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REVIEW ARTICLE

Monitoring of trace chloride ions at different stages of the gas production process

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Water content;
Sweetening and dehydration

Abstract Fifty gas and liquid samples at different stages of Obaiyed gas plant in Egypt were selected and subjected for determining chloride ion and hydrocarbon compositions. The trace levels of chloride in the water extracted from natural gas, condensate, Benfield and glycol samples were achieved using ion chromatograph (IC), electrical, conductivity and potentiometric methods, respectively. The hydrocarbon compositions were analyzed and evaluated using capillary gas chromatography. The chloride ions in natural gas and condensate are a function of water content and their concentration mainly depends on the separation efficiency. Variability in natural gas and condensate compositions seasonally is not an uncommon occurrence. Our aim is monitoring of chloride ion to select and optimize the conditions of sweetening and dehydration regenerators in order to follow and prevent their gradient in gas plant.

Contents

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1. Introduction

As one of the cleanest, safest, and most useful of all energy sources, natural gas is a vital component of the world's supply of energy (Speight, 2007). Natural gas is a combustible mixture of hydrocarbon gases and small quantities of various non-hydrocarbons existing in the gaseous phase or solution with oil in natural underground reservoirs at reservoir conditions (Widia, 2003; EIA, 2005; Fox et al., 1996; Carcoana, 1992).

From whatever reservoir, the composition of natural gas as produced from the earth depends on the field, the formation, or the reservoir from which it is produced (GPA, 1998). The principal constituent of natural gas is methane (Fox et al., 1996). Other constituents are paraffinic hydrocarbons such as ethane, propane, butanes and a small proportion of pentane + (C_5+) hydrocarbons (Mokhatab et al., 2006). Some aromatics such as benzene, toluene, and xylenes can also be present, raising safety issues due to their toxicity. Natural gas may also contain other contaminates such as hydrogen sulfide, carbon dioxide, mercaptans, and water vapor.

Water vapor is the most common undesirable impurity in gas streams (Nivargi et al., 2006). All natural gases contain water vapor to some extent (Manning and Thompson, 1991), which comes from the water phase in the reservoir. Concentration of such water vapor range from trace amounts to saturation (Kidnay and Parrish, 2006). This water vapor is the main source of the chloride ion in natural gas and its concentration depends on the concentration of the chloride ions in the reservoir water phase. The vapor cause operational problems such as hydrate formation, corrosion, high pressure drop, and consequently slugging flow and reduction in gas transmission efficiency (Karimi and Abdi, 2006). In particular, moisture level in natural gas must be maintained below a certain threshold so as to prevent hydrate formation and minimize corrosion in transmission pipelines (Campbell, 1992; Manning and Thompson, 1991; Pearce and Sivalls, 1984; Grizzle, 1993).

The Obaiyed field is a gas-condensate reservoir located in the Western Desert of Egypt (Obaiyed Training Manual). The reservoir contains up to 8 mol% CO_2, requiring special metallurgy to avoid corrosion and acid gas removal to meet sales gas specifications. Obaiyed production facilities are designed to produce a daily contract quantity (DCQ) of 360–425 MMscfd of sales gas at an export pressure of 101 bars. The facilities consist of two gas processing trains, each train having a capacity of 210 MMscfd, and therefore the utility systems are designed for a throughput of 420 MMscfd sales gas.

The processing of natural gas consists of the separation of some of the components present at the well exit, such as water, acid gases and heavy hydrocarbons, to adjust the gas to transport or commercials specifications (Rojey et al., 1997). The distribution of these operations between the field and the delivery point is dictated by economic considerations. It is usually preferable to conduct on the production site only operations that make the gas transportable. In simple terms, the gas processing industry gathers, conditions and refines raw natural gas from the earth into saleable, useful energy forms for use in a wide variety of applications (GPA, 1998).

Our study based on monitoring the chloride ion concentration in natural gas in the outlet gas separators streams and during sweetening and dehydration of natural gas. This study was performed by collecting the samples through three trips in one year. Obaiyed gas plant uses (Benfield solution) for acid gas removal process. The Benfield solution is a 30 wt% potassium carbonate solution, with 1 wt% (ACT), (UOP) a proprietary activator with speed up the reaction, and 1 wt% of vanadium pentoxide as corrosion inhibitor that passivates carbon steel. Glycol was used as a dehydrator absorbent for natural gas stream.

