

Measurement of Hydrocarbon Dew Point for Natural Gas of Titas Gas Field in Bangladesh

Soumik Mahmood Leon¹, Mohammad Shaheen Shah^{1,*}, Syed Istiyak Ahmed¹,
Mohammad Shimul Hossain¹, Tasnim Jahan Nausheen², Farzana Yeasmin Nipa¹, Rafsanjani Rafi¹

¹Department of Petroleum and Mining Engineering, Jessore University of Science and Technology, Jessore, Bangladesh

²Department of Environmental Science and Technology, Jessore University of Science and Technology, Jessore, Bangladesh

Email address:

shaheenshah_just@yahoo.com (M. S. Shah)

*Corresponding author

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Abstract: Hydrocarbon dew point (HCDP) measurement is universally used in the natural gas industry as an important quality parameter and it is noteworthy for the transportation of natural gas safely through the pipelines. Necessary measures should be taken to avoid hydrocarbon condensation as it can create ice or plug in the pipe line if the hydrocarbon dew point of pipelined natural gas is too high. This problem is rising in single phase transportation. Thus, for the best use of natural gas maintaining all safety measures prediction of hydrocarbon dew point is a must. In this study a scientific investigation has been conducted by the authors to scientifically investigate the hydrocarbon dew point of several gas wells (Location-A, C, E, G) of Titas Gas fields in Bangladesh. As per latest Petrobangla re-estimation, total recoverable gas reserve of Titas gas field is 7,582 billion cubic feet (BCF). Commercial gas production from this field was commenced in April 1968 and till May 31, 2018 total 4545.491 billion cubic feet gas or 59.95% of reserves has been recovered. Applying various experiments has been conducted for this measurement with a view to finding the effect of the volume of the sample gas, the chamber's temperature and the sample conditioning. It is observed that, no volume effect or sample conditioning effect was found. Despite chamber's temperature is observed that ranges from 73 to 90 °C which has an effect of approximately 0.9 °C on the measured dew points. This research depicts the another challenging issue is adsorption phenomena which is observed of heavy hydrocarbons inside the rig, which is common in HCDP measurements, this effect is more predominant in gases consisting of heavier compounds, as in the case of the real gas.

Keywords: Hydrocarbon Dew Point (HCDP), Hydrocarbon Condensation, Titas Gas Field, Bangladesh

1. Introduction

Natural gas is a mixture of hydrocarbon predominantly of methane CH₄ (70-90% v/v) and some other hydrocarbons likewise ethane, propane and butane. Non-hydrocarbon contaminants such as H₂O, CO₂, N₂, and H₂S are often be found in small percentages. Natural gas is the untainted fossil fuel and can be used every sectors, from households to high energy demanding plants. This is the reason why natural gas pipeline networks have been developed for the transportation of the gas throughout the world [1-2].

There prevails always a chance of hydrocarbon plugging in

natural gas transmission pipelines. Hydrocarbon liquid from condensation will increase the pressure drop and introduce functioning problems emerging from multi-phase flow. It is very much important to intercept abridgement by keeping the natural gas temperature and pressure in the single-phase region. Optimal follow up of the hydrocarbon dew point is therefore important for economical, functioning and safety reasons [3-5].

Rich gas is partially refined natural gas transported in the opaque phase region, where the pipeline capacity is limited by a minimum possible arrival pressure (cricondenbar). Dry gas conveyance is the transport of fully refined natural gas.

The lowest satisfactory temperature is limited by the hydrocarbon dew point designation on sales gas (cricondetherm) and the requirement of no liquid hydrocarbon formation in the export pipelines. To employ the natural gas fabrication and transference system optimal it is significant to be able to predict the phase behavior of natural gases both near the cricondetherm and cricondenbar [6-7].

The knowledge of the hydrocarbon dew point (HCDP) is of great importance for the oil and gas industry. Natural gas pipelines are delineated for single-phase conveyance and therefore, hydrocarbon condensation could have severe consequences for the secure transportation of the gas. In order to assure an effective utilization of the natural gas pipelines, accurate measurement and prediction of hydrocarbon dew points is necessary [8-10].

In the oil and gas industry, thermodynamic models are used for the prediction of the phase envelope. Such models are both traditional cubic equations of state (EOS) and more advanced models [11-12]. In this experiment, the uniform hydrocarbon dew points are used to assess three models: SRK and PC-SAFT equations of state as well as the UMR-PRU model that belong to the class of the so-called EOS/GE models [13-16].

