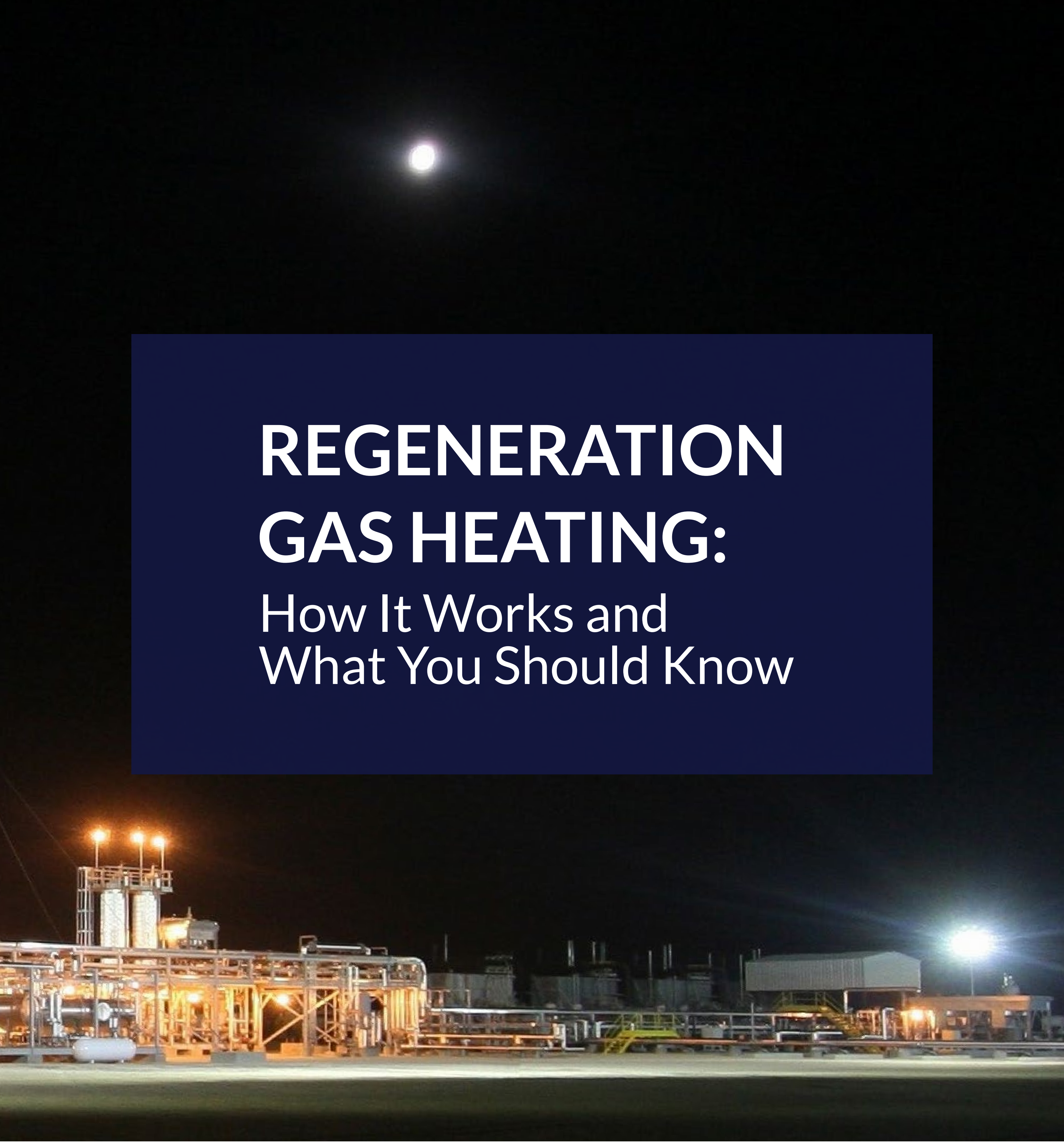

# REGENERATION GAS HEATING:

## How It Works and What You Should Know

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With the advent of improved shale oil and gas extraction technologies, the North American energy industry has seen significant growth over the past few years. This revival has spurred the construction of numerous "cold process" gas plants, including mechanical refrigeration plants, cryogenic gas plants, and liquefied natural gas (LNG) plants. Cryogenic gas plants operate at temperatures below -90 ˚F (-68 ˚C) and LNG plants operate below -250 ˚F (-155 ˚C) to extract the heavier hydrocarbons as natural gas liquids (NGL).

