

Dynamic Inspection Analysis of A Detect Chloride Ion at Distinctive Point of Natural Gas Output Operation

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ABSTRACT

Fifty gas and liquid samples from Regime gas plant in Nigeria were chosen for analysis of chloride ion and hydrocarbon contents. Water collected from natural gas, condensate, Benfield and glycol samples was tested for chloride using IC, electrical, conductivity and potentiometric techniques. Capillary gas chromatography was used to study the hydrocarbon compositions. The concentration of chloride ions in natural gas and condensate relies on the separation efficiency. Seasonal variations in natural gas and condensate composition are typical. Our goal is to check chloride ions to choose and optimize the settings of sweetening and dehydration regenerators in gas plants.

Keywords: Natural gas; Condensate; Capillary gas chromatography; Regime; Chloride ion; Ion chromatography; Electrical; Conductivity; Potentiometric; Water content; Sweetening and dehydration

I. INTRODUCTION

Natural gas is one of the world's cleanest, safest, and most effective energy sources (Speight, 2007). Natural gas is a flammable combination of hydrocarbon gases and nonhydrocarbons found in natural subterranean reservoirs under oil reservoirs (Widia, 2003; EIA, 2005; Fox et al., 1996; Carcoana, 1992).

The incorporation of natural gas depends on the field, formation, or reservoir from which it is generated (GPA, 1998). Natural gas is mostly methane (Fox et al., 1996). Some pentane + (C5+) hydrocarbons and ethane are also present (Mokhatab et al., 2006). Hazardous aromatics including benzene, toluene, and xylenes may also

be present. Other contaminants in natural gas include sulfur dioxide, carbon dioxide, mercaptans, and water vapor.

Water vapor is by far the most prevalent gas contaminant (Nivargi et al., 2006). Water vapor is present in all natural gases (Manning and Thompson, 1991). Water vapor concentrations vary from detectable to saturation (Kidnay and Parrish, 2006). The concentration of chloride ions in this water vapor is dependent on the concentration of chloride ions in the reservoir liquid state. The vapor causes operational issues such hydrate development, corrosion, excessive pressure drop, and reduced gas transmission loss (Karimi and Abdi, 2006). The moisture content of natural gas must be kept below a specified threshold to avoid hydrate development and pipeline degradation (Campbell, 1992; Manning and Thompson, 1991; Pearce and Sivals, 1984; Grizzle, 1993).

Nigeria's Eastern Land has the Regime gas-condensate field (Regime Training Manual).

Special metallurgy is required to prevent corrosion and acid gas removal to fulfill sales gas criteria. Regime output facilities are intended to generate 360–425 MMscfd of sales gas at 101 bar export pressure. The facilities have two 210 MMscfd gas operating trains, hence the utility systems are intended for 420 MMscfd sales gas.

To transport or sell natural gas, it must be separated from components such as water, acid gases, and heavy hydrocarbons (Rojey et al., 1997). These procedures are split between the region and the delivery point for economic reasons. Only actions that make the gas accessible should be performed on the output location. This sector collects, refines, and sells raw natural gas from the

ground for use in a broad range of applications (GPA, 1998).

Our research focused on the chloride ion content in natural gas streams after gas separators and during sweetening and dehydration. This research collected samples across three visits in one year. Regime gas plant employs (Benfield solution) to remove acid gas. The Benfield solution is a 30% potassium carbonate solution containing 1% (ACT), a patented activator, and 1% vanadium pentoxide as a corrosion protection that passivates carbon steel. Glycol was utilized as a natural gas dehydrator absorber.

II. EXPERIMENTAL

2.1. analysis of Hydrocarbon compositional

2.1.1. Gases

The Agilent 6890 plus HP gas chromatograph was used to evaluate C1-C9 hydrocarbons, CO₂, and nitrogen. The packed Porapak-Q column of 40 ft length and 1/8 inch internal diameter was used to analyze light hydrocarbons, whereas the capillary column of 15 m length and 0.53 inch internal diameter was employed to evaluate nitrogen. A 60 m long and 0.32 mm internal diameter DB-1 capillary column was also utilized with TCD and FID. 4 ml min⁻¹ of helium carrier gas was utilized. The examined gas combination was eluted by programming temperatures from 50 to 200 C at a rate of 10 C min⁻¹. The gas combination was quantitatively analyzed using a standard solution natural gas sample [ASTM: D 1945-03]. The injector and detector were 200 and 250 C. The results were calculated using the HP chemstation software and the area under the corrected chromatographic profiles.