2. Geological Setting

The Titas Gas field is situated some 100 km away to the direction of northern-east from capital of the Bangladesh, Dhaka. It lies at the periphery of Brahmanbaria town. Titas anticline is a north-south elongated semi-domal structure.

This is in contrast to all the neighboring anticlines, which have narrow elongated forms. The fabric of Titas gas field is higher than the surrounding Rashidpur and Habiganj structures suggesting that it probably has been influenced by tectonically positive element from the deep subsurface. Titas anticlinal closure is one of the largest (179 km) in Bangladesh. The structure is lopsided in nature with dizzy dip in the eastern flank and clement dip in the western flank. There has been indication of faulting in the deeper level in the eastern flank, as shown by seismic reflection discontinuities [18-19].

The Titas gas field is formed by a gentle subsurface anticlinal structure with a broad axial area. The structure has one of the largest closures among the gas fields in the country, measuring in excess of 17 km by 9 km at the topmost pay sand level. There is no surface expression of Titas structure as it is covered by the Titas-Meghna flood plain.

The broad axial nature of Titas anticline is in contrast to the neighboring anticlines which are narrow in their outlines. It's position is structurally higher than the surrounding anticlines which indicates that Titas gas field probably have been influenced by tectonically positive element from deep subsurface. The structure is elongated in north south direction and is asymmetric with steeper eastern flank ($12^{\circ}\pm$) and gentler western flank ($6^{\circ}\pm$). Evidence of faulting is not conclusively shown as some studies suggested fault in the eastern flank, while other suggested no evidence of fault in the gas sand levels [18-19, 24].

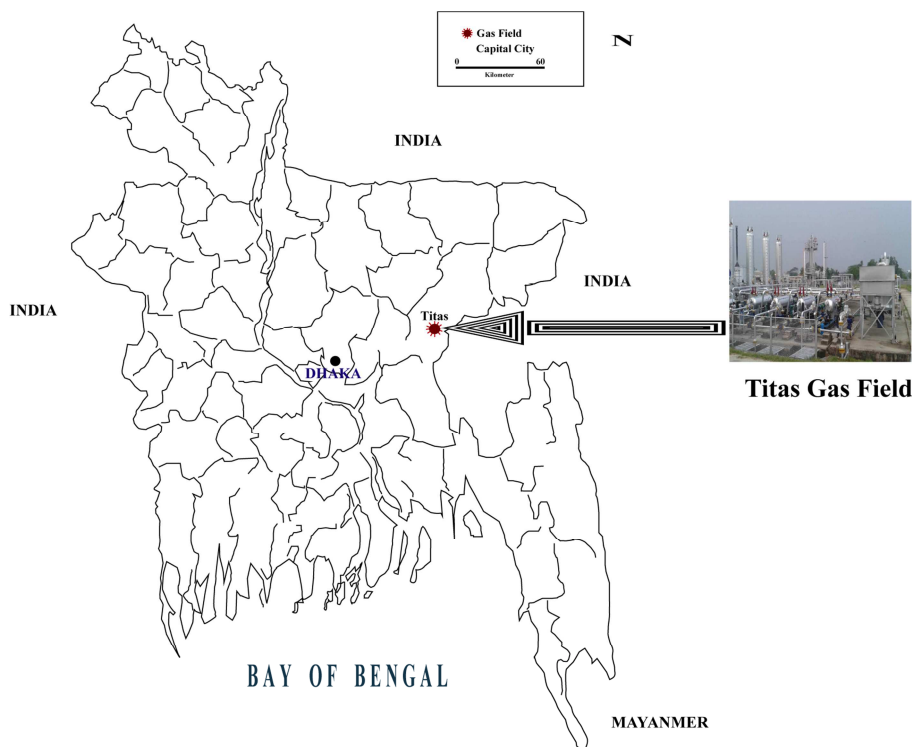


Figure 1. Titas Gas Field location map; Modified after [17].

