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Gas Leak Detection Using Gas Quality in Natural Gas Processing Plant

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ABSTRACT: The two major parameters used in determining the quality of a processed natural gas are the water content and water dew point. For every natural gas contract, the minimum amount of water the processed gas contained and the water dew point must be specified. Natural gas treatment processes include the removal of unwanted components or the reduction of these unwanted components, such as acid gases (carbon dioxide-CO_2, hydrogen sulphide-H_2S), nitrogen-N_2 and water vapour. Their presence in natural gas can be detrimental to natural gas process facility and gas pipeline efficiency, hence the need to remove or reduce their concentration to the barest minimum or acceptable standard in natural gas transportation and utilization. Natural gas treatment allows the gas to pass through different stages with specific functions, such as: pressure control; separation of gas and condensate; sweetening; dehydration; regeneration of sweetening and dehydration solvents; dew point control. This report focuses on simulating natural gas plant which integrate the different stage, focusing on two scenarios; the first scenario is without gas leak in the plant and the second scenario is with leak in the gas plant. The results were compared to determine the impact of the leak in the quality of the processed natural gas (dry gas). It was found out that as the volume of gas leak increases, the quality of the gas increases (i.e low water content; water dew point; increase mole fraction of methane). This is a very good finding, since it is the target of gas processors.

KEYWORDS: Gas Leak, Water Content, Water Dew Point, Gas Quality

INTRODUCTION

Natural gas is composed of water vapour and acid gases, which must be treated in a gas processing plant that has both sweetening and dehydration units. Natural gas that contains only water vapour will be treated in a gas processing plant that has only dehydration unit. This second scenario is prevalent in the Nigerian Niger Delta region, with little or no amount of hydrogen sulphide and as such, most natural gas processing plant in Nigeria has only dehydration unit to remove the water vapour. The case study utilized for this report is sourced from Obite Gas plant.

A process flow diagram was first designed to identify the equipment that makeup the plant and stages in the processing plant. Figure 1 is the process flow diagram for the natural gas plant used in this report. The figure clearly identifies the equipment in the gas plant. Each unit of the process plant has been clearly identified, to make for easy understanding and flow of information. There are four (4) stages or units in the gas plant: pressure control unit; gas condensate, and free water separation unit; dehydration unit and TEG regeneration unit.

