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# PETROLEUM ENGINEERING

# PTE 316

# ANSWERS

1. Natural gas is usually produced along side with oil when extracting the latter from sub-surface formation/ it is produced from natural gas formation and field. Among all hydrocarbon natural gas has the highest amount of energy per unit mass,but due to its gaseous state it also has the lowest amount of energy per unit volume. Nigeria despite being the largest african countries with most natural gas reserves can not fully store it natural gas and thus result to Gas flaring. This is perphaps due to the volatile nature of the gas and the high cost of its storage facilites. Natural gas is preferably stored underground. Some of these underground facilities are:
   1. Storage tanks: this is used to store relatively small volumes of natural gas. This sort of storage is mainly used in the downstream sector as distribution pipeline are connected to these storage tanks. The location of these tanks are usually at the outskirts of major cities. They serve to supply an entire city of Natural gas and are replenished by natural gas from compressor station through state-to-state transmission line.
   2. Depleted reservoir: The most prominent and common form of underground storage consists of depleted gas reservoirs. Depleted reservoirs are those formations that have already been tapped of all their recoverable natural gas. This leaves an underground formation, geologically capable of holding natural gas. In addition, using an already developed reservoir for storage purposes allows the use of the extraction and distribution equipment left over from when the field was productive. Having this extraction network in place reduces the cost of converting a depleted reservoir into a storage facility. Depleted reservoirs are also attractive because their geological characteristics are already well known. Of the three types of underground storage, depleted reservoirs, on average, are the cheapest and easiest to develop, operate, and maintain. The factors that determine whether or not a depleted reservoir will make a suitable storage facility are both geographic and geologic.
      1. Geographically, depleted reservoirs must be relatively close to consuming regions. They must also be close to transportation infrastructure, including trunk pipelines and distribution systems.
      2. Geologically, depleted reservoir formations must have high permeability and porosity. The porosity of the formation determines the amount of natural gas that it may hold, while its permeability determines the rate at which natural gas flows through the formation, which in turn determines the rate of injection and withdrawal of working gas. In certain instances, the formation may be stimulated to increase permeability.
      3. The existing infrastructure must be suitable for retrofitting the equipment to inject and produce gas at the necessary pressures and rates;
      4. Natural gas must be contained by effective seals otherwise there will be lost volumes that cannot be recovered.
   3. Aquifer: An aquifer is suitable for gas storage if the water-bearing sedimentary rock formation is overlaid with an impermeable cap rock. While the geology of aquifers is similar to depleted production fields, their use in gas storage usually requires more base (cushion) gas and greater monitoring of withdrawal and injection performance. Deliverability rates may be enhanced by the presence of an active water drive. Usually these facilities are operated on a single annual cycle as with depleted reservoirs. The geological and physical characteristics of aquifer formation are not known ahead of time and a significant investment has to go into investigating these and evaluating the aquifer’s suitability for natural gas storage. If the aquifer is suitable, all of the associated infrastructure must be developed from scratch, increasing the development costs compared to depleted reservoirs. This includes installation of wells, extraction equipment, pipelines, dehydration facilities, and possibly compression equipment. Since the aquifer initially contains water there is little or no naturally occurring gas in the formation and of the gas injected some will be physically unrecoverable. A consequence of the above factors is that developing an aquifer storage facility is usually time consuming and expensive. Aquifers are generally the least desirable and most expensive type of natural gas storage facility.
   4. Salt caverns: Underground salt formations offer another option for natural gas storage. These formations are well suited to natural gas storage in that salt caverns, once formed, allow little injected natural gas to escape from the formation unless specifically extracted. The walls of a salt cavern also have the structural strength of steel, which makes it very resilient against reservoir degradation over the life of the storage facility. Essentially, salt caverns are formed out of existing salt deposits. These underground salt deposits may exist in two possible forms;
      1. Salt domes are hollow thick formations created from natural salt deposits that, over time, leach up through overlying sedimentary layers to form large dome-type structures. They can be as large as a mile in diameter, and 30,000 feet in height. Typically, salt domes used for natural gas storage are between 6,000 and 1,500 feet beneath the surface, although in certain circumstances they can come much closer to the surface.
      2. Salt beds are shallower, thinner formations. These formations are usually no more than 1,000 feet in height. Because salt beds are wide, thin formations, once a salt cavern is introduced, they are more prone to deterioration, and may also be more expensive to develop than salt domes.

