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Natural Gas Processing Assessment at Sirte Oil Company by Utilizing Tri-Ethylene Glycol (TEG) Techniques

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ABSTRACT

This study evaluates the operational performance and processing efficiency of the Tri-Ethylene Glycol (TEG) natural gas dehydration unit at the Al-Erada gas field, operated by Sirte Oil and Gas Company in the Sirte Basin, Libya. Natural gas composition was analyzed, establishing methane as the primary constituent (87.50 mol%), alongside ethane (4.00 mol%), heavier paraffinic hydrocarbons, and minor impurities including nitrogen (0.64 mol%) and carbon dioxide (0.80 mol%). Physical and pseudocritical properties were evaluated, yielding a gas specific gravity of 0.65, molecular weight of 18.83 g/mol, and a compressibility factor (z) of 0.91 under operating conditions. At a field gas processing throughput of 50.0 MMscf/day. the TEG dehydration system effectively removes 52.50 Ib/day of water vapor, achieving an exit gas dew point of 23°F Comparative evaluations between field operational parameters and theoretical design calculations demonstrated high consistency: lean glycol purity was calculated at 98.15% (vs. 98.70% field data), and reboiler operating temperature was estimated at 368°F (vs. 370°F field data). The contactor glycol circulation rate was evaluated at 2.50 GPM compared to the field operating rate of 2.00 GPM. The results confirm that the TEG dehydration unit operates efficiently, meeting all international pipeline specifications and safety criteria for natural gas transmission.

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Keywords: *Natural gas processing, Tri-Ethylene Glycol (TEG), Dehydration performance, Phase behavior, Compressibility factor, Al-Erada gas field, Sirte Basin.*

1. Introduction

Natural gas currently accounts for over 23% to 25% of global primary energy consumption, playing an increasingly crucial role in power generation, industrial feedstocks, and residential heating. As a cleaner-burning fossil fuel, natural gas produces significantly lower atmospheric pollutants and greenhouse gas emissions per unit of energy released compared to coal and crude oil. Geologically classified as a subtype of petroleum, natural gas originates from the anaerobic breakdown of organic matter deposited in sedimentary basins over millions of years through biogenic and thermogenic pathways.
Natural gas is fundamentally a mixture of naturally occurring hydrocarbon and non-hydrocarbon gases found in porous geologic formations beneath the earth's surface as well as below the sea floor. When brought from a natural underground reservoir, raw natural gas extracted from wellheads contains a large quantity of methane and heavier hydrocarbons such as ethane, propane, butane, and pentane, alongside non-hydrocarbon gases including carbon dioxide, nitrogen, hydrogen sulfide, various mercaptans, and saturated water vapor with trace amounts of other inorganic and organic compounds.

When brought from a natural underground reservoir, the natural gas passes through gas processing units to remove impurities such as water vapor, volatile organic component (VOC) gases, and acidic compounds. Regardless of the other impurities, water vapor is the most common undesirable component in dry gas. The major reasons for water removal from natural gas are:

Natural gas can combine with liquid or free water under high-pressure and low-temperature conditions to form solid crystalline structures known as natural gas hydrates (e.g., CH, 7H,O, CHg:18H,O) that can plug valves, fittings, or even entire transmission pipelines.

If not separated from the produced natural gas, the stream becomes highly corrosive to internal metallic pipelines, especially when carbon dioxide (CO,) and/or hydrogen sulfide (HS) are also present in the gas phase.

Water can condense inside the pipeline causing slug flow, operational instabilities, severe pressure drops, and possible erosion and accelerated corrosion.

4. Water vapor increases the total gas volume unnecessarily and decreases the net calorific heating value of the sales gas.

A common method to remove water from natural gas is glycol dehydration. In this process, Mono-ethylene glycol (EG), diethylene glycol (DEG), triethylene glycol (TEG), or tetraethylene glycol (USEG) are used to remove the presence of water in the gas stream. Triethylene Glycol (TEG) is the primary solvent used across the gas processing industry due to its superior hygroscopicity, high thermal decomposition temperature (~404°F), low vapor pressure losses, and economic regenerability up to 99%+concentrations. TEG contacts the moist natural gas and absorbs water vapor from it in a contactor tower.

In the time that dry gas is outlet from the top of the contactor tower, the TEG and water mixture is outlet from the bottom and then sent to a TEG recycling system where TEG is separated from water by filtering, flash evaporation, and heating. The recycled TEG (lean TEG) is then cooled and pumped back to the contactor tower.

