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Specification for Glycol-Type Gas Dehydration Units

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SECTION 1
SCOPE

1.1 Coverage. This specification covers the minimum requirements for materials, design, fabrication and testing of a conventional lease glycol type gas dehydration system utilizing triethylene glycol as the desiccant. Conventional systems are normally designed to operate an an inlet temperature between 60°F and 120°F and at or above 400 psig pressure but not to exceed pressure limited by ANSI B16.5 Class 600 flanges. This specification encompasses a system which includes an inlet separator, a glycol/gas contractor, gas/glycol heat exchanger, glycol reboiler, glycol surge tank, glycol circulating pump(s), filter(s), glycol/glycol heat exchanger, glycol flash separator (optional) and skid(s). While this specification does not preclude dehydrators for service on offshore platforms, it should be noted that considerable additional requirements may apply to offshore units.

The manufacturer of the completed glycol type dehydration unit shall be responsible for assuring that all material, design, fabrication procedures, examinations, inspections, and tests required by this specification have been met.

Appendix A through H, Section 2, and Section 3 of this specification are for information only and are not to be considered as mandatory.

1.2 Referenced Documents. Industry Codes, Specifications and Recommended Practices are referenced and as applicable, become requirements of this specification. The latest editions and revisions of the specification, and the referenced industry codes, specifications, recommended practices and other requirements current at the time of manufacture should be considered applicable at the time of manufacture of glycol type gas dehydration units. Referenced documents may be obtained from the following sources.

ANSI: American National Standards Institute, 1430 Broadway, New York, NY

API: American Petroleum Institute, Production Department, 2535 One Main Place, Dallas, Texas 75202-3904

ASME: American Society of Mechanical Engineers, 345 E. 47th St., New York, NY 10017

ASTM: American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103

AISC: American Institute of Steel Construction, Inc., 400 N. Michigan Ave., Chicago, IL 60611

NACE: National Association of Corrosion Engineers, P.O. BOX 218340, Houston, TX 77218

TEMA: Tubular Exchanger Manufacturers Association, New York, NY 10017

SECTION 2
TERMINOLOGY

2.1 **Absorption Process.** The attraction and retention of vapors (water) by liquids (glycol) from the gas stream.

2.2 **Actual Tray.** The number of trays installed in a column or the equivalent number of actual trays for a packed column. The number of actual trays is equal to the number of theoretical trays divided by the overall tray efficiency.

2.3 **Bubble Cap Tray.** Horizontal plate holding bubble caps and downcomers in the contactor.

2.4 **Bubble Caps.** Slotted metal caps attached over elevated nozzles (risers) on the bubble cap trays. The slots cause the gas to break up into small bubbles for intimate contact with the glycol.

2.5 **Condensate.** Light liquid hydrocarbons.

2.6 **Contactor (or Absorber).** A vertical pressure vessel where gas and glycol are intermingled countercurrently to remove water vapor from the gas. The contactor usually contains bubble cap trays, valve trays or packing.

2.7 **Dehydration.** Removal of water vapor from a gas. Maximum water content of the dehydrated gas is normally 7 lbs. H_2O/MMSCF.

2.8 **Design Pressure.** The pressure used in the design of a vessel for the purpose of determining the minimum permissible thickness or physical characteristics of the different parts of the vessel. When applicable, static head shall be added to the design pressure to determine the thickness of any specific part of the vessel.

2.9 **Dew Point.** The temperature at which vapor begins to condense into a liquid at a particular system pressure. A natural gas stream exhibits both a hydrocarbon and water dew point.

2.10 **Dew Point Depression.** The difference in water dew point temperature between the inlet and outlet gas.

2.11 **Downcomer.** The vertical conduit between trays which allows liquid to pass from tray to tray.

2.12 **Firetube.** The firetube is that portion of the firebox in contact with the liquids. Natural gas or hydrocarbon liquids are normally used to fire the reboiler through a submerged furnace chamber called the firetube. The firetube normally consists of one of more U-tubes fired at one end and exhausting through a vertical stack at the other end for each U-tube.

2.13 **Free Water.** Liquid water which is not dissolved or emulsified with any other substance.

2.14 **Gas/Glycol Heat Exchanger.** A shell-and-tube, pipe-in-pipe, or other type heat exchanger employed to cool the lean glycol with the gas leaving the contactor before the glycol enters the contactor.

2.15 **Glycol.** A liquid desiccant used to absorb water vapor from the gas. Triethylene glycol is the most common glycol used in gas dehydration.

a. Lean Glycol (or Dry Glycol). Glycol that has been regenerated and is essentially free of water.

b. Rich Glycol (or Wet Glycol). Glycol that has absorbed water.

2.16 **Gas-Condensate-Glycol Separator (Flash Separator).** A two or three phase separator which is used in the rich glycol stream to remove entrained gas and hydrocarbon liquids.

2.17 **Glycol/Glycol Heat Exchanger.** A shell-and-tube, plate type, double pipe, internal coil within the surge tank or other type heat exchanger employed to recover heat from the outgoing hot lean glycol from the reboiler and preheating the incoming cool rich glycol from the contactor.

2.18 **Heat Density.** This term is commonly applied to the heat release through the cross section of the firetube, expressed as BTU/hour/square inch of cross sectional area.

2.19 **Heat Duty.** Heat absorbed by the process, expressed as BTU/hr.

2.20 **Heat Flux.** The average heat transfer rate through the firetube, expressed as BTU/hr./square foot of exposed area.

2.21 **Inlet Scrubber.** A separator which removes free liquids from the inlet gas stream. This separator may be separate or integral with the contactor and contains a mist extractor which is usually a wire mesh type.

2.22 **Intake Flame Arrestor.** A device placed on the air intake of the firetube to prevent propagation of flame from inside the firetube to the outside atmosphere. It normally consists of a corrugated aluminum cell mounted in a metal housing which attaches to the firebox.

2.23 **Liquid Seal.** A liquid column in the downcomer that forces the gas to pass up through the trays rather than up the downcomer.

2.24 **MMSCF.** One million standard cubic feet of gas. One SCF is a cubic foot of gas at standard conditions specified, for example 60°F and 14.65 psia.

2.25 **Maximum Allowable Working Pressure (MAWP).** The maximum gage pressure permissible at the top of a vessel in its operating position for a designated temperature. This pressure is based on calculations for every element of the vessel using nominal thicknesses less allowances for corrosion and thickness required for loadings other than pressure. It is the basis for the pressure setting of the pressure relieving devices protecting the vessel.

2.26 Operating Pressure. The pressure at the top of a pressure vessel at which it normally operates. It shall not exceed the maximum allowable working pressure and it is usually kept at a suitable level below the setting of the pressure relieving devices to prevent their frequent opening.

2.27 Packing. "Rings," "saddles" or other shaped pieces in the contactor, still column or reboiler stripping column that provides a large surface area for intermingling liquid and vapor during absorption or distillation.

2.28 pH. Measure of acidity of a liquid on a scale of 0-14 with 7 being neutral. 0-7 is acidic and 7-14 is alkaline.

2.29 Reboiler (Reconcentrator/Regenerator). The vessel where water is boiled out of the glycol.

2.30 Reflux. Term given to the process of partially condensing still column vapor and allowing the condensed liquid to flow back down the column.

2.31 Removable. Total component is field replaceable without welder assistance.

2.32 Saturated Gas. A gas stream which contains the maximum amount of water vapor at a given temperature pressure without condensing the water.

2.33 Sparging Tube. Internal pipe in the reboiler used to distribute stripping gas.

2.34 Still Column (Reflux Column). Vertically mounted fractionation column on top of the reboiler.

2.35 Stripping Column. Packed column where glycol from the reboiler flows downward while gas is flowing upward stripping the glycol of water.

2.36 Stripping Gas. Gas that is passed through glycol being regenerated to help remove water that can not be removed by the distillation process alone. Sparging tubes and stripping columns are two methods of gas stripping.

2.37 Surge tank. Reservoir for regenerated glycol which may be integral with or separate from the reboiler.

2.38 Theoretical Tray. One in which the vapor leaving the tray is in equilibrium with the liquid leaving. Both leave the tray at the same pressure and temperature.

2.39 Tray Efficiency. The ratio between the number of theoretical and actual trays.

2.40 Valve Tray. Horizontal plate holding valves and downcomers in the contactor. A valve consists of a liftable metal plate which covers a hole in the tray, providing a variable area for gas flow.

2.41 Water Content. The amount of water vapor contained in the gas expressed in pounds of water per million cubic feet (MMSCF) of gas.

2.42 Water Vapor. Water in a gaseous form.

SECTION 3
PROCESS DESCRIPTION

3.1 General. A natural gas stream can be dehydrated by contacting the gas with glycol. This process (see Figure 3.1) is normally carried out at an elevated pressure in a vessel called a contactor or absorber. After absorbing the water, the glycol is reconcentrated by boiling off the water at atmospheric pressure in a regenerator. A pump is used to recirculate the glycol to the contactor.

3.2 Inlet Scrubber. An inlet scrubber is required, either integral with the contactor or as a separate vessel upstream, to remove free liquids from the gas stream going to the contactor. The mist extractor in this vessel removes larger droplets entrained in the gas.

3.3 Contactor. The contactor vessels may be categorized as to the manner in which the absorption process is accomplished. One type uses trays equipped with bubble caps, valves, other devices, to maximize gas-to-glycol contact. The action of the gas flowing upward through the glycol layer on each tray creates a froth above the tray, where most of the absorption takes place. The other type of contactor is referred to as a packed tower. It is filled with packing, which has a large surface area per unit volume. Glycol flowing downward wets the entire packing surface. Absorption takes place as the gas flows upward through the packing, contacting the wetted surface. In either type of vessel, a mist extractor removes entrained glycol droplets from the dehydrated gas stream before it leaves the top of the contactor. On larger units, an optional residue gas scrubber may be justified. Rich (wet) glycol is directed from the bottom of the contactor to the regeneration system.

