SG.17.1.5

TECHNICAL GUIDANCE DOCUMENT NUMBER 5: GLYCOL DEHYDRATORS

Introduction

This document provides technical guidance to Partners of the CCAC Oil and Gas Methane Partnership (OGMP). It is one in a series describing a core source of methane emissions from oil and natural gas production operations. The guidance documents introduce suggested methodologies for quantifying methane emissions from specific sources and describes established mitigation options that Partners should reference when determining if the source is "mitigated."[1] The OGMP recognizes that the equipment and processes described in these documents are found in a variety of oil and gas operations, including onshore, offshore, and remote operations, and the way in which the emissions are quantified and mitigated may vary across locations and operational environments. As such, operational conditions, as well as logistical, safety, and cost considerations, must be evaluated on a case-by-case basis. The OGMP assumes that methane emission mitigation actions that require shut-downs of non-redundant equipment/processes (e.g., that would stop operations) would be carried out during regularly scheduled maintenance activities, unless the Partner deems the corrective action to be worthy of an early/additional shut-down.

Description of Source

Glycol dehydrators in the natural gas industry have the primary purpose of removing water from an incoming wet gas stream using monoethylene glycol, diethylene glycol, or, most commonly, triethylene glycol (TEG). "Lean," or dry, glycol is pumped via a pneumatic or electric pump to a gas contactor where it mixes with the natural gas stream. The glycol absorbs water from the gas stream, in addition to lesser amounts of methane, volatile organic compounds (VOCs), and hazardous air pollutants (HAPs), producing dry gas and "rich," or wet, glycol. Dehydrators can have a variety of configurations, which affect methane emission levels from their operation:

- Saturated glycol is sent to a regenerator/reboiler, where it is heated to boil off the water. In addition to the absorbed water, methane, HAPs, and VOCS are boiled off and routed with the steam to disposal (atmosphere, flare, etc.).
- Some dehydrators inject gas into the glycol feed to the regenerator to act as a "stripping gas" to aid in removing water from the glycol at a lower temperature. This gas vents with the steam and other gases.
- In the case of energy exchange pumps, the low-pressure glycol is pumped into the absorber by pistons driven by the high-pressure glycol leaving the absorber. The additional gas necessary for a pneumatic gas-assisted glycol circulation pumps passes through the regenerator and vents with the steam as well. In addition, the wet glycol can leak through the internal pump seals and contaminate the dry glycol, causing the dehydrator to operate less efficiently, requiring a higher circulation rate to achieve dry gas moisture specifications.

[1] For reporting purposes as described in the CCAC Oil and Gas Methane Partnership Framework, Section 3.

Additional motive gas and some of the dissolved gas can be separated from the rich glycol ahead of the regenerator with a "flash tank separator." This simply disengages the free gas from the wet liquid glycol. A flash tank can be operated at any pressure that can put the recovered gas to beneficial use: fuel, low-pressure sales line, or compressor suction. A flash tank captures approximately 90 percent of the methane entrained by the TEG when using an energy exchange pump, but achieves only small reductions (some of the dissolved hydrocarbons) using an electric pump. Replacing the energy assist circulation pump with an electric pump will eliminate most of the methane, VOC, and HAP emissions from the dehydrator system when no stripping gas (natural gas) is used in the regenerator. Capturing, redirecting, or eliminating the dehydrator regenerator vent emissions to a useful outlet allows for significant fuel gas savings or gas monetization. Putting an air condenser on the regenerator vent can condense the steam so that the non-condensable methane can be recovered.

