NASA TECH BRIEF

Lewis Research Center

Method of Predicting Ionization-Type Vacuum Gage Sensitivity for Various Gases

Gage Type	Typical Gage Accelerating Voltage, V_a, Volts	Ionization Cross Section, σ*
1. Bayard - Alpert (10^{-3} - 10^{-11} Torr)	150	σ_{Max} or σ_{100} or $\sigma_{0.67V_a}$ †
2. Triode (10^{-3} - 10^{-8} Torr)	150	σ_{Max} or σ_{100} or $\sigma_{0.67V_a}$ †
3. High Pressure (10^{-5} - 1 Torr)	60	$\sigma_{0.67V_a}$
4. Alphatron (10^{-4} - 10^{3} Torr)	10,000	σ_{5000}

*Numerical subscripts refer to cross section energy level in volts. Subscript Max refers to maximum value of cross section for each gas.

†Any of these three values of cross section can be used with no increase in the probable error of the computed gage sensitivity.

The Problem:

Hot-cathode ionization vacuum gases are commonly used for measuring pressures below 10^{-3} torr. The gages ionize the gas in the system by bombarding it with electrons. Both the ionized (i+) and ionizing (i-) particles are collected and measured, and the pressure (P) in the system is related to these two currents by the formula:

$$P = \frac{1}{s}\left(\frac{i+}{i-}\right)$$

where s is the sensitivity of the gage.

Gage sensitivity is a function of characteristics of the gage and the properties of the gas in the system. A value for the sensitivity of a gage with a particular gas can be determined by calibration, however, a gage must be separately calibrated for each different gas on which it is used. A means was needed for relating the sensitivity of a gage for other gases to that of the gas used for calibration in order to eliminate calibrating each gage for every gas.

The Solution:

It has been determined, by experimental research and correlation analysis, that the sensitivity of a gage for one gas can be correlated to its sensitivity for other gases by

(continued overleaf)

the ratio of the gas ionization cross sections. The following relation could therefore be used to predict the sensitivity of a gage for a particular gas:

$$\frac{S\ (\text{particular gas})}{S\ (\text{calibration gas})} = \frac{G\ (\text{particular gas})}{G\ (\text{calibration gas})}$$

How It's Done:

The ionization cross sections which best correlate with gage sensitivities vary according to gage type and the ionization cross section energy level. The table shows the ionization cross sections which best correlate with gage sensitivities for the four different types of ionization gage covered by the study. Shown also are the pressure ranges in which the gages normally operate and the typical accelerating voltages for the gages. With this information, the relative sensitivity of a particular gage for a particular gas can be predicted within a probable error of 10 percent or less.

Notes:

1. The following reference was used to obtain the gas ionization cross sections: D. Rapp, P. Englander-Golden: J. Chem. Phys., Vol. 43, p. 1464, 1965.
2. Further information is available in the following report:

   NASA TN-D-6815 (N72-28454), Sensitivity of Hot-Cathode Ionization Vacuum Gages in Several Gases

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B73-10409
3. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B73-10409

Patent Status:

NASA has decided not to apply for a patent.

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