When natural gas is produced from a well, it is saturated with water vapor. But in order to operate effectively, the water content of the natural gas must be reduced to about 0.1 ppmv. A typical natural gas dehydration system utilizing ethylene glycol (EG) or triethylene glycol (TEG) is able to reduce the water content to 100-140 ppmv. Use of solid desiccant systems is the most common way to attain desired water levels; molecular sieves, in particular, are the most popular solution. Dehydration of air in an air separation plant (e.g., the production of N2, O2, Ar, etc.) uses the same types of processes.

*Processing Plant in the Delaware Basin*

Molecular sieves (mol sieves) are manufactured or naturally occurring aluminosilicates, which are very selective due to the small pore size of their crystalline structure. The mole sieves used in natural gas dehydration have a pore size (typically 4 angstroms) which preferentially adsorbs water.

Adsorption (with a "d") is a surface phenomenon, in that the water is adsorbed into the surface pore structure. The stronger the mol sieve holds the water molecules, the lower the achievable water content; the drawback, however, is that more heat is required during regeneration of the mol sieve to "drive" the water out. This process is referred to as mol sieve bed regeneration, and the heating process is referred to as regeneration gas heating. Some processes that do not require very low water content can make use of silica gel or alumina, operating on the same basic principles while reducing energy costs and working at a lower regeneration temperature.

Figure 1: Mol Sieve System in a Cryogenic Plant

A typical mol sieve regeneration system is shown in Figure 1. A schematic of a two-bed system is shown in Figure 2; however, some systems require three or more beds. Mol sieve suppliers can determine the number of beds required to minimize pressure vessel costs.

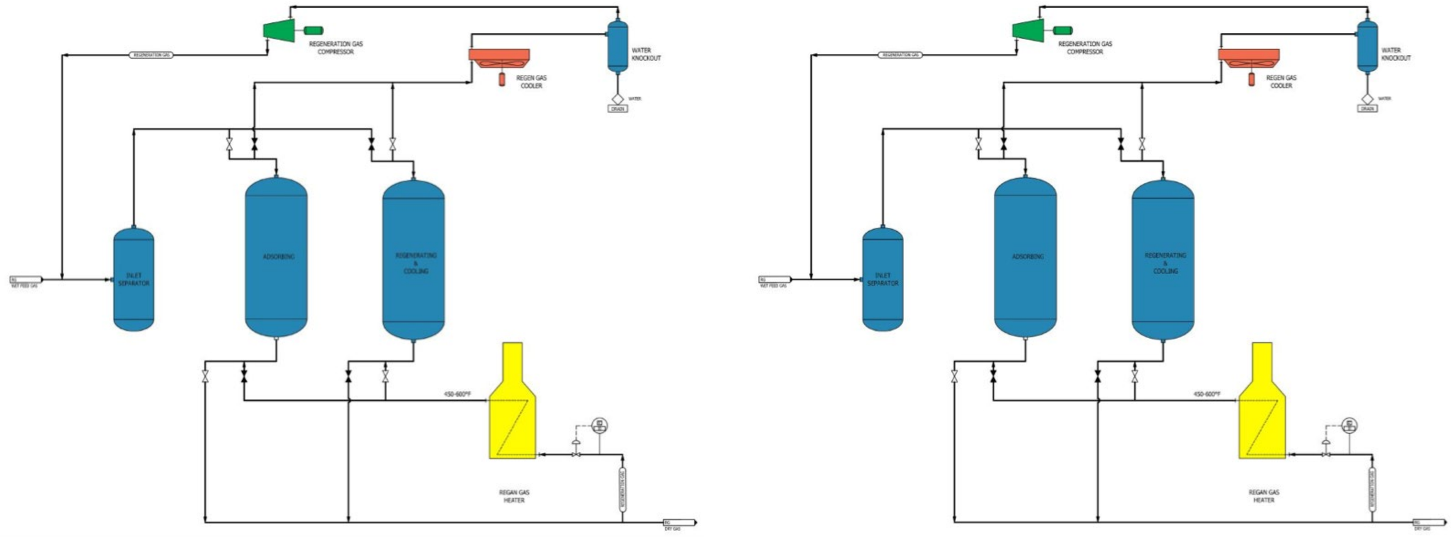



Figure 2: Two-Bed Mol Sieve Dehydration Schematic

In Figure 2, the wet feed gas is passed through an inlet filter/coalescer to remove particulates and any entrained liquids, which could foul the sieve. The gas is then introduced to the left bed, which is in the adsorption phase of operation. The gas flows from the top of the bed to the bottom, where all of the water vapor is removed from the gas. As the water is adsorbed, the sieve at the top is saturated with water, and the area of adsorption moves down the bed.