2. Experimental

2.1. Hydrocarbon compositional analysis

2.1.1. For gases

Hydrocarbons from C_1 to C_9, carbon dioxide, and nitrogen were analyzed using Agilent model 6890 plus HP gas chromatograph equipped with thermal conductivity detector "TCD" and flame ionization detector "FID". The packed column Porapack-Q, 40 ft in length and 1/8 inch in internal diameter was used to analyze light hydrocarbons and capillary column 15 m in length and 0.53 inch in internal diameter and packed with molecular sieve was used for the analysis of nitrogen. DB-1 capillary column, 60 m in length and 0.32 mm in internal diameter was also used in attachment with TCD and FID, respectively. Helium gas was used as carrier gas at flow rate of 4 ml min^{-1}. The elution of the studied gas mixture was achieved with temperature programming ranging from 50 to 200 °C at a rate of 10 °C min^{-1}. The quantitative analysis of the gas mixture was achieved using a standard natural gas sample of known composition and according to the standard [ASTM: D 1945–03]. The injector and detector temperatures were 200 and 250 °C, respectively. The data were estimated by integration of the area under the resolved chromatographic profiles, using the HP computer of software chemstation.

2.1.2. For condensate

Hydrocarbons from C_2 to C_{36+} were analyzed using Agilent 6890 plus HP gas chromatograph equipped with FID using fused silica capillary column HP-1 of 60 m in length, 0.32 in internal diameter and 0.5 μm film thickness. The elution of the studied liquid was achieved with temperature programming from 40 to 320 °C at a rate of 5 °C min^{-1}. Nitrogen gas (oxygen free) was used as carrier gas flowing at a rate of 1 ml min^{-1}. The injector and detector temperatures were 320 and 350 °C, respectively. The data were estimated by integration of the area under the resolved chromatographic profiles, using the HP computer of software chemstation.

2.2. Chloride analysis

2.2.1. For gases

There is no standard method to analyze the chloride ions in gas stream. Since the source of the chloride in the gas is dissolved water, therefore we extract such water and analyze the chloride in such extracted water by ion chromatograph.

2.2.1.1. Method of extraction.

1. First, the cylinders were washed carefully with a proper solvent followed by deionized water and then dried.
2. The cylinders were evacuated by connecting them to the vacuum pump.
3. The bottom cylinder valve was inserted in deionized water and opened to suck a sufficient amount of this water and then the valve was closed.
4. The cylinder was checked for 1 h.
5. The water in the cylinder was analyzed by ion chromatograph to measure any amount of chloride ions in the used water.
6. We repeated steps 3, 4 and 5 until the chloride ions in water were nil or were as low as possible.
7. 100 ml of deionized water was inserted in the cylinder (as in step 3) and it was allowed to settle down.
8. The upper cylinder valve was connected to the suction pump to evacuate the air inside the cylinder to facilitate the entrance of the gas volume into the cylinder.
9. 300 ml volume of gas sample was entered into the evacuated cylinder using gas meter and it was connected to the upper valve of the cylinder and it was opened to suck such volume of gas and then the valve was closed.
10. The gas water mixture was checked for 1 h.
11. The water from the cylinder was discharged into a bottle and it was analyzed by ion chromatography to measure the chloride ion concentration.

Water containing chloride ions were analyzed using Dionex model DX 600 ion chromatograph(IC) using high capacity column [ASTM D 4327]. The condition of analysis is as follows:

Column	Ion Pac AS9-HC (4 × 250 nm)
Eluent	9.0 mM Na_2CO_3
Flow rate	1.0 ml/min
Detector	Electrochemical detector (Dionex, Ed50)
Injection volume	10 μl

2.2.2. For condensates

The chloride ions present in condensate samples were determined according to ASTM: D 3230-89 by electrometric method. This test method is based on the conductivity of a solution of condensate in a polar solvent when subjected to an alternating electrical stress. The sample was dissolved in a mixed solvent and placed in a test cell consisting of a beaker and two parallel stainless steel plates. An alternating voltage is impressed on the plates and the resulting current flow was shown on a milliammeter. The salt content is obtained by reference to a calibration curve of current versus salt content of known mixtures.

2.2.3. For water samples

The anions in water sample were determined experimentally according to ASTM: D-4327 using the same method conditions used in the analysis of the water extracted from gas samples.

Each water sample was filtered using Whatman No.42 filter paper and diluted with deionized water prior analysis. Total of five and six mixed anion standard solutions were used for instrument calibration.

Aliquots of the water samples were diluted with measured volume to be within the measuring range, and 10 μl of the solution was injected into the column.

2.2.4. For Benfield and glycol samples

Chloride ions in both lean and rich carbonate solution were achieved by potentiometric titration method according to ASTM D 512. Titrando Meterohm 836 potentiometer equipped with silver electrode was used in such analysis using $AgNO_3$ as titrant.

3. Results and discussion

Gas plants have field operations and a network of pipelines feed the raw natural gas and liquids into the plant. Field operations may include dehydration, CO_2 and H_2S removal, and compression. Unless the gas is completely free of any liquids, once it enters the plant, the gas and liquids go into inlet receiving, where the initial gas–liquid separation is made. Condensed water, hydrocarbon liquids, and solids are removed. Water and solids are processed for disposal, and the hydrocarbon liquids go on to liquids processing (EIA, 2005).