Glycol dehydrator systems may be configured in a variety of ways. Some options include the following:

Table 5.1: Configurations for Glycol Dehydrators

Configuration	Mitigated or Unmitigated
Dehydrator does not have a flash tank separator and regenerator vents are routed to the atmosphere. Exhibit A	Unmitigated
Dehydrator has a flash tank separator that vents to atmosphere. Exhibit B	Unmitigated
Dehydrator uses stripping gas (natural gas) in the regenerator that vents with the steam and other gases to the atmosphere.	Unmitigated
Dehydrator has a flash tank separator that directs gas to beneficial use (e.g., fuel gas, low-pressure sales line, compressor suction) or control device (e.g. flare); no stripping gas is used in the regenerator and regenerator vents are routed to the atmosphere. Exhibit C	Mitigated (if confirmed to be functioning with low[A] or no methane emissions) **(OPTION A)**
Dehydrator system has all vents routed to a flare[2], VRU, or other beneficial use. Exhibit D	Mitigated (if confirmed to be functioning with low[A] or no methane emissions) **(OPTION B(a))**
Dehydrator has an electric circulation pump and uses no stripping gas (which will eliminate most of the methane, VOC and HAP emissions), and vents to the atmosphere. Exhibit E	Mitigated (if confirmed to be functioning with low[A] or no methane emissions) **(OPTION B(b))**

[A] Expected emissions levels considering mitigation option is in place and functioning properly (e.g., flare is not extinguished, etc.).

For the purposes of the OGMP, Partners will quantify and evaluate for mitigation any of the configurations in Table 5.1 that are identified as "unmitigated" for methane emissions, as described in the sections below. Even for "mitigated" configurations, Partners should evaluate the system [3] to ensure that it is functioning properly and minimizing methane emission levels. Possible equipment failures resulting from improperly functioning systems include a venting system malfunction or an extinguished flare. Moreover,

[2] "Flare" in this document refers to vertical combustion devices using an open or enclosed flame.

[3] Estimation and mitigation of fugitive emissions (e.g., glycol pumps) is provided in the OGMP Technical Guidance Document Number 2: Fugitive Equipment and Process Leaks.

Partners should evaluate gases from glycol dehydrator that are routed to a flare (flow rate, composition) to estimate methane emissions resulting from the flare combustion efficiency.

Quantification Methodology

To ensure consistent quantification of glycol dehydrator methane emissions and comparable evaluation of mitigation options, the OGMP recommends that Partners use one of the following quantification methodologies: direct measurement, engineering calculation with software, or emission factor calculation. In principle, direct measurement is the most accurate method for quantifying methane emissions.[4] With direct measurement, Partners can be more certain of emissions levels and economic costs and benefits (i.e., value of gas saved). As such, measurement is highly encouraged whenever possible. Individual Partners may choose an alternative quantification methodology if judged to be more accurate by the Partner; in this case, the Partner should document and explain the alternative methodology in the Annual Report. Measurement is highly encouraged whenever possible. However, without a vent condenser on a glycol dehydrator, the vent temperature is above 250^{o}F (120^{o}C) and difficult to measure or sample.

- Direct Measurement[5]:
  Prior to measurement, it is important to determine where the gas stream resulting from the regenerator is routed to help ensure that the measurement point(s) are accurately identified.
  Viewing the glycol dehydrator system overall with an IR leak imaging camera will identify possible fugitive leak emissions. Because the regenerator vent with a vent air condenser can be well above 140°F (60°C), the temperature above which personnel protection is required, Partners should confirm that the tools being used can safely measure at these conditions. For hot vented gases, recommended measurements tools include the following:

    - Vane anemometer.
    - Hotwire anemometer.
    - Turbine meter.

  For more details regarding each measurement and detection tool, including applicability and measurement methods, please refer to Appendix A.

- Engineering Calculation with Software:
  For triethylene glycol (TEG) systems, the best method for calculating glycol dehydrator emissions of methane as well as VOCs and HAPs (benzene, toluene, ethylbenzene, xylenes) is GlyCalc®[6]. This model is not expensive and accurately calculates the quantity and composition of the hot vent stream with different dehydrator configurations. Detailed information needed to run the simulation includes: wet

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[4] Partners should conduct measurements with appropriately calibrated instruments and per the instrument manufacturer instructions. Measurements should also be conducted in different operating conditions, to the extent that those can affect emissions levels. Appendix A to the Technical Guidance Documents includes guidance on instrument use. Partners seeking to generate Emission Factors for their operations should use direct measurement based on a statistically sound number of measurements and gas analyses to understand the content of methane and other valuable hydrocarbons.

