Gas Correction Factors for Bayard-Alpert Ionization Gauges

The sensitivity factor, S_g, supplied by gauge manufacturers (usually in $Torr^{-1}$), *is valid only for the gas for which it is specified* and the readout of the controller provides a direct pressure reading only for that specific gas. The standard gas, used by the entire industry for gauge specification, is *nitrogen* and, unless gas correction factors are applied, all readings are considered to be 'nitrogen-equivalent pressures'.

In This Application Note

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Nominal *relative sensitivity factors*, R_g, to convert nitrogen-equivalent readings into direct pressure readouts for gases other than nitrogen, are available from most gauge manufacturers and from the public vacuum literature. A summary table and reference list, is included in this application note. For gases where little or no data are available, it has been shown that a reasonable approximation to the relative sensitivity factor, R_g, can be obtained from the ratio of ionization cross sections at 150 eV of electron energy. Several ionization cross section tables are also available in the scientific literature.

Once the relative sensitivity factor is known, direct pressure readings are calculated from the straightforward mathematical equation:

$$P = [I_c / (S_g \cdot I_e)] \qquad \text{(eqn.1)}$$

where

$S_g = S_{N2} \cdot R_g$

S_g, sensitivity factor for gas 'g' [$Torr^{-1}$]

S_{N2}, sensitivity factor for nitrogen [$Torr^{-1}$]

R_g, gas correction or relative sensitivity factor

I_c , ion collector current [amps]

I_e, electron emission current [amps]

See the application note, 'Bayard-Alpert Ionization Gauges' for a detailed explanation of gauge sensitivity.

Note

The IGC100 controller stores a nitrogen sensitivity factor, S_{N2} (N2 Sense Factor), and a single relative sensitivity factor, R_g (Gas Correction Factor), for every BAG connected to its back panel. The two parameters are automatically applied to the calculation of pressures according to eqn. 1 when the N_2 Sensitivity Factor is selected as Calibration Source from the Gauge Setup menu.

The Gas Correction Factor is fixed at 1.0 when 'Cal Curve' is selected as the IG Calibration Source.

Nominal Gas Correction Factors for Common Gases

(relative to N_2 = 1.00)

Gas	R_g
He	.18
Ne	.30
D_2	.35
H_2	.46
N_2	**1.00**
Air	1.0
O_2	1.01
CO	1.05
H_2O	1.12
NO	1.15
NH_3	1.23
Ar	1.29
CO_2	1.42
CH_4 (methane)	1.4
Kr	1.94
SF_6	2.2
C_2H_6 (ethane)	2.6
Xe	2.87
Hg	3.64
C_3H_8 (Propane)	4.2

IMPORTANT!

Nominal relative sensitivity factors cannot be relied upon for accurate measurements since they are known to vary significantly between seemingly identical gauges and even more for different gauge types, filament materials, and operating potentials. For general vacuum use, the discrepancy in reported measurements is not greater than 10% for the common gases, rising to a little above 20% for the less common gases, where less accurate information is available. Relative sensitivities are pressure dependent and become particularly unreliable above 10^{-5} Torr. Where greater precision is required, gauges must be calibrated individually against the specific gases and under conditions as close as possible to the operating conditions of the vacuum system.

References

Gas Correction factors

R. L. Summers, "Empirical Observations on the sensitivity of hot cathode ionization type vacuum gauges", NASA Technical Report, NASA-TN-D-5285, published 1969. *Comment: This publication is the industry standard used by BAG manufacturers to specify gas correction factors for their gauges. It includes a fairly complete compilation and review of prior literature numbers.*

R. Holanda, "Sensitivity of hot-cathode ionization vacuum gauges in several gases", NASA Technical Report, NASA-TN-D-6815 E-6759, published 1972. *Comment: Includes calibration data for 12 different gases and 4 different gauges.*

R. Holanda, "Investigation of the Sensitivity of Ionization-Type Vacuum Gauges", J. Vac. Sci. Technol. 10(6) (1973) 1133. *Comment: Demonstrates the good correlation between gas correction factor and ionization cross sections.*

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J. E. Bartmess and R.M. Georgiadis, "Empirical methods for determination of ionization gauge relative sensitivities for different gases", Vacuum 33(3) (1983) 149. *Comment: Includes data for 74 different gases including various organic compounds. All hydrocarbon numbers of Table I. were extracted from this report.*

C. R. Tilford, "Reliability of high vacuum measurements", J. Vac. Sci. Technol. A 1(2) (1983) 152. *Comment: A must-read paper on BAG readings and the different variables that affect them. Includes correction factors for several gases plotted as a function of pressure and a very useful discussion on the subject.*

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Ionization cross sections

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