Analysis Report

Water/Gas Samples

HAG-GT1 Well

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1. Procedures Description

1.1. Sampling Sequence

The sampling kit with a purging tee was connected to a branch manifold from the drillpipe. The water well was choked to 250 psi for 15 minutes. A purge was conducted to determine the nature of the sample, the sample collected at the purge tee was just gas with very little liquid.

After flowing the well for 1 hour at a rate of 150 m^3/hour , the sample was collected using the displacement procedure from the branch manifold at 14:45. During the sampling, the well was flowing at a pressure of about 100 psi and a rate of 140m^3/hour.

The second pressurized liquid sample was collected after an hour of well flowing , again at 140 m^3/hour and 100 psi.

The pressurized gas sample was collected at 16:15 with the well flowing, with a backpressure of 250psi.

An additional atmospheric gas sample was collected in a baloon from the annulus.

1.2. Samples Preliminary Checks and Analysis

1.2.1. Visual Inspection upon Receiving the Samples

Upon receipt, the samples were visually inspected for any obvious faults, i.e. leaks, bent valves or any other mechanical problems. The sample cylinders were all found to be in good condition.

1.2.2. Opening Pressure Measurement

The pressurized sample cylinders at room temperature were connected at the water end to a high pressure pump, the opening pressure was read at the pump display.

For the gas cylinder, a pressure gauge was attached to the top valve at room temperature. The opening pressure was read directly at the gauge.

1.2.3. Gas Bottle Water Check

With the gas sample in a vertical position, a few cc's were purged from the bottom valve in order to check the water content. All the water found was drained.

1.2.4. Gas H_2S Presence Check

With the gas sample in a vertical position, a few cc's were purged on a paper strip imbibed with Lead Acetate. H_2S reacts specifically with lead acetate to form a lead sulfide brown stain. There was a very slight change in color indicating that there was some infinitesimal H_2S amount. During the purge, some H_2S smell could be vaguely perceived.

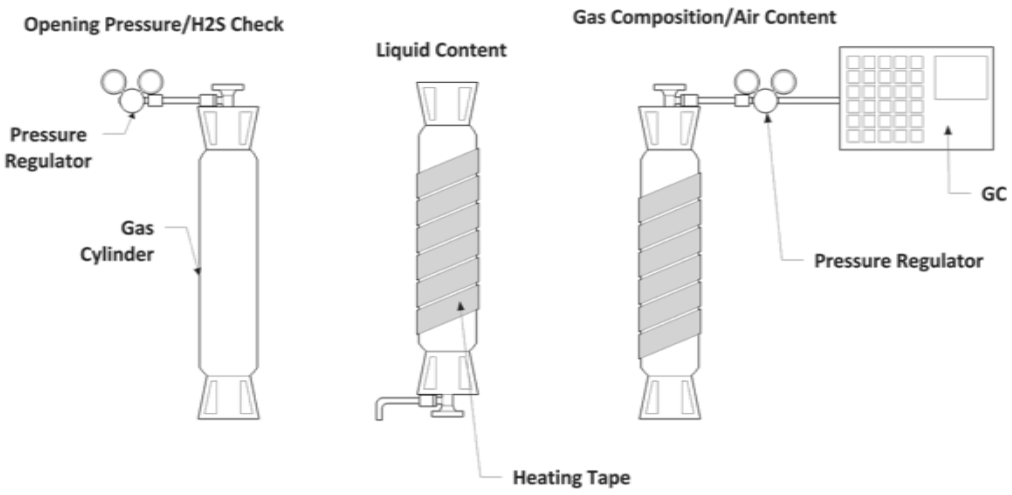

Figure 1-Gas Samples Quality Check

1.2.5. Samples Restoration

The liquid samples were pressurized to the working pressure and stabilized by shaking. While connected to a positive displacement pump, the samples were heated up to a temperature of 95^0C and homogenized for 24 hours prior to any removal of samples.

1.2.6. Bubble Point Measurements

The liquid samples were subjected to pressures ranging from pressures higher than the reservoir pressure to much lower pressures at reservoir temperature.

The change in the slope of the PV curve indicates the bubble point pressure.