2.1.2. Condensate

The Agilent 6890 plus HP gas chromatograph with FID was used to analyze hydrocarbons from C2 to C36+ utilizing 60 m long fused silica capillary column HP-1 with 0.32 inner

Column Ion Pac AS9-HC (4 · 250 nm)
Eluent 9.0 mM Na₂CO₃
Flow rate 1.0 ml/min
Detector Electrochemical detector (Dionex, Ed50)
Injection volume 10,1

2.2.2 Condensate

The electrometric determination of chloride ions in condensate samples followed ASTM D 3230-89. This test technique measures the conductivity of a condensate solution in a polar solvent under alternating electrical stress. The material was dissolved in a solvent mixture and put

diameter and 0.5 lm film thickness. The examined liquid was eluted by varying the temperature from 40 to 320 C at a rate of 5 C min⁻¹. The carrier gas was nitrogen (oxygen-free) flowing at 1 ml min⁻¹. The injector and detector were 320 and 350 C. The results were calculated using the HP chemstation software and the area under the corrected chromatographic profiles.

2.2. Analysis of Chloride

2.2.1. Gases

The analysis of chloride ions in gas streams is not standard. Because the chloride in the gas is soluble water, we collect it and analyze it using an ion chromatograph.

2.2.1.1. Extraction Method

1. The cylinders were thoroughly rinsed with a suitable solvent, then deionized water, and dried.
2. The vacuum pump was used to empty the cylinders.
3. The bottom cylinder valve was put in deionized water, opened to suck enough water, then closed.
4. One hour of cylinder testing
5. The utilized water was tested by ion chromatography for chloride ions.
6. Repeat procedures 3, 4 and 5 until the water contains no or very few chloride ions.
7. 100 ml deionized water was added to the cylinder and allowed to settle.
8. The top cylinder valve was attached to the suction pump to remove air from the cylinder and let the gas volume in.
9. The top valve of the evacuated cylinder was opened to suck 300 ml of gas sample and then closed.
10. It was examined for 1 hour.
11. The cylinder's water was pumped into a container and tested for chloride ions using ion chromatography.

The Dionex DX 600 ion chromatograph (IC) was used to examine chloride-containing water [ASTM D 4327]. Here is the condition of analysis:

in a beaker with two parallel stainless steel plates. After impressing the plates with an alternating voltage milliamperes showed the current flow. A calibration curve of current versus salt concentration of known mixes gives the salt content.

2.2.3 Water samplers

The anions in the water sample were determined experimentally using the same approach as the water recovered from gas samples. Pre-filtering and diluting each water sample with deionized water was used. Instrument calibration employed five and six mixed anion standard solutions, and 10₁ of the diluted water sample solution was injected into the column.

2.2.4 Glycol and Benfield samples

Potentiometric titration was used to get chloride ions in both lean and rich carbonate solutions. This investigation employed a Titrandometerohm 836 potentiometer with a silver electrode..

III. RESULTS AND DISCUSSION

Field operations and pipelines deliver raw natural gas and liquids into gas plants. Extraction of CO₂ and H₂S from the air in the field. Unless the gas is totally liquid-free, it is sent to input receiving for first gas-liquid separation. Hydrocarbon liquids and solids are filtered out. Water and solids are disposed, and hydrocarbon liquids are operated (EIA, 2005).

However, gas plants are primarily responsible for producing high-quality natural gas and hydrocarbon liquids. The sale of liquids is a major source of revenue for these factories. Plants maximize profitability by changing liquid recovery while fulfilling natural gas standards.

Fig. 1 shows the skeletal structure of the examined gas plant and the sampling places. Table 1 displays the accumulated gas and liquid data throughout one year.

3.1. Outlet separator samples

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

In order to compute the wt percent of well stream content from the combination of flash gas

and separator oil samples, the latter was acquired by combining condensate sample data and its dissolved gas. Because chloride ions are only dissolved in water, any chloride concentration in gas and condensate data is also dissolved in water.

Since there is no conventional technique for detecting chloride content in gases, the effectiveness of measuring chloride content in gases relies on how water is extracted from the gas sample. Fig. 2 shows the gas sample composition from output separators Tr-1 and Tr-2 throughout three trips. The paraffinic concentrations of natural gas changed in separator Tr-1 across the three periods examined. These three eras had middle paraffinic fractions ranging from 26.12 to 26.28 wt % (ethane to pentanes).

