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**AN ASSIGNMENT**

**ON**

**FUNDAMENTALS OF NATURAL GAS ENGINEERING**

**PTE 316**

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**SUBMITTED TO**

**THE DEPARTMENT OF PETROLEUM ENGINEERING,**

**COLLEGE OF ENGINEERING,**

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**ASSIGNMENT QUESTIONS**

1. Discuss in details the different methods of storing natural gas.
2. Why is compressor station necessary in oil and gas industry?
3. Outline the key component parts of a compressor station and what are their functions?

**DISCUSSION**

Natural gas can be stored for a very long period of time just like most other commodities. The exploration, production, and transportation of natural gas takes time, and the natural gas that reaches its destination is not always needed right away, so it is injected into underground storage facilities. These storage facilities can be located near market centers that do not have a ready supply of locally produced natural gas.

1. **METHODS OF STORING NATURAL GAS**

The most important type of gas storage is in underground reservoirs. There are three principal types; depleted gas reservoirs, aquifer reservoirs and salt cavern reservoirs. Each of these types has distinct physical and economic characteristics which govern the suitability of a particular type of storage type for a given application. However, other methods exist outside these three methods.

1. DEPLETED GAS RESERVOIR

These are the most prominent and common form of underground storage of natural gas. They are the reservoir formations of natural gas fields that have produced all or part of their economically recoverable gas. The depleted reservoir formation should be readily capable of holding sufficient volumes of injected natural gas in the pore space between grains (via high porosity), of storing and delivering natural gas at sufficient economic rates (via high permeability) and be contained so that natural gas cannot migrate into other formations and be lost. In addition the rock (both the reservoir and the seal) should be capable of withstanding the repeated cycle of an increase in pressure when natural gas is injected into the reservoir and in reverse the drop in pressure when natural gas is produced.

Using such a facility that meets the above criteria is economically attractive because it allows the re-use, with suitable modification, of the extraction and distribution infrastructure remaining from the productive life of the gas field which reduces the start-up costs. Depleted reservoirs are also attractive because their geological and physical characteristics have already been studied by geologists and petroleum engineers and are usually well known. Consequently, depleted reservoirs are generally the cheapest and easiest to develop, operate, and maintain of the three types of underground storage.

In order to maintain working pressures in depleted reservoirs, about 50 % of the natural gas in the formation must be kept as cushion gas. However, since depleted reservoirs were previously filled with natural gas and hydrocarbons, they do not require the injection of gas that will become physically unrecoverable as this is already present in the formation. This provides a further economic boost for this type of facility, particularly when the cost of gas is high. Typically, these facilities are operated on a single annual cycle; gas is injected during the off-peak summer months and withdrawn during the winter months of peak demand.

A number of factors determine whether or not a depleted gas field will make an economically viable storage facility:

1. The reservoir must be of sufficient quality in terms of porosity and permeability to allow storage and production to meet demand as required.
2. Natural gas must be contained by effective seals otherwise there will be lost volumes that cannot be recovered.
3. The depleted reservoir and field infrastructure must be close to gas markets.
4. The existing infrastructure must be suitable for retrofitting the equipment to inject and produce gas at the necessary pressures and rates.
5. AQUIFER RESERVOIR

Aquifers are underground, porous and permeable rock formations that act as natural water reservoirs. In some cases they can be used for natural gas storage. 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. As a result, aquifer storage typically requires significantly more cushion gas than depleted reservoirs; up to 80% of the total gas volume. Most aquifer storage facilities were developed when the price of natural gas was low, meaning this cushion gas was inexpensive to sacrifice. With rising gas prices aquifer storage becomes more expensive to develop.

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.

1. SALT FORMATION

Underground salt formations are well suited to natural gas storage. Salt caverns allow very little of the injected natural gas to escape from storage unless specifically extracted. The walls of a salt cavern are strong and impervious to gas over the lifespan of the storage facility.

Once a salt feature is discovered and found to be suitable for the development of a gas storage facility a cavern is created within the salt feature. This is done by the process of solution mining. Fresh water is pumped down a borehole into the salt. Some of the salt is dissolved leaving a void and the water, now saline, is pumped back to the surface. The process continues until the cavern is the desired size. Once created, a salt cavern offers an underground natural gas storage vessel with very high deliverability. Cushion gas requirements are low, typically about 33 % of total gas capacity.

Salt caverns are usually much smaller than depleted gas reservoir and aquifer storage facilities. A salt cavern facility may occupy only one one-hundredth of the area taken up by a depleted gas reservoir facility. Consequently, salt caverns cannot hold the large volumes of gas necessary to meet base load storage requirements. 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. LIQUIFIED NATURAL GAS STORAGE TANK

LNG facilities provide delivery capacity during peak periods when market demand exceeds pipeline deliverability. LNG storage tanks 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 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. PIPELINE CAPACITY

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.

1. GAS HOLDERS

Gas can be stored above ground in a gasholder (or gasometer), largely for balancing, not long-term storage. These store gas at district pressure, meaning that they can provide extra gas very quickly at peak times. Gasholders are perhaps most used in the United Kingdom and Germany. There are two kinds of gasholder;

1. Column-guided: These are guided up by a large frame that is always visible, regardless of the position of the holder.
2. Spiral-guided: These gas holders have no frame and are guided up by concentric runners in the previous lift.
3. **IMPORTANCE OF COMPRESSOR STATIONS IN OIL AND GAS INDUSTRY**

The natural gas compressor station plays a vital role in the oil and gas industry. Companies construct these stations along natural gas pipelines using them to compress gas so as to allow continous downstream flow of the gas to its final destination, which may either be a storage tank, retail or utility companies. Compressor stations enable the natural gas itself to travel through the pipelines which is crucial to the natural gas transport system. They also allow the gas to be rerouted into storage areas during periods of low demand. In addition, compressor stations are often accompanied by PIG launchers and PIG receivers which are vital for the maintenance and efficiency of the pipeline. They even include many safety features allowing the pipeline and station to function safely. Compressor stations are necessary in natural gas industry because it compresses natural gas and raise its pressure to make it continue flowing to reach further distances.

1. **KEY COMPONENT PARTS OF COMPRESSOR STATION AND THEIR FUNCTIONS**

The key component parts of a compressor station are explained as follows;

1. 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 pit to be burned, while the condensate will go to the condensate gathering header.
2. GAS MANIFOLD OR A DISTRIBUTION HEADER: 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 to be compressed. Before entering the compressing train it goes through a strainer to eliminate any liquid droplets.

3. GAS COMPRESSOR: A compressor is a large engine that uses positive displacement to compress gas. A compressor station may have one or multiple compressors on site. Single or multiples stages according to the required pressure. It 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. Compressors are equipped with seal 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.

4. 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.

5. 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.

6. 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 sparer to guarantee the homogeneous propagation in the pipeline.

7. CORROSION INHIBITOR SKID: Because of compression and cooling for the natural gas, water vapor will be converted to liquid water, it may react with hydrogen sulfide 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, injection pressure must be higher than the gas pipeline pressure, otherwise there will be no chemical injection.

8. DEHYDRATION UNIT: Each gas compressor station is equipped with a gas dehydration unit, it is used to remove the water vapor from natural gas.

9. 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.

10. BLOW DOWN FLARES: It is a kind of flare used to dispose the gas from the compressor station when shut down happens. This is done by Emergency Shut-Down Valves (ESDVs) that are equipped in each scrubber.

11. UTILITIES: These include systems such as instrument air system and fire fighting system.