3.4 Gas/Glycol Heat Exchanger. Absorption is improved with lower temperature glycol. A gas/glycol heat exchanger is required which uses dehydrated gas to cool the lean (dry) glycol before it enters the top of the contactor.

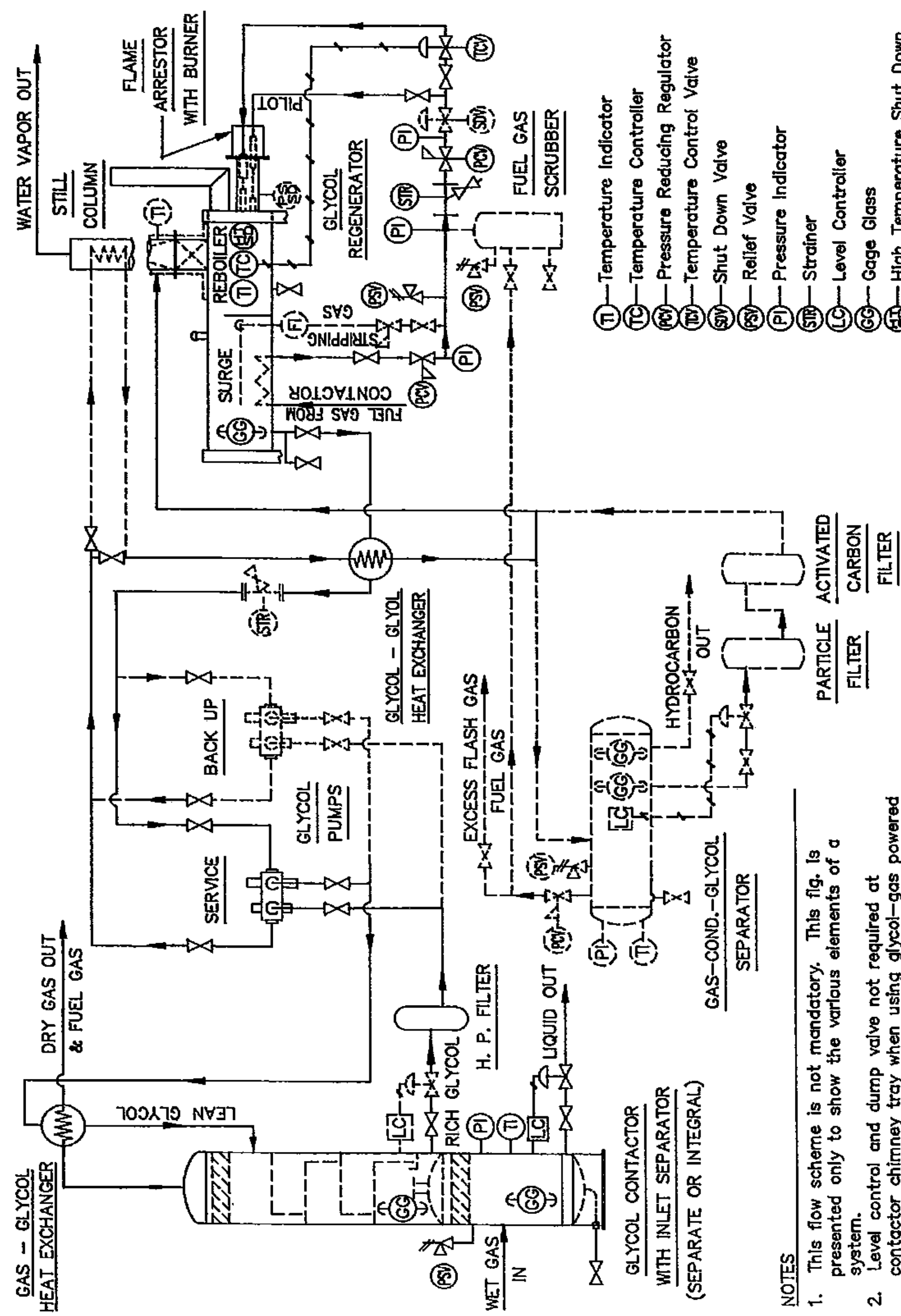
3.5 Regeneration System. The regeneration system consists of several pieces of equipment. If glycol-gas powered pumps are installed, energy from the high pressure rich glycol along with a small amount of gas is used to pump the lean glycol. If an optional reflux coil in the still column is provided, the rich glycol flows through it before entering the glycol/glycol heat exchanger. The glycol/glycol heat exchanger serves two purposes: 1) to cool the lean glycol to a temperature as recommended by the pump manufacturer, and 2) to conserve energy by reducing the heat duty in the reboiler.

3.6 Gas-Condensate-Glycol Separator. A frequently used option in regeneration systems is a gas-condensate-glycol separator, and should be included when the inlet gas contains condensate. It may be located upstream or downstream of the glycol/glycol heat exchanger and usually operates at a pressure of 25-75 psig. It removes condensate from the glycol prior to the reboiler, which minimizes coking and foaming problems. The separator also captures flash gas that is liberated from the glycol and exhaust gas from the glycol-gas powered pumps, so that the gas may be used as fuel. Glycol is regulated from the separator to the reboiler by means of a level controller and dump valve. Condensate removal may be controlled automatically or manually.

3.7 Reboiler. Rich glycol enters the reboiler through the still column. It is then heated to 350-400°F, which causes the water that was absorbed in the contactor to vaporize. The reboiler is usually heated by combustion of natural gas, but may utilize other fuels, steam, hot oil or other heat sources. The regenerated lean glycol gravity feeds from the reboiler, through the glycol/glycol heat exchanger, and into the pump suction for recirculation back to the contactor. Either electric, gas-powered, or glycol-gas powered pumps may be used.

3.8 Still Column. Water and glycol vapors from the reboiler enter the bottom of the still column, which is mounted on top of the reboiler. The bottom section contains packing, while the top section of the still column may contain a reflux coil or external fins. Reboiler vapors are cooled and partially condensed to provide reflux, which improves the separation between glycol and water. The remaining water vapor leaves the top of the still column and vents into the atmosphere.

3.9 Filters and Strainers. Regeneration systems contain various types of filters and strainers. A particle filter or fine mesh strainer is required to protect the pump. To reduce foaming, an activated carbon filter may be installed to remove heavy hydrocarbons from the glycol. There is no standard arrangement for these items in the system.



NOTES

1. This flow scheme is not mandatory. This fig. is presented only to show the various elements of a system.
2. Level control and dump valve not required at contactor chimney tray when using glycol-gas powered pumps.
3. Optional items are shown in dashed lines.

FIG. 3.1
TYPICAL SCHEMATIC FLOW DIAGRAM
GLYCOL TYPE GAS DEHYDRATION UNIT

SECTION 4
MATERIAL

4.1 General. The materials acceptable for use in construction of glycol type gas dehydration systems are given in this section. The specification and identification of materials by the manufacturer shall comply with the requirements given by the specific code or standard under which the material is used in fabrication. Materials of unknown specifications or those not meeting the requirements of the applicable code shall not be used. Material shall be marked and be identifiable at the time of fabrication. Materials given are to be considered as the minimum qualities of their kinds and such specifications do not exclude the use of any other material acceptable to the ASME, ANSI, TEMA, or ASTM code or standard under which the material is fabricated.

Pressure retaining components exposed to corrosive gases such as carbon dioxide and hydrogen sulfide shall meet the requirements as specified by the purchaser (See Appendix B for guidelines).

4.2 Pressure Vessels. Materials used in the fabrication of pressure vessels shall comply with the requirements of the latest edition of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

4.3 Pipe Heat Exchangers. Materials used in the fabrication of pipe heat exchangers shall comply with the requirements of the latest edition of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

4.4 Plate Heat Exchangers. Specification and identification of materials used shall be stated and shall comply with the Manufacturer's standard which defines the pressure-temperature rating marked on the plate heat exchanger and described in the Manufacturer's literature.

4.5 Shell and Tube Heat Exchangers. Material used shall comply with the requirements of the Standards of Tubular Exchanger Manufacturers Association and the ASME Boiler and Pressure Vessel Code Section VIII, Division 1. The application of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1 stamp is required.

4.6 Structural. Specification of load bearing skid and other structural materials is to conform to ASTM A-36.

4.7 Piping. Piping is to be steel. Specification and identification of piping components, including flanges, fittings, and gaskets, shall comply with the appropriate standard given in ANSI 31.3 (see Table 326.1).

4.8 Proprietary Parts. Specification and identification of proprietary parts shall comply with the Manufacturer's standard which defines the pressure-temperature rating either marked on the part or described in the Manufacturer's literature.

4.9 Other Equipment. Materials for atmospheric reboilers, surge tanks, lugs, clips, baffles, firetubes, stacks, etc., require identification to a specification which will confirm that the physical and chemical properties are satisfactory for welding with a qualified welding procedure specification.

4.10 Coatings. The purchaser is to specify both internal and external coatings when required. All coatings are to be specified and identified by the coating manufacturer's standard which defines the service restrictions of the material as described in the manufacturer's literature.

4.11 Relief Valves. Relief valves shall comply with the requirement of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1. Specification and identification shall comply with the Manufacturer's standard which defines the pressure-temperature rating and the service requirements as either marked on the part or described in the Manufacturer's literature.