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.

Skeletal diagram of the studied gas plant is shown in Fig. 1 indicating the points from which the samples were collected. Table 1 shows the collected gas and liquid samples through three timed averages in one year.

3.1. Outlet separator samples

3.1.1. Gas samples from outlet separators Tr-1 and Tr-2

For each gas sample, there is some amount of condensate and water, so it is important to calculate the wt% of well stream composition from the combination of the compositions of flash gas and separator oil and the latter was obtained from the combination of the condensate samples and its dissolved gas. The chloride ions were dissolved only in water, so any chloride contents in gas and condensate are accompanied with the water dissolved in gas and condensate samples.

The efficiency of measuring the chloride content in gas samples depends mainly on the method of water extraction from gas sample, because there is no standard method for measuring the chloride contents in gases.

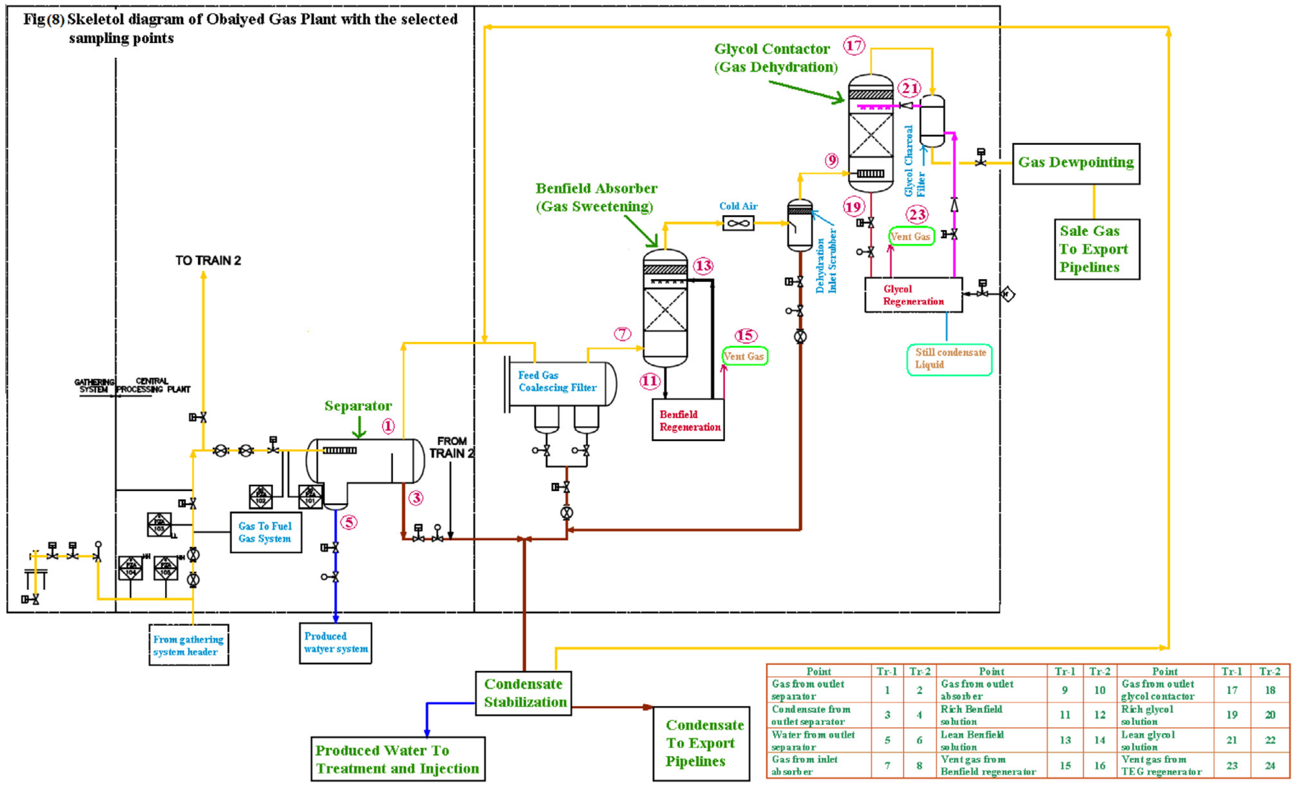
The composition of the gas samples from outlet separators Tr-1 and Tr-2 through the three trips are shown in Fig. 2.

With respect to separator Tr-1, there is some change in the parrafinic compositions of natural gas through the studied three periods. The wt% of the middle paraffinic fractions (from ethane to pentanes) were 26, 21.12 and 26.28, respectively with the selected three periods

Hexanes + (C6+) fraction exceed by time and in the trip C, C6+ has the highest wt%. The volatile organic compounds, benzene, toluene, ethyl benzene, and xylenes (BTEX) are present in different values. The last trip (C) exhibits the highest BTEX value and this may be accompanied with the increase of the heavy fraction (C6+) in such trip.

