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Extended Abstract

Effect of Compositional Variations on Gas Condensate Fluid Properties and Associated Flow Metering Challenges

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1 INTRODUCTION

Differential pressure-based flow meters are often used to measure the flow rate of gas from gas-condensate fields [1]. These meters require the density and viscosity of the gas under flowing pressure and temperature to convert the measured differential pressure into a gas flow rate. Most flow meters today are equipped with a flow computer that can take an input of the gas composition, and automatically calculate the density and viscosity of the gas under flowing conditions, based on an equation-of-state model chosen by the user. However, an error in the input composition will translate into incorrect density and viscosity of the gas, which will consequently affect the calculated gas flow rate. In this paper, we explore the effect of compositional variations on the flow metering of gas-condensate fields under 2 scenarios:a) the actual produced gas has 1 mole percent less Heptane+ (C_{7+}) components and 1 mole percent more methane (C_1) instead and b) the actual produced gas produces 2 mole percent less Hydrogen Sulphide (H_2S) and 2 mole percent more methane (C_1) instead.

2 COMPOSITIONAL CHANGES - SCENARIOS

The two scenarios considered in the paper are described below. It was simply assumed that a different composition was produced through the flow meter at surface, rather than a (outdated) baseline composition input into the flow computer. In both cases, no consideration was given to change in dewpoint or liquid dropout or other changes that may occur in fluid behaviour due to a change in composition.

2.1 Scenario 1 – Liquid Dropout & Gas Cycling

Vo, 2010 [2] discusses the effect of liquid loading and the subsequent decrease in heavier (C_{5+}) components being produced at the wellhead. Subsequently, when the reservoir pressure is increased by gas cycling, there is an increased C_{5+} production, and the production returns to a more normal behavior. Using a typical Gas Condensate composition, the variation in physical properties for a 1 mole % change in C_{7+} fraction was calculated. A corresponding change of the opposite sign was assumed for C_1 composition.

2.2 Scenario 2 – Compositional Grading due to H_2S

Temeng et al [3] describe the variation in gas composition (particularly H_2S) with depth, possibly due to bacterial activity. Authors of Temeng et al [3] contend that the observed variation in gas density and condensate-gas-ratio (CGR) is "contrary to expectations from gravity-chemical equilibrium theory". Using compositions for well D2 in [3], a model for the behavior of the gas was developed. The effect of a 2% decrease in H_2S content on the physical properties was calculated by considering a corresponding change in the opposite direction in C_1 content.

3 RESULTS – EFFECT ON PHYSICAL PROPERTIES

3.1 Scenario 1

Figure 1 and Figure 2 shows the density of the baseline composition and the effect of a 1% change in C_{7+} content respectively for different pressures and temperatures. It is clear that the density of the actual gas with 1% less C_{7+} may be up to 7-9% lower under the conditions within the flow meter.