Titas gas field is located in Brahmanbaria district in the outskirts of its town in Bangladesh. This field was discovered

by Pakistan Shell Oil Company in 1962. The structure is an elongate north-south asymmetrical anticline measuring about 19x10 square km with a vertical closure of 500 m (Figure 1). As per latest official re-estimation, maximum redeemable gas reserve of Titas gas field is 4,740 billion cubic feet (134 km³). Commercialized gas yielding from this field was started in 1968 and till August 31, 2006 total 2,581.162 billion cubic feet (7.30904×10¹⁰ m³) gas has been produced. The wells are lies (surface location) at 6 (six) dissimilar locations elongated over about 9 km distance. At present maximum 475 million cubic feet (13,500,000 m³) of gas is produced daily from 16 wells of this field and processing through 5 nos. glycol dehydration and 6 nos. Condensate produced (540 bbl per day on an average) with gas as by-product is fractionated into MS (Petrol) and HSD (Diesel) through two fractionation plants [18-19].

With a view to evaluating the impact of the adsorption appearance on the dew point measurements different functional parameters of the rig, related to adsorption, were examined. The parameters examined are [20-23].

- The volume of the gas used for each measurement,
- the temperature applied inside the chamber of the rig and
- The gas sample conditioning.

3. Materials and Methods

3.1. Dew Point Measurements

A good understanding of the hydrocarbon dew point measurements requires the comprehension of the laws regulating these measurements [9].

3.2. Principle of Dew Point Measurements

Isobaric cooling is the method on which dew point measurements are depended. Obligation for an accurate dew point measurement is the conservation of the sample gas in single-phase region. The dew point identification is the finding of a restrained decrease of temperature at constant pressure. In other words, for every pressure level the operator is interested in, the temperature is being decreased slowly until the detection of the dew [9, 25]. Figure 2 is representative of the dew point measurement principle.

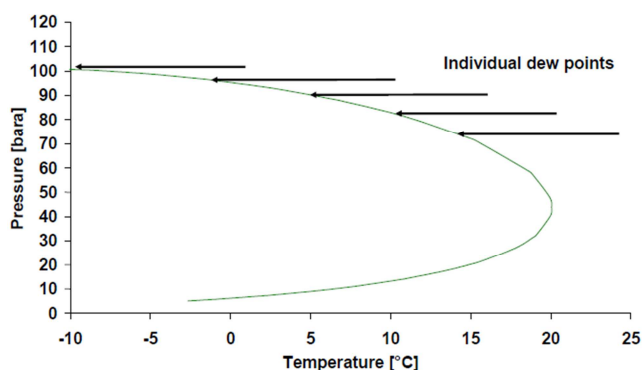


Figure 2. Isobaric Cooling.

Assume that the operator is interested in measuring the hydrocarbon dew point of a sample at constant pressure that the gas is in single-phase region (end of the arrows). The operator is decreasing slowly the temperature until the first dew begins to form. The dew is formed when the dew point curve is reached (tip of the arrows). This is the HCDP of the gas being measured for the specific pressure. The temperature then increases so as the gas moves outside the two-phase region [9, 25].

The determination of water content in gases used for commercial and domestic purposes is required because water contamination can cause corrosion and other equipment problems, especially in regulation and metering stations. The determination of hydrocarbon contamination of pipeline gas is necessary if hydrocarbon dew point specifications of natural gas transportation contracts are to be met. Gases which are most frequently tested for water content include natural gas, sour gas, heat-treating-furnace gas and industrial gases as Nitrogen, Oxygen, Hydrogen, and bottle gas [26-29]. The various instruments available for determining water content, the most accurate and widely used is the Bureau of Mines Type Dew Point Tester. After test measurements were averaged by the Bureau, less than a 0.2 degree Fahrenheit dew point temperature difference was recorded. The instruments meet ASTM D1142-GPA 2140 standards. Accuracy and repeatability of the testers are maintained without recalibration [6-9, 30].

The Bureau of Mines Type dew point Tester duplicates the conditions required by the definition of dew point. When a gas-water vapor is cooled out of contact with liquid water, the humidity of the water content remains constant, but saturation increases until it reaches 100 percent, and moisture begins to condense. The temperature at condensation is known as Dew point [30-31]. This determination is the classical method demonstrated in high school chemistry and physics courses. However, for the Bureau of Mines Type dew point Tester, the procedure is modified to make it suitable for measuring dew point at high pressures and is accomplished by enclosing a mirror, which is chilled by refrigerant and on which moisture or hydrocarbons condense, in a pressure chamber. A window in the pressure chamber allows viewing of moisture condensation [6, 25, 32].