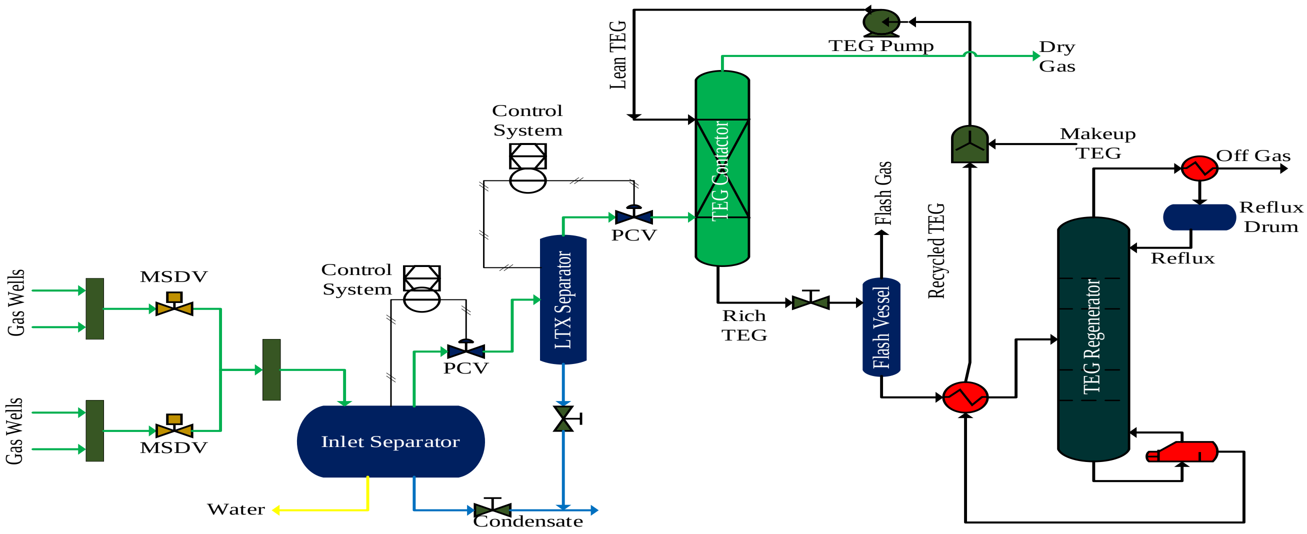

Figure 1: Process Flow Diagram Showing the Different Stages of Natural Gas Plant

To execute this work, two scenarios were investigated: firstly, we have a gas plant without any gas leak in the gas processing system, meaning that the total gas flow rate into the inlet separator remains the same. Secondly, we deliberately initiate a leak in the gas processing plant, between the pressure control unit and the gas-condensate-free water separation unit. The impact of the leak in the plant process condition and quality of the dry gas was then investigated. This scenario implies that the gas flow rate into the inlet separator changes as the leak either increase or decrease. This work entails the simulation of natural gas plant with and without gas leak, with water content and water dew point been put into consideration for investigation and were obtained from the simulation

DESCRIPTION OF THE PROCESS

Natural gas composition from Obite Gas Plant was used as the feed to the natural gas plant. Four (4) natural gas streams from different gas wells and their flow parameters formed the initial gas streams entering the gas processing plant through a pressure control unit (manifold). The four gas flow lines were designed and simulated to carry the gas from the wells to the pressure control unit. The four gas flowlines profile are given in Figure 2 to Figure 5.