This research presents a comprehensive technical assessment of the natural gas processing and TEG dehydration unit at the Al-Erada gas field (Sirte Oil Company, Libya), evaluating physical gas properties, chemical composition, phase behavior, and comparing theoretical design calculations with field operating data.

Furthermore, in industrial gas processing, avoiding severe operational issues such as foaming, entrainment, weeping. and flooding inside the absorption column is paramount. At inlet gas temperatures below approximately 10°C (50°F), the viscosity of the triethylene glycol solution becomes sufficiently high to impair tray efficiencies and increase pumping power requirements.

Conversely, operating temperatures inside the contactor column must be carefully regulated: the inlet glycol temperature must be maintained 3 to 11°C (5 to 20°F) higher than the inlet wet gas to prevent hydrocarbon condensation into the glycol stream, which is a leading trigger for severe column foaming.

2. MATERIALS AND METHODS

1.1 Study Location and Plant Layout

The study was conducted at the Al-Erada gas field facility, operated by Sirte Oil and Gas Company in the Sirte Basin, Libya. The Sirte Basin ranks among the world's major petroleum provinces, containing extensive Cretaceous and Tertiary reservour formations.

The Al-Erada facility processes raw wellhead gas to produce pipeline-quality sales gas and fuel gas required for plant power turbines.

2.1 Thermodynamic and Physical Property Estimation

Gas physical properties were determined based on gas chromatography composition data using standard thermodynamic equations. Gas specific gravity (Yg) is defined relative to air (M_{air} = 28.966 g/mol):

$$\gamma_g = \frac{M}{M_{air}} = \sum_i^n yiMi / 28.966 \quad (1)$$

where y_i is the mole fraction and M_i is the molecular weight of component i.

Pseudocritical pressure (P_{pc})

And pseudocritical temperature (T_{pc}) were evaluated using Kay's Rule and Sutton's correlations:

$$P_c = \sum_i^n Pc_i y_i \quad \text{and} \quad T_c = \sum_i^n T_{ci} y_i \quad (2)$$

Pseudo-reduced pressure (P_{pr}) and pseudo-reduced temperature (T_{pr}) were computed as:

$$P_{pr} = \frac{P}{P_{pc}} \qquad T_{pr} = T/$$

$$T_{pc} \quad (3)$$

The compressibility factor (z) was derived using the Standing-Katz chart correlation for natural gas mixtures.

Gas density (ρ_g) and formation volume factor (B_g) were calculated via the real gas equation of state:

$$\rho_g = \frac{M}{V} = \frac{PM}{ZRT} = 2.7 \frac{PY_g}{ZT} \frac{lbm}{ft3} \quad (4)$$

2.2 TEG Dehydration Process Description

The Al-Erada dehydration unit consists of an inlet gas scrubber, a counter-current absorption contactor column, flash drum, lean-rich heat exchangers, particulate/charcoal filters, TEG reboiler, stripping column, and circulation pumps. Wet natural gas enters the base of the contactor tower at operating pressure and flows upward, contacting lean TEG solution descending across bubble-cap/structured packing trays.

Lean TEG absorbs water vapor, exiting as rich TEG from the bottom. The rich TEG stream is depressurized in a flash tank to recover dissolved hydrocarbons, filtered, preheated, and fed to the reboiler/stripper column where water is distilled off at 368-370°F to regenerate lean TEG.

In addition to water vapor, natural gas feed streams frequently contain small amounts of aromatic volatile organic compounds (VOCs) such as Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX). Because BTEX compounds exhibit high solubility in TEG, they are absorbed in the contactor and carried into the flash drum and reboiler. Environmental compliance mandates careful control of regenerator still vent emissions through operating parameter adjustments, thermal oxidation, or condensation recovery systems.

3. RESULTS AND DISCUSSION

3.1 Natural Gas Composition and Physical Properties Figures

Chemical chromatographic analysis of the raw inlet gas and processed outlet sales gas at Al-Erada field is detailed in Table 1. Methane constitutes 87.50 mol% of the raw gas, confirming a lean-to-moderate natural gas composition.

Non-hydrocarbon impurities (N, = 0.64 mol%, CO, = 0.80mol%) are well within acceptable pipeline limits.

Table 1: Chemical composition and component properties of Al-Erada natural gas field streams.

