

Hydrocarbon, Sulphur and Carbon Dioxide Contents for Natural Gas Processing Plant

Ashraf Yehia El-Naggar 

Chemistry Department, Faculty of Science, Taif University, KSA
Egyptian Petroleum Research Institute, Nasr City, Cairo, Egypt

Abstract: Four gas samples (two from outlet and two from inlet) were collected at two periods from Meleiha compressor in Egyptian Agiba Petroleum Company and analyzed for composition analysis by gas chromatography (GC) connected with thermal conductivity and flame ionization detectors. The sulphur content in gas samples was analyzed using GC connected with a selective amperometric sulphur detector, the hydrogen sulphide was analyzed on site using sulphur meter. It has been found that methane followed by ethane and propane represent the highest percentage of the all gas composition. Also, It is observed that the weight percent of hydrogen sulphide in inlet separator is higher than that in outlet separator.

Keywords: gas samples, Petroleum Company, gas chromatography, thermal conductivity, flame ionization detector, sulphur detector.

1. Introduction

Natural gas processing consists of separating all of the various hydrocarbons and fluids from the pure natural gas [1], to produce what is known as 'pipeline quality' dry natural gas to meet the specifications of marketable natural gas[2]. That means that before the natural gas can be transported it must be purified. While the ethane, propane, butane, and pentanes [3-5] must be removed from natural gas, this does not mean that they are all 'waste products'. One of the most important parts of gas processing involves the removal of sulfur and carbon dioxide. Natural gas from some wells contains significant amounts of sulfur and carbon dioxide [6, 7]. Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, but commonly includes varying amounts of other higher alkanes and even a lesser percentage of carbon dioxide, nitrogen, and hydrogen sulfide[1]. Natural gas is an energy source often used for heating, cooking, and electricity generation. It is also used as fuel for vehicles and as a chemical feedstock in the manufacture of plastics and other commercially important organic chemicals. Natural gas is a major source of electricity generation through the use of cogeneration, gas turbines and steam turbines. Natural gas is also well suited for a combined use in association with renewable energy sources such as wind or solar[30]

Particularly high efficiencies can be achieved through combining gas turbines with a steam turbine in combined cycle mode. Natural gas burns more cleanly than other hydrocarbon fuels, such as oil and coal, and produces less carbon dioxide per unit of energy released.[8-12].

2. Experiments

2.1 Standard natural gas:-

The NGPA natural gas reference standard (C₁, CO₂, C₂, C₃, iso-C₄, n-C₄, iso-C₅ and n-C₅) was provided from Phillips Petroleum Company Bartlesville. Okiaahoma 74004.

2.1 Sampling

It is a waste of time, manpower, and money to make a highly accurate analysis and inaccurately collected sample, so the sampling is as important as the analysis itself. The greatest care must be exercised in obtaining a representative sample and these samples must be taken by personnel trained in sampling techniques four natural gas samples were collected from Meleiha compressor in Egyptian Agiba Petroleum Company by evacuated cylinder method according to API recommended practice for sampling petroleum reservoir fluids, API (1966) 44. There are another two methods first one. purging method. And second one filling a piston type cylinder which has been introduced in recent years. It has the advantage of making it easier to maintain the sample in single phase whilst sampling and in addition the sample does not come into contact with any other fluid that might give rise to contamination.

2.3 Sample quality checking (Sample validity checks)

The gas sample container was heated to the temperature at which the sample was collected and stable for two hours with shaking to revalorize any liquid. With the cylinder in the vertical position the bottom valve was cracked carefully to check for liquids and then the opening pressure was



Ashraf Yehia El-Naggar (Correspondence)



aynaggar361@yahoo.com



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determined. This pressure was equal to or slightly greater than the pressure at the time of sampling.

2.4 Gas Chromatographic Analysis

The mixed gases C₁, CO₂, C₂, C₃, iso-C₄, n-C₄, iso-C₅ and n-C₅ were analyzed using Agilent 6890 plus HP gas chromatograph, equipped with thermal conductivity detector (TCD) and flame ionization detector (FID), using the fused silica plot Q capillary column 15 meters in length and 0.35 mm int. diameter, attachment with the TCD. Also using the packed column DC 200 of stainless steel in type, 10 feet in length and 1/8 inch in diameter, attachment with the FID. The elution of the studied gas mixtures was achieved with temperature programming from 60 to 200 °C at a rate 10 °C min⁻¹. The different mobile phases used are nitrogen, hydrogen and helium gases, these all gases are Oxygen-free. Flow rates were measured from the end of the column with a soap bubble flow rate. Methane as an unretained marker was used to correct the dead volume in the column in the case of FID, and air used as marker in the case of TCD.

The injector and detector temperatures are 200 °C and 250 °C respectively. The data was estimated by integration of the area under the resolved chromatographic profile, using the HP computer of software chemstation.

