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NASA TECH BRIEF

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Estimating Sensitivity of Vacuum Gages

Empirical methods of estimating the response (or sensitivity) of hot cathode ionization type vacuum gages for particular gases have been determined.

Most vacuum pressure measurements of less than 1×10^{-3} torr utilize hot cathode ionization gages. In operation, the ion gage creates ions by electron bombardment of the gas whose pressure is to be measured. The ratio of the ion current to the electron current is then divided by a specific quantity, the gage sensitivity, to give the gas pressure. Proper usage of an ionization gage requires knowledge of the gage response to the gas environment. This gage response (or sensitivity) varies with the nature of the gas and the gage configuration. Normally, individual calibration for each gage-gas combination is required. Unfortunately, the process of calibration is difficult and time consuming, so that only a limited number of gage sensitivities are known.

As an alternate approach, gage sensitivity for a particular gas can be estimated empirically and with reasonable accuracy using the known performance of the gage with a different gas, and either the performance of other gages in the gas of interest or calculations using some property of that gas.

Using gage sensitivity data from the literature, a study of empirical methods of estimating gage sensitivity was conducted. Various empirical rules have been previously published, and are in use, although their accuracies have never been defined. All of these rules define only the relative gage sensitivities, which are the ratios of gage sensitivities for various gases to the gage sensitivity of a given reference gas. In a NASA study, two of the previously published rules were found to have usable accuracy. In addition, as part of the study, a new method of estimating relative gage sensitivity was postulated and tested.

The most basic and most widely used of the empirical rules states that the relative gage sensitivities are invariant with gage configuration. This rule was found to have a probable error of 8 percent.

A second rule equates the ratio of gage sensitivities for any two gases to the ratio of ionization cross sections for the same two gases. In previous applications, the values of ionization cross section utilized were chosen at an ionizing electron energy corresponding to the gage grid potential. In this study, the maximum value of ionization cross section for each gas was used and found to be equally accurate. The probable error associated with this rule was found to be 10 percent.

A new empirical rule is proposed which equates the ratio of gage sensitivity for any two gases to the ratio of the gases' molecular polarizabilities. Molecular polarizability is related to, and may be replaced by, the molar polarizability or the refractive index. The probable error in estimating relative gage sensitivity from these molecular properties is 13 percent.

Using the above rules, the relative gage sensitivities for over 100 gases and vapors have been estimated. An estimated gage sensitivity for a particular gage exposed to any of these gases can therefore be estimated easily if the gage sensitivity is known for nitrogen as the reference gas.

(continued overleaf)

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Notes:

1. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
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   Reference:
   NASA-TN-D-5285 (N69-29331), Empirical Observation on the Sensitivity of Hot Cathode Ionization Type Vacuum Gages

2. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
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