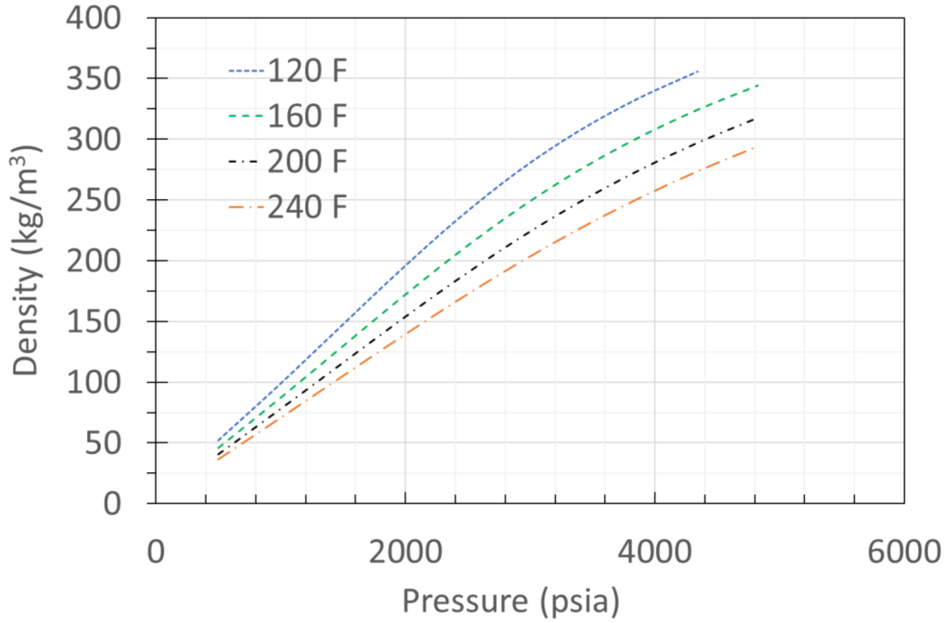

Figure 1 – Scenario 1: Density of Baseline Composition

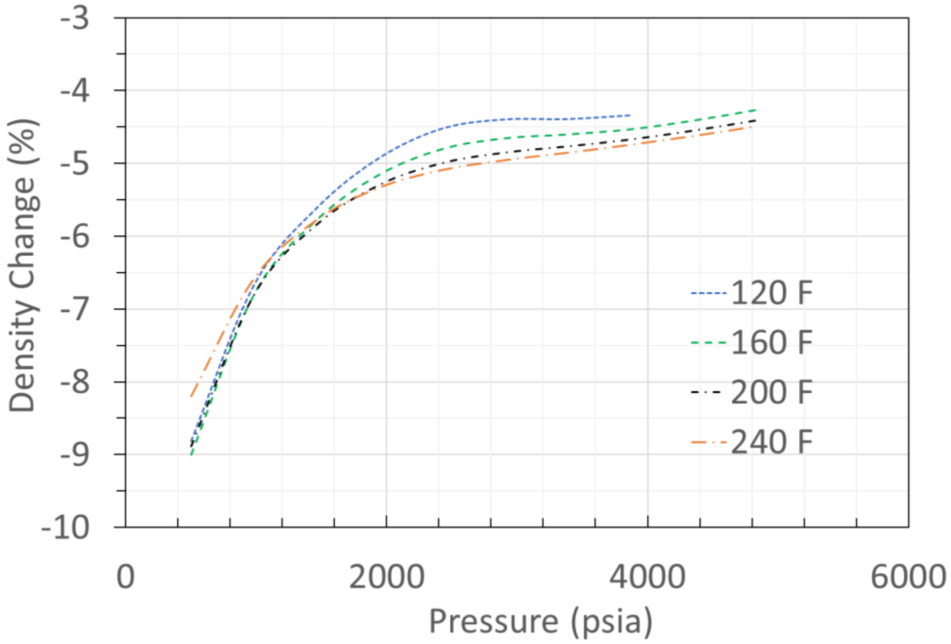

Figure2 – Scenario 1: Change in Density

3.1 Scenario 2

Figure 3 and Figure 4 shows the density of the baseline composition and the effect of a 2% change in H_2S content respectively for different pressures and temperatures. It is evident that there is not a big difference in the density of produced gas.

