VIKING PUMP®

MEETING THE CHALLENGES OF GLYCOL DEHYDRATION

A White Paper by

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Introduction

While servicing the pumping needs of energy customers (oil and gas producers/mid-streamers), Viking Pump® received multiple inquiries from engineering leaders about the feasibility of developing a fit-for-purpose pumping solution for glycol circulation in the natural gas dehydration process.

Although we were not glycol dehydration experts at the onset of this endeavor, Viking Pump® did have previous experience, and best-in-class solutions, in applications with similar challenges:

- pumping thin liquids at high pressures (crude oil pipeline injection – LACT)
- pumps in high temperature conditions (hot oil fryer market)
- encountering abrasives (asphalt pumps, sugar pumps, etc.)
- pumping glycol for heat trace or cooling
- providing critical leak-free or explosion-proof solutions to energy companies (API line-up).

Viking engineers proceeded to apply their unique combination of pumping application knowledge, to address the requirements of a new/challenging market, where few pumps, if any, were designed to meet the growing need for motor driven pumps.

As part of design and development of a new pump specifically engineered for the natural gas glycol dehydration market, we researched and studied the challenges of this critical gas production process. Our goal was to enhance the pumping experience at glycol dehydration facilities concerned with absorbing the water to attain a high-quality end product, while also reducing pipeline corrosion and eliminating line blockage caused by hydrate formation. The white paper is an opportunity for us to share what we learned over the years and to offer solutions, from a pumping perspective, to a varied audience—from fabricators of gas production equipment, to oil and gas producers, engineers, plant managers, maintenance teams, and purchasers. In other words, the whole supply chain involved in designing, operating, servicing, and purchasing dehydrators will find this information of interest.

Background

Why dehydration is needed

Dehydration is a critical step in the treatment of natural gas before it can travel through transportation pipelines and ultimately be sold to end users. Initially, the untreated gas contains water and crystalline solids, or hydrates, both of which can damage downstream pipelines and other equipment (by freezing/hydrate formation**,** creating iron oxide buildup/rusting, forming mineral deposits that can clog the system, etc.). Hydrate formation is especially problematic, as it can occur at above normal freezing temperatures due to increased pressure, putting valves at risk throughout the entire pipeline/transport system. This necessitates the separation of water from the gas early in the process.

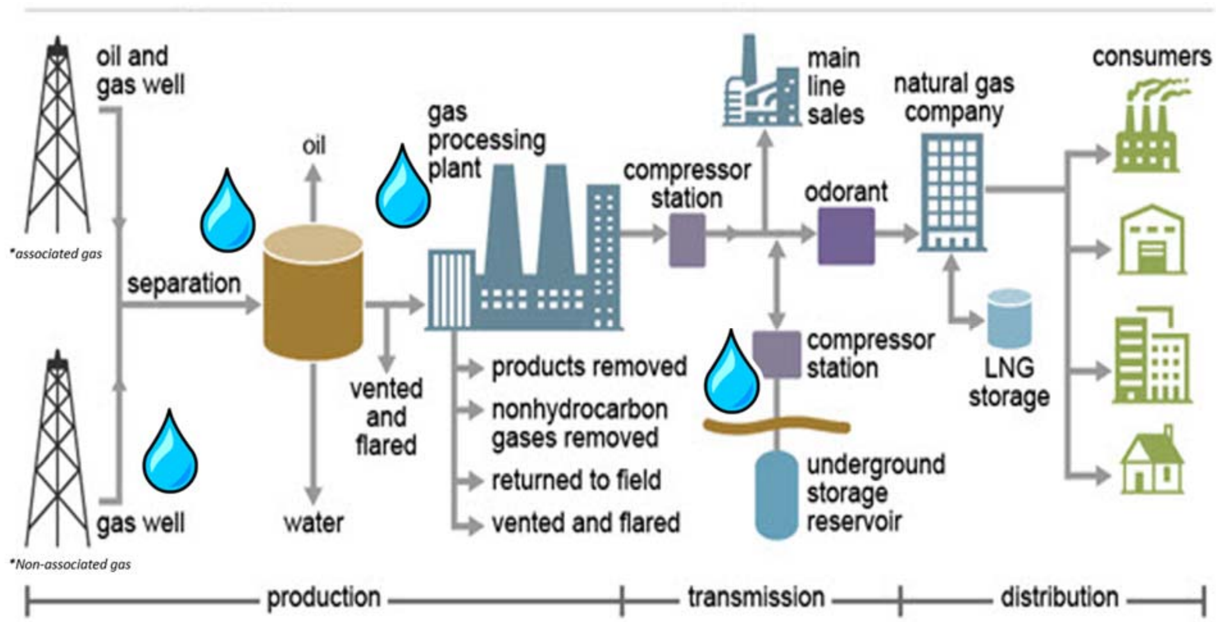
> **By definition**, *glycol dehydration is essentially a liquid desiccant system for the removal of water from natural gas and natural gas liquids (NGL). It is the most common and economical means of water removal from these streams*.