2. Results and discussion

Natural gas sample consists of light gases such as methane, ethane and propane and heavy hydrocarbons from butanes to hexanes plus. Also it contains inorganic gases such as nitrogen and carbon dioxide. So, the complete analysis of natural gas required two detectors one is named thermal conductivity detector TCD which used for light hydrocarbon with the inorganic gases. The other is the universal flame ionization detector FID which used for detecting the heavy hydrocarbons in natural gas up to hexanes plus.

With respect to the used chromatographic columns, molecular sieve column was used for determining nitrogen percentage, porapak Q was used to separate the light hydrocarbons in addition to carbon dioxide and silicon oil column was used for eluting the heavy hydrocarbons in natural gas. The evaluation of hydrogen sulphide and mercaptans required a selective amperometric sulphur detector and 95 % dimethyl, 5 % vinyl polysiloxane, stationary phase.

The analysis of all studied natural gas samples from inlet and from outlet separator are given in Tables 1,

2, It has been found that they contain paraffinic hydrocarbons up to nonanes. They contain nitrogen and carbon dioxide mol percents about unity and 5 respectively with very slight difference. The composition of the gas samples from inlet and outlet separators shows some change in the paraffinic compositions of natural gas in the separators through the studied two periods. Methane from inlet and from outlet separator is the predominate with respect to all composition followed by ethane and propane. All studied gas samples contain the light aromatic hydrocarbons, benzene, toluene, ethylbenzene and xylenes (o-, m and p-xylene) but with different mol and weight percentages.

The molecular weights and specific gravities of the gas samples are given in Tables 1 and 2 and calculated from their compositions which obtained from gas chromatography. The gross and net calorific values were calculated from gas composition according to the standard method. It has been found the molecular weight of gas samples from inlet separator at the two periods 12:00 am and 12:00 pm are 29.187 and 32.765 respectively, these values are higher than that from outlet separator at the two studied periods 12:35 am and 12:30 pm (27.694 and 30.768 respectively).

The behavior of specific gravity SG is the same like molecular weight property, the SG of the gas samples at 12:00 am and 12:00 pm are 1.0077 and 1.1313 respectively, and the SG of gas samples from outlet separator at 12:35 am and 12:30 pm are 0.9562 and 1.0623 respectively.

The high and low heat values of the gas samples from inlet separator at the two studied periods exhibit high values compared with that values from outlet separator as given in Tables 1 and 2.

Sulphur analysis

Hydrogen sulfide is the most common sulfur-containing compound encountered in natural gas [13]. Natural gas are the products of thermal conversion of decayed organic matter (called kerogen) that is trapped in sedimentary rocks. High-sulfur kerogens release hydrogen sulfide during decomposition, and this H₂S stays trapped in the gas deposits [14]. In fact, hydrogen sulfide is the predominant impurity in natural gas [15, 16]. Many natural gases contain hydrogen sulfide (H₂S) in concentrations ranging from barely detectable quantities to over 30 mole % [17].

Table 1: GC analysis of gas samples from inlet separator

Components	at sampling time:12:00 am		at Sampling time: 12:00 pm	
	Mol. %	Wt. %	Mol. %	Wt. %
Nitrogen	0.996	0.956	0.988	0.845
Carbon Dioxide	5.464	8.239	4.885	6.562
Methane	50.806	27.925	43.498	21.298
Ethane	18.116	18.664	17.381	15.951
Propane	14.661	22.150	17.163	23.099
i-Butane	2.916	5.807	4.222	7.490
n-Butane	4.032	8.029	6.238	11.066
i-Pentane	1.080	2.670	1.960	4.316
n-Pentane	0.869	2.148	1.667	3.671
hexanes	0.625	1.845	1.294	3.403
Benzene	0.016	0.043	0.031	0.074
Heptanes	0.208	0.714	0.241	0.737
Toluene	0.029	0.092	0.044	0.124
Octanes	0.142	0.556	0.303	1.056
Ethyl-benzene	0.005	0.018	0.008	0.026
P,m-xylene	0.010	0.036	0.022	0.071
o-xylene	0.003	0.011	0.006	0.019
Nonanes	0.022	0.097	0.049	0.192
Decane plus	0.000	0.000	0.000	0.000
Total	100.000	100.000	100.000	100.000
Mol Wt	29.187		32.765	
Sp Gr (Air =1.0000)	1.0077		1.1313	
Gross Calorific Value, Btu/ft3	1562.097		1768.113	
Net Calorific Value, Btu/ft3	1426.703		1618.677	