4.12 Rupture Disks. Rupture disks shall comply with the requirements of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1. Specification and identification shall comply with the Manufacturer's standard which defines the pressure-temperature rating and the service requirements as either marked on the part or described in the Manufacturer's literature.

4.13 Instruments. Specification and identification of instruments shall comply with the Manufacturer's standard which defines the pressure-temperature rating either marked on the instrument or described in the Manufacturer's literature.

4.14 Instrument Tubing and Fittings. Tubing and fittings are to be steel. Specification and identification of tubing and fittings shall comply with an ASTM specification. The pressure-temperature rating of the tubing is to be determined by ANSI B31.3.

4.15 Electrical. Electrical components shall be specified to meet the requirements as to class, division, and group using API RP 500B "Recommended Practice for Classification of Locations for Electrical Installations at Drilling Rigs and Production Facilities on Land and on Marine Fixed and Mobile Platforms."

4.16 Welding Materials. Specification of welding materials shall comply with the requirements of the ASME Boiler and Pressure Vessel Code Section IX.

4.17 Insulation. Specification and identification of insulation materials shall comply with an ASTM standard and the Manufacturer's standard which defines the thermal resistivity and temperature rating either marked on the material or described in the Manufacturer's literature. Insulation jacketing shall be aluminum or stainless steel. Specification and identification of jacketing shall comply with an ASTM standard and the Manufacturer's standard which defines the thickness and service limits of the material as described in the Manufacturer's literature.

4.18 Trays. Tray support rings, trays, and tray components are to be steel. Specification and identification of tray parts welded to the shell of a pressure vessel shall be specified and identified as required in Paragraph 4.2 of this section. Tray material subject only to minor pressure and load stresses is to comply the specification of an ASTM designation and identification of the material is to be to the tray manufacturers standard practice of marking or packaging.

4.19 Packing. Specification and identification of packing shall comply with the Manufacturer's standard which defines the type, size, and temperature rating as described in the Manufacturer's literature.

4.20 Mist Extractors. Specification and identification of mist extractors shall comply with the Manufacturer's standard which defines the type, size, and temperature rating as described in the Manufacturer's literature.

SECTION 5
DESIGN

5.1 General. A conventional lease glycol type dehydration unit furnished to this specification is to be a skid mounted assembly. The inlet scrubber and contactor may be skid or foundation mounted separate from the reconcentrator skid upon agreement between the purchaser and the manufacturer.

The User Design Information Sheet and the Manufacturer Data Sheet given in Appendix C may be used by both the purchaser and the manufacturer to specify the detailed requirements of design and fabrication of the equipment.

Sizing criteria for the individual pieces of equipment are given in Appendix D.

5.2 Inlet Scrubber. The inlet scrubber furnished to this specification is to be vertical and is normally available in sizes and maximum allowable working pressure ratings shown in Table 5.1. Table 5.1 is for nominal industry standards. Available sizes and working pressures may vary from the stated ratings. Other types, sizes, pressures, and temperature ratings may be furnished by agreement between the purchaser and manufacturer provided they conform to API Specification 12J.

The inlet scrubber may be separate or integral with the contactor as specified by the purchaser. The inlet scrubber requires a mist extractor and an integral scrubber also requires a chimney tray with a sufficient volume to prevent glycol overflow into the scrubber during shutdown.

5.3 Contactor. The gas contactor furnished to this specification is to be vertical and is normally available in sizes and maximum allowable working pressure ratings shown in Table 5.2. Table 5.2 is for nominal industry standards. Available sizes and working pressures may vary from the stated ratings. Other sizes, pressures, and temperature ratings may be furnished by agreement between the purchaser and manufacturer.

Many types of packing may be used in the contactor for the contacting of the gas with the glycol. Several of the elements are rings, saddles, and structured. A contactor provided with packing shall not exceed 8 feet of packing height without redistribution of the glycol in the tower.

A contactor provided with trays shall utilize a minimum of 18 inches tray spacing.

The contactor shall be provided with a mist extractor to prevent excessive glycol loss. The minimum distance from the top tray to the mist extractor shall be equal to the tray spacing plus six (6) inches. Prevention of gas channeling from the mist extractor to the outlet nozzle shall be accomplished by either a minimum distance of 0.35 times the inside vessel diameter or the addition of an effective outlet distribution system.

5.4 Gas/Glycol Heat Exchanger. The gas-glycol heat exchanger may be either external or internal to the contactor.

5.5 Gas-Condensate-Glycol Separator (optional). A flash separator furnished to this specification may be either two phase or three phase. The separator is sized for the retention time recommended in Appendix D based on the liquid design circulation rate.

5.6 Reboiler. A reboiler furnished to this specification is to be horizontal. The firetube shall be field removable for inspection. The heat duty requirement of the reboiler shall include the benefit of a heat exchanger used for heat recovery in the reconcentrator system.

The reboiler should be designed for a minimum of 1½ psi of internal pressure or full of water, whichever is greater. The deflection of flat end closures should be limited to the diameter divided by 500 with 1½ psi internal pressure or full of water, whichever is greater.

Typical reboiler nominal duties are given in Table D.9 of Appendix D.

5.7 Still Column. A still column furnished to this specification is to be integral with the reboiler. The column is to be flanged such that it is removable and is to be provided with one or more lugs for removal.

5.8 Surge Tank. The surge tank is used to provide glycol for operating purposes and is not considered as storage. Additional holding capacity for glycol from the other equipment during shutdown must be specified by the purchaser.

A surge tank furnished to this specification is to be horizontal and may be integral with the reboiler.

5.9 Glycol-Glycol Heat Exchanger. A glycol to glycol heat exchanger furnished to this specification is to be either external or integral with the surge tank. The exchanger shall be capable of cooling the lean glycol to the maximum temperature recommended by the pump manufacturer.

5.10 Skid. Some skid mounted items may be shipped separately from the skid by agreement of the purchaser and manufacturer. The skid provided to this specification is to have a pull bar or lift lugs for loading and unloading for shipment. The skid is to be capable of a single end lift as assembled for shipment.

5.11 Firetube Heat Flux. The average heat flux shall be no higher than 10,000 BTU/hr.-sq. ft. of exposed area.

> Example: 8⅝″ O.D. Sch. 20, 0.25″ wall fire tube having 25.0 square feet of surface, 51.85 sq. in. cross sectional area and rated at 250,000 BTU/hr. heat duty.

$$\text{Average Heat Flux} = \frac{\text{Firetube Rating (BTU/hr.)}}{\text{Sq. Ft. of Firetube Surface}}$$

$$= \frac{250{,}000}{25.0} = 10{,}000 \text{ BTU/hr.-sq. ft.}$$

5.12 Firetube Heat Density. Heat released through the cross-sectional area of the firetube is regulated by the burner mixer and burner nozzle. A firetube conforming to the specification shall have a maximum heat density of 15,000 BTU/hr.-sq. in. for natural draft burners.

Example from Par. 5.11

$$\text{Heat Density} = \frac{\text{Firetube Rating (BTU/hr.)}}{\text{(Cross Sectional Area, in}^2\text{) (Efficiency)}}$$

Where: Efficiency = 0.7 (constant for this calculation)

$$= \frac{250{,}000 \text{ BTU/hr.}}{(51.85 \text{ in}^2)(0.7)} = 6{,}888 \text{ BTU/hr.-sq.in.}$$

5.13 Stack Height. The height of the stack shall be no less than required to provide draft sufficient to overcome the pressure drop in the firetube, flame arrestor, stack, returns, turbulators, dampeners, and stack flame arrestor if provided. The operating site elevation shall be considered in the draft calculations. The purchaser shall advise the manufacturer of the site elevation.

5.14 Firetube. The firetube shall be not less than 0.188 inch minimum wall thickness. Corrosion allowance is not normally added to the firetube wall. The burner shall be equipped with an intake flame arrestor.

5.15 Pressure Relief. All pressure vessels, regardless of size or pressure, shall be provided with pressure relieving devices and set in accordance with ASME code requirements. Multiple pressure relieving devices such as a pressure relief valve in conjunction with a rupture disc may be used to provide the necessary relieving capacity. Pressure relieving devices shall be installed in the vapor space on each vessel, or in the piping connected to the vessel or series of vessels, with consideration given to the internals that may restrict the relieving capacity, provided the piping system does not contain valves which can isolate any vessel in the system. The relief valve is normally set at the maximum allowable working pressure (MAWP). The rupture disk is normally selected to relieve above the set pressure of the relief valve. The pressure relief devices need not be provided by the manufacturer, but overpressure protection shall be provided prior to placing the pressure vessels in service. The Purchaser should determine who has the responsibility to furnish relief devices on the scrubber and contactor.

Thermal relief is permitted on pressure vessels where the vessel can only receive fluids from vessels that are of an equal or lower working pressure and the vessels that provide inlet fluid to the vessel are capable of full capacity relief. Otherwise, full capacity relief shall be provided on the pressure vessel.

Discharge lines from pressure relief devices should receive consideration on an individual basis. A detailed discussion is beyond the scope of this standard. Recommendations for discharge line consideration may be obtained from Appendix M, Installation and Operation, of the ASME Code as well as API RP 520, "Design and Installation of Pressure Relieving Systems in Refineries" and API RP 521, "Guide for Pressure Relief Systems and Depressuring Systems."

