How Can and Why Should Activated Alumina Be Used for Gas Dehydration?

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The recent acquisition of XTO by Exxon Mobil is another signal that the petrochemical industry has gotten serious about recognizing the importance of natural gas as the prime energy source for powering the future energy needs of North America. For the separation scientist it is essential to have some knowledge regarding the fundamentals of natural gas chemistry and to understand the importance of water removal for the processing and transmission of natural gas. By no means is this a primer – rather I shall provide an overview for delivering this clean affordable energy and to assure moisture removal. Water in gas lines if left unattended will form natural gas hydrates and disrupt continuous gas delivery.

Finding the best method for the adsorption and removal of water from natural gas is becoming a significant issue as North America expands the use of its available natural gas supplies. Because of advances in gas extraction there is now a sufficient reserve of natural gas to handle much of our domestic energy needs for the next 100 years if this resource is properly stored and distributed. Maximizing our natural energy supplies will greatly improve our current budget deficit and balance of trade liability.

Trends in energy demand and concerns over our increasing trade imbalance have made natural gas the fastest growing source of domestic energy production. New natural gas fields from the Appalachian Basin, Green River Basin of Wyoming and the Uinta/Piceance Basin of Utah are rapidly coming on line. As these new production fields are commercially developed it is essential that the gas be transported or stored devoid of water vapor and other liquids which can corrode the transport infrastructure. A most attractive method for assuring that the liquid component is removed from natural gas is through the use of a desiccant or drying agent. In terms of cost effectiveness, the most efficient method for achieving the drying of natural gas (whether “sweet” or “sour” i.e. containing significant amounts of hydrogen sulfide or carbon dioxide) is through the use of specialized activated alumina.

Most of the liquids associated with extracted natural gas may be removed by simple separation methods at or near wellheads. Water extruded along with natural gas is removed through the process of direct cooling. The saturated vapor content of natural gas decreases with increased pressure or decreased temperature. Thus hot gases extracted from the ground and saturated with water may be partially dehydrated by direct cooling. The cooling process must reduce the temperature to the lowest value that gas will encounter at the prevailing pressure in order to prevent further condensation of water.

However, the complete removal of water vapor existing in solution in natural gas requires more thorough and complex separation techniques. Commercial processing consists of either using the techniques of absorption or adsorption. Absorption occurs when water

vapor is removed from a gas stream using liquid dehydrating agents, while adsorption occurs when water vapor is condensed and collected on the surface of solid compounds.

Drying of Natural Gas- An Obvious Need for Dryspheres™

Natural gas that is not distributed within certain specific gravities, pressures, Btu content range or water content levels will cause operational problems, pipeline deterioration or can even cause pipeline rupture. The future energy needs of North America require that natural gas be safely delivered through high pressure long distance pipelines to safely reach the customer base.

What is Natural Gas?

Natural gas is a mixture of many components classified into three major groups – hydrocarbons containing hydrogen and carbon, inert elements and trace compounds. Most of the hydrocarbons in natural gas are saturated, with each carbon atom bonded to four other atoms and each hydrogen atom bonded to only one carbon atom. The compounds are also known as alkanes (or paraffins) and aliphatics (which do not contain aromatic rings). The most abundant alkane in natural gas is methane, commonly known as C1 as it contains one carbon atom. Ethane contains 2 carbon atoms (or C2), propane is C3, iso-butane and normal butane C4, isopentane and normal pentane C5. Heavier compounds C6+ consist of more than 100 different compounds including benzene, toluene, ethylbenzene and xylenes.

In addition to hydrocarbons the inert agents are nitrogen and carbon dioxide which are not combustible and are therefore of no heating value to gas. Trace components include hydrogen sulfide, water vapor and helium. Other less common trace components include oxygen, hydrogen and carbon monoxide.

What are the Important Physical Properties of Natural Gas?

Density is the mass (weight) per unit volume of a substance and may be expressed as specific gravity or relative density. For gases, it is the ratio of the density of the gas to the density of air. The specific gravity of natural gas varies from less than 0.600 for methane to greater than 1.000 for gas contains a high percentage of carbon heavy compounds.

Boiling point – this is the temperature at which the vapor pressure of a liquid equals the atmospheric pressure.

Boyles Law – this physical property states that the volume of a sample of gas varies inversely with the pressure under which it is measured, given a constant temperature. If the pressure is doubled, the volume is reduced in half

Hydrocarbon dew point – the temperature at which hydrocarbons start to condense from a gas stream. The hydrocarbon dew point is critical in gas production and transmission

because condensation in a natural gas line will lower the capacity of the line to carry gas. Furthermore, liquids in a gas line make it impossible to accurately measure the gas.

Water measurement – this is measured in parts per million, pounds of water per million standard cubic feet of gas, or some unit of the mass of water vapor per unit volume or mass of water vapor per unit mass of dry gas. That is, humidity is the amount of "vapor phase" water in a gas.

Thermal conductivity – is the property which allows the detector on a chromatograph to quantify the amount of each component in a gas mixture. Thermal conductivity decreases with increasing particle size.

Heating value – A Btu or British thermal unit is equal to the amount of heat required to raise the temperature of one pound of water one degree F at 62 F.