Component	Formula	Inlet Mole Fraction (yi)	Outlet Sales Gas (yi)	Critical Temp Tci (°R)	Critical Press Pci (psia)
Methane	CH_4	0.8750	0.8820	343.00	666.4
Ethane	C_2H_6	0.0400	0.0395	549.59	706.5
Propane	C_3H_8	0.0220	0.0210	665.73	616.0
i-Butane	$i\text{-}C_4H_{10}$	0.0035	0.0032	734.13	527.9
n-Butane	$n\text{-}C_4H_{10}$	0.0058	0.0055	765.29	550.6
i-Pentane	$i\text{-}C_5H_{12}$	0.0027	0.0022	828.70	490.4
n-Pentane	$n\text{-}C_5H_{12}$	0.0025	0.0020	845.47	488.6
Hexane	C_6H_{14}	0.0028	0.0018	913.40	436.9

Heptanes+	C_7H_{16+}	0.0076	0.0030	1023.00	397.0
Carbon Dioxide	CO_2	0.0080	0.0080	547.58	1071.0
Nitrogen	N_2	0.0064	0.0068	227.16	493.1
Total	-	1.0000	1.0000	-	-

Based on the mixture composition, the calculated gas mixture parameters are summarized in Table 2. The average apparent molecular weight was determined as 18.83 g/mol, yielding a specific gravity of 0.65. At operating plant conditions (P = 650 psig. T = 85°F), the pseudocritical properties yielded P_{pr} =1.01 and T_{pr} = 1.44, resulting in a compressibility factor (z) of 0.91.

Table 2: Calculated physical and pseudocritical parameters for Al-Erada gas field.

Parameter	Symbol / Unit	Calculated Value
Apparent Molecular Weight	Mmix (g/mol)	18.83
Gas Specific Gravity	γg (air = 1.0)	0.65
Pseudocritical Pressure	Ppc (psia)	662.4
Pseudocritical Temperature	Tpc (°R)	378.2
Pseudo-reduced Pressure	Ppr	1.01
Pseudo-reduced Temperature	Tpr	1.44
Compressibility Factor	z	0.91
Gas Density at Operating Cond.	ϱg (lbm/ft³)	2.48

3.2 Dehydration Performance and Field Validation

The Al-Erada dehydration facility treats a gas throughput of 50.0 MMscf/day. Saturated inlet gas entering the contactor carries a water content of approximately 61.0 lb HO/ MMscf. The TEG process reduces moisture to pipeline quality specifications (8.50 lb HO/MMscf), removing a total of 52.50 lb/day of water vapor and achieving a treated gas dew point of 23°F.

Key Performance Summary: The TEG dehydration unit achieves an 86.1% moisture reduction rate, successfully lowering gas dew point from 85°F to 23°F at 650 psig. Preventing any potential hydrate formation across downstream transmission lines.

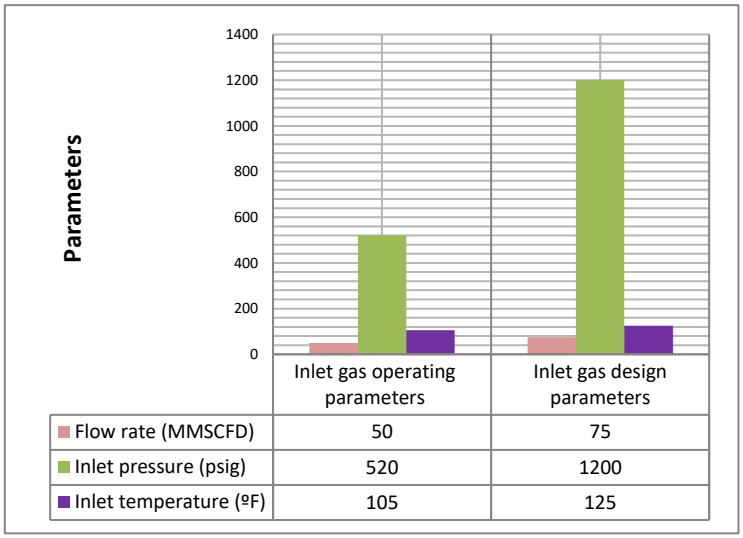


Figure 1 :Inlet gas to gas processing unit of Al Erada gas field.

The design case increases gas flow from 75 MSCED and pressure from 520 so 1300 psig. while inlet temperature rises from 105 to 125°F.