In trip C, C₆+ has the greatest weight percent of hexanes + (C₆+). Each of the BTEX volatile organic compounds (BTEX) has its own value. The final trip (C) has the greatest BTEX value, perhaps due to an increase in the heavy percentage (C₆+).

The paraffinic compositions of Tr-2 vary during the three separate times. The median paraffinic fractions were 24.07, 21.45, and 26.6. Also, C₆+ fraction fluctuates with time, with trip C having the largest wt%. Trips A, B, and C had BTEX concentrations of 0.37, 0.73, and 2.79.

Table 2 shows the chloride ion content in natural gas samples from output separators. Because all natural gases include some water, the amounts of chloride in the examined seasons vary. The operational conditions and the dissolved salt determine the quantity of chloride in natural gas. Water solubility rises with operating temperature and decreases with operating pressure (GPA, 1998). Water in equilibrium with natural gas is reduced by salts dissolved in it. In trip B with surplus water, the greater chloride concentration may be related to the poor separator efficiency.

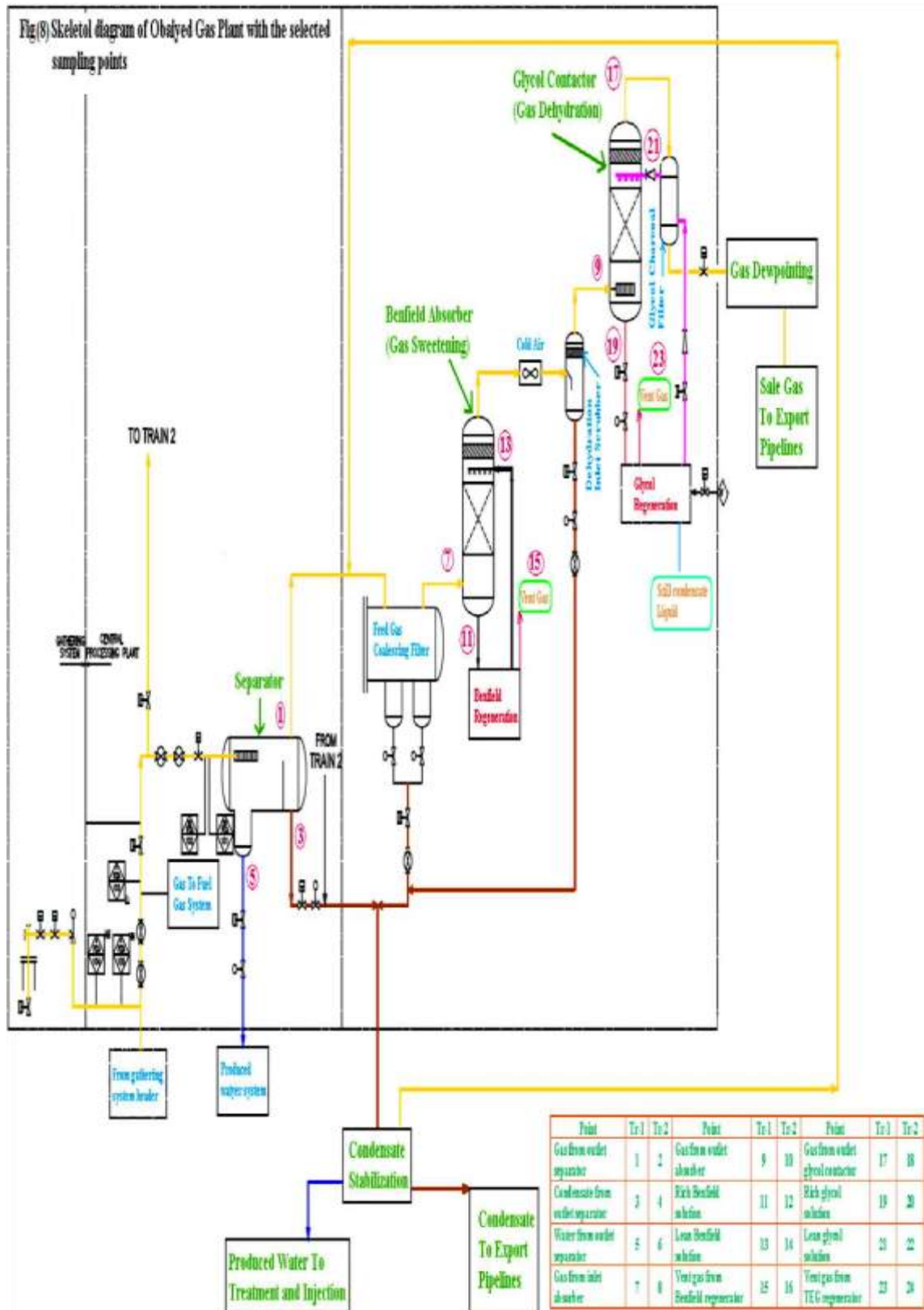


Fig 1.Regime gas plant skeleton with chosen sample points.