TABLE 5.1
INLET SCRUBBERS
SIZE AND WORKING PRESSURE RATINGS

Nominal Diameter, Inches	Maximum Allowable Working Pressure, PSIG @ 130°F			
12¾	720	1000	1200	1440
16	720	1000	1200	1440
20	720	1000	1200	1440
24	720	1000	1200	1440
30	720	1000	1200	1440
36	720	1000	1200	1440
42	720	1000	1200	1440
48	720	1000	1200	1440
54	720	1000	1200	1440
60	720	1000	1200	1440

NOTES:

a. Shell length is generally expanded in 2½ foot increments measured from head seam to head seam and is typically 5 feet, 7½ feet, or 10 feet. A minimum length to diameter ratio of 2.0 is normally used.
b. Vessel diameter is generally expanded in 6 inch increments, measured either as outside diameter (OD) or inside diameter (ID). OD Scrubbers are normally furnished up to 24 inch diameter. Scrubbers above this size may be OD or ID vessels.
c. Integral scrubber is usually the same diameter as the contactor since normally a uniform diameter is most economically constructed and the minimum diameter is generally governed by the allowable velocity of the contactor.
d. The MAWP of 720 and 1440 in the above table are limited by the ANSI class 300 and 600 flange ratings. Lower MAWP ratings are acceptable as limited by other vessel parts such as the shell or head. The MAWP is to be greater than the specified operating pressure by the larger value of 25 psig or 10 percent of the operating pressure.

TABLE 5.2
VERTICAL CONTACTORS
SIZE AND WORKING PRESSURE RATINGS

Nominal Diameter, Inches	Maximum Allowable Working Pressure, PSIG @ 130°F			
6⅝	720	1000	1200	1440
8⅝	720	1000	1200	1440
10¾	720	1000	1200	1440
12¾	720	1000	1200	1440
14	720	1000	1200	1440
16	720	1000	1200	1440
18	720	1000	1200	1440
20	720	1000	1200	1440
24	720	1000	1200	1440
30	720	1000	1200	1440
36	720	1000	1200	1440
42	720	1000	1200	1440
48	720	1000	1200	1440

NOTES:

a. Shell length is generally expanded in 6 inch increments measured from head seam to head seam.

b. Vessel diameter is generally expanded in 6 inch increments, measured either as outside diameter (OD) or inside diameter (ID). OD Contactors are normally furnished up to 24 inch diameter. Contactors above this size may be OD or ID vessels.

c. The MAWP of 720 and 1440 in the above table are limited by the ANSI class 300 and 600 flange ratings. Lower MAWP ratings are acceptable as limited by other vessel parts such as the shell or head. The MAWP is to be greater than the specified operating pressure by the larger value of 25 psig or 10 percent of the operating pressure.

SECTION 6
FABRICATION, TESTING AND PAINTING

6.1 Vessel. Inlet scrubber, contactor towers, glycol condensate separators, filters or any vessel used that is a part of the dehydration unit and has a working pressure greater than 15 psig and an inside diameter greater than 6" shall be shop constructed, tested and stamped in accordance with the latest edition of the ASME Boiler and Pressure Vessel Code Section VIII, Division 1.

6.2 Glycol Reboiler. Shell, firetube stack and accessories shall be fabricated and assembled using good workmanship to assure compliance with the manufacturer's drawings and specifications. The completed reboiler shell and surge tank shall be leak tested at 1.5 psi after the firetube(s) has been installed. The still column shall be tested either before or after installation on the reboiler. The reboiler shall be visually inspected for excessive distortion or bending of any surface area and any deficiencies corrected.

6.3 Heat Exchangers. Shell and tube type heat exchangers greater than 6" inside diameter and with pressure ratings above 15 psig shall be constructed, tested and stamped in accordance with the latest edition of the ASME Boiler and Pressure Vessel Code Section VIII. Pipe type heat exchangers shall be constructed and tested in accordance with ANSI B31.3. Plate coil and water type heat exchangers, limited to glycol/glycol heat exchanger service, shall be tested to 1.5 times design pressure but may be excluded from ASME Code construction.

6.4 Piping. All screwed or welded piping 1" nominal diameter and larger shall conform to ANSI 31.3 except screwed piping shall have a minimum wall thickness of schedule 80 and welded piping shall have a minimum wall thickness of schedule 40.

6.5 Painting. Before shipment, all components of the unit shall be mechanically cleaned of rust, grease, loose scale and weld spatter. At least one coat of good grade commercial metal primer suitable for the operating surface temperatures shall be applied to all outside surfaces. Finish coats or special painting systems shall be applied if so required by the purchaser at the time of the purchase. All sight gages, pressure gage glasses, pump plungers, packing, nameplates and any other components that could be damaged by sandblasting or paint over-spray shall be protected to prevent damage.

6.6 Insulation. Reboilers shall be primed, insulated and covered with a weatherproof protective jacket. Other components may be insulated as specified at time of purchase. See Section 4 for insulation materials.

SECTION 7
MARKING

7.1 Nameplates. Manufacturers of glycol type dehydration units furnished to this specification shall identify each of the following components with a separate corrosion resistant nameplate.

7.1.1 Reboiler

7.1.2 Contactor

7.1.3 Inlet Scrubber (if not integral with contactor)

7.1.4 Gas-Condensate-Glycol Separator (if furnished)

7.1.5 Glycol/Glycol and Gas/Glycol Heat Exchanger (if not identified by the respective manufacturer)

7.1.6 Glycol Pump (if not identified by the respective manufacturer)

7.2 Reboiler. A nameplate shall be attached to the firetube flange end of the reboiler above the flame cell opposite the stack and shall bear the following information:

7.2.1 Spec 12GDU

7.2.2 Manufacturer's name

7.2.3 Manufacturer's serial number

7.2.4 Year built

7.2.5 Weight empty, lbs

7.2.6 Firetube rating, BTU/hr at ______ BTU/hr/ft^2

7.2.7 Firetube area, sq. ft.

7.2.8 Shell sizes, O.D., in. x length, feet

7.2.9 Design Pressure, psig

7.2.10 Additional markings such as firebox diameter, length, thickness, material; turbulators installed; still column material desired by the manufacturer or requested by the purchaser are not prohibited.

7.3 Contactor. A nameplate shall be attached to the side of the vessel at about eye level (5 to 6 ft above skid level if practical) and shall contain the information required by the ASME Code plus:

7.3.1 Spec 12GDU

7.3.2 Number of trays (for tray tower)

7.3.3 Tray spacing (for tray tower)

7.3.4 Type of packing (for packed contactor)

7.3.5 Height of packing (for packed contactor)

7.3.6 Type of mist extractor

7.4 Inlet Scrubber. A nameplate shall be attached to the side of the vessel at about eye level and shall contain the information required by the ASME Code plus:

7.4.1 Spec 12GDU

7.4.2 Type of mist extractor

7.5 Gas-Condensate-Glycol Separator. A nameplate shall be attached to the side of the vessel at about eye level and shall contain the information required by the ASME Code plus:

7.5.1 Spec 12GDU

7.5.2 Type of mist extractor (if applicable)

7.6 Glycol/Glycol and Gas/Glycol Heat Exchanger. A nameplate shall be attached to each component and shall contain the information required by the ASME Code (if applicable) and the following information:

7.6.1 Manufacturer's name

7.6.2 Manufacturer's serial number

7.6.3 Year built

7.6.4 Design Pressure, psig

7.6.5 Design Temperature, °F

7.6.6 Either type or model number that can be traced to the heat exchanger manufacturer's engineering data or it shall include enough information so that heat transfer calculations can be made.

7.7 Glycol Pump. The glycol pump shall have a nameplate attached in a visible location with the following information:

7.7.1 Manufacturer's name

7.7.2 Manufacturer's serial number

7.7.3 Manufacturer's model number or type that may be traced to the pump manufacturer's engineering data or it shall include enough information to allow calculations to be made for glycol rate.

7.8 Valves and Controls. It is the manufacturer's responsibility to assure that valves and controls necessary to the operation of the unit have proper identification markings so that traceability to a manufacturer can be accomplished for future information.

7.9 ASME Code Marking. ASME components furnished to this specification shall have a nameplate affixed to the vessel as required by the latest edition of the ASME Code. In lieu of separate API nameplate and at the discretion of the manufacturer, the information required by Section 7 may be included on the ASME Code nameplate below the Code required markings.

7.10 Stamping. Stamping directly on the vessel shell may be injurious to the vessel and should be avoided.

SECTION 8
INSPECTION AND REJECTION

8.1 ASME Code Inspection. The Authorized Inspector shall perform all duties required by the ASME Code Section VIII, Division 1.

8.2 Inspection by the Manufacturer. It is the obligation of the manufacturer to assure the unit complies with the content of this specification.

APPENDIX A
PROCESS CONSIDERATIONS

A.1 Inlet Gas Temperature. One of the key design and operating variables of a glycol-type gas dehydration unit is the temperature of the entering wet gas. For operation, this temperature should be maintained between 60°F and 120°F. At lower gas temperatures, glycol on the contactor trays will become very viscous, resulting in reduced tray efficiency, increased pressure drop, and glycol carryover. Higher Temperatures will increase the amount of water vapor to be removed, as well as require very pure lean glycol to meet the dehydration specification. Glycol vaporization losses will also increase at higher gas temperatures. Inlet gas cooling equipment is outside the scope of this specification, but if needed, it should be located upstream of the inlet gas scrubber.