The dew point tester incorporates a pressure-tight chamber to contain the gas or vapor test sample and valves for controlling gas flow. At one end of the chamber, a clear plastic window is installed to allow observation of the chamber's interior and mirror. The mirror is highly polished stainless steel and is attached at its center to a copper thermometer well. A chiller attached to the thermometer well controls expansions of refrigerant and the temperature of the mirror. The mirror's temperature is indicated by a thermometer whose bulb is located close to the mirror's back surface [30-31].

Three types of chillers are available: a regular chiller, a quick chiller, and a liquid Nitrogen chiller. The quick chiller and Nitrogen chiller permit much faster dew point determinations, but they must be operated with care to

prevent overshooting the dew point temperature. The liquid Nitrogen chiller is used for extremely low dew point determinations. A pressure gauge is attached to the upper side of the pressure chamber, and a socket for the tripod is threaded into its bottom [33].

Designed for field and laboratory use, Dew point tester models A and B are fabricated of stainless steel except for parts requiring higher thermal conductivity; these are copper. Model B is a mechanical redesigned of the original Bureau of Mines Type, and its window is about four times larger (Figure 3). The differences in window area are materials of construction account for their differences in pressure ratings [30-31, 33].



Figure 3. Dew point tester Model: Model A and Model B [33].

Manual Visual Dew Point tester is the most extensively used method for the measurement HCDP and requires the simplest apparatus. It can also be used to measure water dew point (WDP) in natural gas. This Bureau of Mines dew point tester has been used since the 1930s to provide manual readings. This procedure is used for spot checking the dew point of a sample when extracted from a tap on the pipeline from any location of a gas processing facility, or point of use. It requires patience and training to be able to operate this instrument properly [20, 34, 35].

There are two chambers within the instrument. One is the sample chamber that is suitable for pipeline pressures to 5000 psig, containing a mirror visible through a window. There is also a method for measuring the temperature of the mirror. A second chamber allows a coolant to be conducted across the back of the mirror [36].

The operator connects the sample to the sample inlet port and begins purging the chamber with a flow of sample. A coolant, typically an expandable gas like propane, liquid

carbon dioxide or liquid nitrogen is connected to the coolant inlet. The operator then throttles the coolant through a valve, cooling the polished mirror in contact with the sample gas until the dew point is observed. This image is indicated by the first appearance of very small droplets of hydrocarbon condensate appearing on the mirror. The temperature is immediately read and the value noted since the operator must interpret the image seen on the mirror, there will always be some subjectivity in this method [33, 36]. The proper procedure is described in ASTM D1142, but operator experience is critical for best accuracy. The condensate is a shiny, transparent coating that requires training to distinguish and interpret the image on the mirror.

3.3. Additional Equipment.

Chiller

There are three types of chiller devices available for use with the standard dew point tester or the ChanScope.

- Standard Chiller
- Quick Chiller
- Liquid Nitrogen Chiller

The Quick Chiller and the Liquid Nitrogen Chiller allow much faster dew point determination but there is an increased risk of error and temperature overshoot if components are not allowed to reach thermal equilibrium. The Quick Chiller can be used for dew point measurements down to -20°F (-30°C) with propane, and down to -90°F (-70°C) with liquid CO₂ refrigerant. The Nitrogen Chiller is a dipstick type and can be used with liquid N₂ for dew points down to and below -200°F (-130°C). The Nitrogen Chiller can also be used with dry ice/acetone for dew points down to -100°F (-75°C) [33, 36].

3.4. Adsorption

The main challenge of the hydrocarbon dew point measurements is the presence of adsorption phenomena. Adsorption is defined as the adhesion of particles from a gas, liquid, or dissolved solid to a surface; the opposite process is desorption. Adsorption is affected by many factors such as temperature, pressure and the surface material. Adsorption phenomenon is described by Langmuir isotherm equation:

$$\theta = \frac{KP}{1 + KP}$$

Where θ is the surface coverage given as the fraction of adsorption sites occupied, K is the equilibrium constant and P is the pressure. This means that the higher the pressure is the more θ approaches unity, therefore, full surface coverage. Moreover, adsorption is an exothermal reaction while desorption is an endothermal one. Thus, at constant pressure, high temperature promotes desorption. Inside the dew point apparatus, gas particles are often adsorbed onto the surface of the rig resulting into a change to the composition of the gas. The components adsorbed are the heavier compounds of the mixture which are mostly responsible for the shape of the dew point line. When heavy components are adsorbed, the

sample gas becomes lighter and, therefore, the dew point line moves to the left. As a result, the dew point is measured at a lower temperature. The measurements are, therefore, inaccurate and the experimental dew points are not representative of the sample gas. The study of volume effect, chamber's temperature effect and sample conditioning effect derive from the need to ascertain the existence or not of adsorption phenomena inside GERG rig [33, 36].

