Tikrit University

College of Petroleum Processes Engineering

Department of Petroleum and Gas Refining Engineering

Gas Technology

Forth Class

Lectures 5

By

Jasim I. Humadi

Gas Specifications and Standard Conditions

Market sales of natural gas require some specifications set by the consumers regarding the maximum contents allowable for the following: acidic gases and sulfur, oxygen and carbon dioxide, water vapor, and liquefiable hydrocarbons. The thermal heating content of the gas sets another value to be met as a minimum. **In general, the standards specify that the natural gas:**

- Be within a specific range of heating value (caloric value). For example, in the United States, it should be about 1,035 ± 5% Btu per cubic foot of gas at 1 atmosphere and 60 °F (41 MJ ± 5% per cubic metre of gas at 1 atmosphere and 0°C).
- Be delivered at or above a specified hydrocarbon dew point temperature (below which some of the hydrocarbons in the gas might condense at pipeline pressure forming liquid slugs which could damage the pipeline).
- Be free of particulate solids and liquid water to prevent erosion, corrosion or other damage to the pipeline.
- Be dehydrated of water vapor sufficiently to prevent the formation of methane hydrates within the gas processing plant or subsequently within the sales gas transmission pipeline.
- Contain no more than trace amounts of components such as hydrogen sulfide, carbon dioxide, mercaptans, nitrogen, and water vapor.
- Maintain mercury at less than detectible limits (approximately 0.001 ppb by volume) primarily to avoid damaging equipment in the gas

processing plant or the pipeline transmission system from mercury amalgamation and embrittlement of aluminum and other metals.

Irrespective of the source of natural gas, the final specifications set for market sales requirements are usually as given in Table 1:

Table 1: Natural Gas Market Sales Requirements

H_2S	0.25–0.3 grain per $100ft^3$ (one grain = 64.799 mg)
Total sulfur	20 grains per 100 ft^3
Oxygen (air)	0.2% by volume
Carbon dioxide	2% by volume
Liquefiable hydrocarbons	0.2 gal per 1000 ft^3
Water content	7 lbs/MMSCF (in a 1000-psia gas line)
Thermal heating value	1150 Btu/ft^3

As for the standard conditions used in the gas industry for reporting the volumetric properties of the gas, two common standard conditions of temperature and pressure are used:

1. Universal scientific, reported at 32^{o}F and 760mmHg

2. Natural gas industry, reported at 60 ^{o}F and 14.7 psia

Under the universal standard conditions, for an ideal gas, the following is applied:

1 g mole occupies 22.4 liters

1 kg mole occupies 22.4 cubic meters

1 lb mole occupies 359 cubic feet

Effect of Impurities Found in Natural Gas

Field processing operations of natural gas, which is classified as a part of gas engineering, generally include the following:

1. Removal of water vapor, dehydration

2. Removal of acidic gases (H_2S and CO_2)

3. Separation of heavy hydrocarbons

The effect of each of these impurities has on the gas industry, as end user, is briefly outlined in Table 2:

Table 2: Effect of Impurities on Gas Industry

Water vapor	H_2S and CO_2	Liquid hydrocarbons
It is a common impurity. It is not objectionable as such. (a) Liquid water accelerates corrosion in the presence of H_2S gas. (b) Solid hydrates, made up of water and hydrocarbons, plug valves, fittings in pipelines, and so forth.	Both gases are harmful, especially H_2S, which is toxic if burned; it gives SO_2 and SO_3 which are nuisance to consumers. • Both gases are corrosive in the presence of water. • CO_2 contributes a lower heating value to the gas.	Their presence is undesirable in the gas used as a fuel. • The liquid form is objectionable for burners designed for gas fuels. • For pipelines, it is a serious problem to handle two-phase flow: liquid and gas.

Natural Gas Phase Behavior

The natural gas phase behavior is a plot of pressure vs. temperature (Figure 1) that determines whether the natural gas stream at a given pressure and temperature consists of a single gas phase or two phases: gas and liquid.

- **Bubble Point Curve**: the curve that separates the pure liquid (oil) phase from the two-phase (natural gas and oil) region. This means that at a given temperature, when pressure decreases and below the bubble point curve, gas will be emitted from the liquid phase to the two-phase region.
- **Dew Point Curve**: the curve that separates the pure gas phase from the two-phase region. It is the connected points of pressure and temperature at which the first liquid droplet is formed out of the gas phase.
- **Critical Point**: the point on the phase envelope where the bubble point curve meets the dew point curve. At that given pressure and temperature, gas properties are identical to liquid properties. The pressure and temperature at the critical point are called critical pressure and temperature, respectively.
- **Cricondentherm**: the highest temperature at which liquid and vapor can coexist. That means the mixture will be gas irrespective of pressure when the temperature is larger than cricondentherm.
- **Cricondenbar**: the highest pressure at which a liquid and vapor can coexist.

