White Paper

Liquid Ring Compressors for Flare Gas Recovery Systems

Gas Flaring Overview

The demand for energy has increased globally due to population growth and an increase in living standards, especially in developing countries. Oil and gas production, upstream at production sites, midstream, and downstream at refineries has also increased to meet this demand.

All crude oil produced from wells has associated gas dissolved in the liquid. As part of the production process, the associated or co-produced gas is flashed from the liquids through a series of gas/liquid separators. The midstream process stabilizes the crude and light condensate for transport to the downstream refineries, and refines the gas to be sold commercially for use as fuel, while the oil liquids are processed in downstream refineries to be used as motor fuels, lubricants, and asphalt.

All upstream, midstream, and downstream facilities have flares that are used to safely and efficiently destroy waste gases generated. However, all combustion of volatile organic compounds (VOCs) produces carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx) and potentially sulfur oxides (SOx) if there are sulfur containing compounds in the gas being burned. We do not live in a perfect world, and no combustion process is 100% efficient and that means that there is also some small amount of VOCs emitted from flares during the combustion process. As global demand and energy production has increased, so too have the global emissions of pollutants as a result of the flaring process.

Flares are an integral safety device at all of the above mentioned facilities, protecting plants from excessive pressure build-up from normal operations that produce gases and vapor, or from process upsets, start-ups and shutdowns. Flares prevent the release of unburnt VOCs to the atmosphere. An uncontrolled relief of VOC gas to atmosphere could lead to an explosion inside the production facility, or outside of the plant once the vapor cloud reaches an ignition source. Waste gases are collected in piping headers, commonly referred to as the flare network, and delivered to the flare for safe disposal using the combustion process.

A production/processing facility may have multiple flares to treat various sources of waste gas. Flare gas can come from utilities, safety valves in process units, vent gas connection feeds, product storage tanks, and pressure control valves used to control pressure within a process unit. The flare gas composition depends on the process units and utilities which are connected the flare networks. This leads to a wide variation of gas composition from flare network to flare network.

Flare gas flows can be lumped into two broad categories. The first category is flow that is a result of a plant emergency. This can be cause by events such as electrical power loss, instrument air loss, runaway reactions, loss of cooling, etc. Usually this results in a very large flow of gases in the flare network that must be destroyed safely. The second flow category are flows that are generated from normal plant operation, including purge gas, sweep gas, vent gas, valve leakages, and the depressurization of equipment for maintenance. Flare gas recovery (FGR) systems are typically designed to recover the second flow category.

An FGR system is designed to capture waste gases that would go to the flare tip during normal operations. The FGR system is located upstream of the flare to capture and recover some or all of the waste gases before they are flared. Most flares operate at pressures just above atmospheric pressure, and therefore the gas must be compressed to a higher pressure for transport throughout the plant and for use at the intended destination.

There are many potential benefits of an FGR system. The flare gas may have a substantial heating value and could be used as fuel within the plant to reduce the amount of purchased fuel. FGR systems also reduce the amount of vapor/gas being continuously burned in the flare, which subsequently reduces the utilities required for flare operation (if the flare tip is an assisted flare tip), the associated smoke, thermal radiation, noise and pollutant emissions associated with flaring, as well as extending the life of the flare tip.

Flare gas recovery systems are rarely sized for emergency flare loads. Sometimes, economics dictate the capacity be provided for a normal flare rate, above which gas is flared. Flare loads vary over time, and the normal rate may represent some average flare load or a frequently encountered maximum load. Actual loads on these systems will vary widely, and they must be designed to operate over a wide range of dynamically changing loads. Flare gas recovery systems are sometimes installed to comply with local regulatory limits on flare operation and, therefore, must be sized to conform to any such limits.