4. Results

The manual visual method needs a proper trained operator and patience. The optical device must be clean before starting any measurements. The sample pressure should be at the contract pressure. The sample should be allowed to bleed through the device per the ASTM standard D1142. Chill the mirror down gradually at a rate that "does not exceed 1°F (0.5°C) per minute", per ASTM Standard D1142 (ASTM, 1995) until a visible condensate forms on the optical surface. When the facsimile is recognized as the HCDP, the

thermometer should peruse the HCDP temperature. The mirror temperature should then be granted to upraise slightly and then cooled again to "home in" on the true reading. These readings should be repeated a minimum of three times with reasonable agreement to qualify as being accurate.

For each of the data sets, the field, sample location, pipeline pressure, water dew point and various HCDP's are presented in the tables. The HCDP's composed of direct measurement by the chilled mirror method and by the PR and SRK equations of state for the three gas compositions: i. standard C₉⁺ analysis, ii. extended analysis, and iii. modified C₆⁺ characterization using 47% C₆, 38% C₇, and 17% C₉ [37-39].

The reader should remember that data for this study were not collected in a controlled laboratory setting but were rather gathered in the field under typical operating conditions. This approach undoubtedly introduces more variability into the analysis but alternatively, results from the study should more closely reflect the conditions under which most pipelines operate.

Table 1. Measurement of H/C Dew Point, Moisture/Water Dew Point, Water Content, Pressure and Flow Rate with GPS Records of the Titas Gas Field Sales Line (Location-A).

Sales Line (Location)	GPS Records		H/C Dew Point, °F	Moisture Dew Point, °F	Water Content, lbs/MMScf	Calculated Pressure, Psig	Flow Rate, MMScf
	Latitude	Longitude					
A	23°59'47.64"N	91°06'47.34"E	73	-4	2.8	920	60.927

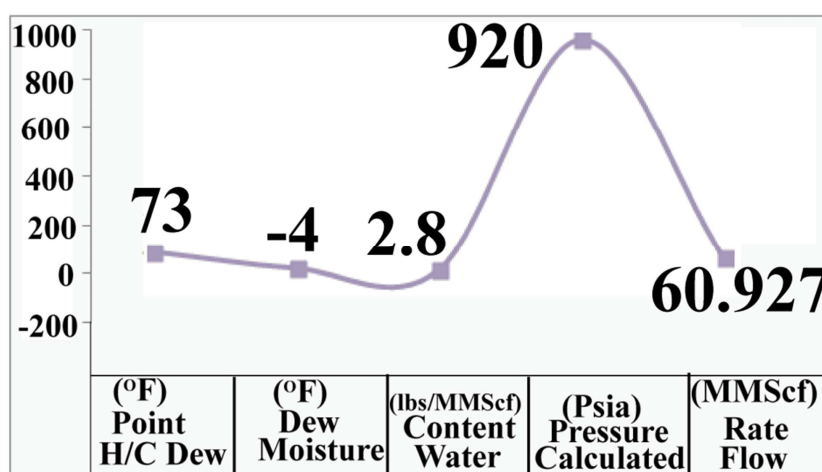


Figure 4. Calculated throughput of sales line (Location-A).

In sales line (Location-A) the flow rate is almost 60.927 MMScf and the Pressure is 920 Psig in which hydrocarbon Dew Point is found at 73°F whereas the water dew point is found at -4° F. In this condition the water content is 2.9 lbs/MMScf (Table 1, Figure 4).

Table 2. Measurement of H/C Dew Point, Moisture/Water Dew Point, Water Content, Pressure and Flow Rate with GPS Records of the Titas Gas Field Sales Line (Location-C).