With respect to Tr-2, the paraffinic compositions are also variable through the three different periods. The middle paraffinic fractions were 24.07, 21.45 and 26.6 for the sequence of the three trips. Also, C_6+ fraction varies with time and the highest wt% was observed in trip C. BTEX contents were 0.37, 0.73 and 2.79 for trips A, B and C, respectively.

The concentration of the chloride ions in natural gas samples from outlet separators are given in Table 2. The source of chloride in natural gas is the water content associated in the gas, the natural gases in the studied seasons contain chloride with different concentrations since all natural gases contain water to some degree. The variability of chloride concentration in Obaiyed gas plant is because of there being two big factors the operating conditions and the dissolved salt which affect the amount of chloride in natural gas. The solubility of water increases as the operating temperature increases



Point	Tr-1	Tr-2	Point	Tr-1	Tr-2	Point	Tr-1	Tr-2
Gas from outlet separator	1	2	Gas from outlet absorber	9	10	Gas from outlet glycol contactor	17	18
Condensate from outlet separator	3	4	Rich Benfield solution	11	12	Rich glycol solution	19	20
Water from outlet separator	5	6	Lean Benfield solution	13	14	Lean glycol solution	21	22
Gas from inlet absorber	7	8	Vent gas from Benfield regenerator	15	16	Vent gas from TEG regenerator	23	24

Figure 1 Skeletol diagram of Obaiyed gas plant with the selected sampling points.

Table 1 List of the samples collected from the studied gas plant through three averaged times.

No.	Sample No.	Type	Trip
1	A-1	The gas stream from the outlet separator Tr-1	A
2	A-2	The gas stream from the outlet separator Tr-2	A
3	A-3	The condensate stream from outlet separator Tr-1	A
4	A-4	The condensate stream from outlet separator Tr-2	A
5	A-5	The water stream from outlet separator Tr-1	A
6	A-6	The water stream from outlet separator Tr-2	A
7	A-9	Gas from outlet absorber (inlet glycol) Tr-1	A
8	A-10	Gas from outlet absorber (inlet glycol) Tr-2	A
9	A-15	Vent gas from Benfield regenerator Tr-1	A
10	A-16	Vent gas from Benfield regenerator Tr-2	A
11	A-17	Gas from outlet glycol contactor Tr-1	A
12	A-18	Gas from outlet glycol contactor Tr-2	A
13	A-19	Rich glycol samples Tr-1	A
14	A-20	Rich glycol samples Tr-2	A
15	A-21	Lean glycol sample Tr-1	A
16	A-22	Lean glycol sample Tr-2	A
17	A-23	Vent gas from TEG regenerator Tr-1	A
18	A-24	Vent gas from TEG regenerator Tr-2	A
19	B-1	Gas stream from outlet separator Tr-1	B
20	B-2	Gas stream from outlet separator Tr-2	B
21	B-3	Condensate stream from outlet separators Tr-1	B
22	B-4	Condensate stream from outlet separators Tr-2	B
23	B-5	Water stream from outlet separator Tr-1	B
24	B-6	Water stream from outlet separator Tr-2	B
25	B-9	Gas from outlet absorbers Tr-1	B
26	B-10	Gas from outlet absorbers Tr-2	B
27	B-11	Rich Benfield solution Tr-1	B
28	B-12	Rich Benfield solution Tr-2	B
29	B-13	Lean Benfield solution Tr-1	B
30	B-14	Lean Benfield solution Tr-2	B
31	B-15	Vent gas from Benfield regenerator Tr-1	B
32	B-16	Vent gas from Benfield regenerator Tr-2	B
33	C-1	The gas stream from the outlet separator Tr-1	C
34	C-2	The gas stream from the outlet separator Tr-2	C
35	C-3	The condensate stream from outlet separator Tr-1	C
36	C-4	The condensate stream from outlet separator Tr-2	C
37	C-5	The water stream from outlet separator Tr-1	C
38	C-6	The water stream from outlet separator Tr-2	C
39	C-11	Rich Benfield solution Tr-1	C
40	C-12	Rich Benfield solution Tr-2	C
41	C-13	Lean Benfield solution Tr-1	C
42	C-14	Lean Benfield solution Tr-2	C
43	C-15	Vent gas from Benfield regenerator Tr-1	C
44	C-16	Vent gas from Benfield regenerator Tr-2	C
45	C-19	Rich glycol sample Tr-1	C
46	C-20	Rich glycol sample Tr-2	C
47	C-21	Lean Glycol sample Tr-1	C
48	C-22	Lean Glycol sample Tr-2	C
49	C-23	Vent gas from TEG regenerator Tr-1	C
50	C-24	Vent gas from TEG regenerator Tr-2	C

and decreases as the operating pressure increases (GPA, 1998). Salts dissolved in the liquid water in equilibrium with natural gas reduce the water content of the gas. Therefore the higher chloride concentration of the gas from outlet separator Tr-1 in trip B containing excess water may be due to the low separator efficiency through this trip.