Basic Requirements for Flare Gas Recovery

The primary safety risk to integrating a FGR system is air ingress into the flare header. The ingress of air could result in a flammable mixture inside the flare system being ignited by the flare pilots. There are two potential avenues for air ingress into the flare network. One is through the flare tip itself, since flares are open flame combustion devices, the flare tip exit is open to atmosphere. The other is through leaking flanges in the flare header network.

There are two primary safety protocols to follow to ensure that air does not enter the flare header network. The flare tip requires a certain amount of gas flow through to tip to keep air from entering the tip, known as the flare tip purge rate. The implementation of an FGR system does not remove the requirement to purge the flare tip. The other protocol is to maintain positive pressure, above atmospheric pressure, within the flare header network at all times to ensure that any leakage will be directed out of the flare network.

A liquid seal vessel (LSV) is a critical piece of equipment for the safe and successful operation of an FGR system. LSVs were initially developed as flashback prevention devices for flares, if there was a detonation in the flare stack, the LSV would stop the propagation of the flame front into the flare header network. The liquid seal vessels have an internal down spout that is inserted into a liquid, typically water, this creates a hydrostatic seal in the dip tube. If there is enough gas flow to displace the hydrostatic head created by the seal in the down comer, the gas will bubble through the liquid to flow out of the LSV up to the flare tip to be safely combusted.

Typical flare liquid seal vessels designed for flashback prevention have a fairly shallow dip tube depth of around 6 to 9 inches (150 - 230 mm). To ensure that a positive pressure is maintained within the entire flare header network and to provide enough operation control bandwidth for the FGR system, the depth of dip tube insertion into the seal liquid needs to be increased to around 30 inches (760 mm) at a minimum. LSVs used in conjunction with FGR systems are commonly termed “deep liquid seals”. It is crucial that the LSV is properly designed and sized to handle the changes in flow and transition safely from normal gas flow rates to any emergency flare gas flow rate. Typically, the LSV is installed downstream of the flare Knock-Out Vessel near the base of the flare stack.