Sales Line (Location)	GPS Records		H/C Dew Point, °F	Moisture Dew Point, °F	Water Content, lbs/MMScf	Calculated Pressure, Psig	Flow Rate, MMScf
	Latitude	Longitude					
C	24°00'56.46"N	91°07'22.26"E	76	12	4.4	930	47.96

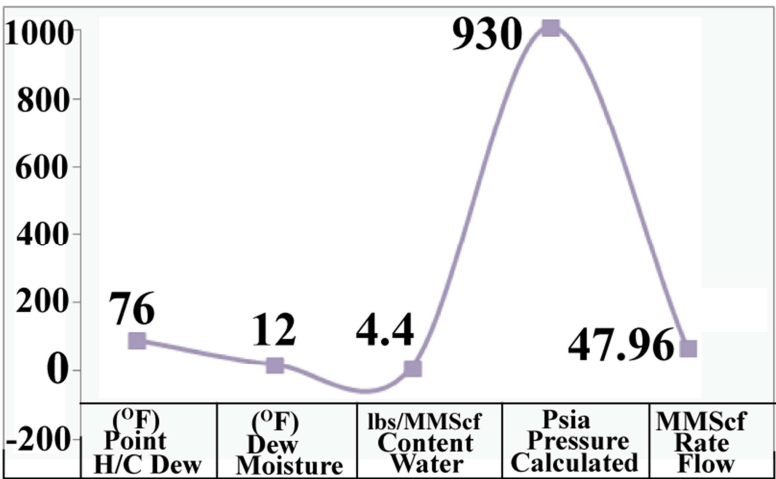


Figure 5. Calculated throughput of sales line (Location-C).

In sales line (Location-C) the rate of flow is observed 47.96 MMScf and the Pressure found in the line is 930 Psig. In this condition the hydrocarbon Dew Point is seen at 76°F whereas the water dew point is found at 12°F and at the same time the water content in the line is 4.4 lbs/MMScf (Table 2, Figure 5).

Table 3. Measurement of H/C Dew Point, Moisture/Water Dew Point, Water Content, Pressure and Flow Rate with GPS Records of the Titas Gas Field Sales Line (Location-E).

Sales Line (Location)	GPS Records		H/C Dew Point, °F	Moisture Dew Point, °F	Water Content, lbs/MMScf	Calculated Pressure, Psig	Flow Rate, MMScf
	Latitude	Longitude					
E	24°02'25.62"N	91°07'01.69"E	80	17	4.8	900	94.25

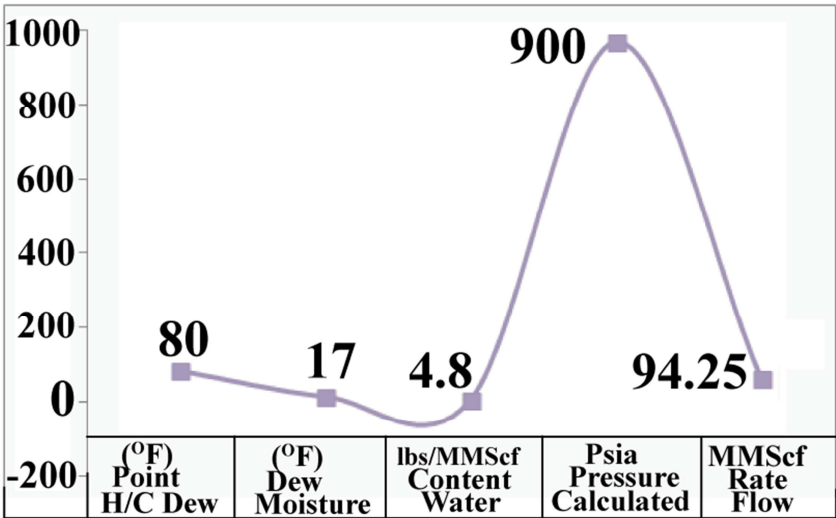


Figure 6. Calculated throughput of sales line (Location-E).

In sales line (Location-E) the flow rate is the highest of all the sales line which is 94.25 MMScf but the pressure is little bit lower and that is 900 Psig in which both hydrocarbon Dew Point and water dew point is found at higher temperature than before. Hydrocarbon dew point is observed at 90°F whereas the water dew point is found at 17°F. In this condition the water content is 4.9 lbs/MMScf (Table 3, Figure 6).

Table 4. Measurement of H/C Dew Point, Moisture/Water Dew Point, Water Content, Pressure and Flow Rate with GPS Records of the Titas Gas Field Sales Line (Location-G).