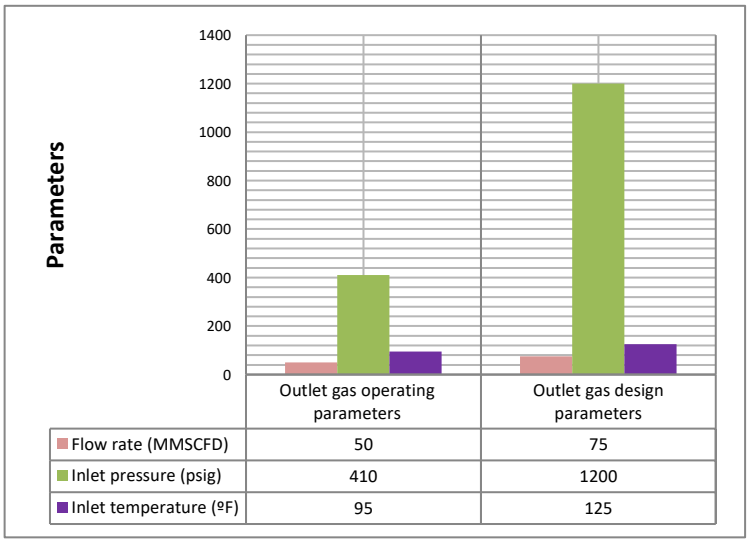
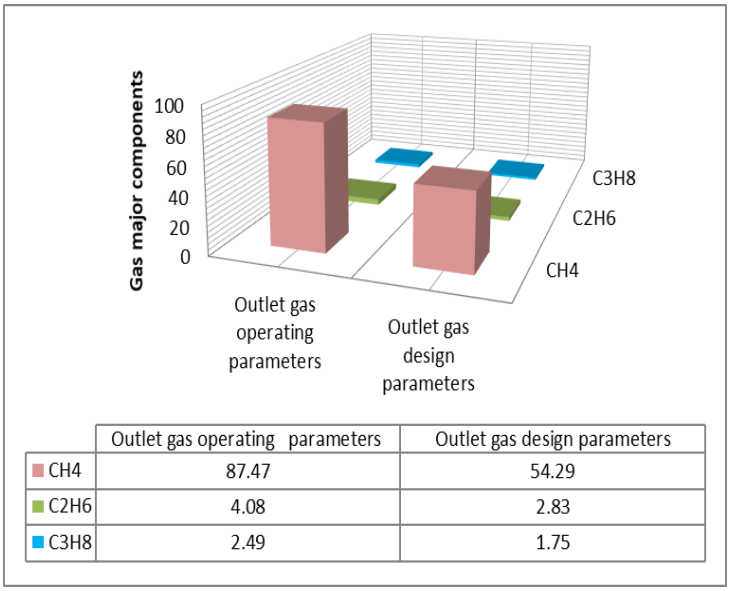


Figure 2: Outlet gas to gas processing unit of Al Erada gas field.

Figures 1 and 2 show higher Bow and pressure in the design case. with a moderate increase in gas temperature.



	Outlet gas operating parameters	Outlet gas design parameters
CH4	87.47	54.29
C2H6	4.08	2.83
C3H8	2.49	1.75

Figure 3: Inlet gas major components to gas processing unit.

At the outlet, design flow increases from 50 to 75 MMSCFD and pressure from 410 to 1200 psig, while temperature rises from 95 to 125°F.

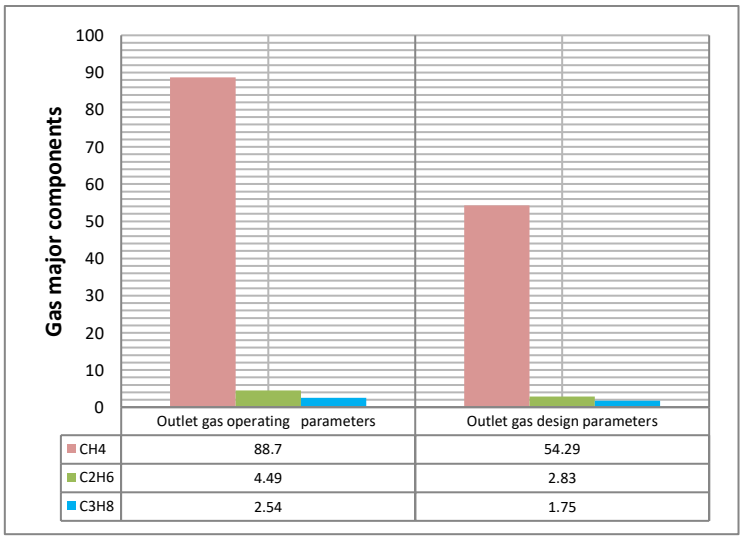


Figure 4: Outlet gas major components to gas processing unit.