A.2 Inlet Separation. An inlet scrubber with a mist extractor, either integral in the contactor tower or a separate vessel located just ahead of the contactor, is essential to proper operation of a glycol type gas dehydration system. Free liquids, water, hydrocarbon condensate and compressor lube oil in the gas stream can cause problems in several ways. First, the extra water puts an unnecessary load on the glycol, and can overload to the point that the required outlet gas dew point is not met. Second, hydrocarbon liquid and compressor lube oil cause glycol to have a higher tendency to foam, leading to a reduction of gas handling capacity in the contactor and to higher glycol losses from the contactor and the regeneration system. Also, liquid hydrocarbons and lube oil will degrade in the reboiler, build up on the firetube and create hot spots. The mist extractor may be one of several designs; for example, a section of parallel vanes, or a wire mesh pad. The mist extractor should remove from the gas stream essentially all of the small droplets of liquid (normally down to 10 micron diameter) before the gas leaves the vessel. A gas stream containing compressor lube oil needs special considerations in separator design and a coalescing filter-type scrubber is recommended. In cold weather applications, a heating coil may be needed in the liquid section of the scrubber to prevent freezing.

A.3 Contactor. The contactor diameter, tray spacing/number of trays or packing, inlet and outlet nozzle sizes, vapor disengagement spacing between the mist extractor and the top of the trayed or packed section, and spacing to the outlet nozzle should be considered in the contactor design. The contactor should have a mist extractor designed to remove essentially all of the glycol droplets which exceed 5 microns in diameter.

A.4 Gas/Glycol Heat Exchanger. It is important that the glycol entering the contactor be cooled to a 10° to 30°F above the temperature of the gas stream. This is necessary because the equilibrium conditions between the glycol and the water vapor in the gas are affected by temperature. At higher temperatures, more water vapor will remain in the gas stream. A cooler glycol temperature will decrease the glycol vaporization losses but hydrocarbons may condense in the contactor.

A.5 Glycol Reboiler Heat Flux/Temperature. Glycol degradation should be minimized by designing the glycol reboiler firetube with an average heat flux of no higher than 10,000 BTU/hr/ft^2. The normal range of heat flux is 6,000 - 10,000 BTU/hr/ft^2. Burner flame pattern and flame length should also be designed to avoid hot spots on the firetube. Bulk temperature for triethylene glycol should not exceed 400°F. The maximum tube wall temperature should not exceed 430°F. Additional firetube surface area may be needed to meet thermal efficiency requirements.

A.6 Glycol Surge Tank. The glycol surge tank should have enough volume to handle start up, normal operation, and shut down fluctuations due to contactor drainage and should have a reservoir large enough to adequately maintain the system for a reasonable time as normal losses occur. In addition, the glycol surge tank elevation shall always supply adequate liquid head to the glycol pump.

A.7 Circulation Rates. Typical glycol type gas dehydration units have glycol circulation rates from 2.0 to 3.0 gallons of glycol per pound of water removed. The design rate must be chosen by considering the purity of the glycol at the inlet to the contactor; the number of trays/packing height in the contactor; and the dew point depression required.

A.8 Still (Reflux) Column. The glycol reboiler should be equipped with a still column complete with packing in order to minimize glycol vaporization losses. On larger systems it may be economical to include a reflux system which utilizes the incoming rich glycol in an internal coil to cool the outlet vapor stream. Outlet vapor piping should be sized for minimum pressure loss. Vapor piping should not be restricted (See Appendix H.).

A.9 Stripping Gas. Stripping as may be used to obtain higher glycol purities to meet some dehydration requirement.

A.10 Glycol Losses. For a properly designed gas dehydration unit during normal operation, the glycol losses should not exceed 0.1 gallon of glycol per million standard cubic feet of gas dehydrated.

APPENDIX B
CORROSION CONTROL GUIDELINES
GLYCOL-TYPE GAS DEHYDRATION UNITS

B.1 General

B.1.1 Variables affecting Corrosion Potential. Glycol-type gas dehydration units present several different environments. The potential for internal corrosion of equipment in these environments and the need for an approach to corrosion control is dependent upon many variables. Stream compositions, operating pressure and temperature conditions, and design/fabrication details such as metallurgy, stress, welding procedures and heat treatment all have a part in the corrosion potential of a system. Since carbon steel is the major material of construction for typical glycol-type gas dehydration units, corrosive environments require special considerations. It is the responsibility of the purchaser to advise the manufacturer when corrosion control measures and other special materials are required.

B.1.2 Stream Compositions. Of primary concern is the presence of acid gases (carbon dioxide-CO_2 and/or hydrogen sulfide-H_2S) and/or oxygen-O_2 in the flow streams. Carbon dioxide partial pressures in the gas phase below 3 psia typically do not require corrosion control. Between 3 and 30 psia, some form of corrosion control may be required, such as pH control or inhibitor injection. Corrosion resistant metals may also be needed. For carbon dioxide (CO_2) partial pressures above 30 psia, design/operational corrosion control measures will be required. Hydrogen sulfide (H_2S) and oxygen (O_2) are corrosive at very low concentrations. In addition to corrosion, hydrogen sulfide (H_2S) can lead to sulfide stress cracking (SSC). NACE Standard MR-01-75 (latest edition) "Materials Requirement — Sulfide Stress Cracking Resistant Metallic Materials for Oil Field Equipment" should be used for selection of materials.

B.2 Environments, Corrosion, and Corrosion Control

B.2.1 Wet Gas. The wet gas environments are present in the inlet gas piping and the inlet separator (either integral with the contactor or as a separate vessel upstream). Methods for corrosion control used in other wet gas systems are also applicable to vessels and piping of dehydration units. Internal coatings, linings or resistant metals may be required depending upon the severity of the environment. NACE Standard RP-01-81 (latest edition) "Recommendation Practice — Liquid Applied Internal Linings and Coatings for Oil Field Production Equipment" presents guidelines and procedures for coating vessels.

B.2.2 Rich (Wet) Glycol. The rich (wet) glycol environments are present in the bottom of the contactor, rich side of the glycol/glycol heat exchanger, rich glycol regenerator still column. The corrosiveness of rich glycol is dependent on many variables, especially the amount of carbon dioxide (CO_2), hydrogen sulfide (H_2S) or Oxygen (O_2) dissolved in the glycol. Glycol degradation products, such as organic acids, may lower the pH of the glycol, also leading to a corrosive environment. Solids from glycol degradation may collect in low flow or stagnant areas resulting in under-deposit type corrosion. The severity of the corrosion also will be a function of the temperature, water content, and amount of salt contamination of the rich glycol.

The most common method for controlling corrosion in rich glycol is "stream quality control"; that is, control of the glycol pH with buffers or neutralizers, and filtration to remove solids. pH's in the range of I.0 to 8.0 are usually considered satisfactory. Lower pH can be corrosive; higher pH can cause foaming and excessive glycol losses. Internal coatings and/or sacrificial anodes may be required in the bottom portion of the contactor if the environment is severe. Special filters, corrosion coupons, and sampling connections may also be helpful.

B.2.3 Lean (Dry) Glycol. The lean (dry) glycol environments are usually considered non-corrosive. An exception would be lean glycol with an extremely low pH. In such cases, raising the pH should solve the problem.

B.2.4 Dry Gas. The dry gas environments may be considered non-corrosive.

B.2.5 Reboiler. The reboiler environments are usually only mildly corrosive because most of the water and dissolved gases are boiled off in the still column. Corrosion may be a problem in the bottom of the reboiler shell and on the fire tube if solids drop out and build up. Adequate filtration avoids such problems.

B.2.6 Still (Reflux) Column and Overhead Piping. The still (reflux) column and overhead piping environments can be quite corrosive anywhere water or water/glycol solutions condense. In addition to water vapor, the overhead stream contains the carbon dioxide (CO_2), hydrogen sulfide (H_2S), Oxygen (O_2), and light degradation products that boil out of the glycol. These materials dissolve in any water that condenses, resulting in a corrosive solution. Corrosion resistant metals may be used to control corrosion in these problem areas. The still column packing should be made of a corrosion resistant material.

B.2.7 Glycol Surge Tank. The glycol surge tank environments contain lean glycol and thus may be considered non-corrosive.

APPENDIX C
GLYCOL TYPE GAS DEHYDRATION USER DESIGN INFORMATION SHEET

Field name and Location: ____________________

Design Conditions

GAS RATE __________ MMscfd (maximum)

__________ MMscfd (minimum)

DESIGN PRESSURE __________ psig

DESIGN TEMPERATURE, Maximum __________ °F

DESIGN TEMPERATURE, Minimum __________ °F

OPERATING PRESSURE __________ psig Minimum __________ psig Maximum

OPERATING TEMPERATURE __________ °F Minimum __________ °F Maximum

GAS SPECIFIC GRAVITY __________ (AIR = 1.0)

INLET GAS WATER CONTENT __________ lb/MMSCF

INLET GAS DEW POINT __________ °F

OUTLET GAS WATER CONTENT OR DEW POINT REQUIRED __________ lb/MMSCF or __________ °F

H_2S Content __________ PPM CO_2 Content __________ %

AVAILABLE UTILITIES (ELECTRICITY, INSTRUMENT AIR, FUEL GAS, ETC.)