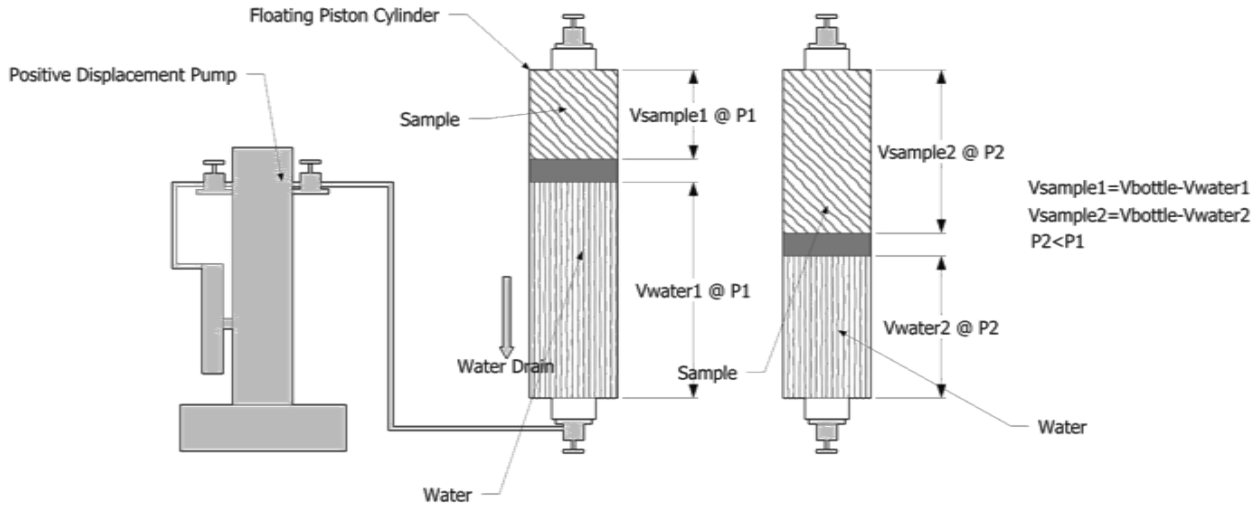

Figure 2-Bubble Point Measurement

1.2.7. Compositional Analysis

1.2.7.1. Flash Separation

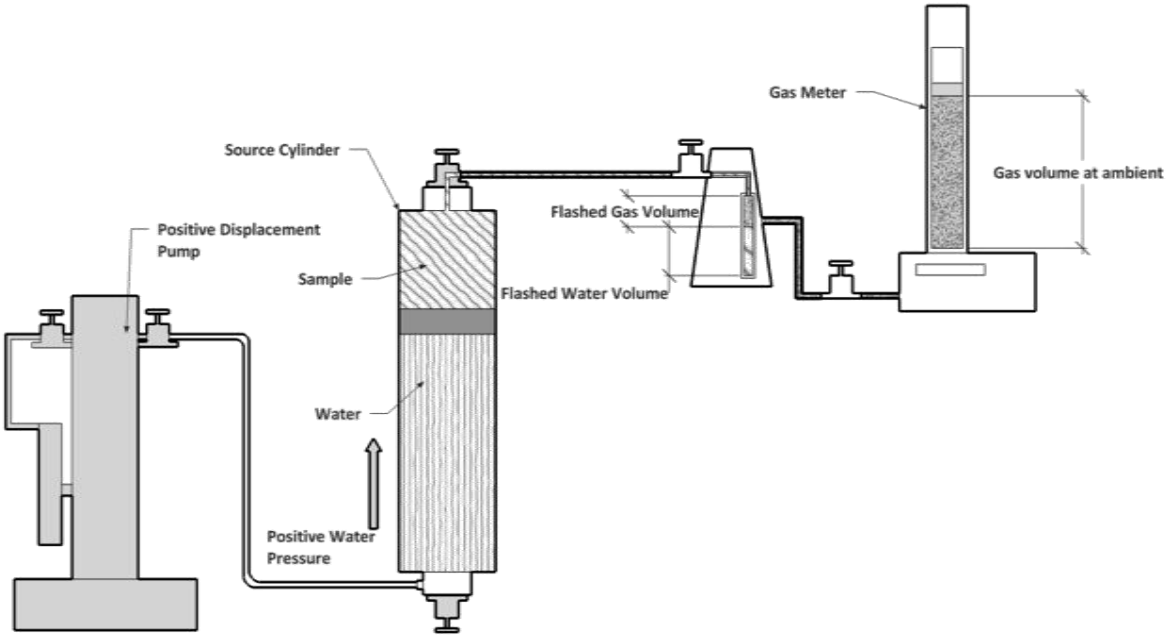

Figure 3-Flash Separation

A volume of a single-phase fluid was pumped from the sample cylinder into a trap connected to a gas meter at atmospheric conditions of pressure and temperature. The flashed water and gas volumes, separation temperatures and atmospheric pressures were accurately recorded.

The composition of gas was subsequently measured using the procedure described below. The flash GOR (gas oil ratio) was calculated as well as the ratio between the flashed liquid and the collected gas.

1.2.7.2. Sample Composition

The resulted gas fraction was analysed using the gas chromatography procedure.

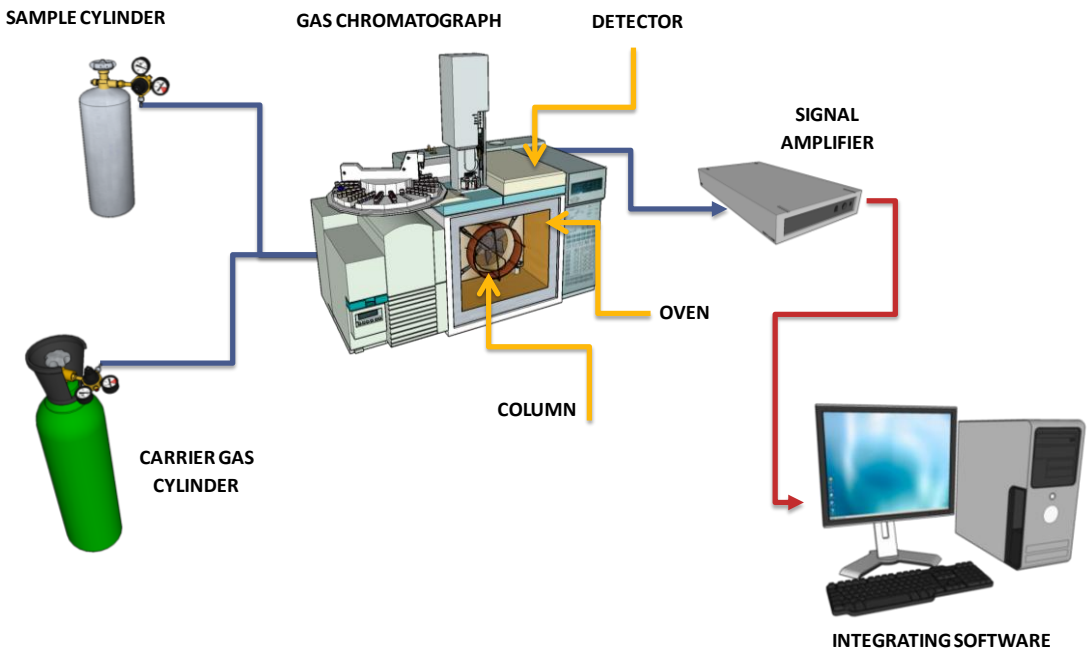

Figure 4-General Chromatographic Procedure Layout

Compositions up to C_{11+} were measured. Components: porous polymer and mole sieve columns, TCD detector (for C_1-C_3, permanent gases), capillary column and FID detector (for C_4 to C_{11+}).