Sales Line (Location)	GPS Records		H/C Dew Point, °F	Moisture Dew Point, °F	Water Content, lbs/MMScf	Calculated Pressure, Psig	Flow Rate, MMScf
	Latitude	Longitude					
G	23°57'32.159"N	91°7'24.291"E	79	16	4.6	920	57.05

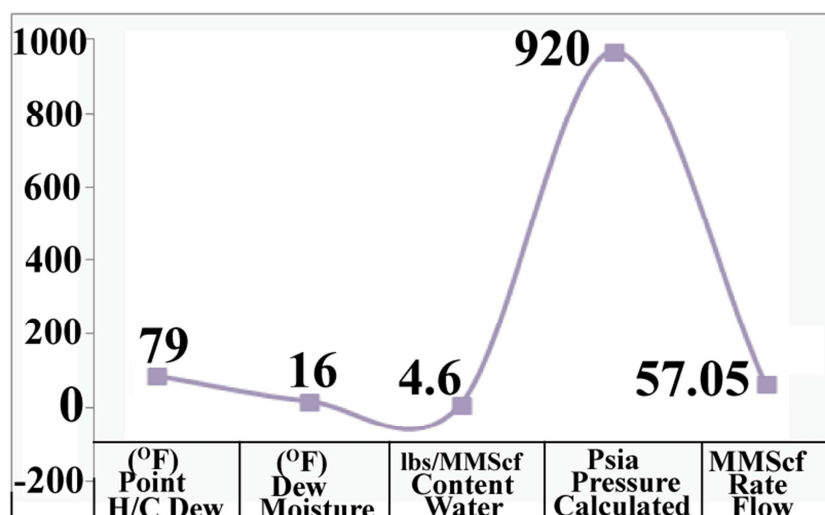


Figure 7. Calculated throughput of sales line (Location-G).

In sales line (Location-G) moderate flow rate is noticed and that is 57.05 MMScf and the pressure is almost similar to other lines which is 920 Psig. In such flow rate and pressure, the hydrocarbon Dew Point is found at 79°F and the water dew point is found at 16°F. In the overall condition the water content is 4.6 lbs/MMScf (Table 4, Figure 7).

5. Discussion

This work is based on the operating condition of Titas Gas Field. Here operating principles are the gas flow rate, wellhead temperature, pressure, gas composition, gas properties, water-content in raw gas etc. So, with the change of these conditions the total results can be changed also. This work is mainly measurement of hydrocarbon dew point and modeling of it. The results got in the overall work are established on theoretical proof and some practical knowledge.

So, the process to outline any glycol dehydration plant will be same as we have drafted here but the outcomes can be different. In the categorizing of Inlet 3-phase boundary the liquid capacity is 66 bbl/day. But, the OD and elevation of the boundary is fabricated for the liquid capacity of maximum 100bbl/day to gratify any overrun of gas. Though the fabricating condition is not the benchmark, so in the sizing of glycol contactor two correction factors of temperature and specific gravity are introduced to identify gas capacity. And the contactor is designed for the maximum gas capacity of 52 MMSCFD.

5.1. All Measurement Techniques

The general methods required to produce good accuracy begin with proper sampling. Proper sampling begins right at the sample tap. The sample should be moved upwards from a place sufficiently away from the inner walls and five diameters downwards of any components, valves etc., which might revise the flow outline within the pipeline. All those sample must be collected and removed through heat traced tubing from the point of withdrawn through to the analyzer.

This is a critical issue since all surfaces relating to the sample gas must be maintained at a temperature higher than any dew point. Speed loops should be used for getting the best speed of response. Sample strainer must remove all particulates and liquid aerosols. However, any required pressure reduction should be taken immediately before delivery to the measurement section of the analyzer [10, 36].

5.2. Manual Visual Analysis

In addition to the general best practices above, the manual visual method requires a well trained operator and patience. The optical device must be cleaned before starting any measurements. The sample pressure should be at the cricondentherm of the specific gas or the contract pressure. The sample should be authorized to pass through the device per the ASTM standard D1142. Cool the reflector down gradually at a rate that “does not exceed 1°F (0.5°C) per minute”, per ASTM Standard D1142 (ASTM, 1995) until a observable drop forms on the optical surface. Once this drop is noticed as the HCDP, the thermometer should collect the HCDP temperature. The mirror temperature should then be authorized to elevate slightly and then cooled again to “home in” on the actual reading. These readings should be repeated a minimum of three times with reasonable agreement to qualify as being accurate [10, 36].