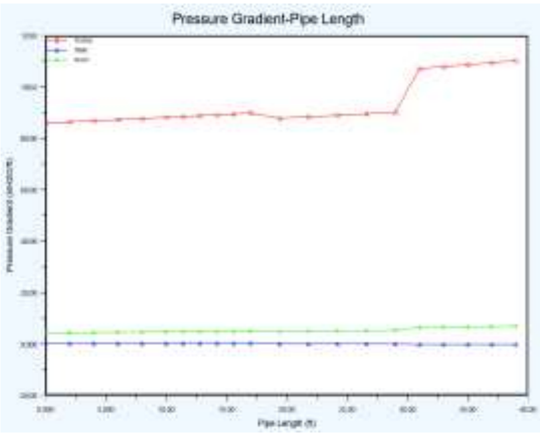

Figure 2: Pressure Gradient for Gas Pipe GP1

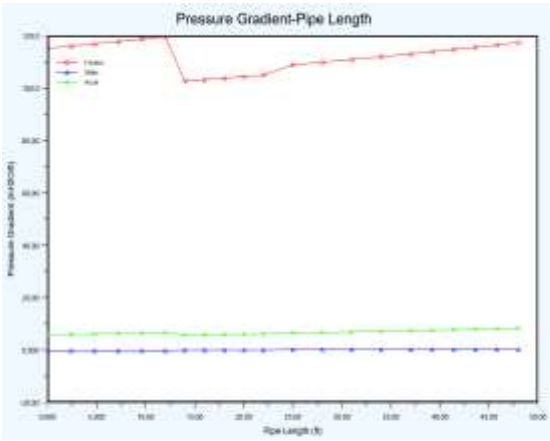

Figure 3: Pressure Gradient for Gas Pipe GP2

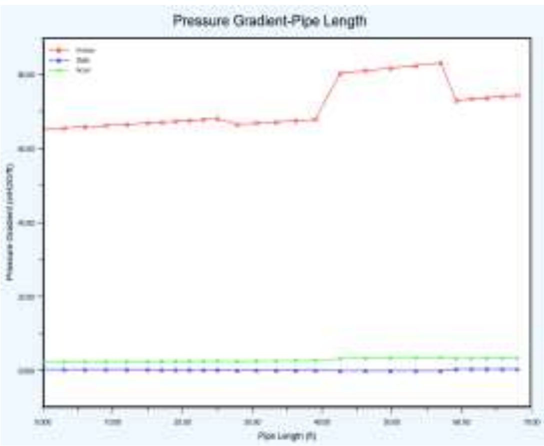

Figure 4: Pressure Gradient for Gas Pipe GP3

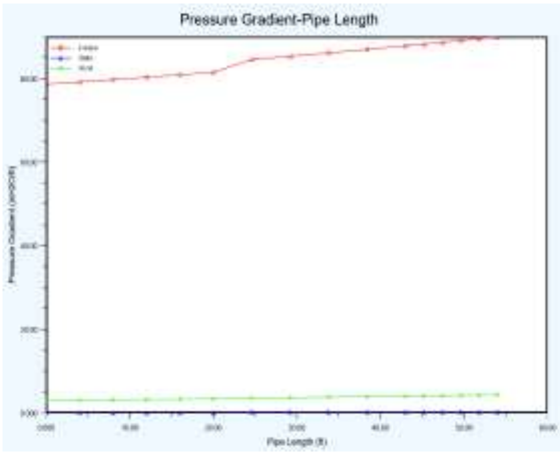

Figure 5: Pressure Gradient for Gas Pipe GP4

These figures are plots of pressure gradient against pipe length and are indications of the response of the gas stream through the gas pipes as the pipe line topology changes with respect to pipe friction; static and acceleration forces. The response of the gas flow in the gas pipeline with respect to pressure and heat transfer were also investigated, the essence of which was to observe the behaviour of heat transfer as the gas flow through the pipeline. Figures 6 to 9 shows the plots of pipeline pressure and heat transfer against pipe elevation.