Water not only has to be removed in order for gas to be transported, but the product also has to meet strict pipeline specifications for transfer and delivery to the customer. In most cases, the natural gas must be dried to a 7% dew point or less. A failure to be “in spec” for moisture content can result in less profits.

The dehydration process

There are different ways to dehydrate gas, the most common way being to pump triethylene glycol (TEG) against the natural gas stream. However, with gas coming out of the ground at pressures as high as 10,000 PSI, the pressure has to be reduced (choked) to 1,440 psi max. Not all positive displacement (PD) pumps are capable of overcoming this pressure as they generate flow, or handling the very "thin" viscosity of TEG for that matter. Also, note that many pumps struggle with the high temperature requirements of glycol dehydration. The glycol is typically 150°F to 200°F at the booster pump, and must be within 20°F of the gas temperature to ensure optimum dehydration levels.

But pumping TEG against the gas stream at the wellsite is just the beginning. There are other points of dehydration in the natural gas stream as it travels through the entire process—from production through delivery (see Figure 1). And pumps are needed at each of those points.



= Points of dehydration in natural gas stream

Figure 1. *Natural gas production and delivery process diagram.*

Dehydration methods

There are several types of dehydration methods employed in the treatment of natural gas, including:

- **Dry Desiccant** – a single-use absorbent material
- **Molecular Sieve** – regenerated synthetic porous material
- **Triethylene Glycol (TEG)** – used in 80% of dehydration applications

Note that the TEG method is the entry point for Viking Pump to participate, as pumps are an integral part of the glycol skid (see Figure 2).

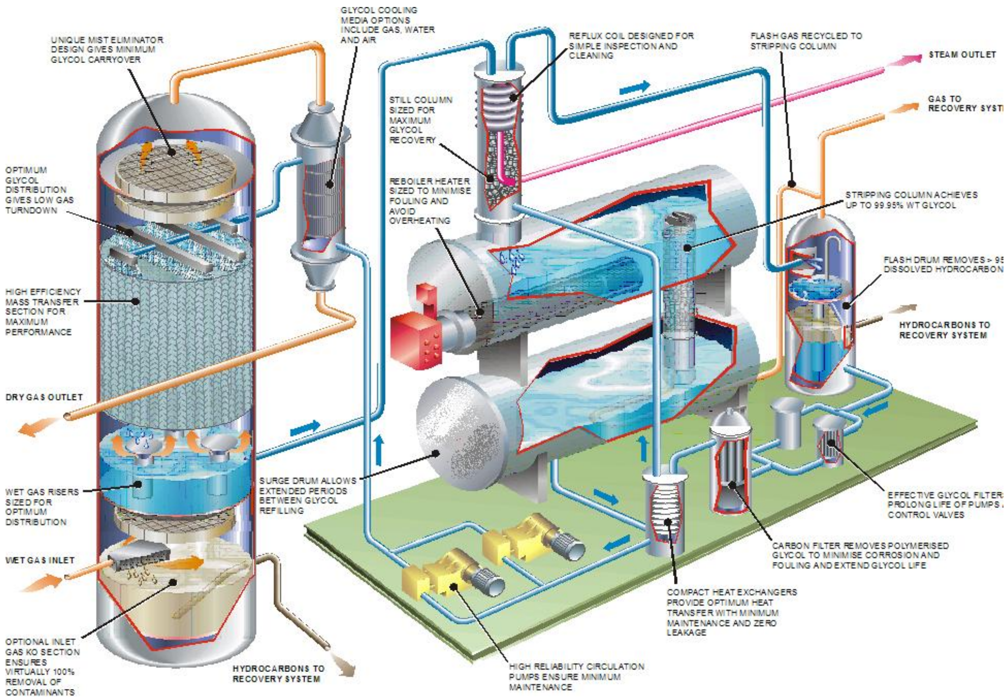


Figure 2. *Glycol dehydration skid components, including: Contact Tower, Reboiler, Surge Drum, Flash Tank, Heat Exchangers, Strainer/Filters, and Pumps.*

Glycol Dehydration Challenges

The main challenges associated with the glycol dehydration process are as follows:

- **Higher pressures –** Up to 1,500 psi differential required
- **Thin viscosity –** TEG is thin, and changes with operating conditions (70°F= 49cP to 200°F = 4cP). Effective absorption happens when glycol is within 20°F of natural gas at the tower (see Figure 3).
- **24/7 duty cycle –** Requires sturdy, reliable pumps with long service wear to avoid costly downtime.
- **Abrasive particles –** Mineral deposits, salt, iron dust, etc.
- **Thermal shock on startup –** Glycol inside the pump can be + 200°F, while pumps are also exposed to ambient atmosphere temperatures outside, resulting in temperature deltas between pump and glycol that could exceed + 150°F. (See Startup section for recommended steps.)
- **Remote outdoor locations –** Require pumping equipment that can withstand harsh environments.

These inherent challenges call for specialized pumps to ensure successful dehydration operations.

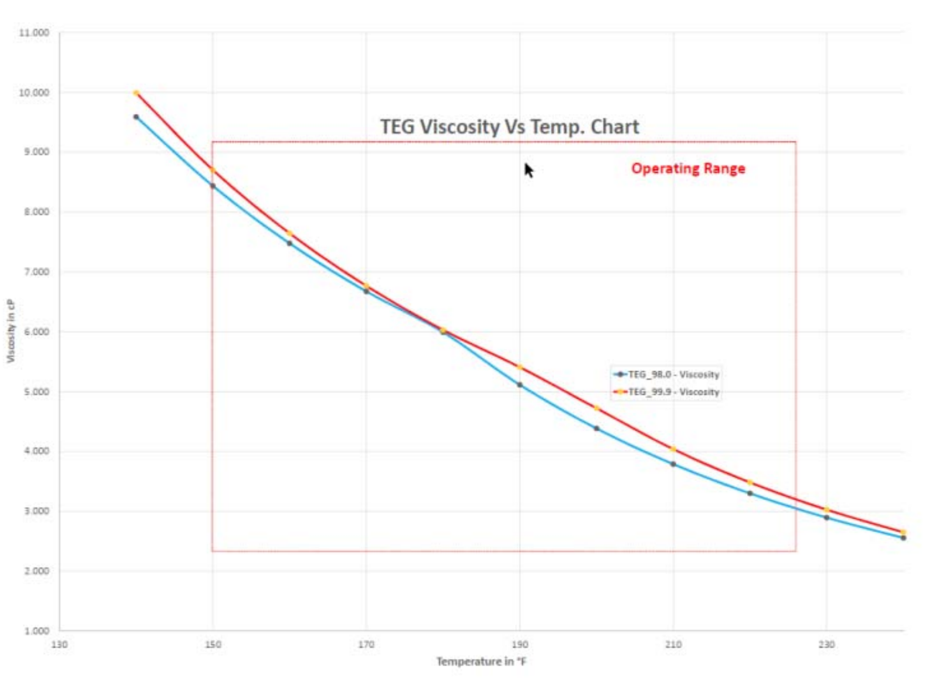


Figure 3. *TEG viscosity versus temperature chart.*

Viking Pump Solutions

With over 105 years of experience providing positive displacement pumps for industrial use, Viking Pump has a long history of designing engineered solutions for tough applications, like glycol dehydration. Now, Viking has the product suited for this specific application.

High performance

Viking Pump's external gear GL-407 Series™ and GL-410 Series™ offer a reliable pumping solution for circulation of TEG in natural gas glycol dehydration systems. These high-performance pumps fulfill a wide range of application needs, as shown in the chart below (Figure 4).

Model	Ports①	Flow rate at 1200 PSI (1750 RPM) on 8 cPs TEG		Max. Continuous Pressure	Max. Recommended Temperature	Approximate Shipping Weight
Ductile Iron	Inch	GPM	GPH	PSI	Deg. F	Lbs.
GL-40758	1" NPT	3	180	1500	350	17
GL-40782	1" NPT	4.5	270	1500	350	18
GL-41009	2" SAE	10	600	1500	350	37
GL-41013	2" SAE	14.5	870	1500	350	61
GL-41018	2" SAE	20	1200	1500	350	72
GL-41026	2" SAE	30	1800	1500	350	85
GL-41039	2" SAE	45	2700	1500	350	110

① 2" SAE Ports use J518 Code 61 SAE flange ports. SAE O'ring ports are available for GL-407 Series™ models. NPT flange adaptors available for GL-410 Series™ models.

Figure 4. *Viking glycol dehydration pump performance chart.*
(Refer to the company flyer on these pump series for more details.)