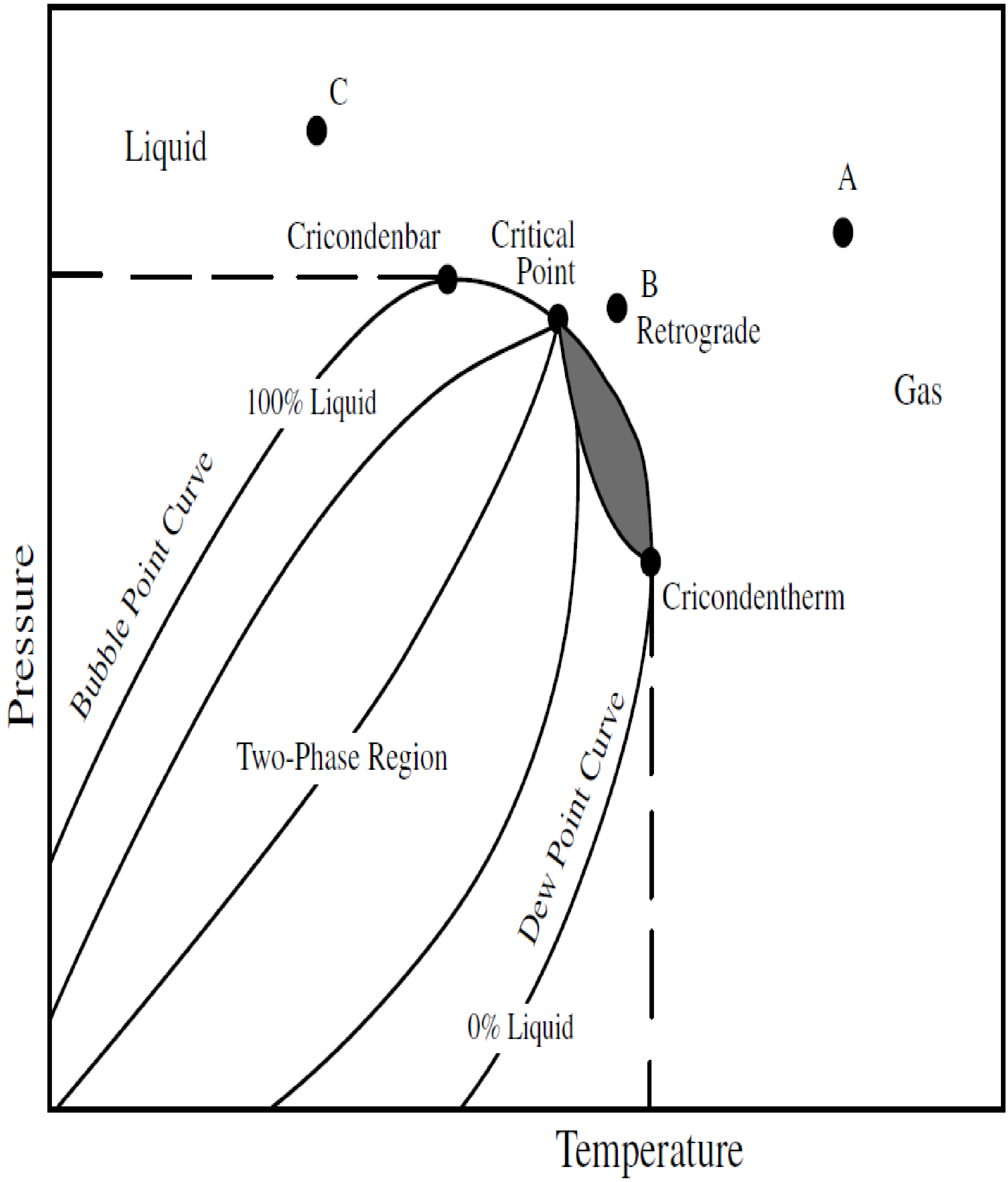

Figure 1: Pressure-Temperature Diagram for A Typical Natural Gas Mixture

LIQUIDS CONTENT

Gas composition plays a critical role in the economics of gas processing. The more liquids, usually defined as C2+, in the gas, the "richer" the gas. Extraction of these liquids produces a product that may have a higher sales value than does natural gas. To quantify the liquids content of a natural gas mixture, the industry uses GPM, or gallons of liquids recoverable per 1,000 standard cubic feet (Mscf) of gas. (In metric units, the quantity is commonly stated as m3 of liquid per 100 m3 of gas.

Note that ethane is not a liquid at 60°F (15.5°C), so the value is a hypothetical value accepted throughout the industry. Also, the actual volume of liquid obtained from a gas will be less than the **GPM** value because complete recovery of ethane and propane is impractical for two reasons:

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1. **Cost**. The low temperature and high compression energy required generally makes recovery of more than about 90 to 95% of the ethane, 98% of the propane, and 99% of the butanes uneconomical.

2. **Heating value specifications**, hydrocarbons must be in the gas to obtain the required heating value.

The rich and lean terms refer to the amount of recoverable hydrocarbons present. The terms are relative, but a lean gas will usually be 1 GPM, whereas a rich gas may contain 3 or more GPM.

Example1. Calculate the GPM of the Alberta gas given bellow Computation of the GPM requires summation of the product of the number of moles of each component in 1,000 scf of gas by the gallons of liquid per mole for that component.

Helium	0.0
Nitrogen	3.2
Carbon dioxide	1.7
Hydrogen sulfide	3.3
Methane	77.1
Ethane	6.6
Propane	3.1
Butanes	2.0
Pentanes and heavier	3.0

SULFUR CONTENT

Sweet and **sour** refer to the sulfur (generally H_2S) content generally, sweet means the gas contains less than 4 ppmv of H_2S. The amount of H_2S allowable in pipeline-quality gas is between 0.25 and 1.0 grains per 100 scf (6 to 24 mg/Sm3, 4 to 16 ppmv).

SUBQUALITY GAS

The Gas Research Institute (Meyer, 2000) classified natural gases from the lower 48 states as high quality and subquality. Subquality is divided into seven categories, depending on the amount of N_2, CO_2, and H_2S present. For their definition of subquality. The gas contains more than 2% CO2, 4%N2, and 4 ppmv H_2S.