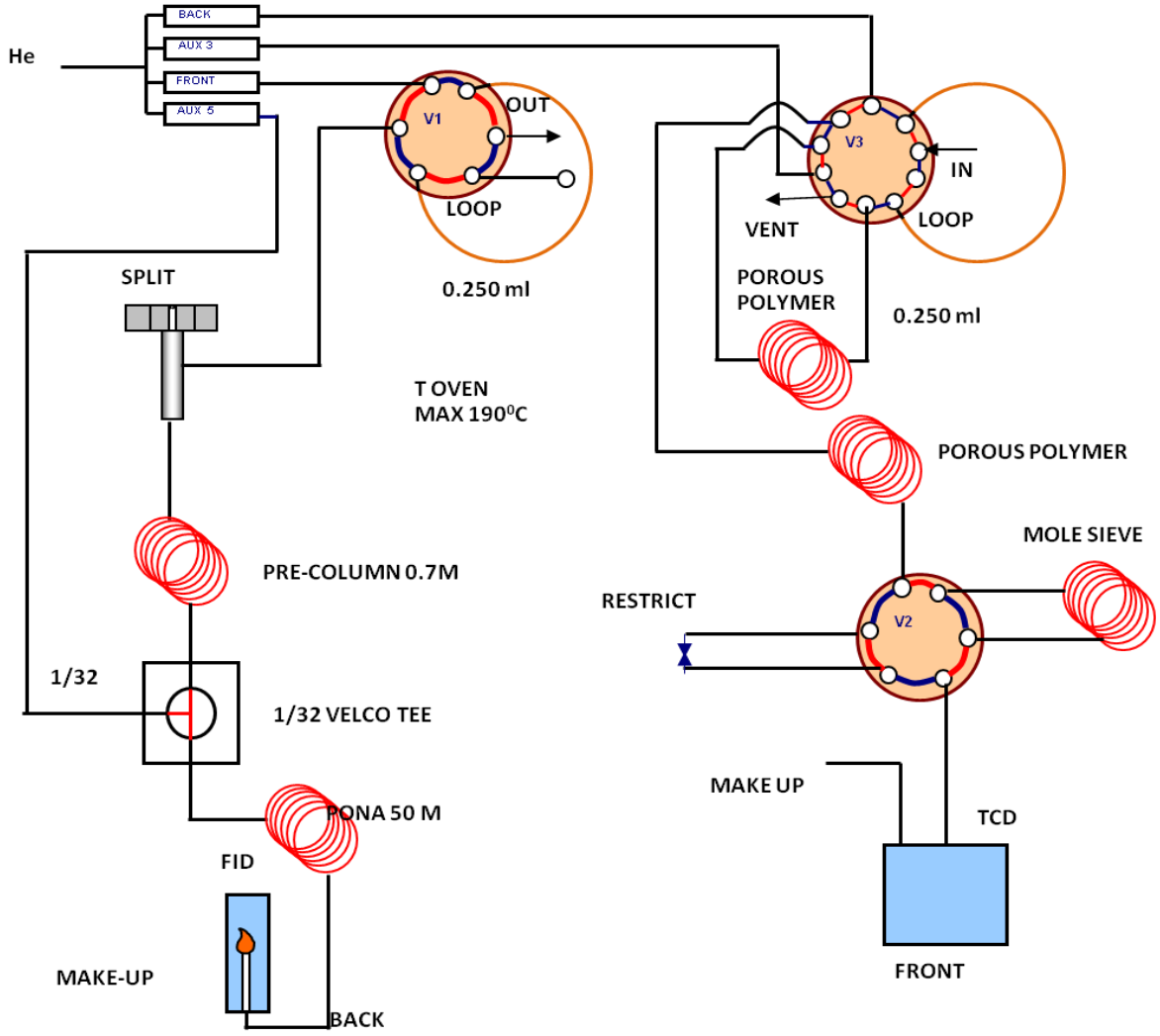

Figure 5-Gas Chromatography Layout

2. Provided Information

2.1.1. Summary of Well Data

Well: HAG-GT1

Reservoir Fluid: Water/Gas

Reservoir Pressure: 3300 psi

Reservoir temperature: 75^{0}C

Vertical Depth: 2301 m

2.1.2. Summary of Sampling Data

Table 1-Summary of Sampling Data

Sample type	Well	Sampling Point	Original bottle no.	Date/Time Sampling	Surface Line Pressure (psi)
Pressurized Liquid	HAG-GT1	Surface – Drill Pipe Manifold	F80009/156	22-9-10/14:45	100
Pressurized Liquid	HAG-GT1	Surface – Drill Pipe Manifold	32138	22-9-10/15:45	100
Pressurized Gas	HAG-GT1	Surface – Drill Pipe Manifold	DW-7214	22-9-10/16:00	100
Atmospheric Gas	HAG-GT1	Surface - Annulus	Plastic Recipient	22-9-10/16:30	250 (back pressure)

3. Analysis Results

3.1. Preliminary Check Results

Table 2-Preliminary Check Results

Sample Type	Cylinder no.	Opening Pressure (psig)	Opening Temperature (^{0}C)	Sample Volume (cc)	Bubble Point (psig) at 75^{0}C
Pressurized Liquid	F80009/156	80	22	700	1320
Pressurized Liquid	32138	84	22	700	1100
Pressurized Gas	DW-7214	380	50	20000	N/A

* Sample volume at opening pressure

3.2. Compositional Analysis

Table 3-Gas Composition Sample no. DW-7214

	Component	Mole%	Weight%
H_2	Hydrogen	0.000	0.000
H_2S	Hydrogen Sulphide	0.000	0.000
CO_2	Carbon Dioxide	1.697	4.267
N_2	Nitrogen	2.424	3.879
C1	Methane	93.074	85.286
C2	Ethane	2.066	3.548
C3	Propane	0.428	1.077
C4	i-Butane	0.039	0.130
C4	n-Butane	0.051	0.168
C5	i-Pentane	0.008	0.033
C5	n-Pentane	0.004	0.018
C6	Hexanes	0.009	0.044
C7	Heptanes	0.003	0.015
C8	Octanes	0.001	0.005
C9	Nonanes	0.000	0.001
C10	Decanes	0.156	1.192
C11+	Undecanes Plus	0.040	0.337
	Total	100.000	100.000
Calculated Gas Properties			
Gas Density (kg m^{-3} @ 15°C)		0.740	
Gas Mole Weight (g mol^{-1})		17.508	
Real Relative (to air) Density of Gas		0.604	
Mole weight of Heptanes Plus (g mol^{-1})		135.569	
Density of Heptanes plus (g cm^{-3} at 60°F)		0.781	
Mole Weight of Undecanes plus (g mol^{-1})		147.000	
Density of Undecanes plus (g cm^{-3} at 60°F)		0.789	
Calorific Value (MJ m^{-3})		37.545	