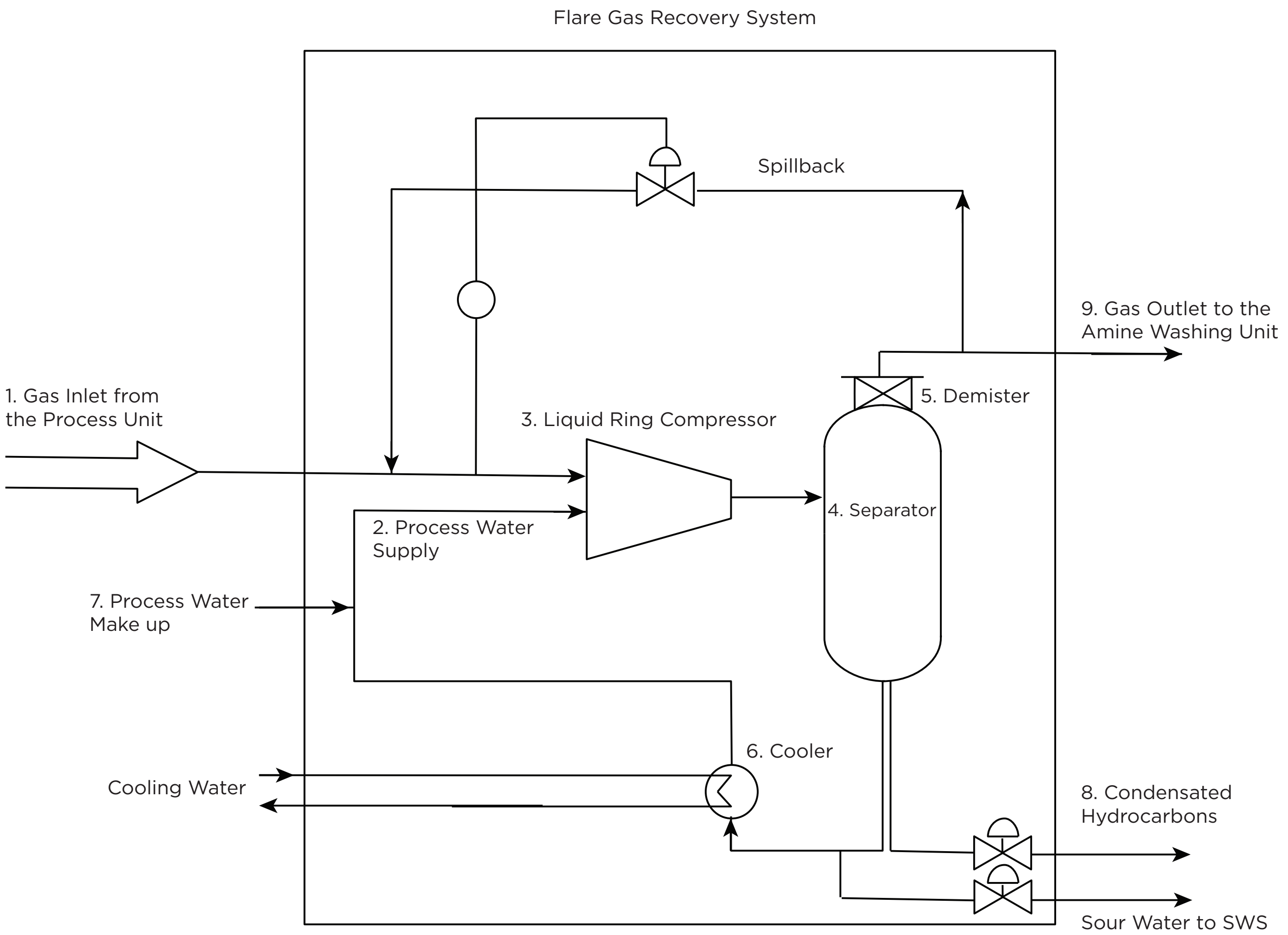
The flow of gas through the seal liquid will induce a series of wave dynamics within the vessel. These wave dynamics become more pronounced with deeper liquid seal depth. These unwanted fluctuations of water levels inside the liquid seal drum can lead to operational problems to both the flare tip and for the operation of the FGR system. These problems may include vibrations, suction pressure instability, and cyclic puffing of the flare. The liquid seal internals design should carefully consider how to counteract these wave dynamics to ensure the continued proper and safe operation of both the flare and the FGR system.

The suction to the flare gas recovery system is tied into the flare header network between the flare Knock-Out Vessel and the liquid seal vessel. This ensures that the implementation of flare gas recovery does not interfere with the emergency operations of the flare, but allows for the FGR system to capture the normal operational flows in the flare header prior to being combusted at the flare. If the volume of gas flow exceeds the capacity of the FGR system, the excess gas will bubble through the liquid seal and be burned safely at the flare tip. If the volume of the flare gas flow is less than the capacity of the FGR system, the inlet volume to the FGR is controlled by recycling the gas from the discharge of the system through a control valve back to the suction of the system.

Process Description

The gas (1) coming from the flare Process Unit enters the Liquid Ring Compressor (2) along with the process water (3). After the compression phase, the gas, water and hydrocarbon mixture enters the separator (4) where the three elements are parted: the gas passes through a demister (5) to have minimum water and leaves the vessel from the top, while condensed hydrocarbons and water are separated by gravity due to lower gas speed. The water is pushed back to the compressor, after being cooled again by a cooler (6). Moreover, a continuous process water make up line (7) in the compressor suction line is provided to ensure a continuous water ring in the compressor. The condensed hydrocarbons are discarded (8). The gas exiting the separator finally heads to the Flare gas Amine Washing Unit (9) where it is amine treated to remove H_2S. The treated gas is then pushed to the Fuel Gas header to be used as fuel.