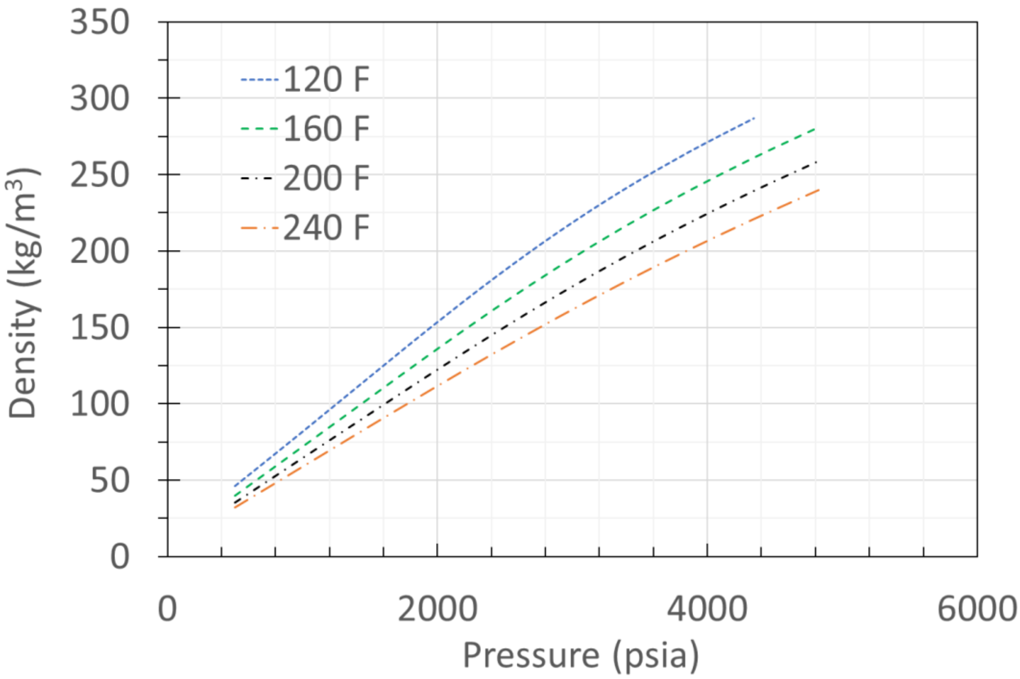

Figure 3 – Scenario 2: Density of Baseline Composition

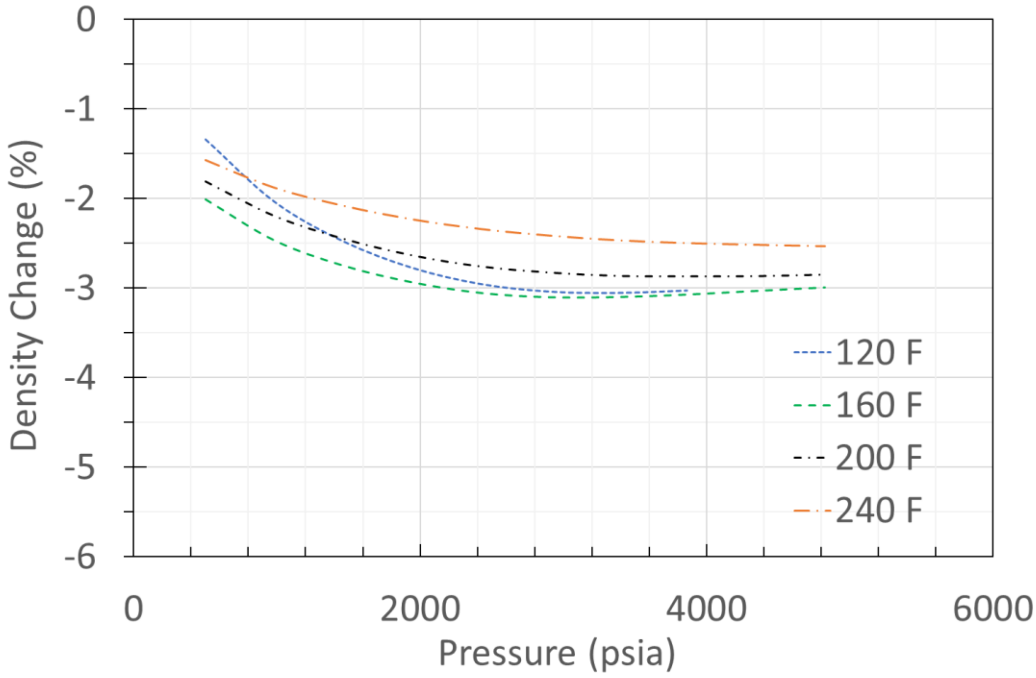

Figure 4 – Change in Density – Scenario 2

3 EFFECT ON FLOW METERING

The effect of density and viscosity variations was then considered on a machined Venturi meter installed on a surface with a nominal diameter of 143.5 mm and a beta ratio of 0.5. The pressure and temperature at the flow meter were taken to be 600 psi and 200°F respectively. The nominal uncertainties for the different parameters in the Venturi meter were adapted from ISO 5167-4 [4] and are given in Table 1 along with the other measured variables. A Monte-Carlo simulation was completed to evaluate the effect of variations outlined in Table 1 on the gas flow rate for a differential pressure ranging from 25 to 125 water-inches.