3.1.2 Condensate from separator outlet Tr-1 and Tr-2

Table 1. List of samples taken from the examined gas plant three 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

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

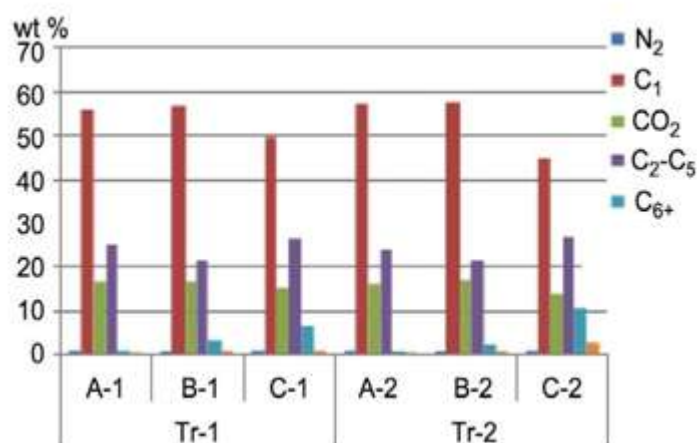


Fig 2. Gas samples from outlet separators.

Table 2. Results of chloride analysis of outflow separator gas samples Tr-1 and Tr-2.

Components (ppm)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	105.43	14.735		95.07	186.96	182.025122.535

3.1.3. Outlet separator water samples Tr-1 and Tr-2

Table 4 shows the chloride concentration of water samples from output separators. The results demonstrate significantly high chloride ion concentrations, suggesting increased salinity of these water samples, with 30066–79239 mg/l range.

3.1.4. Outlet absorbers of Gas Tr-1 and Tr-2

Upon exiting the outflow separators, the saturation feed gas goes via the filter, into the

absorber, and through a Benfield solution utilized in over 600 plants globally. The Benfield process involves chemical absorption of H₂S, CO₂, and COS. Benfield uses an aqueous solution of potassium carbonate and bicarbonate as an anodic inhibitor and an amine as an accelerant. This liquid enters the absorber top. As the solution travels down the column, it contacts the ascending acid gases (CO₂ & H₂S), causing absorption processes and raising the solution's temperature.

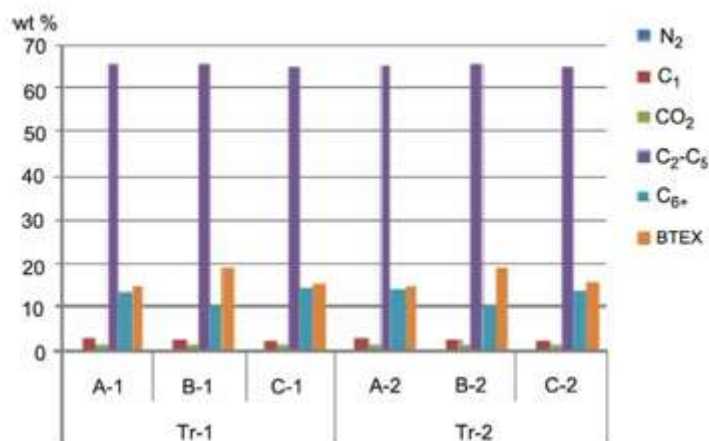


Fig3. Outlet separators Samples of condensate.

In a countercurrent flow, CO₂ and H₂S-rich raw natural gas meets potassium carbonate solution. The potassium carbonate absorbs CO₂ and H₂S as shown below (Campbell, 1992):



During visits A and B, we collect gas samples from outlet absorbers Tr-1 and Tr-2. Fig. 4 shows the components of such gas samples. Returning to the compositional study of gas

samples A-1, A-2, B-1, and B-2 from output separators, the sweetening procedure clearly alters the composition of the natural gas streams. Carbon dioxide concentration drops considerably. During the Benfield absorption procedure, there are minor hydrocarbon coabsorptions. Table 5 shows that after sweetening the natural gas, the chloride concentration decreases. The heated potassium carbonate solution may have absorbed the chloride ions from the gas. Fig. 5 demonstrates the effect of sweetening on the concentration of chloride ions.