By design, the pumps are constructed to address unique challenges commonly encountered in the glycol dehydration process, such as filtration, startup temperature, pipe strain, and even priming the pump.

Filtration

Filtration is key to maintaining flow rate stability and accuracy. This can be challenging when some, or all, of the following glycol system circumstances exist:
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- **Particulate contamination** — Many glycol systems are decades old, containing potentially degraded glycol that could be contaminated with particulate from years of use, e.g. salt, sand, and metal particles from corroded or failed pieces of equipment piped into the system, including pumps.
- **Poor maintenance** — Glycol dehydration facilities vary in their operating parameters and procedures, dictated by the gas itself or where the well is located, as well as different preventative maintenance schedules and processes. Pumps can become partially "starved" by dirty or clogged filters, or see unfiltered glycol entirely.
- **Lack of monitoring** — Some sites have limited electricity availability, limiting the amount of instrumentation they can use to closely monitor the glycol dehydration process. This can lead to gas flowing down the pipeline out of spec. And because the pump needs to stay in operation to maximize profit, if it does go down, start-up procedures are often circumnavigated to get the system back up and running as soon as possible (see Start-up Steps below).

Viking engineers were well aware of filtering pitfalls when designing pumps for the glycol dehydration market, therefore, the pump construction is robust and bulletproof enough to not only operate in clean, new glycol systems with state-of-the art monitoring, but also in a 30-year-old system with dirty, abrasive glycol and limited instrumentation. The construction materials, features, and clearances were selected based on a century's worth of experience to ensure the pumps could manage the extreme variables that might be faced in the field.

To optimize the lifespan of these pumps, Viking recommends the following filter guidelines:

- Use the industry standard filters, which appear to be 20-30-micron mesh filters.
- Put a magnet into the filters to help capture any metallic fines that may be trapped in the system. These metallic fines can be very abrasive, so using a magnet with the filter to optimize material collection out of the system is ideal.
  - Metallic fines can even be present in brand new systems, due to weld beads breaking off into the newly welded pipes.
  - Previous pump failures most likely introduced additional metallic fragments into the glycol system, which would stay trapped there until removed through filtration.

Startup temperature

A crucial part of pump startup is getting the pump within the 100°F acceptable temperature delta between pump temperature and glycol temperature to prevent a thermal shock situation that locks the pump up. The most accurate way to do that is to utilize the "temperature probe" access holes in the pump and a temperature monitoring system to measure pump temperature during startup.

Viking Pump's GL-410 model is specifically designed for 150°F thermal shock resistance Viking glycol pumps are also available with a temperature probe that allows for monitoring the pump temperature on startup. Each of these pumps come standard from the factory with a drilled and tapped port to accommodate the temperature monitor. The temperature probe produces a signal that is linearly proportional to the temperature. Viking offers two different temperature probe options, a Type-J Thermocouple or a Platinum RTD, each available in either a weatherproof or explosion-proof rating.

However, not every system has the capability to support sophisticated temperature probe instrumentation. If using an infrared (IR) gun to measure temperature, Viking recommends painting everything in the system one color, i.e. if checking pump temperature and temperature of the pipes, both should be painted the same color. The paint often holds more heat than an unpainted portion, and different colors in the wavelength spectrum would read differently on the IR gun, even if they were the same temperature. So, making everything the same colors ensures that using an IR gun for temperature monitoring can be as accurate as possible.

Start-up Steps:

Our recommended start-up procedure assumes a situation where the pump and glycol temperature differential exceeds 100°F. If the measured delta is less than 100° F, jump to step 3.

1. Run the pump for 10 seconds to introduce initial system glycol to the pump. Then, stop for a minimum of 15 seconds,
2. Repeat Step #1 a second time. Then, measure pump temperature. Repeat Step #1 until temperature reaches the required maximum delta.
3. Run pump continuously and slowly bring up the system pressure. Once this is done, the pump can now run continuously at the desired speed.

Pipe strain

Pipe strain can cause misalignment and stress on the pump; and is one of the most common reasons why pumps fail prematurely. To reduce pipe strain on the pump ports, Viking Pump recommends the use of flexible hose connected to the suction and discharge ports. Pump design is not acceptable for rigid piping, unless piping is custom-cut specifically for the Viking Pump glycol unit and the piping adequately supported with pipe hangers and/or supports.

Viking Pump also recommends using a liquid pipe sealant/dope for the piping that is threaded into the NPT ports on the pump. DO NOT USE TEFLON TAPE, as this alters the pipe OD and runs the risk of cracking the pump ports.

