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Gas Process Training

TEG Dehydration

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Introduction

In this training module, you will learn about a typical triethylene glycol (TEG) gas dehydration system. You will understand the principles behind natural gas dehydration using glycol as well as the process for regenerating the water-saturated glycol.

Objectives

After completing the *Glycol Dehydration* module, you will be able to:

Describe process flows for:

- Gas stream
- Rich glycol stream
- Lean glycol stream
- Fuel gas

State normal operating parameters for:

- Contactor
- Regenerator
- Flash Separator
- Glycol pumps

Explain why glycol temperature control is critical, and why temperature differs for the Contactor and Regenerator processes

Glycol Dehydration

The main functions of a glycol dehydration system are to:

1. Absorb water from the gas stream using lean glycol
2. Regenerate water-rich glycol to a lean state

Dehydrating the gas is critical in order to prevent hydrates from forming in downstream pipelines or equipment. The *absorption* of water into lean glycol is favored by *high pressure* and *low temperature*. The glycol *regeneration* process (whereby the absorbed water is boiled from the glycol) takes place at *low pressure* and *high temperature*.

As shown in Figure 4-1, the central component used for glycol regeneration is a small distillation column (stripping tower) connected to a reboiler and surge drum. The solution is heated at the bottom by the reboiler and cooled at the tower top by rich glycol from the Gas/Glycol Contactor. Steam and gases are drawn from the stripping tower top, while the lean glycol drains to the reboiler tank and surge drum.

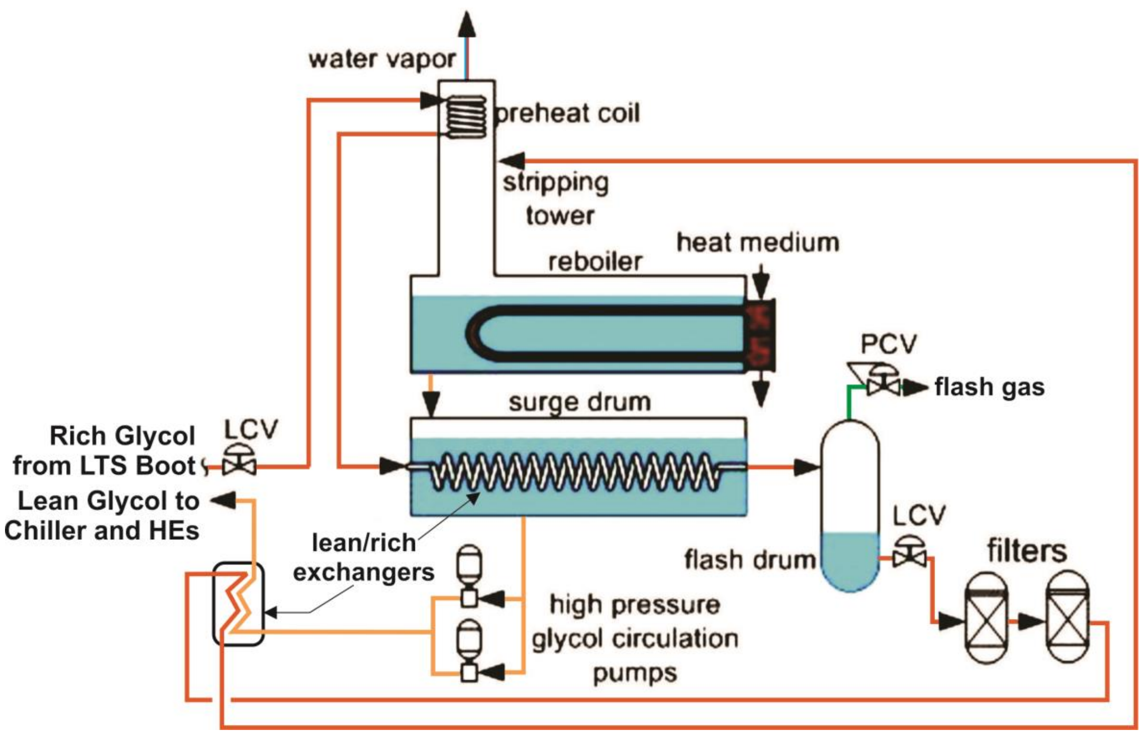

Figure 4-1: Basic glycol regeneration system

Cool rich glycol from the Contactor flows (under level control) to the preheat coil in the stripping tower top. The glycol experiences a significant pressure drop across the level control valve, which lowers the boiling point of the absorbed water.

