leak detection engineering, each part of the device and their whole assembly should be passed leak detection strictly before UHV evacuation. However, the long term baking during the UHV evacuation may cause formerly plugged mini leakage reopen or produce some new mini leakages. In order to improve the tightness reliability of such devices, it is necessary to carry out ultra-sensitive leak detection during the UHV evacuation, especially just before the device be sealed off from the vacuum system. The quadrupole mass spectrometer (QMS) in the UHV evacuation system can be used under accumulate mode to solve this problem. After the long term baking, the UHV will be achieved and the background will be very low if there are no large leaks. Under such condition, the leak detection sensitivity of QMS is high enough to detect small leaks. By closing the all-metal valve in front of the tested device to accumulate helium for a period, a peak can be observed by QMS when the valve reopen if there are mini leakages. The ultra-sensitive leak detection can be achieved by this way. It is found that the open action of the metal valve always severely affects the height of the peak indicated by QMS to bring considerable errors. If denote the mini leakage by the peak area instead of the peak height, the situation will be much improved. It has been proven that this method is quite useful to ensure the tightness quality for the complex sealed UHV devices with small and mini volume.

5:00pm **VT-WeA10 The Spinning Rotor Gauge: From Laboratory Curiosity to Practical Tool***,*

First laboratory investigations on using magnetically suspended rotors for vacuum pressure determination were carried out by Jesse W. Beams and co-workers in the 1940s at the University of Virginia, Charlottesville.@footnote 1@ The suspension system was recognized as useful also for the investigation of a special drag effect on high-speed rotors due to retarded gravitational force interaction as proposed by James C. Keith in 1963.@footnote 2@ For experimental verification of the Keith effect,@footnote 3@ a permanent-magnet suspension was developed in the late 1960s at the University of Bonn that later on provided the technological basis for a first practical SRG. The SRG development was initiated and supported among other magnetic suspension applications, such as turbomolecular pumps, neutron and molecular beam choppers, by George Comsa at KFA Juelich since 1974. Extensive studies by G. Messer at PTB-Berlin and other leading national standard laboratories, in particular the American National Bureau of Standards, in the late 1970s have prepared the way for commercialization of the SRG. A theory on the influence of the rotor surface roughness on the SRG calibration was proposed in 1980.@footnote 4@ Significant technical improvements have been contributed by Bernd Lindenau, KFA-Juelich, and Klaus Witthauer, RWD-Aachen. On occasion of the IVC-8 exhibition in Cannes (1980), MKS Instruments was the first company to apply for licence from KFA-Juelich, followed by Leybold AG in 1981. The commercial units were manufactured on order of the licensing companies by RWD-Aachen. Extension of the SRG operating range beyond the molecular drag regime up to atmospheric pressure was introduced in the mid 1980s and first commercialized by SAES Getters in 1996. @FootnoteText@ @footnote 1@J. W. Beams, J. L. Young, J. W. Moore, J. Appl. Phys. 17, 887 (1946) @footnote 2@ J. C. Keith, Rev. Mex. Fis. 12, 1 (1963) @footnote 3@ J. K. Fremerey, Phys. Rev. Lett. 30, 753 (1973) @footnote 4@J. K. Fremerey, Proc. 4th ICSS and 3rd ECOSS, vol. II, p.869, Cannes (1980)

Author Index

Bold page numbers indicate presenter