The Means to Dehydrate Natural Gas

The three major methods of dehydration are direct cooling, adsorption and absorption. Direct cooling is based on the fact that the saturated vapor content of natural gas decreases with increased pressure or decreased temperature. Therefore, hot gases saturated with water may be partially dehydrated by direct cooling. This method is known as Joule Thomson Expansion, and is the same principal as the removal of humidity from outside air as a result of air conditioning inside a home. Molecular sieves (sieves), silica gel and bauxite were the traditional desiccants used by the natural gas industry in adsorption processes.

The removal of water vapor may be accomplished by bubbling the gas stream through a vessel containing chemicals having an affinity for water. Absorption dehydration involves the use of a liquid desiccant to removal water vapor from the gas. The removal of water using the liquid chemical glycol is through absorption. The liquid selected as most desirable for water absorption should possess the following properties:

1. high absorption efficiency
2. easy and economic regeneration
3. it should be non corrosive to pipes and valves and be non toxic
4. there should be no interaction with the hydrocarbon portion of the gas and no contamination by acid gases

The glycols, particularly ethylene glycol, diethylene glycol, triethylene glycol and tetraethylene glycol come closest to satisfying the above noted criteria. Water and glycols show complete mutual solubility in the liquid phase due to hydrogen oxygen bonds and their water vapor pressures are very low.

However, as natural gas becomes a primary source of energy production superior and more efficient methods for the dehydration of natural gas must be achieved. Far superior to liquid absorption techniques is the use of solid agents for adsorption of water and

water vapor. Adsorption is used for cryogenic systems to reach low moisture contents. Adsorption, or solid bed dehydration uses solid materials which can be regenerated and are used over several adsorption-desorption cycles.

Adsorption dehydration is the process where a solid desiccant is used for the removal of water vapor from a gas stream. For the physical adsorption required for use in gas dehydration the following properties are desirable for a desiccant agent.

1. Large surface area for high capacity, ideally with a surface area of 500-800 m^2/gram
2. Good activity for the components to be removed and good activity retention with time/use
3. High mass transfer rate with a high rate of removal
4. Easy, economic regeneration
5. High mechanical strength to resist crushing and dust formation. The adsorbent also must retain strength when wet
6. Cost effective, non corrosive, non toxic, chemically inert, high bulk density, and small volume changes upon adsorption and desorption of water

What are natural gas hydrates and why are they such a problem?

Natural gas hydrates are solids that form from natural gas hydrocarbons and water. The water molecules have a honeycomb structure with a molecule of one of the natural gas components occupying each void. Because these solids are denser than water ice, their formation is favored at higher pressures and they form at temperatures which are considerably higher than the freezing point of water. Natural gas hydrates may form at temperatures up to 70 F and like liquids these crystalline ice like solids or semi-solids and may interfere with the passage of natural gas through valves and pipes .

What is Pipeline Quality Natural Gas?

Natural gas distributed in North America must satisfy the following criteria

1. Be within the specific Btu range content of 1,035 Btu per cubic foot +/- 50 Btu
2. Be delivered at a specified hydrocarbon dew point temperature level, below which any vaporized gas liquid in the mix will tend to condense at pipeline pressure
3. Contain no more than trace amounts of elements such as hydrogen sulfide, carbon dioxide, nitrogen, water vapor and oxygen
4. Be free of particulate solids and liquid water that could be detrimental to the pipeline or its ancillary operating equipment

An overview for using activated alumina in the dehydration of natural gas is now provided.

As discussed above, natural gases from either well production or storage reservoirs contain water which condenses to form solid ice like crystals called gas hydrates. These block pipeline flow and control systems. Natural gas in transit needs to be dehydrated to a

controlled water content in order to both avoid gas hydrates and to minimize corrosion. The dehydration of gas must occur at the source of the gas production and storage in order to protect the transmission system. Dehydration of natural gas is the removal of the water associated with natural gas in vapor form. Changes in temperature and pressure condense this vapor and alter the physical state from gas to liquid to solid. Unless gases are dehydrated, liquid water may condense in pipelines and accumulate at low points along the line, reducing its flow capacity.

Dalton's Law of Partial Pressures states that the total pressure of a gaseous mixture is equal to the sum of the partial pressures of the components. This allows for computation of the maximum volume of water vapor that natural gas can hold for a given temperature and pressure. As an example one million standard cubic feet of natural gas (MMSCF) saturated at 80 degrees F and 600 PSIG (pound per square inch gauge) will hold 49 pounds of water. At 120 degrees F and at the same pressure one million square feet of natural gas will hold 155 pounds of water. Common allowable water content of transmission gas ranges from 4 to 7 pounds per MMSCF.

Why use Drysphere™?

> **There is no more superior compound for drying out natural gas than Dynamic Adsorbents' Drysphere™. It is the ONLY activated alumina on the market that can extract and adsorb 36% of its own weight in water, which is 3 times more than the standard alumina product offered by competitors, 20% more than silica and 32% more than Drierite.**

Due to amphoteric properties this specially designed activated alumina sphere may be easily used in the presence of both alkaline and acidic gases. The activated alumina is simply reactivated by using heat to regenerate when in its fully hydrated and saturated form. It is able to bind more water, on a weight basis than any other adsorbent agent. It produces an excellent dew point depression value. Drysphere™ have the advantage of being able to withstand rough treatment and shocks of liquid water and heat without disintegration, while other solid desiccants such as silica gel tend to break into smaller particles when subject to shocks of liquid water.

For more information regarding Drysphere™ the reader is referred to http://www.dynamicadsorbents.com/drysphere alumina.htm for more info on this superior method for the drying of natural gas as well as other industrial liquid and gas agents.