The pre-heat coil has two purposes:

1. The rich glycol picks up some "free heat" on its way to being regenerated, and

2. The rich glycol cools vapors rising through the stripping tower, thereby condensing any residual glycol vapors entrained with the O/H water vapor.

From the pre-heat coil, the rich glycol flows through the lean/rich exchanger, which in the example above is a coil submerged in the lean glycol accumulator – other systems use external plate-type heat exchangers (or a combination of both types). The lean/rich exchanger uses inflowing rich glycol to cool the outflowing lean glycol (recall that water absorption works best at low temperatures). At the same time, the rich glycol picks up more "free" heat on its way to regeneration.

From the lean/rich exchanger, the rich glycol enters the flash drum, where any dissolved hydrocarbon gases boil off due to the combined effects of:

1. The pressure drop across the LCV
2. The temperature increase from preheating

Flash Drum O/H gas is recycled (or flared), while the rich glycol flows through filters to the distillation column (stripping tower), where it mixes with hot, rising vapors generated in the reboiler. Reboiler heat vaporizes water in the rich glycol returning it to a lean state.

Glycol Dehydration System Process Control

The Glycol Dehydration System shown in Figure 4-2 is comprised of the:

- Glycol Contactor
- Glycol Catch Pot
- Air/Glycol Exchangers
- Glycol Circulating Pumps
- Particulate Filter
- Charcoal Filter
- Regenerator (reboiler, still column, FG/TEG scrubber, & surge drum)
- Reboiler Overheads Recovery Tank
- Overheads Pump
- Still Overheads Incinerator