3.1.2. Condensate samples from outlet separators Tr-1 and Tr-2

The compositional analysis of the condensate samples of outlet separators Tr-1 and Tr-2 are given in Fig. 3. There is variability of the composition of the condensate samples with time. The chloride contents of condensate samples from outlet separators are given in Table 3. There is a wide range of

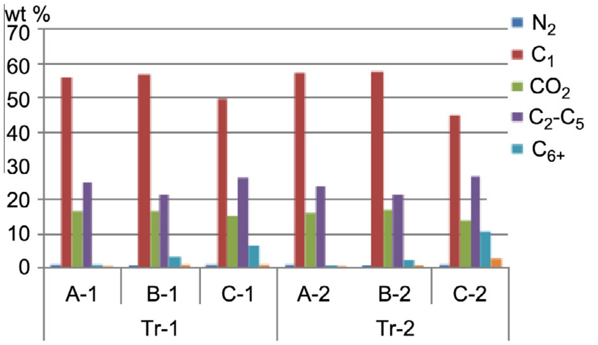


Figure 2 Composition of gas samples from outlet separators.

Table 2 Results of the chloride analysis of gas samples from outlet separators Tr-1 and Tr-2.

Components (ppm)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	105.4	314.735	95.07	186.96	182.025	122.535

variety in the chloride contents since it ranges from 14 to 681 ppm.

3.1.3. Water samples from outlet separators Tr-1 and Tr-2

The chloride contents of the water samples from outlet separators are shown in Table 4. The data obtained show relatively high concentrations of chloride ions indicating the higher salinity of these water samples, since the range of chloride ion concentration is 30066–79239 mg/l.

3.1.4. Gas from outlet absorbers Tr-1 and Tr-2

As the gas streams exit the outlet separators, the saturated feed gas passes from the filter and enters the bottom of the absorber and passes through a Benfield solution which is used in more than 600 plants worldwide. The Benfield process is a chemical absorption of H_2S, CO_2 and to some extent, COS. The Benfield process is based on an aqueous solution of potassium carbonate and bicarbonate, with potassium vanadate as an anodic inhibitor with an amine as an accelerant. The potassium carbonate solution enters the absorber at the top. As the solution flows down the column contacting the up-flowing acid gases (CO_2 & H_2S), the absorption reactions proceed, and the liberated heat of absorption increases the temperature of the solution.

The upward flowing raw natural gas containing CO_2 and H_2S contacts the down flowing potassium carbonate solution in a counter current flow. The potassium carbonate absorbs CO_2 and H_2S and these reactions can be represented as follow (Campbell, 1992):

$$K_2CO_3 + H_2O + CO_2 \leftrightarrow 2KHCO_3 \quad (1)$$

$$K_2CO_3 + H_2S \leftrightarrow KSH + KHCO_3 \quad (2)$$

In our study, we take gas samples from outlet absorbers Tr-1 and Tr-2 during the two trips A and B. The compositions of such gas samples are shown in Fig. 4. In the return to the compositional analysis of gas samples A-1, A-2, B-1 and B-2 from outlet separators, it is clear that there are considerable changes in the compositions of the natural gas streams as a result of the sweetening process. The concentration of the carbon dioxide decreases to considerable limits. Also there are minimum co-absorptions of hydrocarbons occurring during the Benfield absorption process. The results of the chloride ion analysis as given in Table 5, indicate that there is relative decrease in the chloride content after the sweetening of the natural gas. This may be due to the absorption of the chloride ions dissolved in the gas by the hot potassium carbonate solution. Fig. 5 shows the change in the concentration of the chloride ions as a result of the sweetening process.

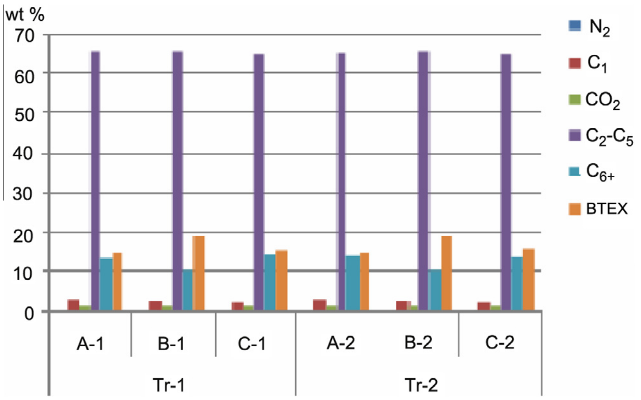


Figure 3 Compositional of condensate samples from outlet separators.

Table 3 Results of the chloride analysis of condensate samples from outlet separators Tr-1 and Tr-2.