[5] Greenhouse Gas Reporting Program, Subpart W – Petroleum and Natural Gas Systems, Section 98.233 Calculating GHG Emissions, 40 CFR 98.233(e). http://www.ecfr.gov/cgi-bin/text-idx?SID=06f07ef849ab6de919f7c4c69e285d11&mc=true&node=se40.23.98_1223&rgn=div8.

[6] http://sales.gastechnology.org/000102.html.

gas hydrocarbon composition, wet gas flow rate, wet gas temperature and pressure, existence of a gas-driven glycol pump, wet and dry gas water contents, glycol flow rate, use of stripping gas flowrate to the regenerator, and the temperature and pressure of the flash tank, if present. For ethylene glycol systems GlyCalc can be used, however additional calculations using another tool (e.g. Aspen HYSYS) will provide better estimate of emissions compounds.

- Emission Factor:
  If direct measurement or engineering calculation with software is not selected, Partners can instead use an emission factor method. Using this method, Partners apply an emission factor that represents emissions of methane volume per year per dehydrator, adjusted for the actual operating factor of the dehydrators. Partners are encouraged to use emission factors that best represent conditions and practices at their facilities. Table 5.2 presents default methane emission factors for glycol dehydrators. The recommended methane emission factor varies by industry segment and do not include the emissions from gas-assisted glycol pumps or stripping gas, which can be a significant source of CH_4 emissions.

Table 5.2: Default Emission Factors from Glycol Dehydrator Vents

Industry Segment	Methane Emission Factor[7]	
	(scm/MM scm throughput)	(scf/MMscf throughput)
Production	275.6	275.6
Processing	121.6	121.6
Transmission	93.72	93.72
Storage	117.2	117.2

Mitigation Option A – Route flash tank (if present) and dehydrator regenerator **vents to beneficial use, such as fuel gas (may require a vapor recovery unit (VRU)).**

Recovering gas that is otherwise vented to the atmosphere may allow for substantial costs savings. Having a flash tank separator prior to the regenerator would allow Partners to capture the majority of the gas entrained in the glycol prior to reaching the regenerator and the opportunity to route the gas to a beneficial use or to a flare. The recovered gas will contain methane as well as other heavier hydrocarbons. Implementing this system to recover gas from the regenerator and/or flash tank separator would involve installing additional piping and valves. The possible outlets for the recovered gas include a low-pressure fuel gas system, a VRU, compressor suction, and/or combustion in a flare.

Operational Considerations
Methane emissions from a dehydrator system are directly proportional to the glycol circulation rate in normal continuous operation when no stripping gas (natural gas) is used in the regenerator. The rich glycol contributes methane emissions from the regenerator vent. With higher circulation rates, these sources generate more emissions. When a stripping gas (natural gas) is injected in the regenerator of an unmitigated dehydrator system, it brings additional methane emissions which are proportional to the gas injection flow rate. Many dehydrators are reported to be operating at a glycol circulation rate that is higher than necessary to meet gas moisture specifications, which does little to improve the gas moisture quality but increases emissions. Therefore, Partners should consider optimizing/reducing the glycol

[7] EPA/GRI. *Methane Emissions from the Natural Gas Industry: Volume 14 – Glycol Dehydrators*, p. 23. June 1996. https://www.epa.gov/sites/production/files/2016-08/documents/14_glycol.pdf.

circulation rate and the stripping gas injection flow rate to reduce emissions at a negligible cost while meeting moisture specifications.