The adsorption phase must end before the bed is completely saturated. The beds are usually sized for the adsorption phase to last six to twelve hours, but times can vary depending on the specifics of the manufacturer's process design. Once the bed is saturated, it is then regenerated.

Some of the dry outlet gas is heated in a heater to 550-600˚F, depending on the sieve used. During regeneration and cooling, the gas flows through the bed from bottom to top. The hot regen gas heats up the mol sieve within the vessel and provides the heat necessary to release the water. The hot gas containing the water is then cooled in a regen gas cooler and the water that condenses out of the gas is removed in the water knockout vessel. A regen gas compressor boosts the pressure, allowing it to be put back into the inlet of the dehydration system. After the bed is regenerated, it is cooled by turning off the heater and allowing the dry regen gas to cool the bed in preparation for another adsorption cycle.

*It's critical to work with a knowledgeable heater supplier to weigh different heating options for your facility.*

Heater selection is particularly important, as the right type of heater will ensure a long system life, minimal downtime, and ease of operation. The earlier in the process the supplier gets involved, the better your chances of reducing capital and operating costs. Experienced suppliers can also assist with site planning to reduce the risks associated with fired equipment.

Several heating systems can be used. Options include:

- Hot Oil Heaters
- Direct Fired Helical Coil Heaters
- Direct Fired Radiant-Convective Heaters
- Direct Fired Convection Heaters
- Electric Circulation Heaters

Each of these heaters features unique advantages and disadvantages that must be considered when determining the best type for your specific application.

HEATING SYSTEM:

# Indirect Fired Thermal Oil System

HOW IT WORKS:

This system is comprised of a heater that uses a circulated synthetic or organic oil as a thermal fluid. That thermal fluid heats the regeneration gas through a heat exchanger, which is typically shell and tube or plate and shell.

## Pro

- Thermal fluid can remain hot between regen cycles, making it ready for immediate use when it is time to regenerate the bed. This allows the temperature of the regen gas to reach its set point quickly, whereas direct fired heaters require a ramp-up time that can take anywhere from 5 to 15 minutes.

- The system can be used to service multiple heat consumer requirements at a single plant site. In a typical cryo plant, this can include dehydration, amine reboilers, and demethanizer reboilers. Multiple secondary circulation loops can be used, each with its own temperature and duty requirement. A typical thermal fluid system might have a main loop temperature of 600˚F and a secondary hot oil loop at 360˚F for the amine reboiler and demethanizer reboiler.

- Using secondary loops to incorporate other heat consumers will also eliminate the need for additional heaters on the plant site, reducing the amount of combustion equipment to maintain and operate.

- The system is fundamentally safer than any direct fired heater design, as there is no potential for direct contact between the products of combustion in the heater and the regeneration gas in the heat exchanger.

## Con

- There is increased complexity compared to a direct fired heater system. There are circulation pumps, interconnecting piping between the heater and heat exchangers, and also thermal fluid that occasionally requires maintenance.

### Cost Implications

If used only for regeneration gas heating, this type of system will typically be more expensive than comparable direct fired heaters. If used to satisfy multiple users within a single plant, this type of system can often be cheaper than purchasing multiple heaters for different processes.


HEATING SYSTEM:

# Direct Fired Tight Wound Helical Coil

HOW IT WORKS:

This system features a heater that uses a single tight wound helical coil in which the regeration gas flows on the tube side and is heated directly. The flame propagates through the center of the helical coil to form a radiant section, and then flue gasses turn back and travel between the insulation and the outside of the helical coil. Single circuits are typically recommended to prevent imbalanced flow and associated hot spots or overheating in any one circuit.

## Pro

- It has the smallest footprint of any heater option.
- It is the least complex fired heater design (from a mechanical and process engineering standpoint).

## Con

- This system has the highest radiant flux rate of any available option, making it more prone to failure due to hot spots or overheating.
- This type of heater requires the flow of regeneration gas before the burner can be operated, resulting in a ramp-up time that adds to the overall regeneration cycle time. That ramp-up time can be anywhere from 5 to 15 minutes, depending on the process and the size of the heater.
- Starting and stopping the heater between every regeneration cycle results in significant thermal cycling. This thermal cycling will decrease the service life of this heater compared to some other alternatives.