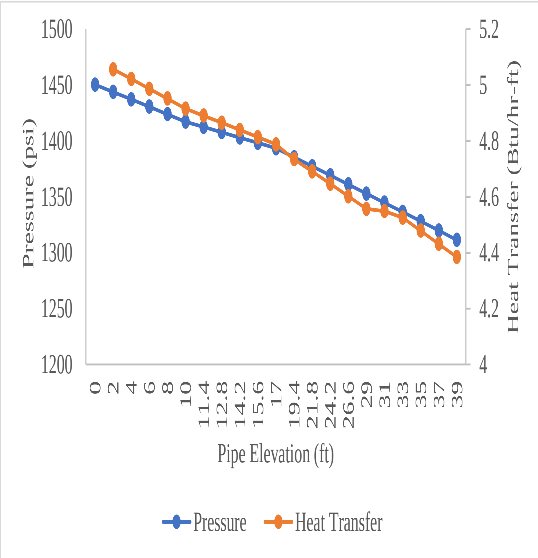

Figure 6: Pressure and Heat Transfer Profile vs Pipe Elevation for GP1

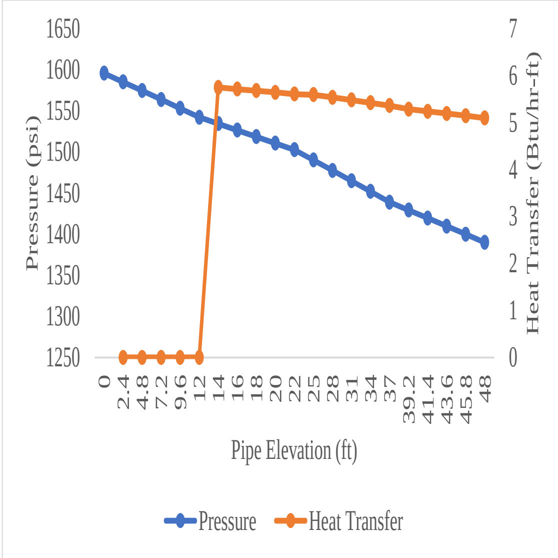

Figure 7: Pressure and Heat Transfer Profile vs Pipe Elevation for GP2

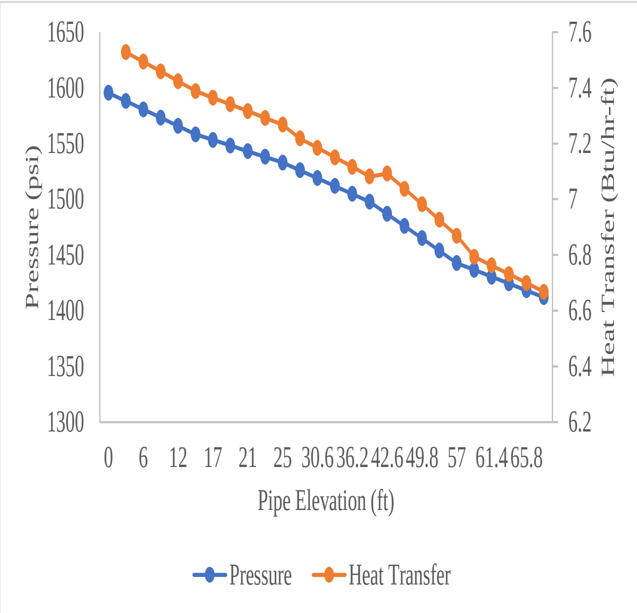

Figure 8: Pressure & Heat Transfer Profile vs Pipe Elevation for GP3

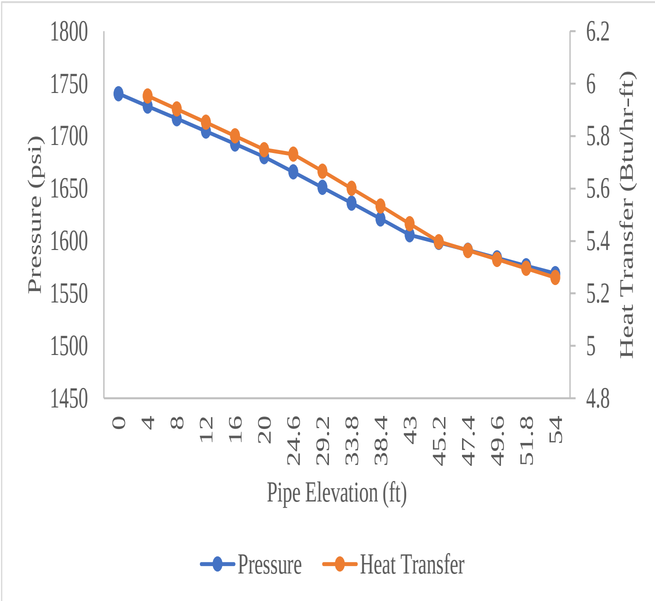

Figure 9: Pressure & Heat Transfer Profile vs Pipe Elevation for GP4

The dehydration unit was designed and simulated at maximum pressure of 800 psia (55.16 bar) and temperature of 140ºF (60ºC), which agrees with the values quoted by Jacob (2014), that a typical absorber column operates effectively at pressure in the range of 40 bar to 80 bar and temperature in the range of 20ºC to 60ºC. The aspect of water content and water dew point in natural gas contract determines the extent of raw natural gas treatment. In this simulation of natural gas plant, the water content and water dew point were put into consideration and were obtained from the simulation without gas leak and with gas leak.

