



A Honeywell Company

Relative Density of Gas Mixtures by Calculation from Composition

UOP Method 948-07

Scope

This method is for calculating the relative density of gas mixtures, generated by typical refinery processes, from their composition as determined by UOP Method 539 or any other suitable method. This method can be used in place of UOP Method 114. The relative density of air is defined as unity (1.00).

References

UOP Method 114, "Relative Density of Gas by Schilling Effusion Method," www.astm.org

UOP Method 539, "Refinery Gas Analysis by Gas Chromatography," www.astm.org

Outline of Method

The sample composition, in mol-%, is determined by UOP Method 539 or other suitable method. The relative density of the sample is then calculated using a commercially available software program. A manual calculation that yields an approximate relative density value is also included in this method. The software program provides the more accurate value because it takes into account deviations from the Ideal Gas Law.

Apparatus

References to catalog numbers and suppliers are included as a convenience to the user. Other suppliers may be used.

Computer, personal, capable of supporting the software application

Software, ProSim Simulus Thermodynamics, Energis Corporation. Other software that performs the same function may be used.

Procedure

Obtain a gas analysis of the sample using UOP Method 539 or other suitable method.

IT IS THE USER'S RESPONSIBILITY TO ESTABLISH APPROPRIATE PRECAUTIONARY PRACTICES AND TO DETERMINE THE APPLICABILITY OF REGULATORY LIMITATIONS PRIOR TO USE. EFFECTIVE HEALTH AND SAFETY PRACTICES ARE TO BE FOLLOWED WHEN UTILIZING THIS PROCEDURE. FAILURE TO UTILIZE THIS PROCEDURE IN THE MANNER PRESCRIBED HEREIN CAN BE HAZARDOUS. MATERIAL SAFETY DATA SHEETS (MSDS) OR EXPERIMENTAL MATERIAL SAFETY DATA SHEETS (EMSDS) FOR ALL OF THE MATERIALS USED IN THIS PROCEDURE SHOULD BE REVIEWED FOR SELECTION OF THE APPROPRIATE PERSONAL PROTECTION EQUIPMENT (PPE).

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Calculations

Preferred Method of Calculation

Install the software on the personal computer and enter the composition data into the program. The program will calculate the sample relative density. The program computes the relative density taking into account deviations from the Ideal Gas Law. Report the results to two decimal places.

Optional Method of Calculation

If a relative density value is needed immediately, and the software is not available, a manual calculation that yields an approximate relative density value for the sample can be performed as follows. Using mol-% values for the components in the sample, calculate the sample relative density using Equation 1:

$$R = \frac{\sum_{i=1}^n \frac{C_i}{100} M_i}{28.964} \quad (1)$$

where:

C = component concentration, mol-%

M = molecular weight of component (from Table), g/mol

R = calculated sample relative density

28.964 = molecular weight of air, g/mol

100 = factor to convert from %

Table
Molecular Weights of Refinery Gas Components

<u>Component</u>	<u>Molecular Weight, g/mol</u>	<u>Component</u>	<u>Molecular Weight, g/mol</u>
Hydrogen	2.016	Propylene	42.08
Argon*	39.95	Isobutane	58.12
Oxygen*	32.00	<i>n</i> -Butane	58.12
Nitrogen	28.01	1-Butene	56.12
Carbon Monoxide	28.01	Isobutylene	56.12
Carbon Dioxide	44.00	<i>trans</i> -2-Butene	56.12
Methane	16.04	<i>cis</i> -2-Butene	56.12
Ethane	30.07	1,3-Butadiene	54.09
Ethylene	28.05	C ₅ Paraffins	72.15
Propane	44.11	C ₅ Olefins	70.14

* Oxygen and argon are not separated by UOP Method 539.

Use values appropriate to the expected sample composition.

Report the final sample relative density to one decimal place. The optional calculation procedure does not take into account deviations from the Ideal Gas Law, and is, therefore, less accurate than the preferred method.

Precision

The precision of this method is limited by the precision of UOP Method 539 or other method used to determine the composition of the sample. If component values can be reported to two decimal

places, then the relative density determined using the preferred method of calculation is also good to two decimal places.

Accuracy

The accuracy of this method is limited by the accuracy of the composition data input into the software program. The software program itself is capable of one percent (relative) accuracy when working with typical refinery gas mixtures at temperatures and pressures not near critical conditions. Accuracy of data generated on atypical gas mixtures cannot be guaranteed.

The accuracy of the manual calculation is also impacted by the gas mixture's deviation from the Ideal Gas Law.

Time for Analysis

The elapsed time and labor requirement for the calculations specified in this method are the same, 0.1 hour for the preferred (ProSim software) method of calculating, and 0.3 hour for the optional (manual) method. See UOP Method 539 for its time requirements.

Suggested Supplier

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