____

SITE ELEVATION __________ FEET ABOVE SEA LEVEL

GLYCOL TYPE GAS DEHYDRATOR — DESIGN DATA SHEET
VENDOR DESIGN DATA SHEET
(To be completed by User and Vendor)

INLET SCRUBBER

Design pressure ____________
Diameter x length ____________
Mist eliminator material and type (wire mesh/vane/filter) ____________
Gas inlet/outlet connection — size and type ____________
Integral with absorber (yes or no) ____________
Weight ____________
Manway/Inspection Opening (yes or no) ____________
Corrosion Allowance (yes or no) ____________

Accessories provided:

Pressure gauge (yes or no) ____________
Thermometer with thermowell (yes or no) ____________
Relief (full or thermal) ____________
Level controller with control valve (yes or no) ____________
Sight glass (yes or no) ____________

CONTACTOR

Design pressure ____________
Diameter x length ____________
Tray or packing type and material ____________
Mist eliminator material and type (wire mesh/vane/filter) ____________
Mist eliminator — size and material ____________
Gas inlet/outlet connection — size and type ____________
Gas/glycol heat exchanger — size and type and heat transfer area ____________
Weight ____________
Manway/Inspection Opening (yes or no) ____________
Corrosion Allowance (yes or no) ____________

Accessories provided:

Pressure gauge (yes or no) ____________
Thermometer with thermowell (yes or no) ____________
Relief (full or thermal) ____________
Level controller with control valve (yes or no) ____________
Sight glass (yes or no) ____________
Low liquid level shutdown ____________

REBOILER

Design pressure __________
Diameter x length __________
Design heat duty __________
Firetube area __________
Firetube wall thickness __________
Average firetube heat flux __________
Insulation Type/Thickness __________
Pressure relieving device or method __________

Accessories provided:

Thermometer with thermowell (yes or no) __________
Temperature controller with control valve (yes or no) __________
High temperature shutdown (glycol) (yes or no) __________
High temperature shutdown (stack) (yes or no) __________
Flame failure shutdown (yes or no) __________
Sight glass/type (yes or no) _____ Type _____
Stack gas test connection (yes or no) __________

STILL COLUMN

Design pressure __________
Diameter x length __________
Packing type and material __________
Reflux oil (yes or no) __________
Insulation thickness and type (if used) __________

SURGE

Design pressure __________
Diameter x length __________
Integral with reboiler (yes or no) __________
Insulation thickness and type __________
Low glycol liquid level alarm/shutdown (yes or no) _____ Type _____

GLYCOL/GLYCOL HEAT EXCHANGER

Design heat duty __________
Design pressure __________
Heat exchanger — size, type and heat transfer area __________
Insulation Type/Thickness __________

PARTICLE FILTER

Manufacturer/Model No. __________
Design pressure __________
Maximum flow capacity __________
Filter element micron removal __________
Insultation thickness __________
Differential Pressure Indicator (yes or no) __________
Bypass valves and piping (yes or no) _____ Type _____

PUMP

Manufacturer/Model No.	________
Type (electric; glycol/gas powered) & speed	________
Spare pump	(yes or no) ________
Flow rate	________
Motor type, hp, voltage, phase, speed	________
Pulsation Dampeners	(yes or no) ________
Flow indicator	(yes or no) ________

MISCELLANEOUS INFORMATION

Level Gage Glass Type	________
Reboiler Temperature (°F)	________
Glycol Purity (weight %)	________
Circulation Rate (gal/hr)	________
Gallons Glycol Circulated/lb Water Removed	________
Estimated Fuel Gas Usage (SCF/hr)	________
Estimated Stripping Gas Usage	________
Reconcentrator Assembly Skid (size & weight)	________
Instrument Tubing Material	________

Additional Optional Requirements

GAS-CONDENSATE-GLYCOL SEPARATOR

Design Pressure	________
Diameter x length	________
Type (vertical/horizontal, 2-phase/3-phase)	________
Glycol retention time	________
Corrosion allowance	(yes or no) ________
Insulation thickness and type	________
Accessories provided:	
Pressure gauge	(yes or no) ________
Therometer with thermowell	(yes or no) ________
Relief (full or thermal)	________
Glycol level controller with control valve	(yes or no) ________
Hydrocarbon level controller with control valve	(yes or no) ________
Sight glasses	(yes or no) ________
Back pressure valve	(yes or no) ________

ACTIVATED CARBON FILTER

Manufacturer/Model No.	________
Design pressure	________
Maximum flow capacity	________
Carbon replacement (bulk/cartridge element)	________
Insulation thickness and type	________
Differential Pressure Indicator	(yes or no) ________
Bypass valves and piping	(yes or no) ____ Type ____

FUEL GAS SCRUBBER	(yes or no) ________
VALVES AND CONTROLS	MFG. STANDARD ________
	Others ________
PILOT IGNITER	(yes or no) ________
WINTER COIL IN INLET SCRUBBER	(yes or no) ________
LIFTING LUGS	(yes or no) ________
PAINTING:	MFG. STANDARD ________
	Others ________
HEAT EFFICIENCY OPTIONS:	
A) SECONDARY AIR ADJUSTMENT	(yes or no) ________
B) TURBULATOR	(yes or no) ________
C) SURGE INSULATED	(yes or no) ________

Comments: ____

____

APPENDIX D
DEHYDRATOR SIZING

D.1 Design Conditions. The following process design data is required for the proper sizing of a natural gas dehydrator.

1. Inlet Gas Flow Rate
2. Inlet Gas Pressure
3. Inlet Gas Temperature
4. Inlet Gas Specific Gravity
5. Outlet Gas Water Content Requirement

D.2 Inlet Gas Scrubber. The scrubber diameter is determined using both Table D.1 and Table D.3. The allowable gas flow rates given in Table D.1 are based on the Souders-Brown equation.

$$V_S = (K)\,[(D_L - D_V) / (D_V)]^{1/2}$$

where:

V_S = allowable gas velocity, feet/sec

D_L = actual density of the liquid, pounds/cu. ft.

D_V = actual density of the vapor, pounds/cu. ft.

K = empirical factor, 0.12 to 0.35 for vertical scrubbers

The maximum empirical factor of 0.35 may be considered adequate for gas streams having trace or small amounts of liquids. API Specification 12J should be consulted for other empirical values relating to other types of separators or for gas streams which may contain larger amounts of free liquids.

Table D.1 was derived using a hydrocarbon liquid having a specific gravity of 0.72 at 60°F. The values in the table were calculated to give the allowable flow rates (G_A) in MMSCF/D-sq. ft. and are used in the following equation which determines the required cross sectional area of the inlet scrubber.

$$A_S = G_S / G_A$$

where:

A_S = cross sectional area of the scrubber, sq. ft.

G_S = gas flow rate, MMSCF/D

G_A = allowable gas flow rate, MMSCF/D-sq. ft.

Using the specific gravity of the gas and the operating temperature, a value for the allowable flow rate (G_A) is selected from the column indicated by the operating pressure. Values may be interpolated. The above equation is then solved for the required cross sectional area (A_S) and this value is used in Table D.3. The column indicating a working pressure above the operating pressure is selected and an area greater than the required area (A_S) gives the diameter (D_S) of the inlet scrubber.

Integral scrubbers are usually the same diameter as the contactor since normally a uniform diameter is most economically constructed and the minimum diameter is generally governed by the allowable velocity of the gas in the contactor.

D.3 Contactor Diameter. The contactor diameter is determined using both Table D.2 and Table D.3. The allowable gas flow rates given in Table D.2 are based on the Souders-Brown equation.

$$V_C = (K)\,[(D_{TEG} - D_G) / (D_G)]^{1/2}$$

where:

V_C = allowable gas velocity, feet/sec

D_{TEG} = actual density of the TEG, pounds/cu. ft.

D_G = actual density of the gas, pounds/cu. ft.

K = empirical factor, 0.16 for 24″ tray spacing
0.12 for 18″ tray spacing

Table D.2 was derived using a 99.1 weight percent TEG solution having a specific gravity of 1.132 at 60°F. The values in the table were calculated to give the allowable flow rates (Q_A) in MMSCF/D-sq. ft. and are used in the following equation which determines the required cross sectional area of the contactor.

$$A_C = G_S / G_A$$

where:

A_C = cross sectional area of the contactor, sq. ft.

G_S = gas flow rate, MMSCF/D

G_A = allowable gas flow rate, MMSCF/D-sq. ft.

Using the specific gravity of the gas and the operating temperature, a value for the allowable flow rate (G_A) is selected from the column indicated by the operating pressure. Values may be interpolated. The above equation is the solved for the required cross sectional area (A_C) and this value is used in Table D.3. The column indicating a working pressure above the operating pressure is selected and an area greater than the required area (A_C) gives the diameter (D_C) of the contactor.

D.4 Dew Point Depression. The outlet dew point (DP_{OUT}) of a gas is obtained using Table D.4. The outlet water content (W_{OUT}) required and the operating pressure are used to determine the outlet dew point (DP_{OUT}). The dew point (DP_{IN}) of a water saturated gas is equivalent to the inlet temperature. The dew point depression is calculated as follows:

$$DP_{DEP} = DP_{IN} - DP_{OUT}$$

where:

DP_{DEP} = dew point depression, °F

DP_{IN} = dew point of the inlet, gas, °F

DP_{OUT} = dew point of the outlet gas, °F

D.5 Number of Trays. The number of trays or the height of packing may be estimated using Table D.5. The dew point depression required (DP_{DEP}) and the circulation ratio of the glycol to water are entered, along with the pressure at which the contactor will be operating, to give the number of trays or the feet of packing required.

D.6 Glycol Circulation Rate. The inlet gas water content is taken from Table D.4 corresponding to the inlet gas temperature and pressure. The water removal rate is determined using the following equation.

$$W_R = [(W_{IN} - W_{OUT})(G_S)] / 24$$

where:

W_R = water removed, lb water/hour

W_{IN} = water content of the inlet gas, lb water/MMSCF

W_{OUT} = water content of the outlet gas, lb water/MMSCF

G_S = gas flow rate, MMSCF/D

The glycol rate is obtained by using the ratio of glycol to water removed (L_W) times the water removal rate (W_R).

$$L = (L_W)(W_R)$$

where:

L = glycol circulation rate, gallons/hour

L_W = glycol/water ratio, gallons of glycol/pound water removed

W_R = water removed, lb water/hour

D.7 Glycol Circulating Pump. The required size of the glycol circulating pump can be determined using the glycol circulation rate and the design pressure of the contactor.