FLARE GAS RECOVERY SYSTEM - TYPICAL PROCESS SCHEME



Liquid Ring Compressors for Flare Gas Recovery Systems

GARO liquid ring compressor systems have been used in flare gas recovery systems since 1986. There are distinct advantages of using the liquid ring compression for flare gas recovery. The compression occurs inside a liquid bath (typically water), making the compression cycle intrinsically safe. The liquid bath also absorbs the majority of the heat generated by compression, actively cooling the gas during the compression cycle. The seal liquid is also cooled to remove heat, and maintain near isothermal compression within the system. The liquid bath is also effective at removing fine particulate matter entrained in the flare gas. Liquid ring compressors can also withstand some small amount of free liquids in the incoming gas stream, potentially removing the need for suction knock-out.

Reliable, capable of running low speeds, reducing noise and vibration, and with low maintenance requirements, liquid ring compressors can be constructed from a range of materials to meet customer specific application needs. liquid ring compressor systems can also handle a range of gas compositions including dirty, explosive, and corrosive gasses and vapors; as well as being suitable for gasses or vapors with a high potential condensate formation at discharge.

GARO's liquid ring compressors are ideal for handling gasses and vapors with a high concentration of H_2S and / or CO_2; as evidenced by GAROs patented Washing Amine Integrated System (WAIS), which is capable of scrubbing H_2S and CO_2 to acceptable levels during a standard compression cycle.

With a global effort to reduce pollution associated with normal flaring, a Flare Gas Recovery System from Garo can not only reduce the amount of toxic gas released into the atmosphere, boosting your facilities environmental credentials, but can also provide economic advantages for operators. a FGR systems can help operators recover valuable, high heat gas to be used as a fuel within the plant, re-used as feed stock, or sold as a product of the facility.

Trust the Experts in Flare Gas Recovery Systems

With over 200 flare gas recovery systems installed worldwide, Garo has the expertise and experience to help optimize oil & gas plant operations and minimize their environmental footprint.

Did you know?

The first GARO Flare Gas Recovery System was installed in one of the most productive Italian Refinery in 1986.

GARO® Customized & Packaged Solutions for EPC Companies

Founded as a liquid ring compressor manufacturer in 1947, we quickly became experts in the engineering, configuration and design of custom packaged solutions. Every day we use our extensive knowledge of liquid ring technology to support customers and EPC companies throughout every step of the project: from the concept/FEED study to the start-up of the system. We also provide customer care and assistance on the long term basis through our global network of GARO CERTIFIED™ Service & Support.

1. From the concept & FEED study, we provide estimates and possible process reevaluation to help end-users and consultancy companies to choose the right technology.

2. During the project definition with EPC, we sustain the clients in the choice and comprehension of the best solutions. We are not suppliers; we are part of your team.

3. In the detailed engineering phase, our qualified engineers design customized systems based on project requirements, to create a tailor made product.

4. We take care of the package manufacturing choosing only the best suppliers and providing scrupulous quality controls.

5. Before the products leave our facility, we take all necessary tests, including, if required, a complete unit running test to demonstrate the full integrity of the compression package.

6. GARO Service & Support not only takes care of the erection, commissioning and start-up supervision of the system, but also trains the customer how to run the package.

7. We never forget our customers after the sale phase: guarantees and warranties are always included. Moreover, GARO Service & Support is always ready to help you to protect your investment by maintaining performance and reliability.

About Garo

Garo delivers a broad range of compressors and custom designed packages to end-users and OEM customers worldwide. We provide reliable and efficient equipment that is put to work in a multitude of demanding industrial process applications. Our products and systems serve industries including oil & gas, chemical, petrochemical, and pulp and paper. Our global offering also includes a comprehensive suite of aftermarket products and services to complement our products.

For further information please visit www.GDGaro.com or contact our sales representatives for more information on Garo's range of flare gas and vapor recovery systems.

Credits for this article go to Brian Blackwell, former Area Sales Manager of Garo in North America.

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