Table 1 – Parameter Uncertainities

Parameter	Uncertainty	Units
Diameter	0.1	mm
Coefficient of Discharge	0.03	absolute
Pressure	0.1	% full scale
Temperature	0.15 + 0.002* temperature	C
Differential Pressure	0.1	% full scale

The effect of variation in density on gas flow rate for Scenario 1 is shown in Figure 5. Compared to the baseline, there is a decrease up to 3-5 % in the measured mass flow rate if the C_{7+} content is lower by 1%. However, on a volumetric basis, the flow rate is higher by 3-5 % under flowing conditions as the actual density of the gas is lower since the heavier C_{7+} components are reduced by 1% (Figure 6). The error bars within each case in Figure 5 and 6, represent the uncertainty in flow rate due to uncertainties in variables listed in Table 1 (95% confidence interval).

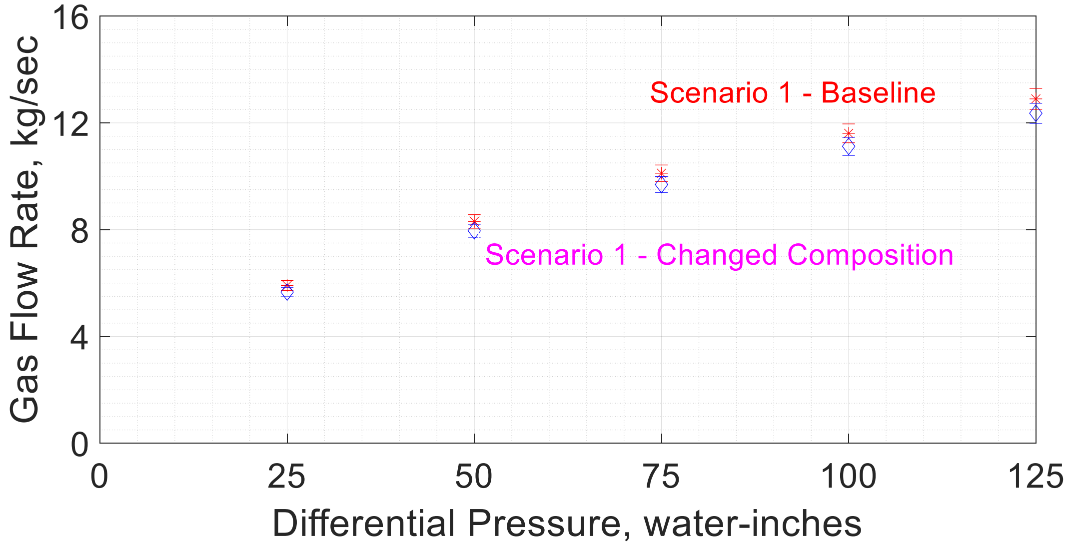

Figure 5 – Scenario 1: Change in Mass Flow Rate of Gas

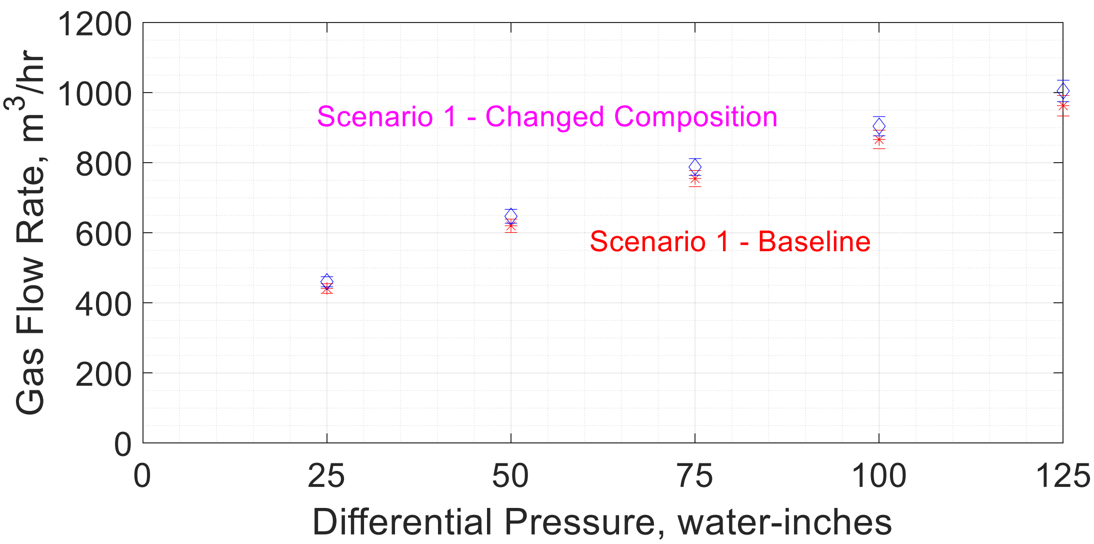