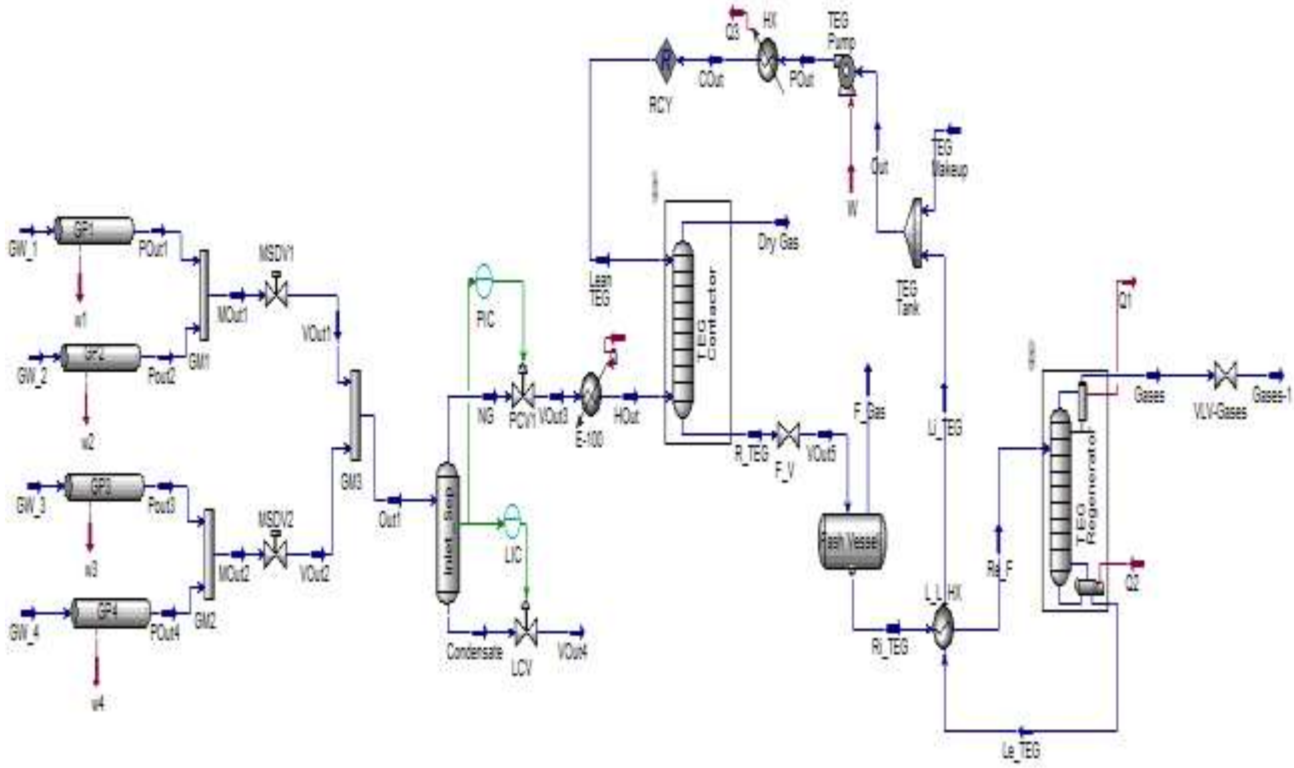

Figure 10: Simulated Process Flow Diagram without leak

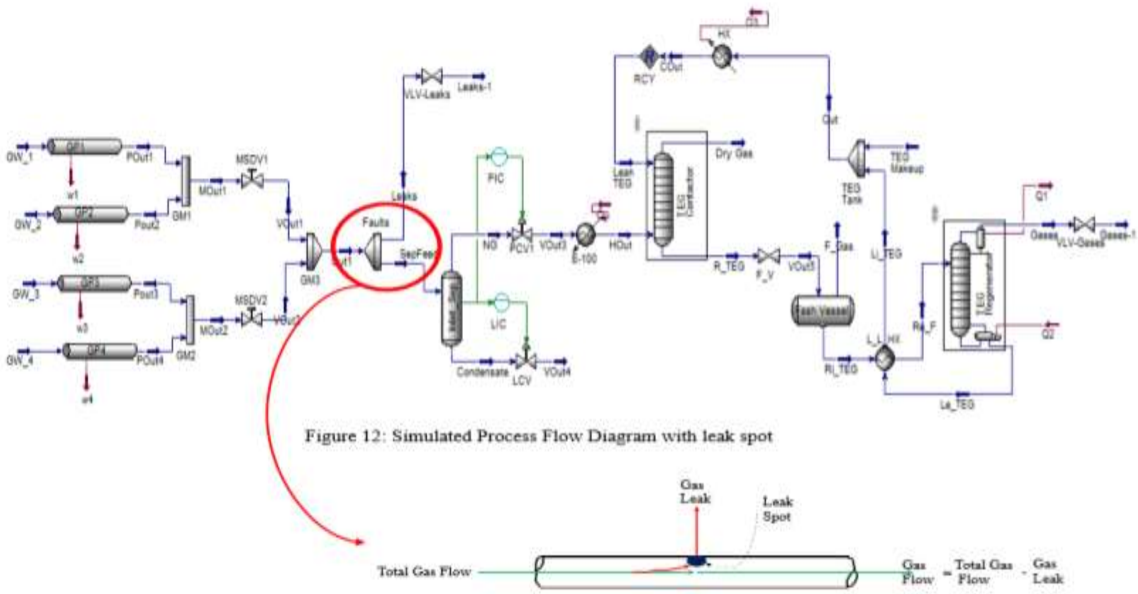

Figure 11: Simulated Process Flow Diagram with leak spot

The design and simulation of the gas plant starts with a steady state. However, to understand the behaviour of the gas plant with respect to changes in process conditions, the steady state simulation was extended to dynamic simulation. The two scenarios stated earlier (gas plant without leak and gas plant with leaks) were done based on dynamic simulation of the process plant, to find out the impact of the leaks on the quality of the processed natural gas. The dynamic control system was designed and simulated on the inlet separator to control the pressure and liquid level of the separator. The reason for the choice of the inlet separator, was the fact that liquid carryover due to rise in liquid level above set point and low vessel pressure may occur and will affect the quality of the gas exiting the separator. Therefore, a proper set point of 45% liquid level and 500 psia vessel pressure were used for the dynamic simulation.

RESULTS AND ANALYSIS

The process description above is applicable to both the first and second scenarios, except the point where the leak was initiated. Figure 10 and Figure 11 show the simulated process flow diagram without leak and with leak. As shown in Figures 12 and 13, data for the water content and water dew point were acquired from the simulation and they are 0.04923lb/MMscf and -48.54ºF (-44.74ºC) respectively, at the “Dry Gas” temperature and pressure of 124.4ºF (51.33ºC) and 551 psia. Leak was initiated upstream of the inlet separator. The leak was designed and simulated such that 0.05 fraction of the total gas flow was allowed to leak out from the pipe and 0.95 fraction flows into the inlet separator, making the total gas flow drop from 810 MMScfd to 769.6 MMScfd. The dynamic state of the process flow diagram was simulation with the leak, and the behaviour/response of the system during gas leak was observed. When the leak was initiated with the above fractions, the methane composition of the “Dry Gas” stream remains almost the same with the composition without leak, but the water content and water dew point drop to 0.03181 lb/MMScf and -56.04ºF (-48.91ºC) respectively, due to drop in gas flow rate from 810 MMScfd to 769.5 MMScfd.