Table 4-Flashed Gas Composition Sample no. F80009/156

	Component	Mole%	Weight%
H_2	Hydrogen	0.000	0.000
H_2S	Hydrogen Sulphide	0.000	0.000
CO_2	Carbon Dioxide	3.371	5.147
N_2	Nitrogen	1.521	1.478
C1	Methane	77.860	43.337
C2	Ethane	1.802	1.880
C3	Propane	2.082	3.186
C4	i-Butane	0.499	1.006
C4	n-Butane	2.827	5.700
C5	i-Pentane	0.907	2.271
C5	n-Pentane	2.515	6.296
C6	Hexanes	1.007	2.934
C7	Heptanes	0.344	1.084
C8	Octanes	0.626	2.034
C9	Nonanes	0.009	0.037
C10	Decanes	0.001	0.005
C11+	Undecanes Plus	4.628	23.604
	Total	100.000	100.000
Calculated Gas Properties			
Gas Density (kg m^{-3} @ 15°C)		0.935	
Gas Mole Weight (g mol^{-1})		28.823	
Real Relative (to air) Density of Gas		0.763	
Mole weight of Heptanes Plus (g mol^{-1})		137.548	
Density of Heptanes plus (g cm^{-3} at 60°F)		0.792	
Mole Weight of Undecanes plus (g mol^{-1})		147.000	
Density of Undecanes plus (g cm^{-3} at 60°F)		0.789	
Calorific Value (MJ m^{-3})		45.407	

Flash Gas Water Ratio: 1.235 Nm^3/m^3

Table 5-Flashed Gas Composition Sample no. 32138

	Component	Mole%	Weight%
H_2	Hydrogen	0.000	0.000
H_2S	Hydrogen Sulphide	0.000	0.000
CO_2	Carbon Dioxide	5.292	12.080
N_2	Nitrogen	2.037	2.959
C1	Methane	88.521	73.661
C2	Ethane	1.827	2.849
C3	Propane	0.485	1.109
C4	i-Butane	0.064	0.194
C4	n-Butane	0.363	1.095
C5	i-Pentane	0.137	0.513
C5	n-Pentane	0.407	1.522
C6	Hexanes	0.412	1.795
C7	Heptanes	0.180	0.852
C8	Octanes	0.265	1.307
C9	Nonanes	0.009	0.056
C10	Decanes	0.001	0.008
C11+	Undecanes Plus	0.000	0.001
	Total	100.000	100.000
Calculated Gas Properties			
Gas Density (kg m^{-3} @ 15°C)		0.818	
Gas Mole Weight (g mol^{-1})		19.279	
Real Relative (to air) Density of Gas		0.667	
Mole weight of Heptanes Plus (g mol^{-1})		94.041	
Density of Heptanes plus (g cm^{-3} at 60°F)		0.797	
Mole Weight of Undecanes plus (g mol^{-1})		147.000	
Density of Undecanes plus (g cm^{-3} at 60°F)		0.789	
Calorific Value (MJ m^{-3})		38.049	

Flash Gas Water Ratio: 0.701 Nm^3/m^3

Table 6-Gas Composition Sample Plastic Baloon

	Component	Mole%	Weight%
H_2	Hydrogen	0.000	0.000
H_2S	Hydrogen Sulphide	0.000	0.000
CO_2	Carbon Dioxide	0.038	0.099
N_2	Nitrogen	1.653	2.760
C1	Methane	95.455	91.250
C2	Ethane	2.183	3.912
C3	Propane	0.497	1.307
C4	i-Butane	0.051	0.176
C4	n-Butane	0.061	0.210
C5	i-Pentane	0.011	0.046
C5	n-Pentane	0.021	0.089
C6	Hexanes	0.028	0.138
C7	Heptanes	0.002	0.010
C8	Octanes	0.001	0.003
C9	Nonanes	0.000	0.000
C10	Decanes	0.000	0.000
C11+	Undecanes Plus	0.000	0.000
	Total	100.000	100.000
Calculated Gas Properties			
Gas Density (kg m^{-3} @ 15°C)		0.711	
Gas Mole Weight (g mol^{-1})		16.782	
Real Relative (to air) Density of Gas		0.580	
Mole weight of Heptanes Plus (g mol^{-1})		88.446	
Density of Heptanes plus (g cm^{-3} at 60°F)		0.783	
Mole Weight of Undecanes plus (g mol^{-1})		147.000	
Density of Undecanes plus (g cm^{-3} at 60°F)		0.789	
Calorific Value (MJ m^{-3})		38.219	