If the regenerator vent gas is routed to a VRU, there are certain things Partners must consider. A VRU can accept additional gas lines of various pressures routed to a tank vapor space from which it takes suction. The large volume and near atmospheric pressure of a tank vapor space acts to dampen variability of individual gas stream flow rates. However, before the additional gas lines are added, Partners should consider incoming gas composition and volume. The regenerator vent includes steam boiled out of the glycol and non-condensable hydrocarbons, including methane and the additional stripping gas (including methane) if any. Glycol dehydrator regenerator vents should have a vent air condenser to knock out most of the steam and condensable hydrocarbons when routing to a VRU. The remaining hydrocarbon gas will be richer in VOC and HAPs than the produced gas being dehydrated. The operator must ensure the VRU has sufficient capacity to accept the additional gas.

Installing a flash tank separator between the gas contactor and the regenerator separates the excess gas, at a pressure that can deliver the gas to fuel, a low-pressure sales line, or compressor suction. A flash tank separator separates gas and liquid at either the fuel gas system pressure or a compressor suction pressure of 40 to 100 psig (2.8 to 7 kg/cm^2). At this lower pressure and without added heat, the gas is rich in methane and lighter in VOCs, but water remains in solution with the TEG. The flash tank captures approximately 90 percent of the methane and 10 to 40 percent of the VOCs entrained by the TEG, thereby reducing emissions. The wet TEG, largely depleted of methane and light hydrocarbons, flows to the glycol regenerator/reboiler, where it is heated to boil off the absorbed water, remaining methane, and VOCs. These gases are normally vented to the atmosphere and the lean TEG is circulated back to the gas contactor.

Methane Emission Reduction Estimate

In a flash tank separator, gas and liquid are separated at either the fuel gas system pressure or a compressor suction pressure of 40 to 100 psig (2.8 to 7 kg/cm^2). At this lower pressure and without added heat, the gas is rich in methane and lighter VOCs but water remains in solution with the TEG. The flash tank captures approximately 90 percent of the methane entrained by the TEG, thereby reducing emissions when that methane is routed to beneficial use.[8]

When routing vents to a VRU, Partners can expect to reduce their methane emissions including those coming from the stripping gas by approximately 95 percent (or more) from regenerator vents. This reduction percentage assumes VRUs operate 95 percent of the year, allowing for 5 percent of downtime for VRU maintenance.

Economic Considerations

The costs for retrofitting a flash tank separator will vary significantly based on what a Partner already has in place. Information provided by flash tank separator manufacturing companies suggests an average equipment cost of the flash tank alone is $3,375 to $6,751. Installation costs up to 80 percent of vessel cost range from $1,684 to $3,031, including delivery, assembly, and labor costs. These costs are described in the technical documents below, based on size and site-specific factors.[9] If the Partner already has a

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[8] Natural Gas STAR Technical Document, *Optimize Glycol Circulation and Install Flash Tank Separators In Glycol Dehydrators.* https://www.epa.gov/sites/production/files/2016-06/documents/ll_flashtanks3.pdf.

[9] Ibid.

flash tank separator and/or VRU with sufficient capacity, the installation costs to implement a gas recovery system will simply be for piping and valves. Depending on gas value, the economic payback due to a relatively small savings in methane emissions could justify these costs.

For more information, see Natural Gas STAR technical documents:

- *Optimize Glycol Circulation And Install Flash Tank Separators In Glycol Dehydrators* (https://www.epa.gov/sites/production/files/2016-06/documents/ll_flashtanks3.pdf).
- *Reroute Glycol Skimmer Gas* (https://www.epa.gov/sites/production/files/2016-06/documents/rerouteglycolskimmer.pdf).
- *Pipe Glycol Dehydrator to Vapor Recovery Unit* (https://www.epa.gov/sites/production/files/2016-06/documents/pipeglycoldehydratortovru.pdf).

Mitigation Option B – (a) Route flash tank (if present) and dehydrator still overheads to flare/combustion device, or (b) replace the gas assist lean glycol pump with an electric lean glycol pump.