Once a suitable salt dome or salt bed deposit is discovered, and deemed suitable for natural gas storage, it is necessary to develop a ‘salt cavern’ within the formation. Essentially, this consists of using water to dissolve and extract a certain amount of salt from the deposit, leaving a large empty space in the formation. This is done by drilling a well down into the formation, and cycling large amounts of water through the completed well. This water will dissolve some of the salt in the deposit, and be cycled back up the well, leaving a large empty space that the salt used to occupy. This process is known as ‘salt cavern leaching’. Salt caverns are usually much smaller than depleted gas reservoir and [aquifer](https://en.wikipedia.org/wiki/Aquifer) storage facilities. A salt cavern facility may occupy only one one-hundredth of the area taken up by a depleted gas reservoir facility. Deliverability from salt caverns is, however, much higher than for either aquifers or depleted reservoirs. This allows the gas stored in a salt cavern to be withdrawn and replenished more readily and quickly. This quick cycle-time is useful in emergency situations or during short periods of unexpected demand surges.

* 1. Pipeline: Gas can be temporarily stored in the pipeline system itself, through a process called **line packing.** This is done by packing more gas into the pipeline by an increase in the pressure. During periods of high demand, greater quantities of gas can be withdrawn from the pipeline in the market area, than is injected at the production area. The process of line packing is usually performed during off peak times to meet the next day’s peaking demands. This method, however, only provides a temporary short-term substitute for traditional underground storage.
  2. Liquefied Natural Gas: [LNG](https://en.wikipedia.org/wiki/Liquefied_natural_gas) facilities provide delivery capacity during peak periods when market demand exceeds pipeline deliverability. [LNG storage tanks](https://en.wikipedia.org/wiki/LNG_storage_tank) possess a number of advantages over underground storage. As a liquid at approximately −163 °C (−260 °F), it occupies about 600 times less space than gas stored underground, and it provides high deliverability at very short notice because LNG storage facilities are generally located close to market and can be trucked to some customers avoiding [pipeline](https://en.wikipedia.org/wiki/Pipeline_transport) tolls. There is no requirement for cushion gas and it allows access to a global supply. LNG facilities are, however, more expensive to build and maintain than developing new underground storage facilities. It mainly contains butane gas.

1. A compressor station is a facility which helps the transportation process of [natural gas](https://en.wikipedia.org/wiki/Natural_gas) from one location to another. Natural gas, while being transported through a gas pipeline, needs to be constantly pressurized at intervals of 40 to 100 miles. Siting is dependent on terrain, and the number of gas wells in the vicinity. Frequent elevation changes and a greater number of gas wells will require more compressor stations. The compressor station, also called a pumping station, is the "engine" that powers an interstate natural gas pipeline. As the name implies, the compressor station compresses the natural gas (increasing its pressure) thereby providing energy to move the gas through the pipeline. Pipeline companies install compressor stations along a pipeline route. The size of the station and the number of compressors (pumps) varies, based on the diameter of the pipe and the volume of gas to be moved. The compressor station is neccessary in the oil & gas industry because:
   1. They compresses the natural gas (increasing its pressure) thereby providing energy to move the gas through the pipeline.
   2. enable the natural gas itself to travel through the pipelines which is crucial to the natural gas transport system by repressurizing the gas.
2. The Natural gas compressor station consists of the following units:

