GEPP-290

SENSITIVITY RATIOS

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March 31, 1977

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Prepared for the U. S. Energy
Research and Development Administration
Albuquerque Operations Office
Under Contract No. EY-76-C-04-0656

ABSTRACT

Sensitivity factors for use with residual gas analyzers in mass spectrometry have been derived for compounds most frequently encountered in vacuum tube exhaust processes. With these factors, calibration of a mass spectrometer may be done for nitrogen and applied by ratio to other compounds.

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INTRODUCTION

Usually, the calibration of a mass spectrometer for residual gas analysis requires the determination of an ionization gage factor for each compound. However, by calculation of a gage sensitivity ratio of various gas compounds to nitrogen (N_2), the mass spectrometer may be calibrated for nitrogen and that calibration can be applied by ratio to the compounds of interest. This is an especially useful tool in analyses of gases repeatedly evacuated from vacuum devices in production.

DISCUSSION

Table 1 lists the sensitivity values for the UTHE Technology International Residual Gas Analyzer Model 100C-02 used in this study. The five compounds listed are the most common gases evacuated from vacuum tubes produced at the General Electric Neutron Devices Department (GEND). The compound sensitivity ratios were derived from the equation:

$$\text{gage sensitivity} = \frac{\text{gage sensitivity of compound}}{\text{gage sensitivity of nitrogen}}$$

The values have been compared to the Catalog of Mass Spectral Data, American Petroleum Institute, Project 44, and found satisfactory. The values were also compared to the Dushman and Young and to the Wagener and Johnson data* and found to be in agreement.

Based on these compound values and the instrument operating conditions as noted in the table, calibration of an individual instrument may be accomplished by actual calibration of only one compound, nitrogen (N_2), and applied by ratio to other compounds of interest.

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*S. Dushman, Scientific Foundations of Vacuum Technique, J. M. Lafferty, Editor, Table 5.7 "Ionization Gage Sensitivity Ratios for Various Gases," John Wiley & Sons, Inc.

Compounds used for these calibrations were calibration grade gases and were incorporated into standard leaks in order to ensure constant rate of flow and system equilibrium.

The final Amps/Torr values shown in Table 1 have been normalized to nitrogen (Mass 28) and are averages of Samples 1, 2 and 3.

Under the conditions noted in the table, the accuracy of the data will fall within a ±25.0% error band.

Table 1. Sensitivity Values for the UTHE Technology International Residual Gas Analyzer Model 100C-02

UTHE Technology International
Residual Gas Analyzer Model 100C-02
Controller S/N 02-088
Analyzer S/N 08-0097
Error Band ± 25.0%

Average Multiplier Gain 2.7×10^4
Reflector Temperature 200°C
Emission Current 2.1 Ma

Ion Energy 14.9 Vdc
Focus Voltage 12.6 Vdc
Electron Energy 70.3 Vdc

Mass to Charge Ratio	No. 1 Sample Pressure* (Torr)	Amps/ Torr	Normalized to Nitrogen 28	No. 2 Sample Pressure (Torr)	Amps/ Torr	Normalized to Nitrogen 28	No. 3 Sample Pressure (Torr)	Amps/ Torr	Normalized to Nitrogen 28	Average Sample Pressure (Torr)	Average Amps/ Torr	Average Normalized to Nitrogen 28
CARBON DIOXIDE (CO_2)												
44		2.7	0.04		2.7	0.04		2.8	0.04		2.7	0.04
28	1.00×10^{-7}	79.9	1.13	1.04×10^{-7}	79.7	1.06	0.98×10^{-7}	80.9	1.18	1.01×10^{-7}	80.2	1.12
16		1.5	0.02		1.4	0.02		1.5	0.02		1.5	0.02
12		4.3	0.06		3.4	0.05		3.6	0.05		3.8	0.05
NITROGEN (N_2)												
28	8.65×10^{-8}	70.9	1	8.20×10^{-8}	75.4	1	8.35×10^{-8}	68.7	1	8.40×10^{-8}	71.7	1
14		4.1	0.06		4.6	0.06		4.2	0.06		4.4	0.06
CARBON MONOXIDE (CO)												
28		58.4	1.05		58.5	0.97		50.2	0.95		55.7	0.99
16	1.43×10^{-7}	0.9	0.02	1.88×10^{-7}	1.0	0.02	1.60×10^{-7}	0.9	0.02	1.64×10^{-7}	0.9	0.02
12		2.4	0.04		2.1	0.03		2.1	0.04		2.2	0.04
NITROGEN (N_2)												
28	8.55×10^{-8}	55.6	1	8.60×10^{-8}	60.2	1	8.95×10^{-8}	52.8	1	8.70×10^{-8}	56.2	1
14		3.4	0.06		3.7	0.06		3.2	0.06		3.4	0.06
METHANE (CH_4)												
16		11.6	0.27		13.5	0.30		11.9	0.25		12.3	0.27
15		9.4	0.22		11.2	0.25		10.4	0.22		10.3	0.23
14		1.8	0.04		2.2	0.02		2.0	0.04		2.0	0.03
13	1.76×10^{-7}	0.8	0.02	1.41×10^{-7}	0.9	0.01	1.54×10^{-7}	0.9	0.02	1.57×10^{-7}	0.9	0.01
12		0.7	0.02		0.6	0.01		0.6	0.01		0.6	0.01
1		0.4	0.01		0.4	0.01		0.4	0.01		0.4	0.01
NITROGEN (N_2)												
28	1.05×10^{-7}	43.4	1	9.10×10^{-8}	44.5	1	8.35×10^{-8}	48.3	1	9.32×10^{-8}	45.4	1
14		2.6	0.06		2.9	0.07		3.1	0.06		2.9	0.06
HYDROGEN (H_2)												
2	2.74×10^{-7}	6.4	0.13	2.50×10^{-7}	5.8	0.11	2.17×10^{-7}	5.9	0.12	2.47×10^{-7}	6.0	0.12
1		0.1	0.002		0.1	0.002		0.1	0.002		0.1	0.002
NITROGEN (N_2)												
28	8.00×10^{-8}	50.8	1	7.50×10^{-8}	52.5	1	8.00×10^{-8}	49.6	1	7.83×10^{-8}	51.0	1
14		3.6	0.07		3.6	0.07		3.4	0.07		3.5	0.07
DEUTERIUM (D_2)												
4		2.0	0.04		2.8	0.06		3.4	0.06		2.7	0.05
3	7.39×10^{-7}	2.4	0.05	6.09×10^{-7}	3.3	0.007	5.65×10^{-7}	4.0	0.07	6.38×10^{-7}	3.2	0.06
2		2.1	0.04		2.2	0.05		3.0	0.05		2.4	0.05
NITROGEN (N_2)												
28	7.00×10^{-8}	52.0	1	8.50×10^{-8}	48.5	1	7.00×10^{-8}	56.3	1	7.50×10^{-8}	52.3	1
14		3.6	0.07		3.2	0.07		4.1	0.07		3.6	0.07

*Sample pressures corrected for gauge sensitivity by factors derived from API Index and Dushman-Lafferty.

**All sample pressure readings are averages of two or more readings.

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