Flaring gas that is otherwise vented to the atmosphere may substantially reduce methane emissions. When a flash tank is present, the majority of the gas entrained in the wet glycol should be released from the liquid stream prior to it reaching the regenerator. This provides the option for the gas to be re-routed for beneficial use. The recovered gas will contain methane as well as other heavier hydrocarbons. Implementing this system to send vent gas to flare from the regenerator would involve installing additional piping and valves. Using a gas assist lean glycol pump contributes methane emissions that could be recovered, but replacing it with an electric lean glycol pump would eliminate most of those emissions, saving a potentially significant quantity of gas rather than flaring it.

Operational Considerations
As discussed under Mitigation Option A, methane emissions from an unmitigated dehydrator system depend directly on the glycol circulation rate and stripping gas flow rate if any in normal continuous operation. Many dehydrators are reported to be operating at a glycol circulation rate that is higher than necessary to meet gas moisture specifications, which does little to improve the gas moisture quality but increases emissions. Therefore, Partners should consider optimizing/reducing the glycol circulation rate to reduce emissions at a negligible cost while still meeting moisture specifications.

When considering an electric pump for replacement, Partners will need to have a reliable source of electricity available. Power can be purchased or generated onsite using recovered gas. After determining an adequate power source, Partners need to determine the correct pump size using the circulation rate and operating pressure of the dehydrator system.

Methane Emission Reduction Estimate
After implementing this technology, Partners can expect to reduce methane emissions by approximately 98 percent from sending recovered gas to flare. The reduction estimate is based on typical flare combustion efficiency of 98 percent and regenerator vent gas composition of 50 percent methane. Partners should calculate their estimated reductions according to the flare efficiency and methane composition of vent gas in their operations.

Economic Considerations

The installation costs will vary significantly based on what a Partner already has in place. To send gas to an existing flare with spare capacity, the installation costs will simply be for piping and valves. Costs to install an electric pump include the purchase, installation, and maintenance costs. Purchase costs for an electric pump can range from $1,425 up to $12,953[10], depending on the horsepower. Installation costs can be estimated to be equal to 10 percent of the capital costs. The most prominent operational cost associated with an electric pump is electricity. Generally, Partners can expect to use about 1 kilowatt (kW) per 1 brake horsepower (BHP) of the pump. Maintenance costs for an electric pump are generally less than gas-assisted glycol pumps. Electric pumps are usually gear-driven, meaning they have no slides, pistons, or check valves that deteriorate and require replacement. Partners can consider about $263 per year in annual costs for electric pumps. This value is attributed to labor, inspection, and maintaining lubrication and seals within the pump.

[10] Natural Gas STAR technical document, *Replace Gas-Assisted Glycol Pumps With Electric Pumps.* https://www.epa.gov/sites/production/files/2016-06/documents/ll_glycol_pumps3.pdf.

Exhibit A – Glycol Dehydrator with Energy Exchange Pump and without Flash Tank Separator[11]