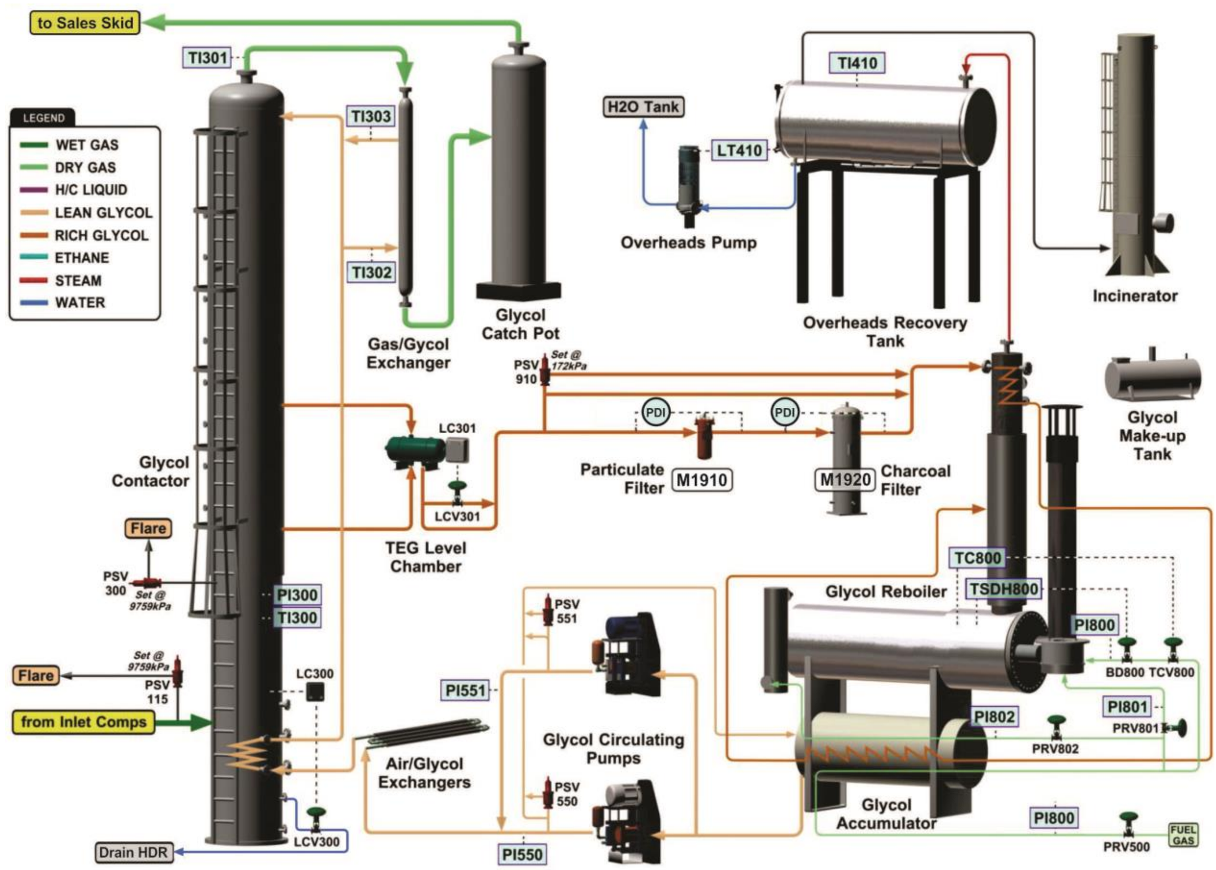

Figure 4-2: Typical Dehydration System process flows and instrumentation

The main process controllers are:

Tag #	Process Description
TC800	Controls ON/OFF Fuel gas valve **TCV800**; maintains Glycol Reboiler temperature at setpoint
LC300	Removes liquid water from the Contactor's gas inlet chamber through **LVC300** to the Drain Header
LC301	Maintains a minimum level in the Contactor TEG Level Chamber by controlling rich TEG flow through **LCV301**
LT410	Maintains a minimum/maximum liquid level in Overheads Recovery Tank by sending Stop/Start commands to the Overheads Pump

Glycol Contactor

The TEG Contactor (Figure 4-3) is a steel column with upper and lower chambers. Wet gas flows from the Inlet Compressors to the Contactor's lower chamber, which functions as a cyclone separator. Free liquid separates from the gas stream, collects in the chamber bottom, and is level controlled to the Drain Header and Produced Water Tank.

Figure 4-3: Glycol Contactor

The gas then exits the lower chamber though a demister screen, which minimizes liquid carryover to the upper chamber. The lower chamber incorporates a heat exchange coil, where lean TEG flowing to the injection nozzles is cooled by the inlet gas.

The upper chamber contains eight evenly spaced bubble cap valve trays (Figure 4-4). Lean TEG is injected above the top tray. On each tray, the glycol forms a layer before overflowing to the tray below. Gas rises through the tray caps and bubbles through successive layers of glycol.

Process conditions vary with height - As the gas rises up the column, its water content decreases; as the glycol drains to successively lower trays, its water content increases. The process continues until water absorption is complete.

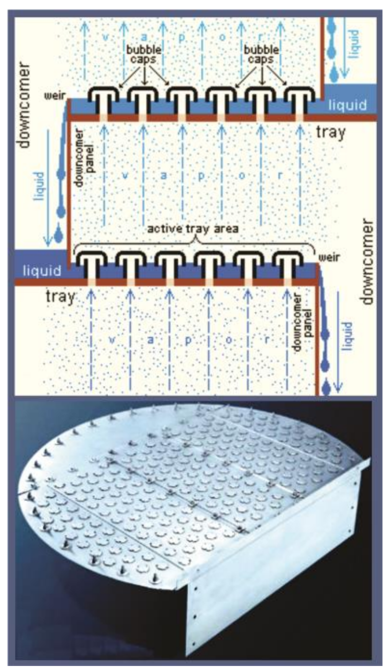

Figure 4-4: Bubble cap trays

Dry gas exits the upper chamber through a second demister, which traps and coalesces glycol mists. The dry gas continues to the Sour Sales skid, while the rich TEG is level-controlled (**LC301**) from the upper chamber bottom through **LCV301** and the rich glycol filters to the Glycol Regenerator.