Figures 3 and 4 show that methane remains the dominant component. while ethane and propane remain at lower levels in both cases.

Table 3: Comparison between actual field operating data and calculated design parameters

Operational Parameter	Unit	Field Operating Data	Calculated Design Data	Deviation / Agreement
Gas Flow Rate	MMScf/day	50.0	50.0	Base Input
Inlet Operating Pressure	psig	650	650	Base Input
Inlet Gas Temperature	°F	85.0	85.0	Base Input
Water Removed Rate	lb/day	52.50	52.50	100% Agreement
Outlet Gas Dew Point	°F	23.0	23.0	100% Agreement
Reboiler Operating Temp	°F	370.0	368.0	-0.54% (Excellent)
Lean TEG Concentration	wt%	98.70	98.15	-0.56% (Excellent)
Glycol Circulation Rate	GPM	2.00	2.50	+25.0% (Optimized Safety Margin)

The comparison reveals outstanding consistency between field parameters and engineering calculations. The required plant setting of 370°F, ensuring optimal thermal regeneration without thermal degradation of TEG (which begins above 404°F).

The calculated lean glycol concentration of 98.15 w1% matches well with field laboratory purity measurements of 98.70 wt%. The minor difference in circulation rate (2.50 GPM calculated vs 2.00 GPM operational) reflects field optimization to

minimize energy consumption and glycol carryover while maintaining full moisture specifications.

3.3 Influence of Operating Conditions on Dehydration Efficiency

To further investigate the sensitivity of the TEG contactor performance, parametric evaluations were conducted across broad ranges of wet gas temperature, system operating pressure, and number of contactor equilibrium stages.

3.3.1 Temperature Effects

Operating temperature exerts a dominant influence or dehydration performance. Increasing wet gas temperature elevates the saturation water vapor content exponentially.

When inlet gas temperatures drop below 10°C (50°F), high glycol viscosity severely impairs tray hydraulic efficiency reboiler temperature of 368°F closely aligns and increases pump work. Additionally, at low temperatures stable emulsions with dissolved liquid hydrocarbons, causing severe column foaming and entrainment. Contactor design best practices dictate maintaining lean glycol entering temperatures 3 to 11°C (5 to 20°F) above inlet gas temperatures using dry gas/glycol heat exchangers. Reboiler temperatures elevated to 187-204°C (370-400°F) routinely produce 98.5-98.9 w1% lean glycol, with stripping gas required for higher concentrations.

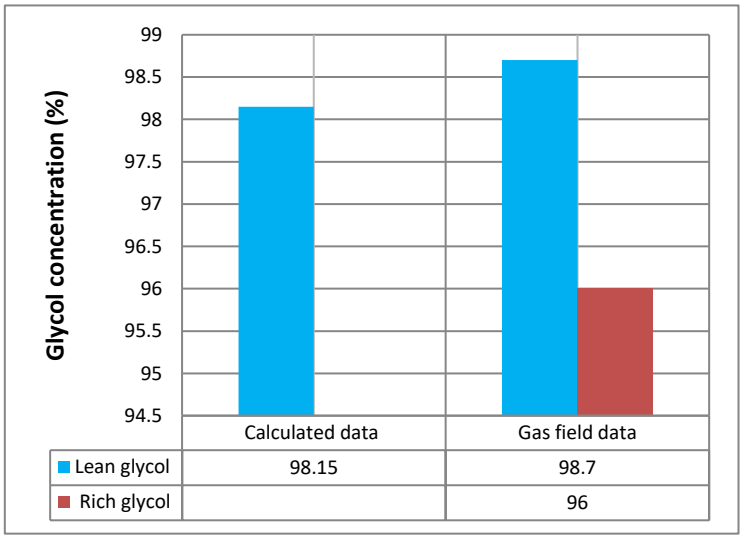


Figure 11: A comparison between lean glycol concentration for processing gas.

Calculated lean TEG concentration (98.15%) closely matches the field value (98.7%), indicating good agreement between the calculated and field operating values.