Table 3. Results of condensate chloride analysis from output separators Tr-1 and Tr-2.

Components (ppm)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	658.1922			14.144681	689.416	447

Table 4. Results of chlorine analysis of outflow separator water stream samples Tr-1 and Tr-2.

Components (mg/l)	Tr-1			Tr-2		
	A	B	C	A	B	C
Chloride	7923946629			46801.4684353006648983		

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

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

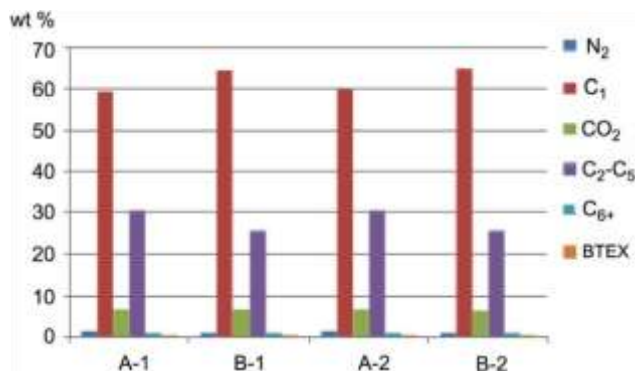


Fig 4. Gas samples from outlet absorbers.

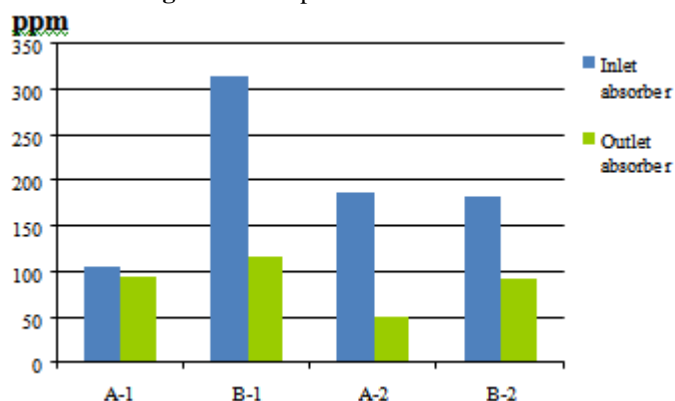


Fig 5. Chloride change during sweetening.

3.1.5. Gas from outlet glycol dehydrator

The Dehydration Input Cooler cools the hot, wet CO₂ treated gas to 55 C. The cooled wet gas enters the glycol contactor under pressure. Fig. 6 shows the composition of gas samples collected from the output absorber in trip A. The structure of the two gas streams (Tr-1 and Tr-2) from the outlet

absorber (inlet glycol) is virtually identical, indicating that the glycol has little hydrocarbon absorption. Table 6 shows the chloride concentration of glycol output gas samples. These gas samples contain no chloride, suggesting great dehydration efficiency.

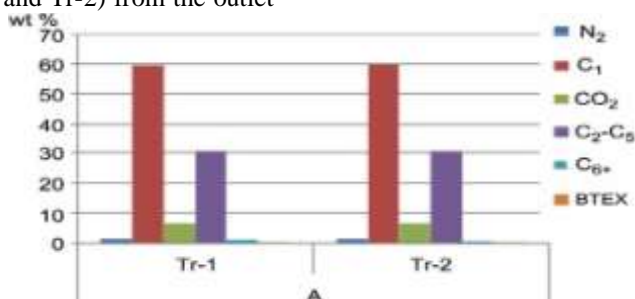


Fig 6. Composition of output contractor gas samples

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

3.1.6. Rich and lean Benfield samples

The rich carbonate solution (KHCO₃ and KHS) exits the absorber and goes to the regeneration system where CO₂ and H₂S are removed and the rich carbonate is reboiled to 112 C.

Fig. 7 shows the gas compositions dissolved in rich and lean Benfield solutions. These gases include significant percentages of CO₂. Last trip B has a lot of BTEX components. Table 7 shows the chloride, carbonate, bicarbonate, and iron concentrations of rich and lean carbonate solutions. Iron particles in such liquid data suggest corrosion deposits. These solutions include considerable amounts of chloride, which is more concentrated in lean solutions. These high levels may be the cause of corrosion deposits. A rich and lean Benfield solution are shown in Fig. 8.

Harjac et al. (2007) recently concluded that in 1 wt percent bicarbonate solution with potassium vanadate inhibitor, pitting occurs at 0.5 wt percent chloride. So, the presence of sulfur and perhaps other chemicals in the examined gas plant may be the source of corrosion concerns.