3.3. Graphs

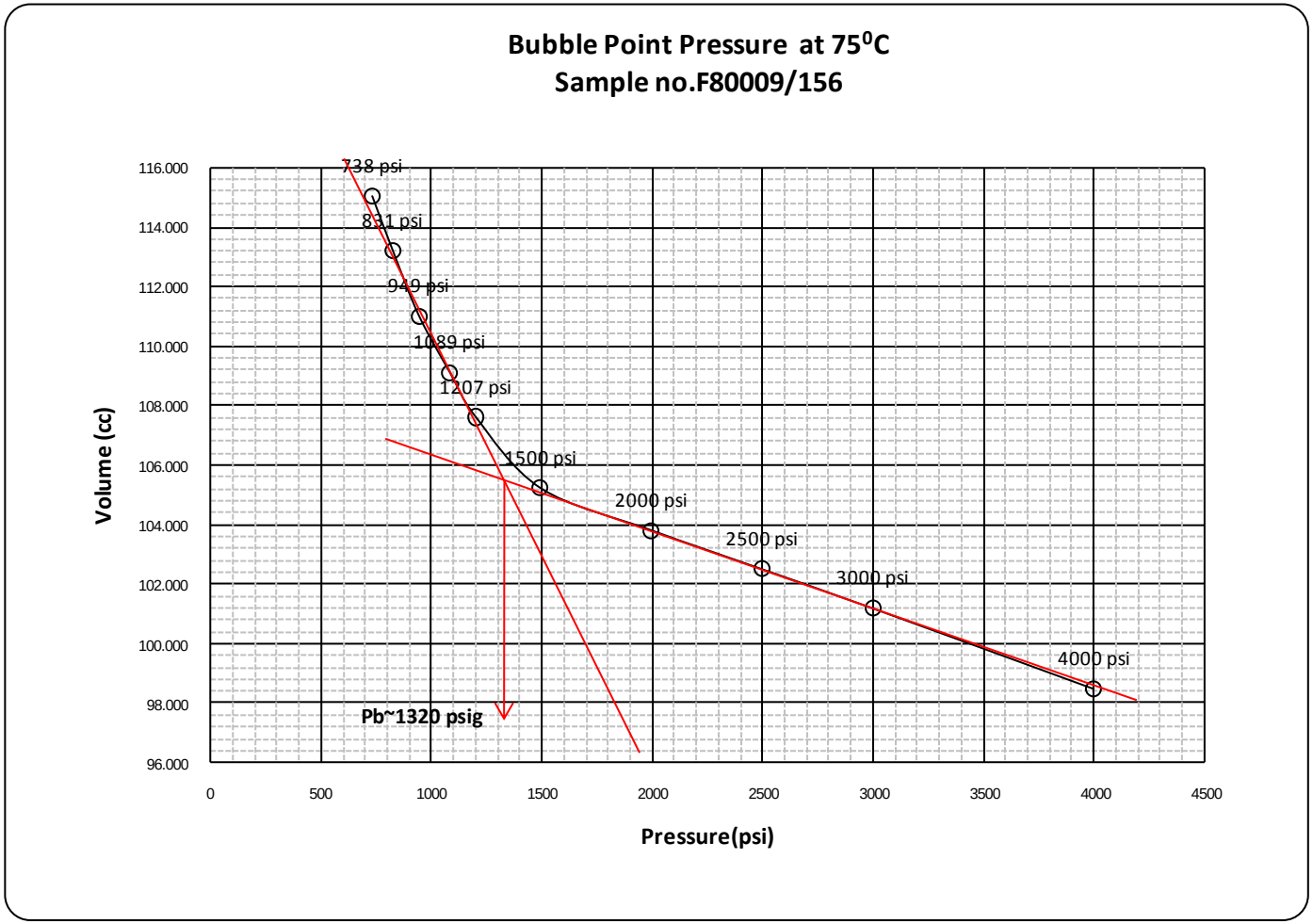

Figure 6-Bubble Point Measurement – Sample no. F8009/156

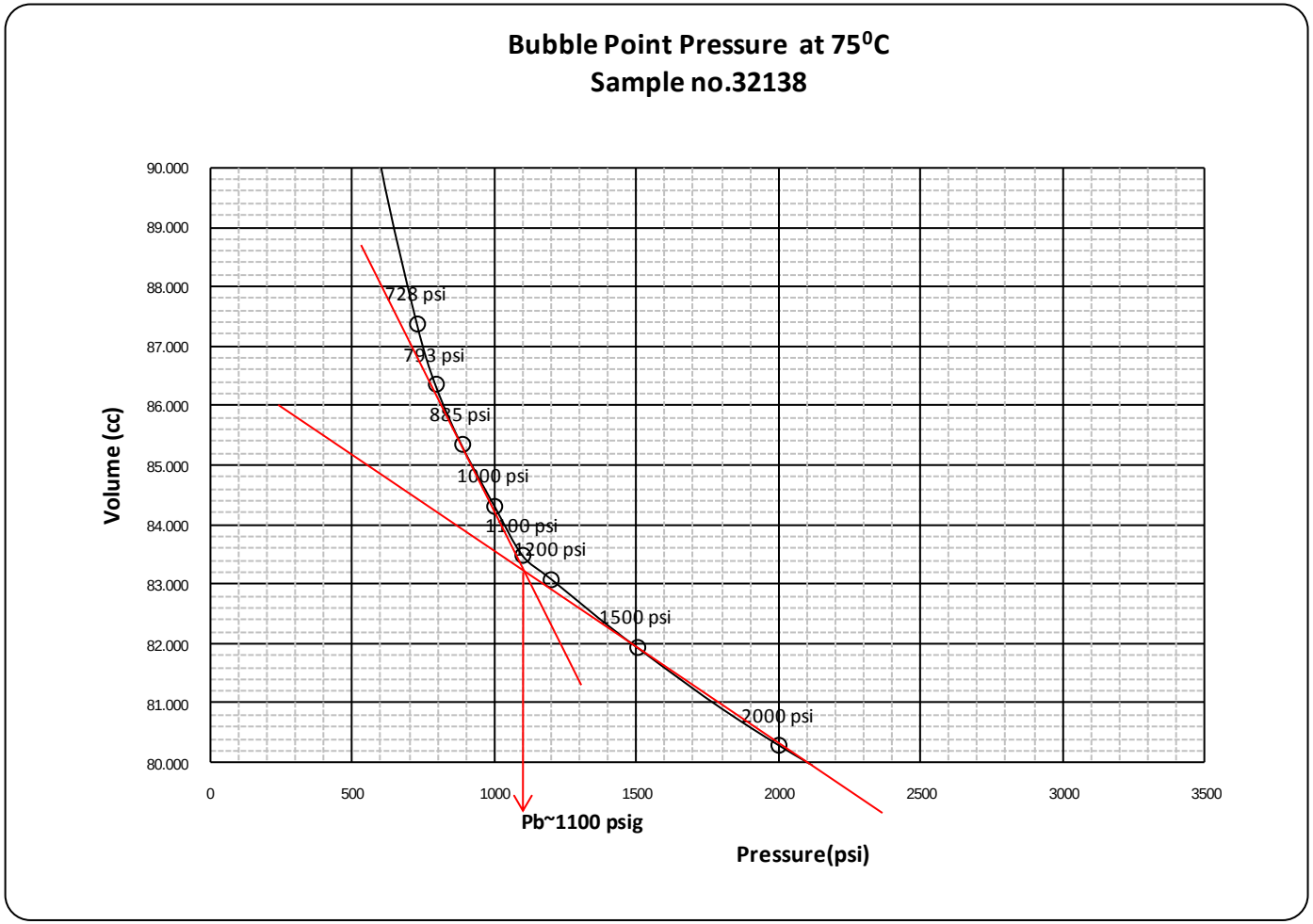

Figure 7-Bubble Point Measurement – Sample no. 32138

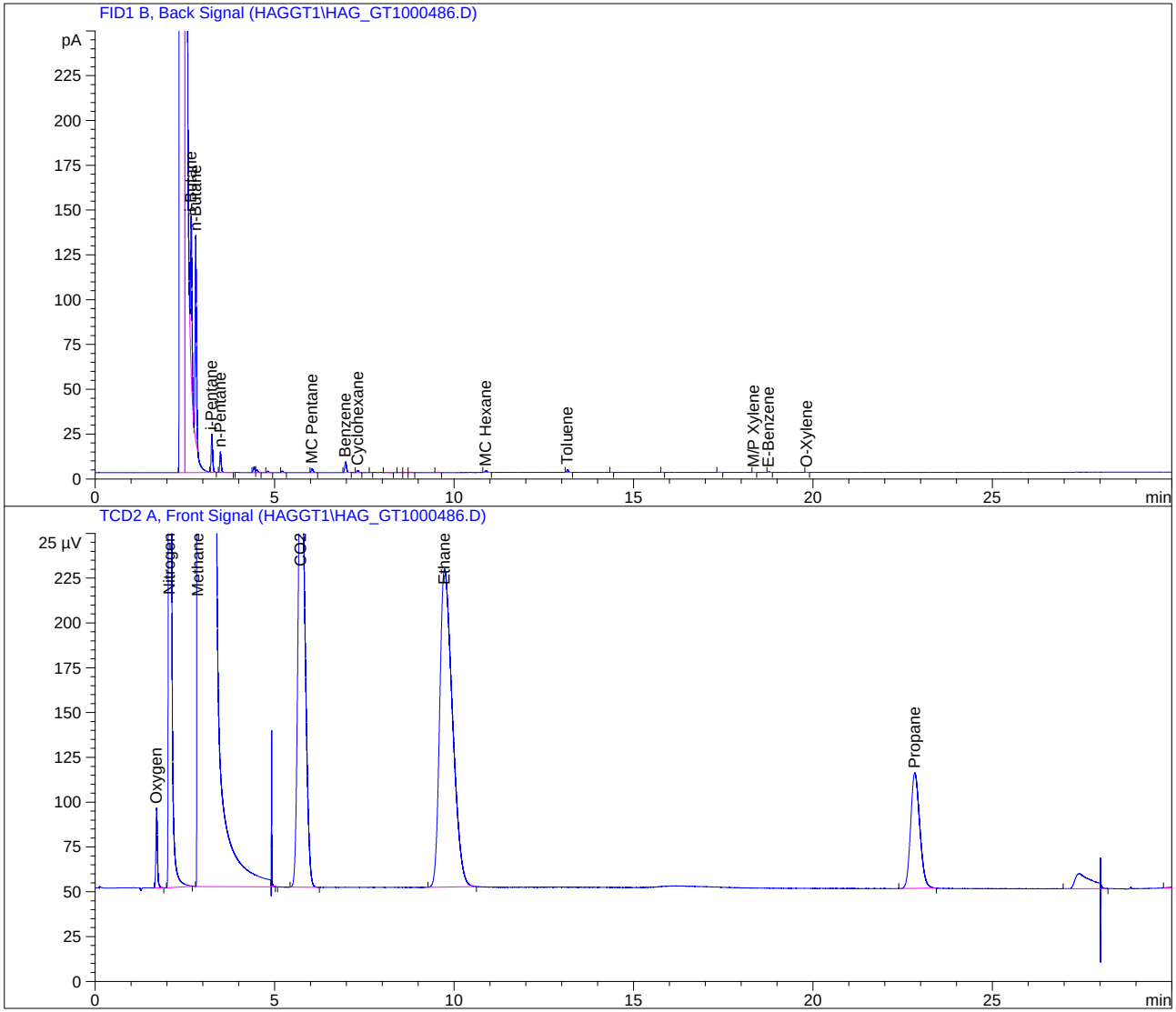

Figure 8-Gas Chromatogram Sample no. DW-7214

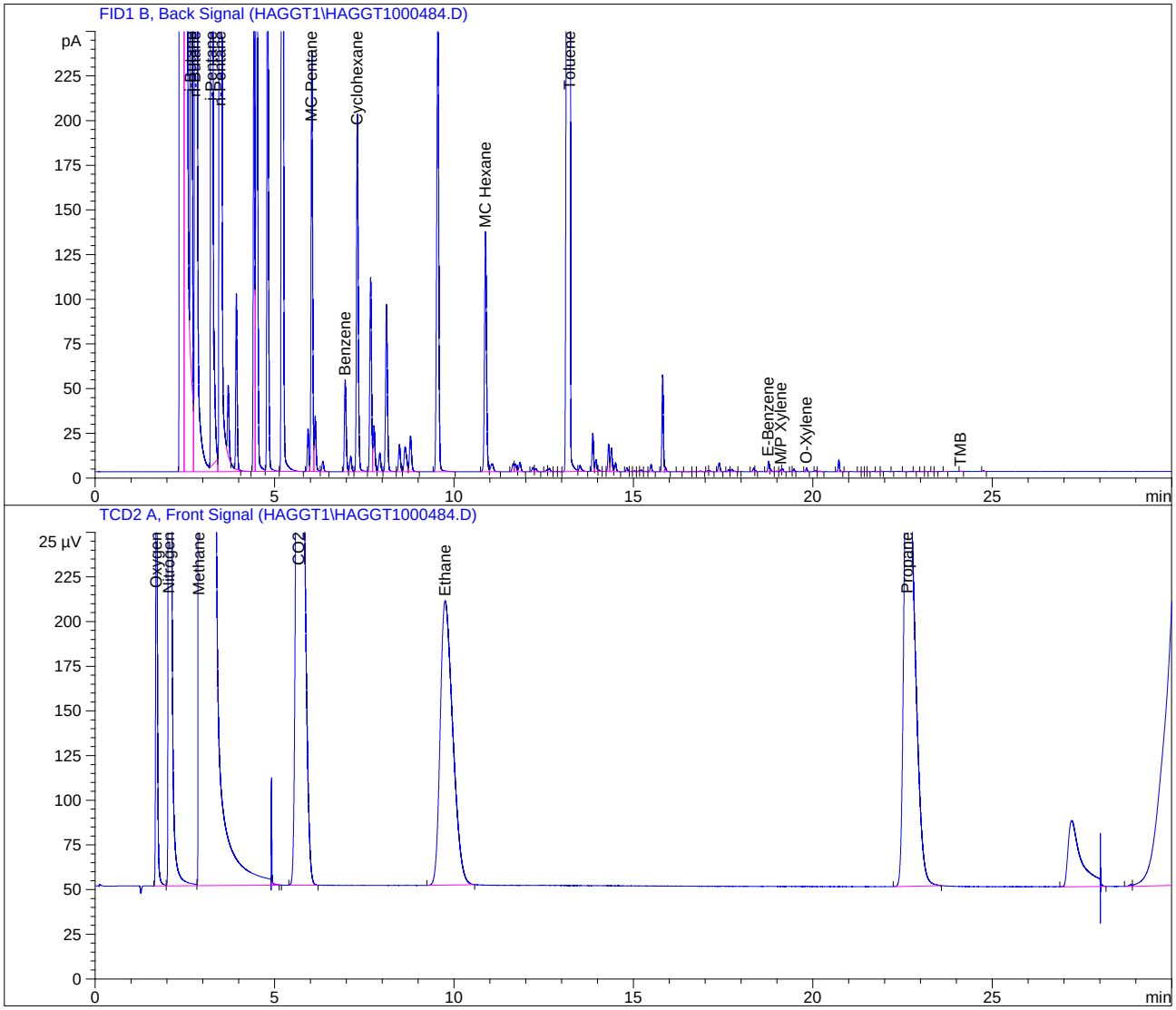

Figure 9-Flashed Gas Chromatogram Sample no. F8009/156

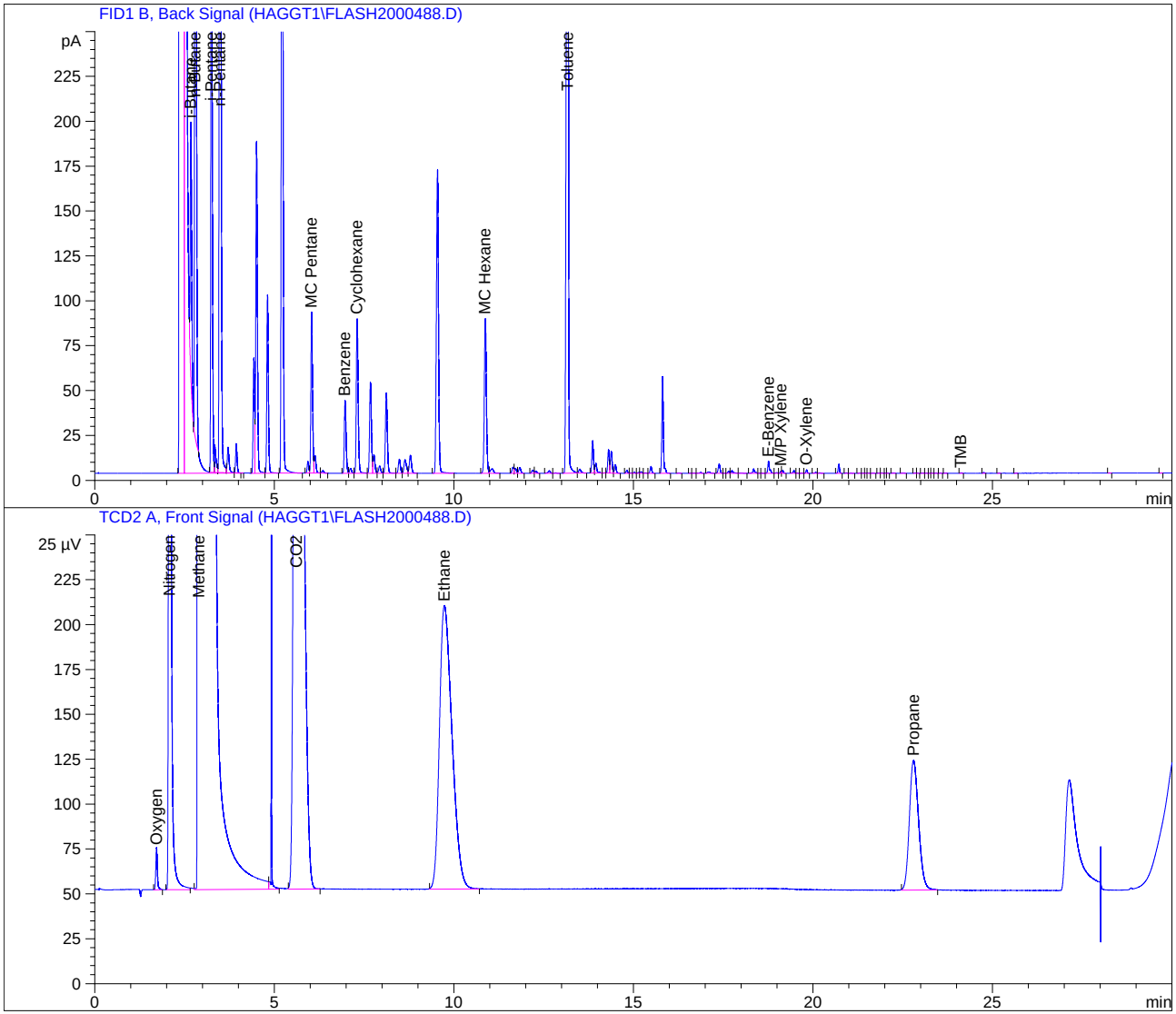

Figure 10-Flashed Gas Chromatogram Sample no. 32138

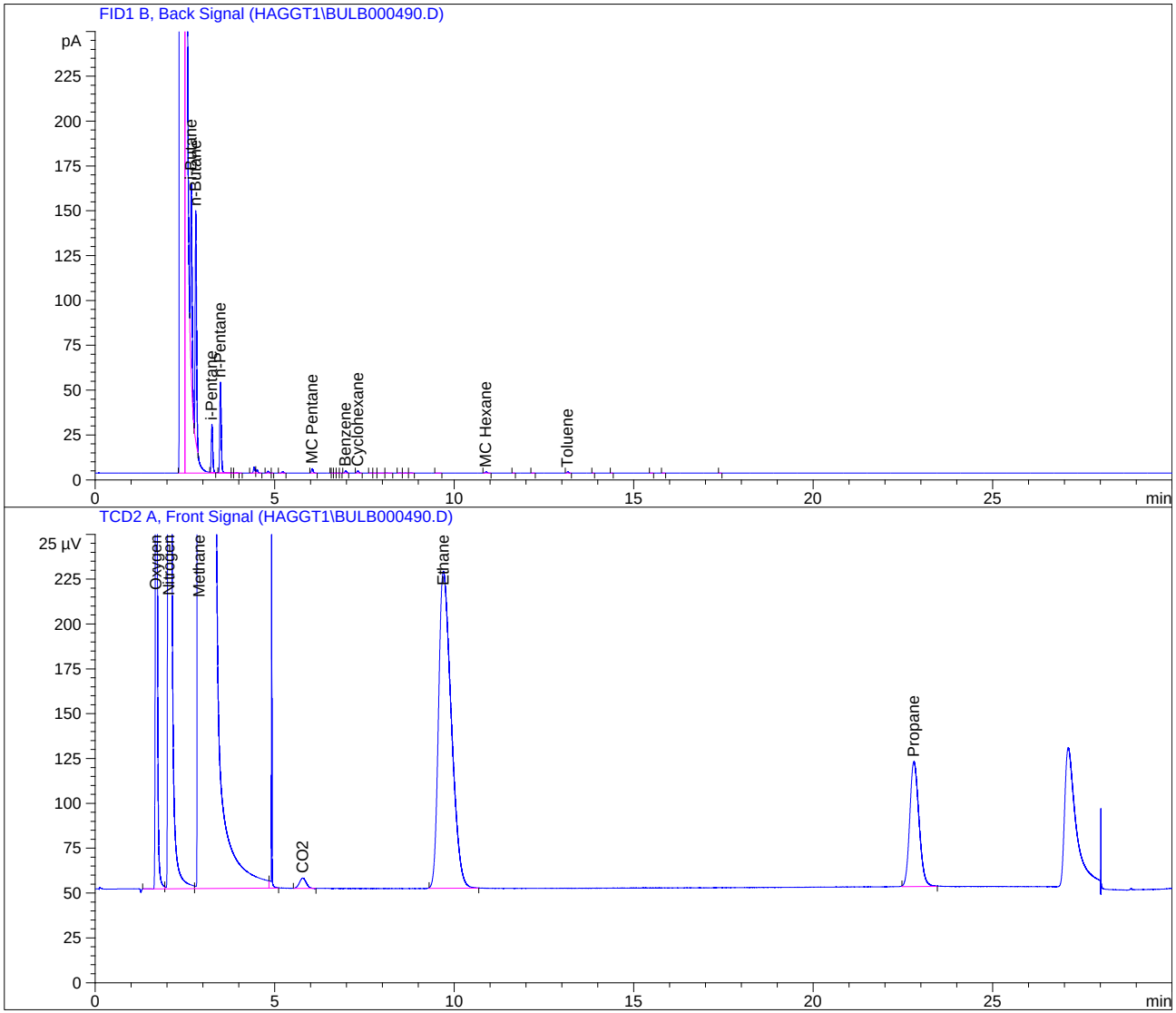

Figure 11-Gas Chromatogram, Plastic Baloon sample

4. Conclusions

In order to obtain a representative sample, the recommended method of sampling is bottomhole sampling, which gives the possibility of