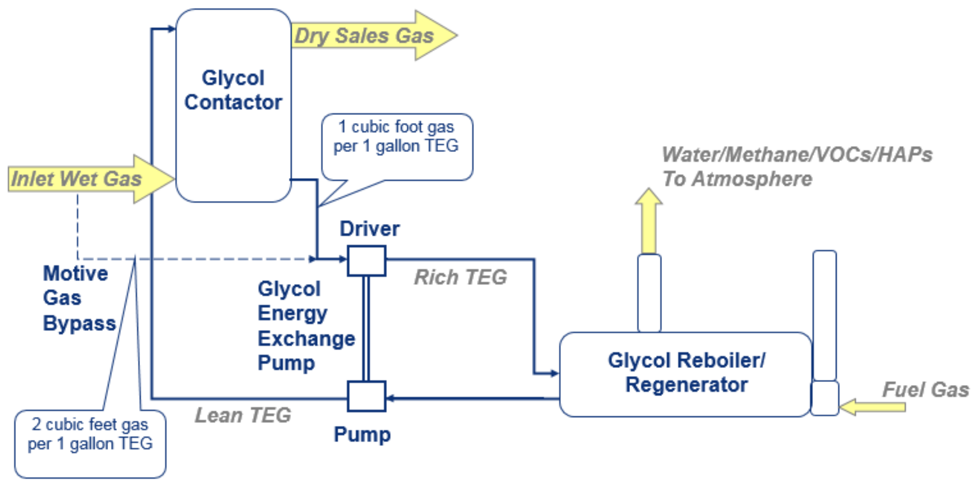
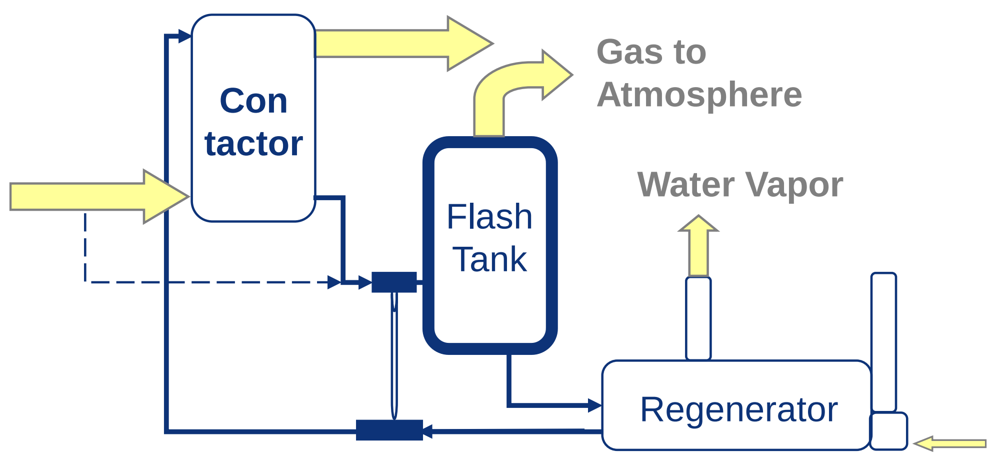


Exhibit B – Glycol Dehydrator with Flash Tank Vented to Atmosphere[12]



[11] Natural Gas STAR Producers Technology Transfer Workshop, Farmington, New Mexico, May 11, 2010: "Natural Gas Dehydration," presented by EPA

[12] Adapted from Natural Gas STAR Producers Technology Transfer Workshop, Farmington, New Mexico, May 11, 2010: "Natural Gas Dehydration," presented by EPA

Exhibit C – Glycol Dehydrator with Flash Tank Separator (FTS) Gas Not Vented[13]