Components (ppm)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	658.1	922	14.144	681.6	89.4	16.447

Table 4 Results of the chloride analysis of water stream samples from outlet separators Tr-1 and Tr-2.

Components (mg/l)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	79239	46629	46801.4	68435	30066	48983

Table 5 Results of the chloride ion analysis of the gas samples from outlet Benfield absorbers Tr-1 and Tr-2.

Components (ppm)	Tr-1		Tr-2	
	A	B	A	B
Chloride	95.76	115.3	50.651	90.9

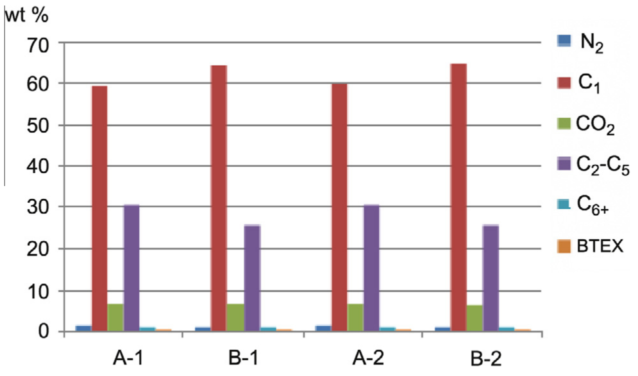


Figure 4 Composition of gas samples from outlet absorbers.

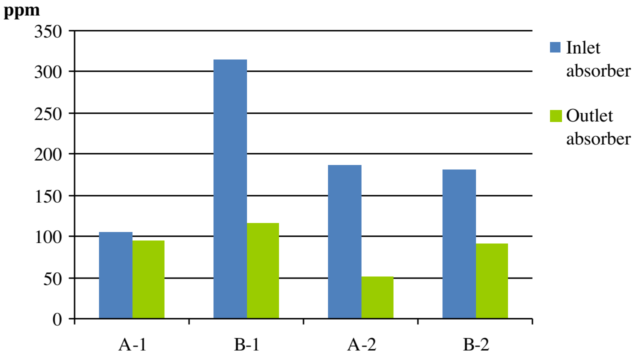


Figure 5 Change in the chloride during the sweetening.

3.1.5. Gas from outlet glycol dehydrator

Hot, wet CO_2 treated gas from the CO_2 absorber passes through the Dehydration Feed Cooler where it is cooled down to 55 °C. The cooled wet gas then passes under pressure into the glycol contactor. We collect the gas from outlet absorber in the first trip A and the compositions of such gas samples were given in Fig. 6. The composition of the two gas streams (Tr-1 and Tr-2) from outlet absorber which named inlet glycol are nearly the same which reveals to that there are no considerable hydrocarbon absorption from the glycol. The chloride content of the glycol outlet gas samples are given in Table 6. There is no chloride content present in such gas samples indicating the higher efficiency of the dehydration process.

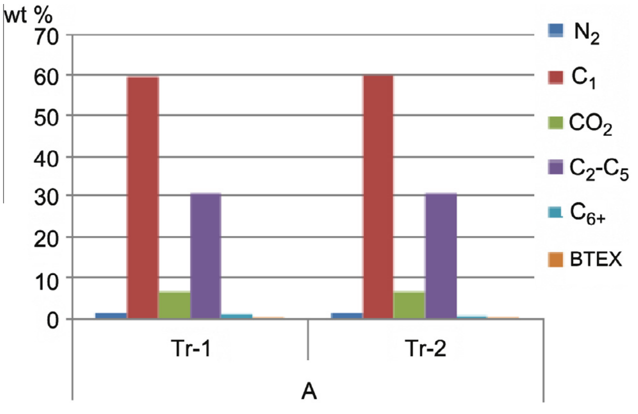


Figure 6 Composition of gas samples from outlet contractor.

Table 6 Results of the chloride analysis of the gas samples from outlet glycol contactors.

Components (ppm)	Tr-1 A	Tr-2 A
Chloride	Nil	Nil

3.1.6. Rich and lean Benfield samples

The rich carbonate solution (containing $KHCO_3$ and KHS) leaves the base of the absorber and flows to the regeneration system in which CO_2 and H_2S are driven out and the rich carbonate is reboiled up to 112 °C and then the lean carbonate enters the top of the absorber.

The compositions of the gases dissolved in rich and lean Benfield solutions are given in Fig. 7. These gases are characterized by the presence of relative high percents of CO_2. The last trip B contains significant proportions of BTEX components. The results of the chloride, carbonate, bicarbonate and iron contents analyses of both rich and lean carbonate solutions are given in Table 7. The presence of iron deposits in such liquid samples indicates the occurrence of corrosion deposits. It was observed that these solutions contain significant proportions of chloride contents and are more concentrated in lean solutions. These high values may be the reason for the presence of the corrosion deposits. Fig. 8 shows the chloride contents in rich and lean Benfield solutions.