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

The reduced partial pressure of the acid gas in the regenerator drives CO₂ out of the carbonate solution (Regime TrainingManual). The regenerator column is reboiled at 112⁰C using hot oil. Acid gases flash onto the regenerator's tray when the regenerator's pressure drops. Steam from the reboiler flows up the packed column, stripping CO₂ and H₂S.

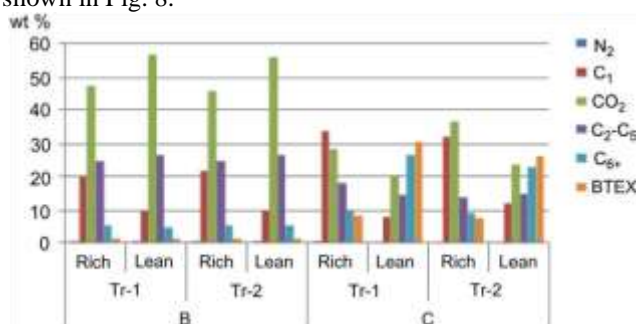


Fig 7. Gas composition in rich and lean Benfield solutions

Table7. Carbonate solution analysis.

Analyticalparameter(ppm)	B				C			
	Tr-1		Tr-2		Tr-1		Tr-2	
	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean
CarbonateCO	63305	156149	56784	181824	4.501	13.679	6.886	13.005
BicarbonateHCO	162618	2564	14537	35978	15.559	5.75	11.044	3.474
Chloridecontents	748	1127	288	478.5	155	267	107	349
Fecontents	11.7	13.35	7.2	9.1	10.06	0.84	33.8	26.97

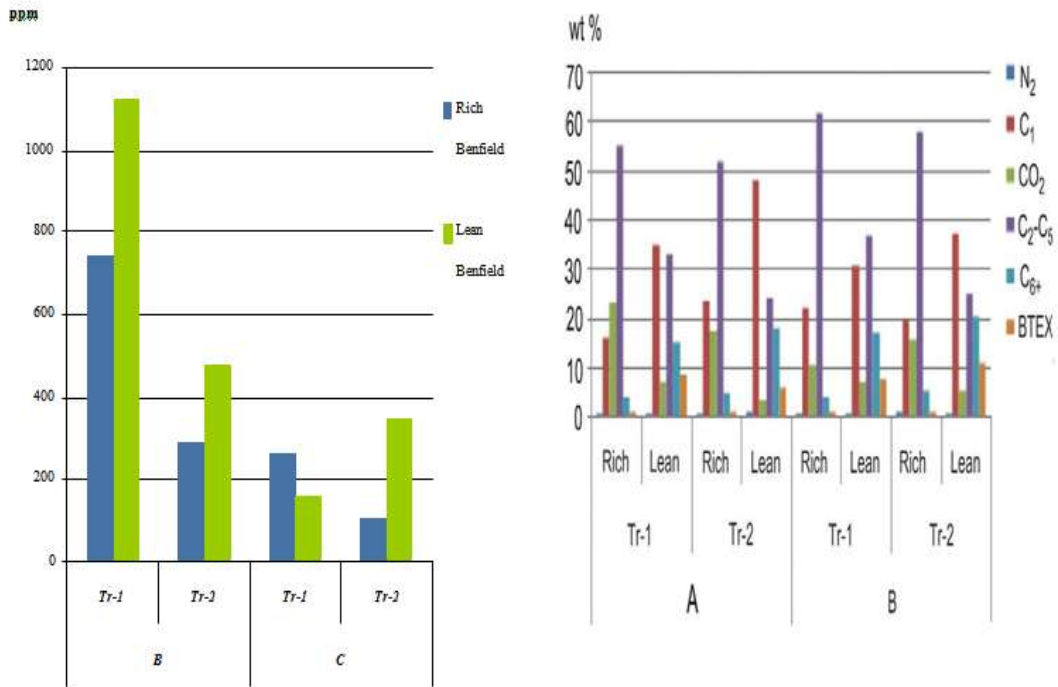


Fig 8. Gas composition in rich and lean Benfield solutions.