Gas/Glycol Exchanger

From the Contactor's O/H outlet, the dry gas flows through the Gas/Glycol Exchanger (Figure 4-5).

The Gas/Glycol Exchanger is designed to cool the incoming lean glycol to about 5.5° C above the temperature of the incoming wet gas. It has manual block and bypass valves, which can be adjusted to regulate the degree of cooling.

If the glycol is too cool, it can cause heavy hydrocarbon compounds in the gas to condense. H/C condensate in the Contactor causes foaming, which decreases tower capacity and increases TEG losses (carryover with the dry gas).

Figure 4-5: Gas/Glycol Exchanger

Glycol Catch Pot

From the Gas/Glycol Exchanger, dry gas flows through the Glycol Catch Pot (Figure 4-6), which captures removes any liquid glycol carried over with the dry gas.

Figure 4-6: Glycol Catch Pot V1330

Glycol Filters

Rich TEG from the Contactor passes through a Particle Filter (Figure 4-7) and a Charcoal Filter (Figure 4-8).

Figure 4-7: Particle Filter

Figure 4-8: Charcoal Filter

The Particle Filter removes dirt and debris. The filter element should be replaced before it becomes completely saturated with particulates. TEG flowing through a new filter cartridge will usually show a pressure drop of 20 to 40 kPa. As the cartridge picks up particles from the glycol stream, it becomes clogged and the pressure drop increases. When the pressure drop reaches 100 to 140 kPa, the filter element should be replaced.

The Charcoal Filter removes heavy hydrocarbons. A DPI gauge monitors pressure drop across the unit, although this may not be a reliable indication of filter element condition. Charcoal Filter elements should be changed periodically to ensure clean TEG.

Glycol Regenerator

The Glycol Regenerator unit (Figure 4-9) is comprised of a Reboiler, Still Column, Fuel Gas/TEG Stripper, and Lean TEG Surge Drum.