Table 2: GC analysis of gas samples from outlet separator

Components	at sampling time:12:35 am		at Sampling time: 12:30 pm	
	Mol. %	Wt. %	Mol. %	Wt. %
Nitrogen	0.994	1.005	0.951	0.866
Carbon Dioxide	5.835	9.273	5.139	7.351
Methane	53.189	30.812	46.334	24.159
Ethane	18.828	20.443	18.029	17.620
Propane	13.979	22.258	17.171	24.610
i-Butane	2.495	5.236	3.852	7.277
n-Butane	3.138	6.586	5.299	10.010
i-Pentane	0.640	1.667	1.328	3.114

n-Pentane	0.455	1.185	1.044	2.448
hexanes	0.228	0.709	0.588	1.647
Benzene	0.013	0.037	0.009	0.023
Heptanes	0.079	0.286	0.148	0.482
Toluene	0.031	0.103	0.012	0.036
Octanes	0.062	0.256	0.082	0.304
Ethyl-benzene	0.003	0.012	0.002	0.007
P,m-xylene	0.013	0.050	0.004	0.014
o-xylene	0.002	0.008	0.001	0.003
Nonanes	0.016	0.074	0.007	0.029
Decane plus	0.000	0.000	0.000	0.000
Total	100.000	100.000	100.000	100.000
Mol Wt	27.694		30.768	
Sp Gr (Air =1.0000)	0.9562		1.0623	
Gross Calorific Value, Btu/ft ³	1473.119		1655.044	
Net Calorific Value, Btu/ft ³	1343.834		1513.662	

The amount of H₂S allowable in pipeline- quality gas is between 4-16 ppm [18]. When H₂S concentrations are well above the ppm levels, other sulfur species can be present. These compounds include carbon disulfide (CS₂), mercaptans (RSH) and sulfides (RSR), in addition to elemental sulfur. Hydrogen sulfide is corrosive to metals and can cause metal fatigue, leading to sulfide stress cracking, which is one of the major failure problems that occur in gas pipeline steels when they are exposed to aqueous hydrogen sulfide (H₂S) environments [19, 20]. Hydrogen sulfide can react with rust or corrosion deposits on equipment to form iron sulfide. This reaction occurs in an oxygen free atmosphere where hydrogen sulfide gas is present or where the concentration of hydrogen sulfide is greater than that of oxygen. Sulphur type analysis of the studied gas samples was achieved by gas chromatography connected with amperometric sulphur detector, the results were given in Tables 3 and 4. The concentration of hydrogen sulphide was measured three times for each sample of the four selected ones

and the average reading was taken. It has been found that the hydrogen sulphide concentration shows higher values in inlet separator than in outlet separator. The carbon disulphide and alkyl mercaptanes from methane to butane are not present in the composition of the studied natural gases from inlet and outlet separators. Because of the corrosiveness of H₂S and CO₂ in the presence of water and because of the toxicity of H₂S and the lack of heating value of CO₂, sales gas is required to be sweetened to contain no more than a quarter grain H₂S per 100 standard cubic feet (4 parts per million) and to have a heating value of no less than 920 to 980 Btu/SCF, depending on the contract [14, 15].

However, the major role of gas plants is to process both associated and non associated gas to produce high-quality natural gas and hydrocarbon liquids. Sale of liquids provides a significant portion of the income from these plants. Plants optimize profits by adjusting the fraction of liquids recovered while meeting the specifications for the natural gas.

Table 3: H₂S Measurements on Site

o.	Sample	H ₂ S PPM	Average
1	Inlet Compressor At 12:00 AM	28.30	28.38
		28.03	
		28.80	
2	Inlet Compressor 12:00 PM	24.40	24.05
		24.2	
		23.56	
3	Outlet Compressor At 12:35 AM	22.70	23.70
		23.60	
		24.80	

4	Outlet Compressor At 12:35 PM	19.90	19.30
		20.80	
		17.20	

Table 4: Sulphur Type Analysis by Gas Chromatography (GC-ASD)

No.	Sample	H ₂ S PPM	COS	Methyl Mercaptanes	Ethyl Mercaptanes	Butyl Mercaptanes
1	Inlet Compressor At 12:00 AM	27.79	Nil	Nil	Nil	Nil
2	Inlet Compressor 12:00 PM	23.61	Nil	Nil	Nil	Nil
3	Outlet Compressor At 12:35 AM	23.24	Nil	Nil	Nil	Nil
4	Outlet Compressor At 12:35 PM	18.92	Nil	Nil	Nil	Nil

Conclusion

- The composition of the gas samples from inlet and outlet separators shows some change in the paraffinic compositions of natural gas in the separators through the studied two periods.
- The high and low heat values of the gas samples from inlet separator at the two studied periods exhibit high values compared with that values from outlet separator.
- The hydrogen sulphide concentration shows higher values in inlet separator than in outlet separator. The carbon disulphide and alkyl mercaptanes from methane to butane are not present in the composition of the studied natural gases from inlet and outlet separators.
- The main role of gas plants is to process both associated and non associated gas to produce high-quality natural gas. Sale of liquids provides a significant portion of the income from these plants. Plants optimize profits by adjusting the fraction of liquids recovered while meeting the specifications for the natural gas.

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