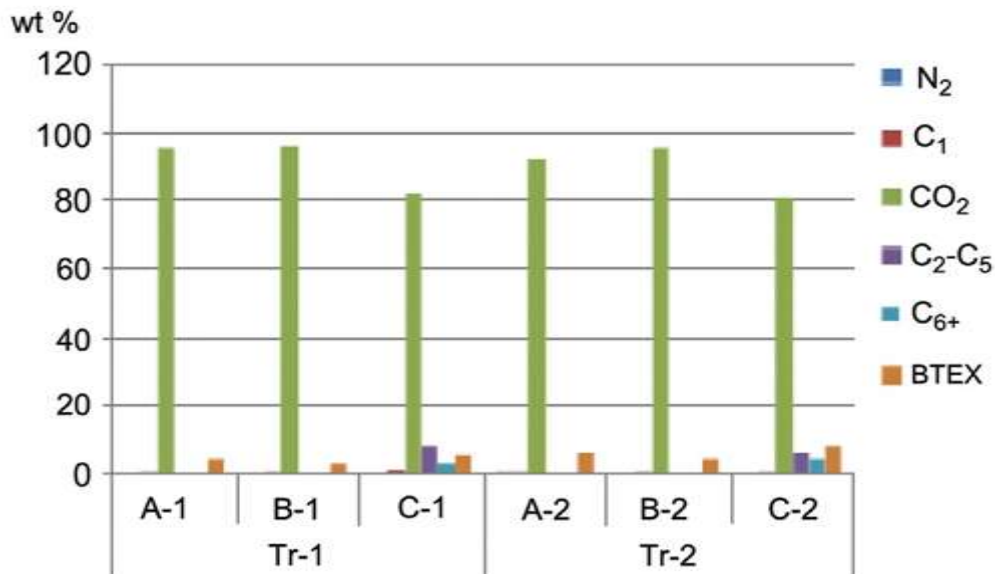


Fig 9. Vent gas compositions from Benfield regenerators.

Table 8. Chloride study of Benfield regenerator vent gases.						
Components (ppm)	Tr-1			Tr-2		
	A	B		A	B	C
		C				
Chloride	164.784.3		Not detected	154.4441.8		Not detected

Steam produces heat to disrupt the carbonate-CO₂ chemical link. So KHCO₃ is reverted to K₂CO₃.

The Benfield regenerator gas was collected and tested. Fig. 9 shows the proportions of such gases. These gases include mostly carbon dioxide from the rich carbonate solution. Table 8 shows the chloride analytical findings. These expelled gases are high in chloride ions.

3.1.8. glycol samples of Rich and lean

The 55^oC rich glycol released from the contactor bottom is regenerated by heating it to 204^oC, where vaporized water is expelled and

condensed (Regime Training Manual). After cooling to 66^oC, lean glycol (99.8%) leaves the glycol regenerator column. Trips A and C capture rich and lean glycol samples. Fig. 10 shows the gas compositions dissolved in such glycols. These gases are heavy because they include a lot of medium (C₂-C₅) and heavy (C₆+) fractions. Table 9 shows that the lean glycol samples had greater chloride concentrations than the matching rich glycol samples. Boiling the rich glycol regenerates it by vaporizing water and precipitating chloride in the liquid glycol.

Table 9. Rich and lean glycol chloride concentrations.

Trip Analytical parameter (ppm)	A		C		C		C	
	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

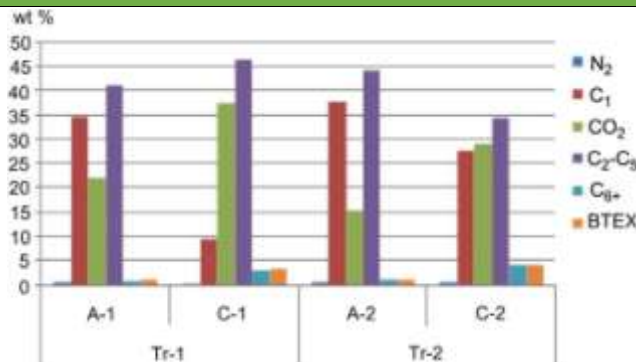


Fig 11. Composition of TEG regenerator vent gases.

Table 10. Chloride study of Benfield regenerator vent gases.

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

3.1.9. TEG regenerator exhaust gas

The TEG gases were collected on visits A and C. These gases' composition vary with time (Fig. 11). As demonstrated in Table 10, these gases have no chloride. The TEG gases were collected on visits A and C. These gases' composition vary with time (Fig. 11). As demonstrated in Table 10, these gases have no chloride.

IV. CONCLUSION

Because water is the source of chloride in natural gas and condensate, the technique used to

measure chloride concentration in gas samples is highly dependent on water extraction accuracy. Trip C has the greatest BTEX values because to the heavy fractions Hexanes +. This is due to salts dissolved in liquid water in equilibrium with natural gas reducing water content and hence chloride ion concentration. During the Benfield absorption operation, there was minimal hydrocarbon co-absorption.