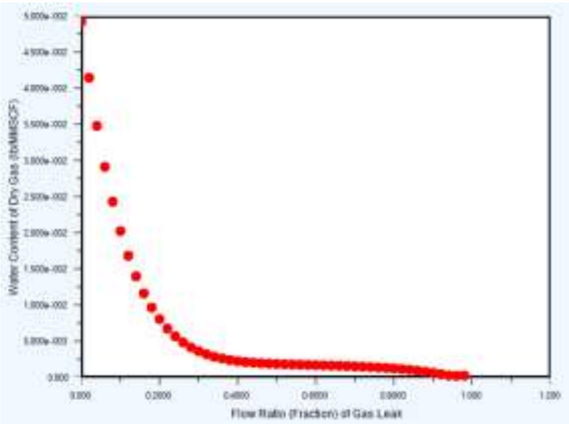

Figure 12: Water Content of Dry Gas and Fraction of Gas

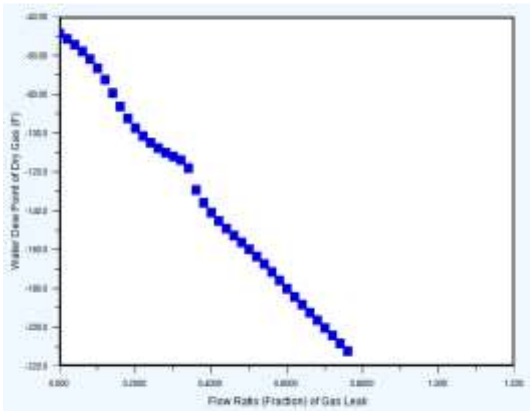

Fig 13: Water Dew Point of Dry Gas vs Fraction of Gas Leak

The result of the simulation with gas leak in the gas plant, showed that there exists a relationship between the volume of gas leaking out from the pipe and the water content and water dew point. To establish this fact the simulation was done for different fraction of gas leak (i.e increasing the amount of gas leak and reducing the amount entering the inlet separator). In the dehydration column, the gas actually makes countercurrent contact with the TEG solvent. Therefore, reducing the amount of gas entering the dehydration column (with TEG flow rate unchanged), have some effect in the natural gas quality (water content and water dew point).

Figure 12 and Figure 13 show a plot of water content and water dew point against fraction of gas leak of the total gas flow. Figure 12 showed that a decaying exponential relationship exist between the water content of the dry gas and the fraction of total gas leak in the gas plant. Figure 13 has a similar behaviour of Figure 12, in a sense that as the fraction of gas leak increase, the water content and water dew point decrease, but the relationship between the water dew point and the fraction of total gas leak is inverse, indicating that increase in any of the parameter will cause decrease of the other parameter.

CONCLUSION

One of the major targets of natural gas processors; especially in natural gas contract, is to treat the natural gas to a point where the water content and the water dew point of the natural gas are very low. Low water content and water dew point of natural gas ensures that flow assurance is guaranteed when transporting the processed/treated gas through region of very low temperature.

In a natural gas processing system without any form of leak in any part of the system, the quality of the gas may remain unchanged or have very minor change due to process upset, such as pressure; temperature and flow rate disturbances. However, the process system can be adjusted by a control system to normalize the disturbances and retain the quality of the gas. Where there is a leak in the natural gas system, the change in the quality of the processed gas becomes obvious as the volume of gas leaking out of the system increases, and this was the finding in this report. As would be the target of every natural gas processor to have low water content and water dew point in the processed natural gas, the simulation in this report finds out that as the volume of gas leak increases, the quality of the gas increases (i.e low water content; water dew point; increase mole fraction of methane). This is very possible as the amount of gas entering the dehydration column is decreasing for the same volume of TEG solvent. This is a very good finding, since it is the target of gas processors, but it possesses a very dangerous outcome, if there is no emergence response.

Whenever there is a gradual or sudden increase in the quality of processed natural gas, the first parameter to check is the gas flow rate (amount of gas entering the dehydration column). If the outcome is affirmative, then there should be thorough search in the system for possible gas leak to avoid disaster that may damage process equipment, claim lives and damage the environment.

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