Recently, Harjac et al. (2007) concluded that in 1 wt% bicarbonate solution containing potassium vanedate inhibitor, the threshold concentration above which pitting might be expected is 0.5 wt% chloride. So chloride depassivation content in the studied gas plant does not appear to be the only cause of corrosion issues, the corrosion occurs may be due to the presence of sulfur and other compounds.

3.1.7. Vent gas from Benfield regenerators Tr-1 and Tr-2

In the regenerator, CO_2 is driven out of the carbonate solution because of its lower partial pressure in the acid gas relative to the corresponding equilibrium pressure of the carbonate solution (Obaiyed Training Manual). The regenerator column runs at near atmospheric pressure and is reboiled at 112 °C using hot oil. The sudden reduction in pressure experienced in the regenerator flashes a large amount of the acid gases on the regenerator's tray. The steam from the reboiler passes up the packed column and strips the CO_2 and H_2S from the solvent.

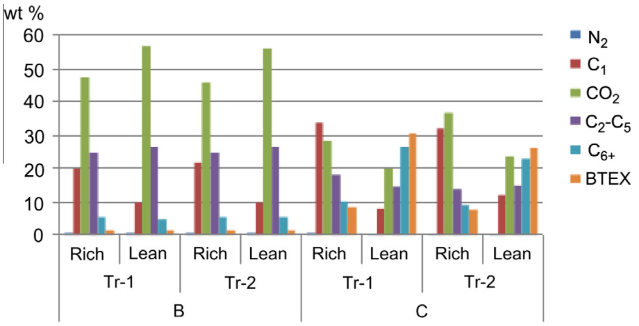


Figure 7 Composition of gases dissolved in rich and lean Benfield solutions.

Table 7 Analysis of rich and lean carbonate solution.

Analytical parameter (ppm)	B				C			
	Tr-1		Tr-2		Tr-1		Tr-2	
	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean
Carbonate CO_3	63305	156149	56784	181824	4.501	13.679	6.886	13.005
Bicarbonate HCO_3	162618	2564	14537	35978	15.559	5.75	11.044	3.474
Chloride contents	748	1127	288	478.5	155	267	107	349
Fe contents	11.7	13.35	7.2	9.1	10.06	0.84	33.8	26.97

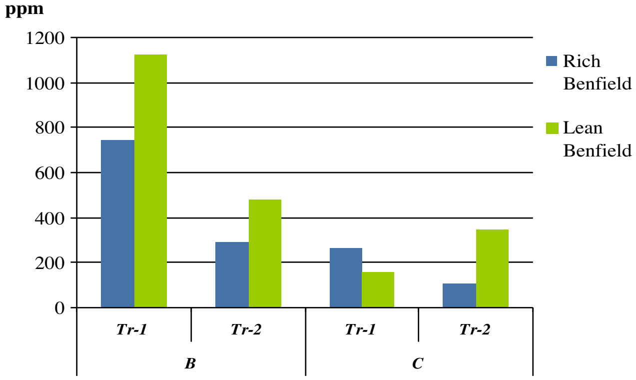


Figure 8 Chloride contents of rich and lean Benfield solutions.

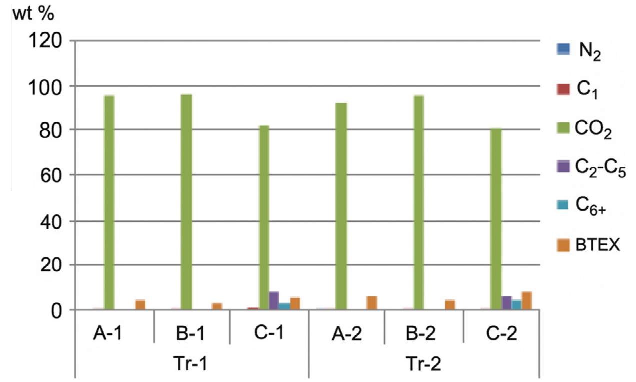


Figure 9 Compositions of vent gas samples from Benfield regenerators.

Table 8 Results of the chloride analysis of vent gases from Benfield regenerators.

Components (ppm)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	164.7	84.3	Not detected	154.44	41.8	Not detected

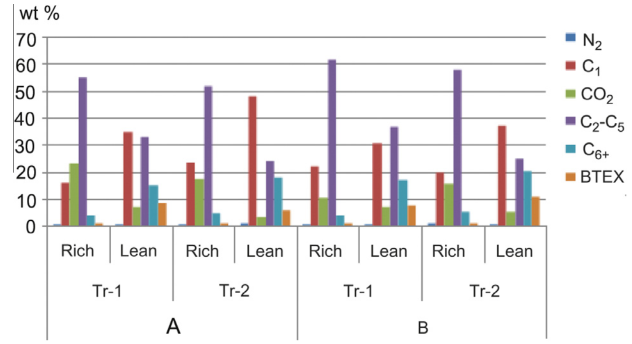


Figure 10 Composition of gas dissolved in rich and lean glycol samples.