The drop in chloride concentration after sweetening may be attributed to chloride ions dissolving in the aqueous potassium carbonate

solution. Due of the increased efficacy of dehydration, there are no chloride ions after dehydration.

Both rich and lean Benfield solutions contain large amounts of chloride, with lean solutions having the highest concentration. These high levels may be the cause of corrosion deposits. The inclusion of sulfur and perhaps other substances in the examined gas plant may be a source of corrosion.

The gas released by Benfield regenerators is mostly carbon dioxide from rich carbonate solution. The expelled gases are high in chloride ions. The lean glycol samples have more chloride ions than the rich glycol samples because boiling the rich glycol results in water vaporization and chloride precipitation. So TEG regenerator gases are chloride-free.

V. RECOMMENDATION

To create high quality natural gas, the gas should be cleansed with dematerialized water after the separators.

Build two salt membranes, one before the Benfield absorber and one before the glycol contactor. These two membranes will remove chloride ions from natural gas.

VI. ACKNOWLEDGEMENT

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REFERENCES

- [1]. Campbell, J.M., 1992. In: Gas Conditioning and Operation, The Equipment Modules, vol. 2. Campbell Petroleum Series, Norman, Oklahoma.
- [2]. Carcoana, A., 1992. Applied Enhanced Oil Recovery. Prentice-Hall Inc., Englewood Cliffs, New Jersey.
- [3]. EIA (Energy Information Administration). 2005. US Department of Energy, Glossary, Natural gas annual, p. 179.
- [4]. Fox, T.J., Van Houtven, G.L, Randall, C.D., 1996. Economic Analysis of Air Pollution Regulations: Oil and Natural Gas Output. US Environmental Protection Agency, P. 4.
- [5]. GPA (Gas Operationors Association). 1998. The Gas Operation Industry: Its Function and Role in Energy Supplies, Gas Operationors Association, Tulsa, OK, pp. 2–6.
- [6]. Grizzle, P.L., 1993. Glycol-Reboiler Emissions-2: glycol mass-balance method for estimating scores high for estimating BTEX, VOC emissions. Oil Gas J. 91 (22), 61.
- [7]. Harjac, S.J., Atrens, A., Moss, C.J., Linton, V. 2007. Passivity breakdown of carbon steel in hot potassium carbonate solutions, J. Mater. Sci., vol. 42, Springer Science + Business Media, LLC, pp. 9940–9946
- [8]. Karimi, A., Abdi, M.A. (2006). Selective Removal of Water From Supercritical Natural Gas, SPE 100442, Society of Petroleum Engineers, Calgary, Alberta, Canada, pp. 1–2
- [9]. Kidnay, A.J., Parrish, W.R., 2006. Fundamentals of Natural Gas Operation. Taylor & Francis Group, P. 1:218.
- [10]. Manning, F.S., Thompson, R.E., 1991. Oilfield Operation of Petroleum. Natural Gas, vol. 1. Pennwell Publishing Company, Tulsa, Oklahoma.
- [11]. Mokhatab, S., Poe, W.A., Speight, J.G., 2006. Handbook of Natural Gas Transmission and Operation. Elsevier Inc., P.2.
- [12]. Nivargi, J.P., Gupta, D.F., Shaikh, S.J., Shah, K.T., 2006. In: TEG Contactor for Gas Dehydration, vol. 22. Finepac™ Structures Pvt. Ltd., Gauri Shankar, Senapati Bapat Road, Pune, P. 1.
- [13]. Pearce, R.L., Sivalls, C.R., 1984. Fundamentals of gas dehydration design and operation with glycol solutions. In: Gas Conditioning Conference. University of Oklahoma, Norman, Oklahoma.
- [14]. Rojey, A., Jaffret, C., Cornot-Gandolphe, S., Durand, B., Jullian, S., Valais, M., 1997. Natural Gas Output Operation Transport, Paris
- [15]. Speight, J.G., 2007. Natural Gas: A Basic Handbook. Gulf Publishing Widia, B.S., 2003. Variation of Density with Composition for Natural Company, Houston, Texas, P.9.
- [16]. Gas Mixture in the Supercritical Region. National Development Regime Training Manual, 1999. Introduction to Regime Operationes, University (UPN) “Veteran”, Indonesia, P. 4. Badr Petroleum Company (BAPETCO), vol. 2, The Nigeriaian Maintenance Company.