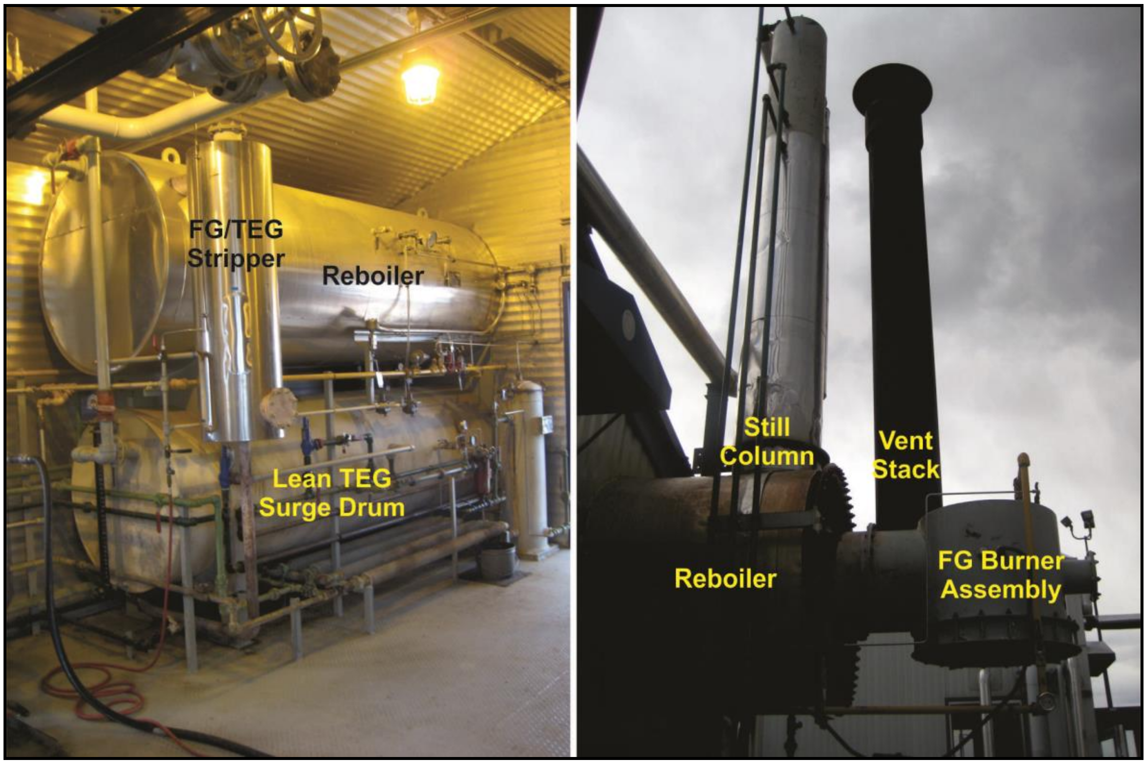

Figure 4-9: Regenerator

Rich TEG exiting the Contactor is relatively cool and contains impurities picked up from the gas stream, so it requires both preheating and filtering prior to regeneration. Contactor pressure drives the rich glycol through the filters and heat exchange coils in the Still Column top and Surge Drum. The Regenerator operates at low pressure (close to atmospheric) and relatively high temperature.

The Reboiler consists of a steel shell containing a fire tube, a burner assembly, a fuel gas valve, and temperature controls. A wire mesh barrier (flame arrestor) admits combustion air, while confining the flame within the tube. The fire tube forms a loop within the shell, with the outside end connected to an external vent stack.

The liquid outlet is located to provide a vapor space above the liquid surface while ensuring the fire tube is always completely submerged in TEG solution. Excess TEG discharges from the outlet and flows down through the Fuel Gas/TEG Stripper and into the lean TEG Surge Drum. Steam boiled from the TEG solution rises through the distillation column and flows to the Overheads Recovery Tank.

The Still Column has a lower section packed with pall rings; a heat exchange coil (reflux coil) is mounted overhead, and the rich TEG inlet is located above the lower packed section. As rich TEG diffuses through the lower section’s pall ring packing, it contacts rising reboiler steam, which evaporates water and some glycol. (Besides the water and glycol vapors, the reboiler steam also contains a small amount of saturated fuel gas from the Fuel Gas/TEG Stripper.)

When the rising vapors reach the reflux coil, the heat exchange with cool rich TEG inside the coil condenses part of the vapor. Because glycol boils and condenses at a lower temperature than water, the reflux condensate tends to be highly concentrated TEG, while the steam venting from the column O/H is mainly water vapor with traces of fuel gas. The cool reflux liquid trickles down though the packing and exchanges heat with rising vapors. This heat exchange condenses more glycol, which further concentrates the TEG solution returning to the reboiler shell.

Heating inside the reboiler shell boils off more water, returning the TEG to a lean state. The lean TEG then discharges through the FG/TEG Stripper, where contact with dry fuel gas removes the remaining water traces and restores the TEG to lean state.

Lean TEG from the Stripper bottom collects in the Surge Drum, which provides lean TEG storage and surge capacity for the Dehydration System. The Surge Drum also contains a heat exchange coil, which preheats rich TEG prior to regeneration, and cools lean TEG ahead of the Glycol Circulating Pumps.

Glycol Pumps

The Glycol Pumps (Figure 4-10) are high pressure, low capacity positive displacement units driven by electric motors.

Figure 4.10: Glycol Pumps

One pump normally operates while the other is on standby. The online pump transfers lean TEG solution from the Regenerator Surge Drum through the Air/Glycol Exchangers, the heat exchange coil in the Contactor's bottom chamber, and the Gas/Glycol Exchanger to spray nozzles located above the bubble cap trays in the Contactor's upper chamber.