## Cost Implications

This system offers the lowest cost of any available fired heater option.

HEATING SYSTEM:

# Direct Fired Radiant-Convective

HOW IT WORKS:

The heater in this system uses a radiant section with generous tube spacing, combined with a separate serpentine fin tube convection section. The flame propagates through the radiant section and then through the separate convection section. Configurations can include cabin style, box style, and vertical cylindrical. API RP 560 is a commonly referenced design standard for these types of direct fired heaters.

## Pro

- This system is more conservatively designed than a tight wound helical coil, most specifically in the radiant section. Spacing of at least two tube diameters between each tube helps to lower the maximum radiant heat flux, which reduces the risk of tube failure.
- The heater is designed to a well known and commonly used standard for oil field applications.

## Con

- Although the risk of radiant tube failure is lower than a tight wound helical coil, a risk still exists in any direct fired heater radiant section.
- This type of heater requires flowing regeneration gas before the burner can be operated, resulting in a ramp-up time that adds to the overall regeneration cycle time. That ramp-up time can be anywhere from ten to twenty minutes depending on the process and the size of the heater.
- Starting and stopping the heater between every regeneration cycle results in significant thermal cycling. This thermal cycling will decrease the service life of this heater compared to some other alternatives.

## Cost Implications

This heater design is likely 50 to 100 percent more expensive than a comparable tight wound helical coil.

HEATING SYSTEM:

# Direct Fired Convection

HOW IT WORKS:

This type of direct fired heater utilizes a separate combustion chamber and flue gas recirculation to reduce combustion chamber temperatures to a maximum of 1,400˚F. There is no radiant tube section and no direct line of sight from the visible flame to the convection coil surface. Fin tubes in a serpentine convection section can be designed to control flux rate on a row by row basis, adding a significant amount of control over tube wall and fin tip temperature.

## Pro

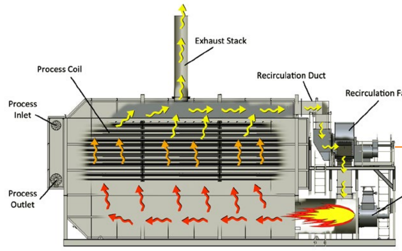
- This is the most conservative direct fired heater design available due to the elimination of the radiant tube section and reduction of flue gas temperature to 1,400˚F. Risk of a tube failure is significantly reduced over both radiant-convective and tight wound helical designs.
- A hot standby mode is possible within this system because of the independent combustion chamber and recirculation fan. This reduces ramp-up time considerably over other direct fired designs.
- Thermal cycling is greatly reduced compared to other direc fired designs due to the availble hot standby mode.

## Con

- Additional complexity over other direct fired designs due to the system's required recirculation fan.

## Cost Implications

This heater design will be considerably more expensive than a comparable tight wound helical coil, but comparable or sometimes less than a radiant-convective heater design.

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HEATING SYSTEM:

# Electric Circulation System

HOW IT WORKS:

Within this system, electric heating elements are inserted into a pressure vessel that forces the regeneration gas to flow across the length of the elements.

## Pro

- Uniform and controlled heat flux across all elements promote even heating and greatly reduce the liklihood of system hot spots when compared to a fired heater.
- The least complex of all available options, as the system does not require burners, fans, or burner control devices.
- Very short ramp-up time and excellent control response.

## Con

- Operating cost of electricity relative to fuel gas in a gas treatment plant is very high.

### Cost Implications

Small electric heaters are very cost effective, but sizes above ~300 kW begin to approach comparable prices to gas fired heaters. Large size electric heaters, such as 2 MW or above, can actually be more expensive than comparable fired heaters.

# About Us

Sigma Thermal designs, engineers, supplies, and services process heating systems for industry. Our products include thermal oil and thermal fluid heating systems, indirect process bath heaters, electric process heaters, biomass fired energy systems, direct fired process heaters, system automation, parts, retrofits/upgrades, and support services. Our staff of dedicated and experienced engineers can help to provide solutions specific to your project needs. Whether you need a standard package heater, a highly engineered process heating system, or just a tune up on your current system, our engineers and technicians have the knowledge and experience to make your project a success.

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