Priming the pump

Another common concern with glycol applications is priming the pump, as it relates to Net Positive Suction Head (NPSH), a measure of the pressure on the liquid being pumped. Viking's rotary positive displacement pumps are inherently self-priming, i.e. they have the ability to evacuate air from the suction line, which creates a reduced absolute pressure at the suction port, promoting flow to the pump port by pressure differential. The pump's priming ability is a function of pump speed and the internal clearances within the pump. Tighter pump clearances result in better priming ability. Faster pump speeds also increase priming ability. A pump with wetted internals (residual liquid/lubricants) will always prime better than a dry pump. Viking's line of Glycol Dehydration Pumps have tight clearances and, thus, they are excellent at self-priming.

Mini Case Study: Marcellus-Utica Shale

Armed with a new line of Glycol Dehydration Pumps, Viking sales targeted the leading natural gas producing region in the United States—the Marcellus-Utica Shale. Almost the same size as the Permian, this area has been nicknamed "The Beast in the East," spanning Ohio, Pennsylvania, New York, and West Virginia.

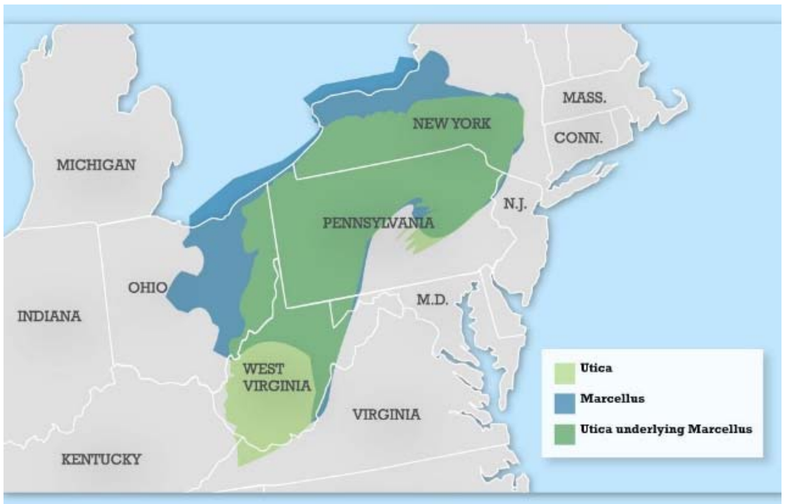

Figure 5. *Marcellus-Utica shale regional map.*

Viking Pump recently had the opportunity to work with one of the region's natural gas dehydration facilities (located in Clearview, PA along the Ohio River). The mid-stream operator was in need of a more reliable glycol processing pump that could provide long service life, given the high temperature, high volume, and 24/7 duty cycle conditions. Frustration and cost were running high, as they had to replace pumps every 2-3 months due to cavitation problems, resulting in frequent downtime.

To prove the capabilities of Viking's pumps expressly designed for this purpose, plus further customization for the particular site requirements, two pumps in the Viking 41013 Model, GLV Series™ were installed. This field trial demonstrated the pumps' superior performance (showing very little difference between the two models) over the predecessor, tripling the lifespan—at the time of this publication, the pumps were still operating trouble-free after nine months, with no downtime or maintenance issues.

Figure 6. *Viking glycol dehydration unit, Model 41013 GLV Series.*

The customer's Sr. Facilities Technician commented about the ease of installation, and how the pumps continued to work all those months "just like they did on day 1." Overall, it was a cost-effective solution down to the retrofitting (via close-coupling brackets attached to with motors already in place); thus, eliminating the need to purchase new motors.

This positive outcome led to the operator switching to Viking pumps for subsequent glycol dehydration pumping needs at the current and future planned sites, where they will be able to take full advantage of the C-faced electric motor (with M drive configuration) for quick mounting on the face of the motor.

A full-length case study is available from Viking Pump.

Conclusion

The natural gas glycol dehydration market is complex and growing among the United States and global gas players. In this white paper, we have presented many lessons learned to date, along with recommendations to mitigate certain issues. As we continue to work in this space, more challenges and solutions will be accumulated and shared at a later time. For now, suffice it to say that Viking Pump is committed to keep researching, innovating, and customizing as we go forward to meet emerging trends and different requirements encountered in the field. We rely on close collaboration with customers and fabricators to stay informed, so we can react quickly to develop new and better pumps, as needed.

The current line of GL-407 Series™ and GL-410 Series Viking glycol pumps are ready for use in the most demanding applications, and can be customized for particular site requirements, whether new or existing systems are in place.

For more information, contact Viking Pump directly, or one of our distributors, to request a Glycol Dehydration Pump flyer. Or visit the website at www.vikingpump.com.