Air/Glycol Exchangers

Lean TEG from the Pumps flows through the Air/Glycol Exchangers (Figure 4-11). The Air/Glycol Exchangers are radiators, which cool the lean TEG in preparation for absorbing water in the Contactor.

Figure 4-11: Air/Glycol Exchangers

Overheads Recovery Tank & Pump

Steam from the Regenerator Still column's O/H outlet is collapsed back to liquid in Overheads Recovery Tank (Figure 4-12). NCGs (non-condensable gases) and residual steam flow to the Incinerator, while Overheads Pump **P560** transfers the condensed water through the Drain Header to the Produced Water Tank.

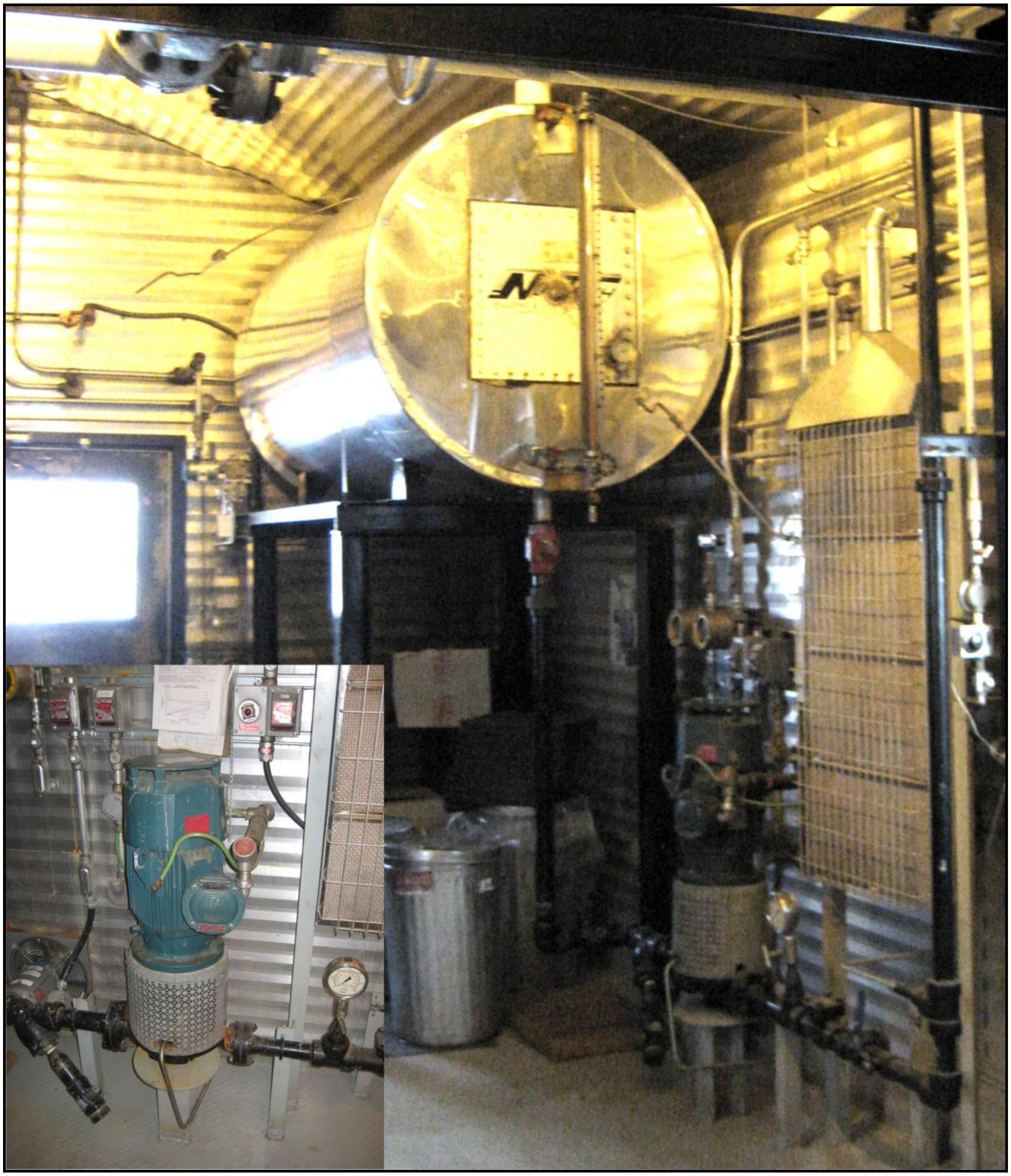

Figure 4-12: Overheads Recovery Tank & Overheads Pump

The Overheads Pump is a vertical centrifugal unit driven by an electric motor. Pump operation is in response to STOP/START commands from the Overheads Recovery Tank level transmitter.

Still Overheads Incinerator

The Incinerator System consists of the Overheads Recovery Tank and the Still Overhead Incinerator (Figure 4-13).

Vapor from the Overheads Recovery Tank vents to the Still Overhead Incinerator.

Off gas from the TEG Regenerator is primarily water vapor and fuel gas, but it can also contain benzene (or other aromatics) absorbed from the gas stream. Any aromatics in the off gas will be combusted in the incinerator stack.

Additional fuel gas under automatic pressure/flow control is mixed with the off gas to ensure complete combustion. All incinerator functions are controlled from a local panel.

Figure 4-13: Still Overhead Incinerator

Module References

Glossary

Module 4 Exercises

Written Exercises ~ Self-Assessed

The following questions apply to normal conditions unless otherwise stated. From the given choices, select the **best** answer to each question. Although other choices may apply under different conditions, do **not** consider these choices as being the best answers. Put your answers on a separate piece of paper. Do **not** write in the manual.

Matching

