How It Works

AGA 8 2017 Part 2 Fluid Properties Computation

Cameron has a respected reputation for excellence in precision measurement. Part of this reputation is earned by being alert to and then evaluating emerging measurement techniques that can improve measurement accuracy. Cameron identified specific benefits to Groupe Européen de Recherches Gazières (GERG) 2008 calculations so included the calculations as a standard offering in the Scanner* 3100 flow computer. In 2017 the American Gas Association adopted this calculation and published it as AGA 8 2017 Part 2. In 2017 they also republished AGA 8 1992 as AGA 8 2017 Part 1. A significant change in the Part 1 publication was the inclusion of speed of sound computations that were previously found in AGA 10. AGA 8 2017 parts 1 or 2 are field selectable choices in the Scanner 3100 flow computer with 3.x or higher firmware.

Summary

To perform accurate gas measurement, knowledge of the density of the fluid being measured is essential. For fluids that are in a gaseous state at standard conditions, the Part 2 equation of state is perhaps the most comprehensive and accurate method available for calculating the density of fluids at flowing or reference conditions. This algorithm is superior to AGA 8 Part 1 when any one of the following conditions occurs:

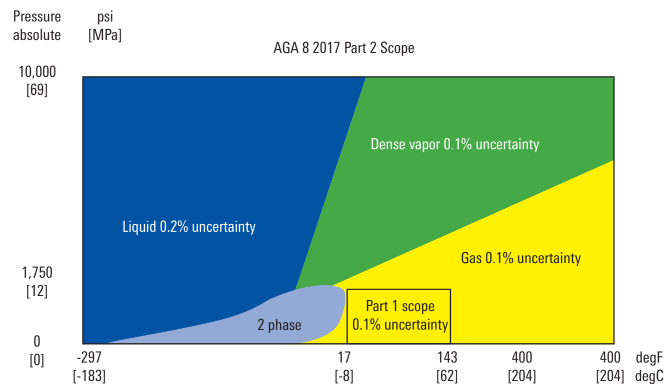
- molecular composition is beyond the Part 1 normal range
- flowing pressure is greater than 1,750 psi [12 MPa]
- flowing temperature is outside the range of 17 to 143 degF [–8 to 62 degC]
- flowing fluid is not in a gas state.

Background

It is well accepted that frequent gas analysis improves measurement accuracy. This is because an error in composition directly influences the fluid density values and the computed volume and mass. It is also recognized that the mathematical models that predict fluid density are evolving and improving as the understanding of molecular behavior can be accurately verified by empirical testing.

AGA recognized that the scope of the original publication of AGA 8 (1985)—which is now known as AGA 2017 Part 1—was focused on natural gas transmission, and the algorithm did not support many of the common gas compositions found in natural gas production. Therefore, AGA introduced the 1992 version that included additional components and broader ranges of composition, pressure, and temperature. This expanded scope did not cover the range of conditions of the 2017 version nor did it offer the same level of certainty as the original AGA 8 scope.

The publication of the AGA 8 2017 Part 2 has dramatically reduced the density uncertainty for a broad range of flowing conditions and fluid compositions. As an equation of state algorithm, it also correctly predicts the fluid state (gas, liquid, or dense vapor) information that is essential to properly account for the enormous change in density during a state transition. Therefore, with an accurate phase prediction correction, factors can be applied to preserve measurement performance. Such correction factors include wet gas correction techniques that recognize that the heavier gas constituents in a flowing stream would have changed to a liquid state, while the lighter constituents would have remained in the gas state.



As indicated in the above graph, the density uncertainty reported by both Parts 1 and 2 is ±0.1%; however, AGA Part 1 covers only a small region of pressure and temperature.

Applications

Unlike AGA 8, Part 1 Part 2 has no molecular composition limits within the listed components, so it is ideal for enhanced oil production schemes where injected and produced streams may be rich or pure carbon dioxide, nitrogen, propane, or butane (the Cameron implementation is ideal for carbon dioxide gas and dense vapor states but is not suitable for liquid carbon dioxide).

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Gases	Part 1	Part 2
Methane	45.0 to 100.0	
Nitrogen	0 to 50.0	
Carbon dioxide	0 to 30.0	
Ethane	0 to 10.0	
Propane	0 to 4.0	
Total butanes	0 to 1.0	
Total pentanes	0 to 0.3	
Hexanes plus	0 to 0.2	0 to 100 (no limits)
Helium	0 to 0.2	
Hydrogen	0 to 10.0	
Carbon monoxide	0 to 3.0	
Argon	0	
Oxygen	0	
Water	0 to 0.05	
Hydrogen sulfide	0 to 0.02	

The exact benefit can only be determined comparing the results computed by the two methods. Cameron recommends this evaluation for any pressure or temperature conditions that are outside region 1 of AGA 8 or a composition that is beyond the normal range.