Both gas powered and electric driven pumps are used for glycol and the manufacturers of these pumps should be consulted for exact sizing to meet the specific needs of the glycol dehydrator.

D.8 Gas-Condensate-Glycol Separator. The flash separator is sized based on a liquid retention time.

$$V = (L)(T)/60$$

where:

V = the required settling volume in the separator, gallons

L = glycol circulation rate, gallons/hour

T = retention time, minutes

= 5 minutes for two phase

= 10 to 30 minutes for three phase

Typical sizes and settling volumes are given in Table D.6 and Table D.7.

D.9 Reconcentrator. The required heat load for the reboiler can be estimated using the following equation:

$$Q_R = (L)(Q_C)$$

where:

Q_R = the required reboiler heat duty, BTU/hr

L = the glycol circulation rate, gallons/hour

Q_C = the heat duty for each gallon circulated, BTU/gallon

Calculated values for Q_C are given in Table D.8 for the typical lean glycol to water removed ratios and the contactor temperatures.

The calculated heat duty is then used with Table D.9 to select a nominal unit in excess of the heat duty required.

D.10 Piping. Pump suction piping should be kept short with a minimum of ells and fittings. The pump suction is to be supplied with a block valve and strainer. The suction piping should be one to two times larger than the suction connection of the pump. Use of eccentric reducers on the pump inlet with the flat side up is required. Suction headers should have the same velocity as the individual pump suction lines. Pulsation dampeners should be considered for use with reciprocating pumps.

The discharge shall be supplied with a check valve and block valve.

The following are maximum flow velocities recommended for reciprocating pump piping:

RPM of Pump	Suction Velocity	Discharge Velocity
250 max.	2 ft/sec	6 ft/sec
330 max.	1½ ft/sec	4½ ft/sec
over 330	1 ft/sec	3 ft/sec

D.11 Tubing. It is recommended that the following tubing sizes be used in the instrumentation of a field dehydration unit:

Individual Instrument Lines	¼"
Laterals	⅜"
Headers	½"

D.12 Additional Information. The following texts are given for the user to consult should the composition of the inlet gas contain an exceptional amount of acid gas or the design conditions are outside the ranges given in this specification. Also, the texts contain additional design criteria and procedures which are not presented in this specification:

1. Gas Purification, Fourth Edition, by Author L. Kohl and Fred C. Riesenfeld, Gulf Publishing Company.
2. Gas Conditioning Fact Book, by the Dow Chemical Company.
3. Engineering Data Book, by the Gas Processors Suppliers Association, Tenth Edition, 1987.
4. Gas Conditioning and Processing, by Dr. John M. Campbell, Copyrighted 1976, Campbell Petroleum Series.
5. Handbook of Natural Gas Engineering, by Donald L. Katz, McGraw-Hill Book Company, Inc.
6. Natural Gas Production Engineering, by Chi U. Ikoku, John Wiley & Sons.
7. Field Handling of Natural Gas, published by Petroleum Extension Service, The University of Texas at Austin, Austin, Texas.
8. Plant Processing of Natural Gas, issued by Petroleum Extension Service, The University of Texas at Austin, Austin, Texas.

TABLE D.1
SCRUBBER RECOMMENDED MAXIMUM GAS FLOW RATES
(MMSCF/D-SQ. FT.)

		OPERATING PRESSURE, PSIG								
SP. GR.	TEMP °F	400	500	600	700	800	900	1000	1100	1200
0.6	60	5.12	5.72	6.28	6.79	7.28	7.73	8.16	8.57	8.96
	70	5.04	5.63	6.18	6.68	7.15	7.60	8.01	8.41	8.79
	80	4.97	5.55	6.08	6.57	7.03	7.47	7.88	8.26	8.63
	90	4.90	5.47	5.99	6.47	6.92	7.34	7.74	8.12	8.48
	100	4.83	5.39	5.90	6.37	6.81	7.23	7.62	7.99	8.34
	110	4.76	5.31	5.82	6.28	6.71	7.12	7.50	7.86	8.20
	120	4.70	5.24	5.73	6.19	6.61	7.01	7.38	7.74	8.07
0.7	60	4.79	5.37	5.90	6.41	6.88	7.33	7.76	8.17	8.56
	70	4.71	5.28	5.80	6.29	6.75	7.19	7.60	7.99	8.37
	80	4.64	5.19	5.70	6.18	6.63	7.05	7.45	7.83	8.19
	90	4.57	5.11	5.61	6.08	6.51	6.92	7.31	7.68	8.03
	100	4.50	5.04	5.52	5.98	6.40	6.80	7.18	7.54	7.88
	110	4.44	4.96	5.44	5.88	6.30	6.69	7.05	7.40	7.73
	120	4.38	4.89	5.36	5.79	6.20	6.58	6.94	7.28	7.60
0.8	60	4.54	5.11	5.64	6.15	6.64	7.11	7.56	7.99	8.40
	70	4.46	5.02	5.53	6.02	6.49	6.94	7.37	7.78	8.16
	80	4.39	4.93	5.43	5.91	6.36	6.79	7.20	7.59	7.95
	90	4.32	4.85	5.34	5.79	6.23	6.64	7.04	7.41	7.76
	100	4.25	4.77	5.24	5.69	6.11	6.51	6.89	7.25	7.59
	110	4.19	4.69	5.16	5.59	6.00	6.39	6.75	7.10	7.43
	120	4.13	4.62	5.07	5.50	5.89	6.27	6.62	6.96	7.28
0.9	60	4.35	4.93	5.49	6.04	6.58	7.13	7.66	8.14	8.54
	70	4.27	4.83	5.36	5.88	6.39	6.89	7.38	7.83	8.22
	80	4.20	4.74	5.25	5.74	6.22	6.69	7.14	7.56	7.94
	90	4.13	4.65	5.14	5.62	6.07	6.51	6.93	7.33	7.70
	100	4.06	4.57	5.05	5.50	5.93	6.35	6.75	7.13	7.48
	110	3.99	4.49	4.95	5.39	5.81	6.21	6.59	6.95	7.28
	120	3.93	4.42	4.87	5.29	5.69	6.07	6.44	6.78	7.10

NOTE: The above values are obtained using a K = 0.35 empirical factor which is adequate for scrubbers handling trace or small amounts of liquids.

TABLE D.2
CONTACTOR RECOMMENDED MAXIMUM GAS FLOW RATES (MMSCF/D-SQ. FT.)

SP. GR.	TEMP °F	OPERATING PRESSURE, PSIG 400	500	600	700	800	900	1000	1100	1200
0.6	60	2.95	3.30	3.63	3.94	4.22	4.49	4.75	5.00	5.24
	70	2.91	3.26	3.58	3.88	4.16	4.42	4.68	4.92	5.15
	80	2.87	3.22	3.53	3.82	4.10	4.36	4.60	4.84	5.06
	90	2.84	3.17	3.48	3.77	4.04	4.29	4.53	4.76	4.98
	100	2.80	3.13	3.43	3.71	3.98	4.23	4.46	4.69	4.90
	110	2.77	3.09	3.39	3.66	3.92	4.16	4.40	4.62	4.83
	120	2.73	3.05	3.34	3.61	3.87	4.11	4.33	4.55	4.75
0.7	60	2.76	3.10	3.42	3.72	4.01	4.28	4.54	4.79	5.04
	70	2.72	3.06	3.37	3.66	3.93	4.20	4.45	4.70	4.93
	80	2.69	3.01	3.32	3.60	3.87	4.13	4.37	4.61	4.83
	90	2.65	2.97	3.27	3.54	3.81	4.06	4.29	4.52	4.74
	100	2.61	2.93	3.22	3.49	3.75	3.99	4.22	4.44	4.65
	110	2.58	2.89	3.17	3.44	3.69	3.93	4.15	4.37	4.57
	120	2.55	2.85	3.13	3.39	3.63	3.87	4.09	4.29	4.50
0.8	60	2.62	2.96	3.28	3.58	3.88	4.17	4.46	4.73	4.99
	70	2.58	2.91	3.22	3.51	3.80	4.08	4.34	4.60	4.85
	80	2.54	2.87	3.17	3.45	3.73	3.99	4.25	4.49	4.73
	90	2.51	2.82	3.11	3.39	3.65	3.91	4.15	4.39	4.62
	100	2.47	2.78	3.06	3.33	3.59	3.83	4.07	4.30	4.51
	110	2.44	2.74	3.02	3.28	3.53	3.76	3.99	4.21	4.42
	120	2.41	2.70	2.97	3.23	3.47	3.70	3.92	4.13	4.33
0.9	60	2.52	2.86	3.20	3.53	3.87	4.22	4.57	4.90	5.18
	70	2.48	2.81	3.13	3.45	3.76	4.08	4.39	4.69	4.97
	80	2.44	2.76	3.07	3.37	3.66	3.96	4.25	4.53	4.79
	90	2.40	2.71	3.01	3.30	3.58	3.85	4.12	4.39	4.63
	100	2.36	2.67	2.95	3.23	3.50	3.76	4.01	4.26	4.49
	110	2.33	2.62	2.90	3.17	3.43	3.68	3.92	4.15	4.37
	120	2.29	2.58	2.86	3.11	3.36	3.60	3.83	4.05	4.26

NOTE: The above values were obtained using a K = 0.16 empirical factor.