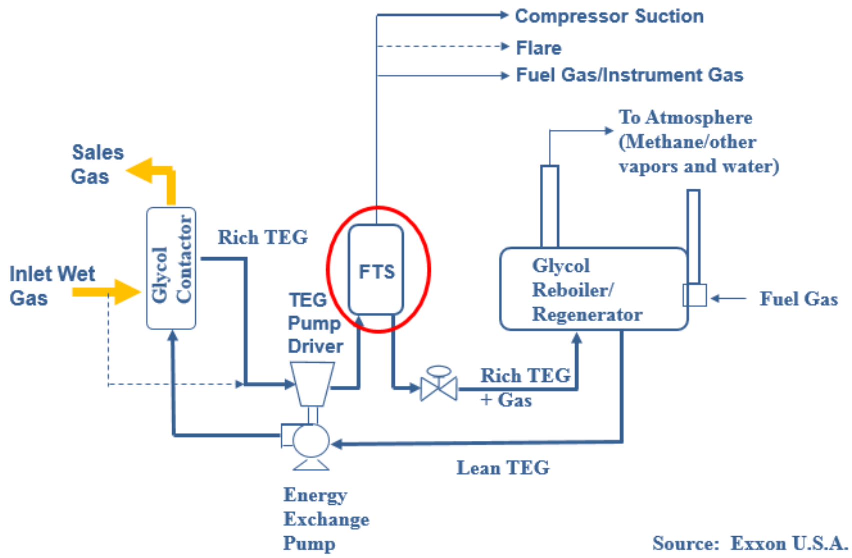
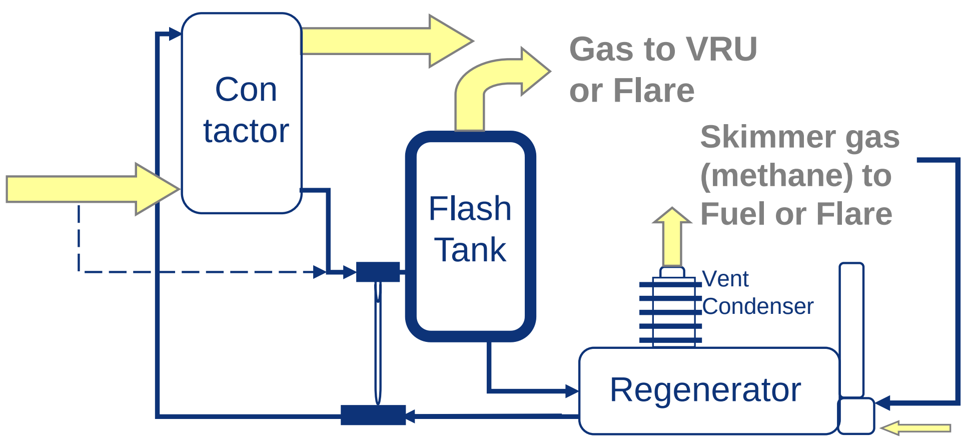
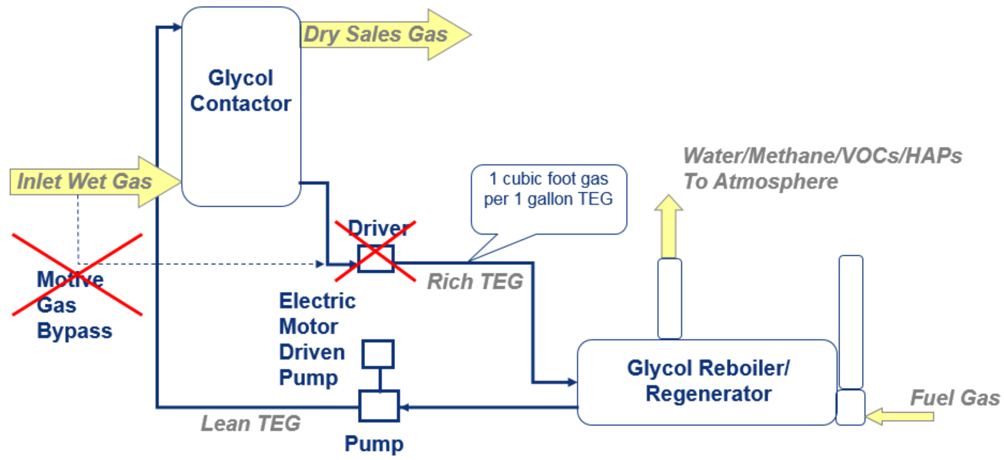


Exhibit D – Glycol Dehydrator with All Vents Captured or Flared[14]



[13] Natural Gas STAR Processors Workshop, Houston, Texas, June 25, 2002: "Improving Dehydrator Efficiency," presentation by EPA
[14] Natural Gas STAR Producers Technology Transfer Workshop, Vernal, Utah, March 23, 2010: "Natural Gas Dehydration," presented by EPA

Exhibit E – Glycol Dehydrator with Electric Circulation Pump[15]



[15] Natural Gas STAR Producers Technology Transfer Workshop, Farmington, New Mexico, May 11, 2010: "Natural Gas Dehydration," presented by EPA