The steam provides heat to break the chemical bond between the carbonate and CO_2. Accordingly, $KHCO_3$ is converted back to K_2CO_3.

The gas vented from the Benfield regenerators was collected and analyzed. The compositions of such gases are shown in Fig. 9. These gases are composed mainly of carbon dioxide that stripped from the rich carbonate solution. The results of the chloride analysis are shown in Table 8. These vented gases contain significant proportions of chloride ions.

3.1.8. Rich and lean glycol samples

The rich glycol discharged from the bottom of the contactor at a temperature of 55 °C is regenerated by increasing its temperature up to 204 °C where the vaporized water is then discharged and condensed (Obaiyed Training Manual). Lean glycol (99.8 wt%) exits the glycol regenerator column after cooling it to 66 °C. The rich and lean glycol samples are collected during trips A and C. The compositions of the gas dissolved in such glycols are shown Fig. 10. These gas samples are heavy gases since these contain a high proportion of middle fraction (C_2–C_5) and heavy fraction C6+. From the results of the chloride analysis as given in Table 9, it was found that the lean glycol samples contain higher chloride contents that those of the corresponding rich glycol. The regeneration of the rich glycol by boiling it leads to the vaporization of the

Table 9 Chloride contents of rich and lean glycol samples.

Trip	A				C			
Analytical parameter (ppm)	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean
Chloride content	24.9	190.1	24.16	196.51	32.27	35.208	190.32	195.356

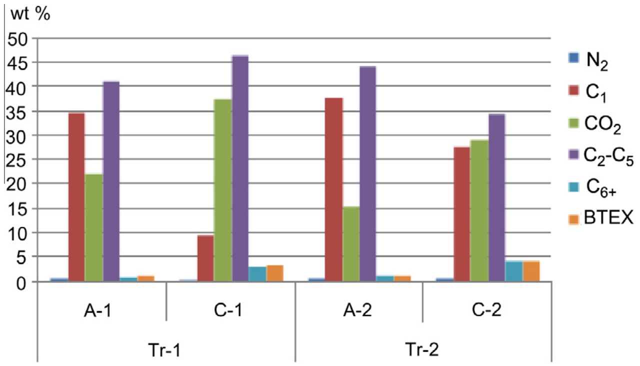


Figure 11 Composition of vent gases from TEG regenerators.

Table 10 Results of the chloride analysis of vent gases from Benfield regenerators.

Components (ppm)	Tr-1		Tr-2	
	A	C	A	C
Chloride	Nil	Nil	Nil	Nil

water vapor and precipitation of the chloride in the liquid glycol.

3.1.9. Vent gases from TEG regenerators

The gases vented from TEG were collected during the two trips A and C. The composition of such gases varies by time as shown in Fig. 11. Also these gases contain no chloride content as shown in Table 10.

4. Conclusion

- The accuracy of the method used for measuring the chloride contents ion gas samples depends mainly on the method of water extraction from gas sample, because the water content is the source of chloride in natural gas and condensate.
- The presence of BTEX is a function of the heavy fractions Hexanes +, so trip C exhibits the highest BTEX values.
- The salts dissolved in the liquid water in equilibrium with natural gas reduce the water content of the gas and this reflected on the chloride ion content.
- There are minimum co-absorption of hydrocarbons occurred during the Benfield absorption process.
- The decrease in the chloride content after the sweetening process may be due to the dissolution of the chloride ions in the aqueous media potassium carbonate solution. After the dehydration process there is no chloride ions content due to the higher efficiency of the dehydration process.
- In rich and lean Benfield solutions, it was observed that these solutions contain significant proportions of chloride contents and are more concentrated in lean solutions. These high values may be the reason for the presence of the corrosion deposits.
- The chloride depassivation content in the studied gas plant does not appear to be the only cause of corrosion issues, the corrosion occurrence may be due to the presence of sulfur and other compounds.
- The gas vented from Benfield regenerators are composed mainly of carbon dioxide that stripped from the rich carbonate solution. The vented gases contain significant proportions of chloride ions.
- The lean glycol samples contain higher chloride ions than those of the rich glycol because the regeneration of the rich glycol (by boiling) leads to vaporization of the water vapor and precipitation of the chloride in the liquid glycol. Therefore gases vented from TEG regenerators have no chloride contents.

5. Recommendation

- After the separators the natural gas should be washed using dematerialized water in order to produce high quality natural gas.
- Two salt membranes should be built, the first one before the Benfield absorber unit and the second before the glycol contactor unit. These two membranes will remove any trace chloride ions and produce high quality natural gas.

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