Match the letter of each TEG Dehydration System component with its corresponding numbered description.

a. Glycol Catch Pot
b. TEG Contactor
c. Particulate Filter
d. Charcoal Filter
e. TEG Reboiler
f. FG/TEG Stripper
g. Lean TEG Surge Drum
h. Overheads Recovery Tank
i. TEG Regenerator
j. Overheads Incinerator

1. ____ removes solids entrained with the TEG

2. ____ uses dry fuel gas to remove water vapour and restore TEG purity

3. ____ currently performs no process function

4. ____ condenses and collects Regenerator O/H vapor

5. ____ main surge control vessel for the TEG System

6. ____ removes hydrocarbons and degradation products from the TEG

7. ____ converts rich TEG to lean TEG

8. ____ contains evenly spaced bubble cap valve trays

9. ____ burns fuel gas and aromatics

10. ____ operates at low pressure and high temperature

Multiple Choice

1. Which of these statements describes a possible outcome if the lean TEG sprayed into the Contactor is too cold?

    a. Heavy hydrocarbons might condense in the Contactor
    b. Foaming might occur in Contactor
    c. TEG might carry over with the dry gas
    d. Contactor capacity might be reduced
    e. all of the above

2. The absorption of water into glycol takes place in the…

    a. Glycol Catch Pot
    b. Reboiler
    c. Contactor
    d. Still O/H Condenser

3. The glycol Regeneration process takes place at…

    a. high pressure, low temperature
    b. low pressure, low temperature
    c. low pressure, high temperature
    d. high pressure, high temperature

4. Rich TEG is returned to a lean state in the…

    a. Gas/Glycol Exchanger
    b. Reboiler
    c. Contactor
    d. Overheads Recovery Tank

5. Steam from the Reboiler's distillation column is collapsed back to vapour in the…

    a. TEG Surge Drum
    b. Glycol Catch Pot
    c. Overheads Recovery Tank
    d. Contactor

Answer Key

Matching

1.	c	**4.**	h	**7.**	i	**10.**	e
2.	f	**5.**	g	**8.**	b		
3.	a	**6.**	d	**9.**	j		

Multiple Choice

1.	e	**3.**	c	**5.**	c
2.	c	**4.**	b		