Figure 6 – Scenario 1: Change in Volumetric Flow Rate of Gas

The effect of variation in density for Scenario 2 on mass flow rate of gas is shown in Figure 7 , and predictably there is not a significant effect of gas composition.

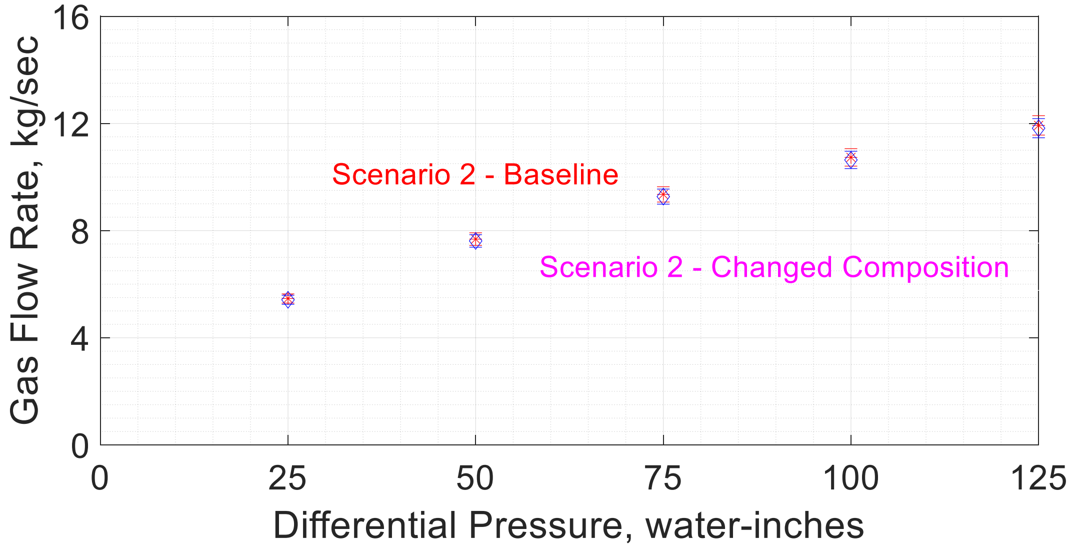

Figure. 7 – Scenario 2: Change in Mass Flow Rate of Gas

4 REFERENCES

[1] Mahalingam, S., Arsalan, M., and Jauregui, Jairo, "Wet-gas Metering – Implications of Changing Well Conditions on Long-term Flow Measurement", North Sea Flow Measurement Workshop, October 2019.

[2] Vo, H. X., "Compositional Variation During Flow of Gas-Condensate Wells", Masters Thesis, Stanford University, 2010, pp. 6.

[3] Temeng, K. O., Al-Sadeg, M. J., and Al-Mulhim, W. A., "Compositional Grading in the Ghawar Khuff Reservoirs", Proceedings of the SPE Annual Technical Conference and Exhibition, New Orleans, September 1998, pp. 685-695.

[4] ISO 5167-4:2003. "Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full - Venturi Tubes", 2003.