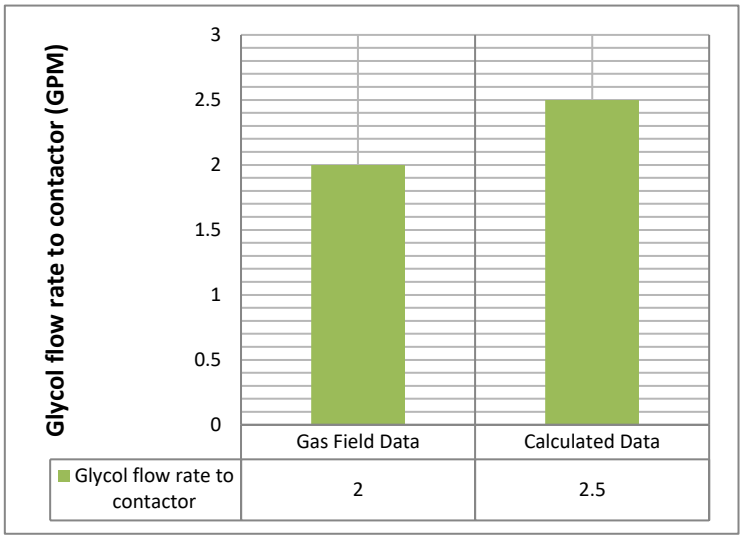


Figure 12: A comparison between glycol flow rate to contactor .

Calculate glycol circulation is 2.5 GPM versus 2.0 GPM in the field, showing a higher flow requirement in the calculated design case.

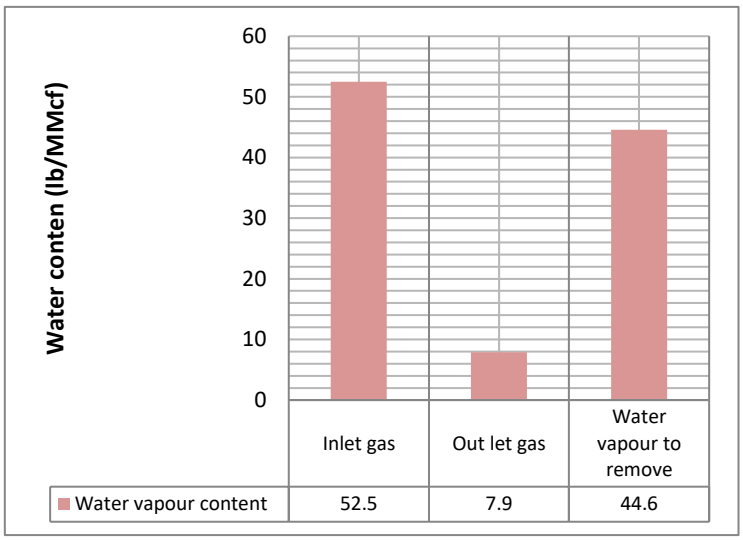


Figure 14: Water vapour contents in inlet, outlet and water vapour to remove of treatment process.

Water vapor decreases from 52.5 to 7.9 lb/MMscf, with about 44.6 Ib/MMscf removed during treatment, demonstrating effective dehydration of the gas.

4 Conclusions And Recommendations

4.1 Conclusions

The natural gas treatment study for the Al Erada gas field showed that the evaluated physical, thermal, and critical properties were suitable for determining the gas compressibility factor, which was found to be 0.91. The gas composition analysis indicated that the gas is sweet, with methane and ethane as the major components, while the concentrations of CO_2 and N_2 were relatively low. The calculated gas flow rate was 50 MMscf/day, with a water vapor content of 52.50 lb/MMcf and a total water removal rate of approximately 2380 lb/day to achieve the required outlet gas dew point. The glycol dehydration process was evaluated based on the required gas specifications. A lean glycol concentration of 98.15% and a glycol circulation rate of approximately 4.13 gpm were obtained, while the calculated reboiler temperature was about 357°F. Comparison with the actual field data showed reasonable agreement in reboiler temperature and lean glycol concentration, although some differences were observed in the glycol circulation rate. Overall, the results demonstrate that the proposed glycol dehydration process provides effective water removal and produces natural gas that meets the required specifications.

4.2 Recommendations

We can recommended by the following:

1. Check the efficiency of the different treatment units.
2. Make periodical maintenance for different equipment.
3. Treatment the corrosion problems by using a certain inhibitor chemicals.
4. Check the producing wells through gas well testing technique to ensure the productivity index.

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