With possible differences as large as 2%, typical differences are one tenth this amount. Regardless, this bias directly translates to an identical volume measurement error, and therefore, the economic benefits can be enormous. Users often invest considerable costs in their equipment or operating practices to gain just a 0.1% accuracy improvement. Part 2 offers this magnitude of saving in a calculation. Best of all is that it is inherent in all Scanner 3100 flow computers and can be applied without additional cost.

This reduction in measurement error applies regardless of whether the flowmeter is volume or mass based. For combustible gases, the accuracy improvement influences the subsequent optional extension of energy computations.

The Part 2 equation is based on 21 natural gas components: methane, nitrogen, carbon dioxide, ethane, propane, n-butane, isobutane, n-pentane, isopentane, n-hexane, n-heptane, n-octane, n-nonane, n-decane, hydrogen, oxygen, carbon monoxide, water, hydrogen sulfide, helium, and argon. These components are identical to the AGA 8 Part 1 algorithm.

AGA 8 Part 1 versus part 2: Density of a carbon dioxide- and nitrogen-rich hydrocarbon gas mixtures as defined in AGA 8 (1994)

		Density lbm/ft^3 [kg/m^3]		**Absolute Pressure** psi [MPa]		**Temperature** degF [degC]	
Composition mole %	AGA 8 Reference						
C1=81.211	Part 1	19.19	307.43	4,525	32.2	36.0	2.25
N2=5.702	Part 2	19.15	306.82				
CO2=7.585	Δ%		0.1993				
C2=4.303							
C3=0.8951	Part 1	21.65	346.83	7,040	48.5	59.8	15.45
C4=0.1510	Part 2	21.61	346.22				
NC4=0.1520	Δ%		0.1742				
	Part 1	17.46	279.63	7,128.3	49.15	189.4	87.45
	Part 2	17.44	279.31				
	Δ%		0.1156				

Appendix A5, Table A.5-1 HICO2-N2.

Contact Cameron for information on the benefits of Part 2 calculations for other gas mixtures and pure gases.

Improved density prediction models are particularly important for highly compressed fluids. In most cases the Part 2 calculation will produce smaller quantities and lower densities.

The Scanner 3100 flow computer can perform the Part 2 calculations in mixed gas or pure gas flow streams, whereas most other flow computer models and brands cannot. The Part 2 calculation estimates the density of a single-component (pure) fluid three times more easily and rapidly as compared with the Part 1 calculation. However, it computes the density of an 18-component mixture 13 times more slowly than the Part 1 calculation. The abundantly powerful Scanner 3100 flow computer processing capacity and Cameron's optimization of the algorithms enables this best-in-class flow computer to accomplish this task without compromising other capabilities or compliance.

AGA 8 Part 2 is consistent with National Institute of Standards and Technology (NIST) Reference Fluid Thermodynamic and Transport Properties Database (REFPROP): Version 9.1 results. AGA 8 Part 2 is also known as ISO 20765. It produces the same results as GERG 2008, which was published in 2012.

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		Density lbm/ft^3 [kg/m^3]		Volume mmcf/day [E3M^3/day]		Mass Lbs/day [kg/day		MJ/day mmBTU/day [mJ/day]	
Composition (pure)	AGA 8 Reference								
Propane	Part 1	29.29	469.23	11.31	320.377	1,297,526	588,549	28,098.26	29,645,236
	Part 2	28.01	448.62	11.06	313.317	1,268,724	575,484	27,474.53	28,987,172
	Δ%		4.594		2.253		2.270		2.270
Carbon Dioxide	Part 1	14.81	237.31	8.17	231.267	923,506	418,896	0	0
	Part 2	14.82	237.31	8.17	231.227	923,358	418,829	0	0
	Δ%		–0.034		0.017		0.016		0
Nitrogen	Part 1	5.84	93.49	8.10	229.332	579,901	263,039	0	0
	Part 2	5.84	93.52	8.10	229.365	579,989	263,076	0	0
	Δ%		–0.014		–0.014		–0.014		0
Ethane	Part 1	14.75	236.25	11.89	336.605	920,933	417,729	20,569.32	21,701,784
	Part 2	14.73	235.93	11.88	336.387	920,306	417,444	20,555.32	21,687,016
	Δ%		0.065		0.068		0.068		0.068

The pressure and temperature in the above table were 1,414.2 PSI [9.7507 MPa] and 160 degF [71.1 degC]

The data in the table was generated in metric units with a soft conversion to US measure units

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