* a suction scrubber.
* a gas manifold or a distribution header.
* gas compressor “single or multiples stages” according to the required discharge pressure.
* gas cooler fan.
* discharge scrubber.
* condensate gathering system.
* [corrosion](https://www.arab-oil-naturalgas.com/corrosion-corrosion-inhibitors/) inhibitor skid.
* a [dehydration](https://www.arab-oil-naturalgas.com/teg-dehydration-operation-problems-and-solutions/) unit.
* metering station.
* blow down flares.
* Utilities

The functions of these components are:

* Suction scrubber: it is the first component of the gas compressor station, its is a 3-phase separator used to separate liquids and condensate from natural gas, the existence of any liquid in the natural gas stream will cause a compressor vibration. The liquids will be disposed to the burn bit to be burned, while the condensate will go to the condensate gathering header.
* Gas manifold: after leaving the scrubber, natural gas will enter a manifold or a distribution header, it is used to distribute the gas to the compressor station trains ” in large compressor station and if there is a big amount of gas is compressed”, before entering the compressing train it goes through a strainer to eliminate any liquid droplets.
* Gas compressor: single or multiples stages according to the required pressure.  its is either driven by a gas turbine or an electric motor, single stage or multiple stages “2 or 3” according to the required discharge pressure. Centrifugal compressors are the most preferred in gas compressor station, and it is equipped with an [anti-surge system](https://www.arab-oil-naturalgas.com/surge-control-centrifugal-compressors/). Compressors are equipped with seal [oil](https://www.arab-oil-naturalgas.com/what-is-crude-oil/) system that seals the sour gas from the lubricating oil, which in turn lubricates the bearings, it is also equipped with vibration, speed and temperature sensors.
* Cooler fan: After being compressed, the temperature of natural gas is greatly increased, sometimes reach to 170 – 180 ºC , this requires cooling the gas, it is done by air cooler fans, which draw air beneath, and cools the gas.
* Discharge scrubber: After being compressed and cooled, vapors in natural gas will condense to liquids, these liquids can be separated and disposed in the discharge scrubber, as mentioned in suction scrubber; liquids will be disposed to the burn bit to be burned, while the condensate will go to the condensate gathering header, each compressing train is supplied with a suction and discharge scrubber.
* Condensate gathering system: the condensates are gathered from all the scrubbers in the compressor station, there are many options to make use of this amount, but the most common one is to inject this condensate in the gas discharge pipeline, there is a special technology to do this, it is injected by a sparger to guarantee the homogeneous propagation in the pipeline.
* Corrosion inhibitor skid: Due of compression and cooling for the natural gas, water vapor will be converted to liquid water, it may react with [hydrogen sulfide](https://www.arab-oil-naturalgas.com/h2s-in-oil-industry/) to form sulfuric acid, this will lead to serious corrosion problems to the pipelines and equipment, so corrosion inhibitor is injected before the air cooler to prevent corrosion. this is done by special type injectors which receive the chemical from a chemical injection skid consists of a dosing pump and a [tank](https://www.arab-oil-naturalgas.com/crude-oil-storage-tanks/), injection pressure must be higher than the gas pipeline pressure, otherwise there will be no chemical injection.
* Dehydration unit: Each gas compressor station is equipped with a [gas dehydration unit](https://www.arab-oil-naturalgas.com/natural-gas-dehydration-p1/),  it is used to remove the water vapor from natural gas.
* Metering station: it is used to measure the quantity of natural gas, gas volumes are expressed in Standard Cubic Foot and the Standard Cubic Meter.
* Blow down flare: it is a kind of [flare](https://www.arab-oil-naturalgas.com/flare-types-and-components/) used to dispose the gas from the compressor station when shut down happens, Emergency Shut-Down [Valves](https://www.arab-oil-naturalgas.com/what-are-the-types-of-valves/) “ESDVs” that are equipped in each scrubber will do this.
* Utilities: these include fire-fighting system & instrument air system.

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