5.3. EOS from GC Analysis Data

Gas Chromatography best practices include using a C9+ GC and then adding data to C12 from laboratory analysis data to modify accuracy of the EOS calculations. Using multiple EOS may also provide data comparison review over time that will determine the historical significance of one formula over another for a specific field or supplier. Keep in mind that field GC installations may not comply with all of the above general best practices and may produce less accurate results. Gas Chromatographic specimens are examined at very low pressures compared to pipeline pressures and are anticipating values by measurements at conditions a lot different from those of the actual pipeline [10, 36].

5. 4. Automatic Dew Point Analyzers

5.4.1. Reliable Detection Method

A reliable detector is a given for all instruments. Rough surfaces will be able to identify the HCDP because the condensate droplet will make the optical surface more reflective and the image easier to detect [36].

5.4.2. Close Proximity to Pipeline Specimen Point

Automatic sections should be mounted close to the specimen tap with internal heaters and insulated housings. By using a specimen already piped to an instrument house may be suitable, but the resulting delay in the update may cause serious lag in reaction time for control purposes. Since each manufacturer has different operating temperature specifications, environmental conditions often dictate this choice [36, 40].

5.4.3. Trap the Sample while taking the Measurement

A sample that is allowed to flow continuously creates an abnormal build up of the heavier hydrocarbons on the optical surface. Blocking in the sample during the measurement cycle will produce more accurate readings [36].

5.4.4. Controlling Measurement Pressure

The derivation of the word cricondenthem is Critical condensation thermal curve – also called the “phase envelope”. The cricondenthem is the point on this curve where pressure and temperature indicate that the maximum HCDP is to be found, so the measurement pressure must be controlled. Many contracts are written with this cricondenthem point as the measuring point for the maximum allowable HCDP in the gas. Contracts written with the reference to the maximum HCDP at any pressure, are describing the same point. Since the profile of this region of the curve is nearly vertical, a change of fifty to a hundred psi either way can be shown to produce very little change in the accuracy of the measurement. In the expanded graph example below, a change of 100 psi results in influencing the HCDP a maximum of only 2°F. In contrast, just 1 ppmv of a C10 component in the sample can change the HCDP by as much as 10°F! It is however, always good practice for the measurement to be performed at the contract pressure which is often the cricondenthem pressure [36, 40].

5.4.5. Heat the Optical Surface between Measurements

Without sensor heating the total cycle time can be three times that of the heated one and result in less reliability of the measurement [9, 36].

5.4.6. Keep Internal Volumes Small

When the volume of sample in the measuring chamber is reduced, it will speed the measurement and allow faster purging of the measurement chamber [36].

5.4.7. Frequent Sampling

Many of the above practices will allow automatic dew point analyzers to make more frequent measurements. Frequent measurement cycles provide for better response to

changes in the gas conditions and allow control functions to be implemented in a more timely fashion [9, 36].

5.4.8. Capability for Coordinating with Contract Data

Historically the working principles of HCDP have been obscurely revised and standards have been written again to assimilate them. If this tendency will continue and remold come into consideration, it is important to have the ability to tune the analyzer to unite with newly refined standards [9, 36].

6. Concluding Remarks

Based on the data obtained from various experiments in this work and the above mentioned discussions, various conclusions can be drawn based on the parameters that affect the precision of the dew point measurements.

The rig has been constructed from materials designed to minimize adsorption appearance, such incident seem to exist as indicated from the dew point measurements testing the chamber's temperature effect. The temperature effect is clear and in agreement with adsorption theory. According to the expectation, at lower chamber temperature the adsorption phenomena are more intense, dew point temperatures are recorded to be lower. As a consequence, between 73 °F and 90 °F, measurements are more accurate at a chamber's temperature of 90°F. Volume effect does not exist between measurements with 300cc and 600cc. The deviations noticed are within the experimental uncertainty. Higher volume of gas means higher volume to surface ratio. Consequently, taking into consideration the presence of adsorption happenings inside the dew point apparatus, employment of 600cc of sample gas is suggested for accurate dew point measurements. Sample conditioning does not seem to have an effect on the accuracy of the dew point measurements. In experimental uncertainty all these effects are generated which points out that adsorption is not an issue inside storage bottles.

Based on the above, it is recommended that hydrocarbon dew point measurements in the rig should be held when the chamber's temperature is 90°F and 600cc of sample gas are used. Preheating of the sample bottle is not required.

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