collecting a single phase sample from the formation level thus preventing the subsequent change in composition (flash). Surface sampling is recommended where there is a separator at surface and the flow rates of both separated fluids (liquid and gas) can be accurately measured.

In the case of the well Hag-GT1 neither of the two scennarios above were possible, therefore the samples were collected without the certainty that the fluid was flowing in single phase. Depending on the degree of choking, various types of fluids (gas, wet gas, water with bursts of gas etc) were encountered during purging process.

Bubble points were lower than the reservoir pressure at reservoir temperature, but different from each other. The gas water ratios were different from each other, i.e. different fluids were flowing through the manifold at the sampling times. Moreover, the gases flashed from the two pressurized samples, the 20l gas sample and the gas sample collected in a plastic baloon were all compositionally different (the 20 l gas sample and the gas baloon appear closer to each other and probably to the real gas composition).

Consequently, there is no way of guaranteeing the representativity of the samples. If the well was flowing with more gas than it actually contains dissolved in the water in the reservoir, then the sample bubble point would be artificially high and the opposite is true for a flow of degassified water.

Although the H_2S presence was detected by Lead Acetate Strip Paper and by smell, there was no H_2S peak during the compositional analysis due to the following:

- extremely low concentration, close to the lower limit of the GC equipment (5 ppm)
- possible absorbtion of part of the already infinitesimal amount into the metal parts of the sampling equipment (sampling hose, lines, cylinder).
- the sampling flowing in two phases and thus releasing the gas fraction leading to the above absorbtion in all metal parts.

Sampling during unstable (two phase) flow is not recommended for very accurate H_2S determination. A wellsite portable measurement equipment could provide much more accurate results (i.e. Draeger tubes with Accuro Pumps) with an accuracy of 0.2-5 ppm H_2S.