TABLE D.3
VESSEL CROSS SECTIONAL AREA (SQUARE FEET)

OUTSIDE DIA. INCHES	WORKING PRESSURE, PSIG 720	1000	1200	1440
6⅝	0.20	0.20	0.20	0.20
8⅝	0.36	0.35	0.33	0.32
10¾	0.56	0.52	0.52	0.50
12¾	0.79	0.75	0.71	0.71
14	0.94	0.90	0.85	0.85
16	1.23	1.18	1.12	1.06
18	1.58	1.48	1.42	1.34
20	1.93	1.84	1.75	1.66
24	2.79	2.65	2.54	2.40
30	4.51	4.35	4.24	4.12
36	6.49	6.26	6.12	5.98
42	8.84	8.56	8.35	8.14
48	11.54	11.17	10.92	10.62
54	14.61	14.12	13.84	13.43
60	18.03	17.49	17.03	16.57

TABLE D.4
WATER CONTENT OF NATURAL GAS
(POUNDS OF WATER PER MMSCF)

TEMP °F	OPERATING PRESSURE, PSIG 400	500	600	700	800	900	1000	1100	1200
15	6.6	5.6	4.9	4.5	4.1	3.8	3.6	3.4	3.3
16	6.8	5.8	5.1	4.7	4.3	4.0	3.8	3.6	3.4
17	7.1	6.1	5.4	4.8	4.5	4.2	3.9	3.7	3.5
18	7.4	6.3	5.6	5.0	4.6	4.3	4.1	3.9	3.7
19	7.7	6.6	5.8	5.2	4.8	4.5	4.2	4.0	3.8
20	8.0	6.8	6.0	5.4	5.0	4.7	4.4	4.2	4.0
21	8.4	7.1	6.3	5.7	5.2	4.8	4.5	4.3	4.1
22	8.7	7.4	6.5	5.9	5.4	5.0	4.7	4.5	4.3
23	9.1	7.7	6.8	6.1	5.6	5.2	4.9	4.6	4.4
24	9.4	8.0	7.0	6.3	5.8	5.4	5.1	4.8	4.6
25	9.8	8.3	7.3	6.6	6.0	5.6	5.3	5.0	4.8
26	10.2	8.6	7.6	6.8	6.3	5.8	5.5	5.2	4.9
27	10.6	9.0	7.9	7.1	6.5	6.1	5.7	5.4	5.1
28	11.0	9.3	8.2	7.4	6.8	6.3	5.9	5.6	5.3
29	11.4	9.7	8.5	7.7	7.0	6.5	6.1	5.8	5.5
30	11.9	10.1	8.8	7.9	7.3	6.8	6.3	6.0	5.7
31	12.3	10.5	9.2	8.2	7.6	7.0	6.6	6.2	5.9
32	12.8	10.9	9.5	8.6	7.8	7.3	6.8	6.4	6.1
33	13.3	11.3	9.9	8.9	8.1	7.5	7.1	6.7	6.3
34	13.8	11.7	10.3	9.2	8.4	7.8	7.3	6.9	6.6
35	14.4	12.1	10.6	9.6	8.7	8.1	7.6	7.2	6.8
36	14.9	12.6	11.0	9.9	9.1	8.4	7.9	7.4	7.1
37	15.5	13.1	11.4	10.3	9.4	8.7	8.1	7.7	7.3
38	16.1	13.6	11.9	10.7	9.7	9.0	8.4	8.0	7.6
39	16.7	14.1	12.3	11.0	10.1	9.3	8.7	8.2	7.8
40	17.3	14.6	12.8	11.4	10.5	9.7	9.1	8.5	8.1
41	18.0	15.1	13.2	11.9	10.8	10.0	9.4	8.8	8.4
42	18.6	15.7	13.7	12.3	11.2	10.4	9.7	9.2	8.7
43	19.3	16.3	14.2	12.7	11.6	10.7	10.0	9.5	9.0
44	20.0	16.9	14.7	13.2	12.0	11.1	10.4	9.8	9.3
45	20.8	17.5	15.3	13.7	12.5	11.5	10.8	10.1	9.6
46	21.5	18.1	15.8	14.2	12.9	11.9	11.1	10.5	10.0
47	22.3	18.8	16.4	14.7	13.4	12.3	11.5	10.9	10.3
48	23.1	19.4	17.0	15.2	13.8	12.8	11.9	11.2	10.7
49	24.0	20.1	17.6	15.7	14.3	13.2	12.3	11.6	11.0
50	24.8	20.9	18.2	16.3	14.8	13.7	12.8	12.0	11.4
51	25.7	21.6	18.8	16.8	15.3	14.1	13.2	12.4	11.8
52	26.6	22.4	19.5	17.4	15.9	14.6	13.7	12.8	12.2
53	27.6	23.2	20.2	18.0	16.4	15.1	14.1	13.3	12.6
54	28.6	24.0	20.9	18.7	17.0	15.7	14.6	13.7	13.0
55	29.6	24.8	21.6	19.3	17.5	16.2	15.1	14.2	13.4
56	30.6	25.7	22.4	20.0	18.1	16.7	15.6	14.7	13.9
57	31.7	26.6	23.1	20.6	18.8	17.3	16.1	15.1	14.3
58	32.8	27.5	23.9	21.3	19.4	17.9	16.7	15.7	14.8
59	34.0	28.5	24.7	22.1	20.1	18.5	17.2	16.2	15.3
60	35.1	29.4	25.6	22.8	20.7	19.1	17.8	16.7	15.8
61	36.4	30.4	26.5	23.6	21.4	19.7	18.4	17.2	16.3
62	37.6	31.5	27.3	24.4	22.1	20.4	19.0	17.8	16.8
63	38.9	32.5	28.3	25.2	22.9	21.0	19.6	18.4	17.4
64	40.2	33.6	29.2	26.0	23.6	21.7	20.2	19.0	18.0
65	41.6	34.8	30.2	26.9	24.4	22.5	20.9	19.6	18.5
66	43.0	36.0	31.2	27.8	25.2	23.2	21.6	20.2	19.1
67	44.4	37.2	32.2	28.7	26.0	23.9	22.3	20.9	19.7

TEMP °F	OPERATING PRESSURE, PSIG 400	500	600	700	800	900	1000	1100	1200
68	45.9	38.4	33.3	29.6	26.9	24.7	23.0	21.6	20.4
69	47.5	39.7	34.4	30.6	27.7	25.5	23.7	22.2	21.0
70	49.1	41.0	35.5	31.6	28.6	26.3	24.5	22.9	21.7
71	50.7	42.3	36.7	32.6	29.6	27.2	25.2	23.7	22.4
72	52.4	43.7	37.9	33.7	30.5	28.0	26.0	24.4	23.1
73	54.1	45.1	39.1	34.8	31.5	28.9	26.9	25.2	23.8
74	55.9	46.6	40.4	35.9	32.5	29.8	27.7	26.0	24.5
75	57.7	48.1	41.7	37.0	33.5	30.8	28.6	26.8	25.3
76	59.6	49.7	43.0	38.2	34.6	31.8	29.5	27.6	26.1
77	61.5	51.3	44.4	39.4	35.7	32.7	30.4	28.5	26.9
78	63.5	52.9	45.8	40.7	36.8	33.8	31.3	29.3	27.7
79	65.5	54.6	47.2	41.9	37.9	34.8	32.3	30.2	28.5
80	67.6	56.3	48.7	43.3	39.1	35.9	33.3	31.2	29.4
81	69.8	58.1	50.3	44.6	40.3	37.0	34.3	32.1	30.3
82	72.0	60.0	51.8	46.0	41.6	38.1	35.4	33.1	31.2
83	74.3	61.8	53.5	47.4	42.9	39.3	36.4	34.1	32.1
84	76.6	63.8	55.1	48.9	44.2	40.5	37.6	35.1	33.1
85	79.0	65.8	56.8	50.4	45.5	41.7	38.7	36.2	34.1
86	81.5	67.8	58.6	51.9	46.9	43.0	39.9	37.3	35.1
87	84.0	69.9	60.4	53.5	48.3	44.3	41.1	38.4	36.2
88	86.7	72.1	62.2	55.2	49.8	45.6	42.3	39.5	37.2
89	89.3	74.3	64.1	56.8	51.3	47.0	43.5	40.7	38.3
90	92.1	76.6	66.1	58.5	52.8	48.4	44.8	41.9	39.5
91	94.9	78.9	68.1	60.3	54.4	49.8	46.2	43.1	40.6
92	97.8	81.3	70.1	62.1	56.1	51.3	47.5	44.4	41.8
93	100.8	83.8	72.2	64.0	57.7	52.8	48.9	45.7	43.0
94	103.9	86.3	74.4	65.9	59.4	54.4	50.3	47.0	44.3
95	107.0	88.9	76.6	67.8	61.2	56.0	51.8	48.4	45.5
96	110.2	91.5	78.9	69.8	63.0	57.6	53.3	49.8	46.8
97	113.5	94.3	81.2	71.9	64.8	59.3	54.9	51.2	48.2
98	116.9	97.0	83.6	74.0	66.7	61.0	56.4	52.7	49.6
99	120.4	99.9	86.1	76.2	68.6	62.8	58.1	54.2	51.0
100	124.0	102.9	88.6	78.4	70.6	64.6	59.7	55.7	52.4
101	127.6	105.9	91.2	80.6	72.7	66.4	61.4	57.3	53.9
102	131.4	109.0	93.9	83.0	74.8	68.3	63.2	58.9	55.4
103	135.3	112.2	96.6	85.4	76.9	70.3	65.0	60.6	57.0
104	139.2	115.4	99.4	87.8	79.1	72.3	66.8	62.3	58.6
105	143.3	118.8	102.2	90.3	81.3	74.3	68.7	64.1	60.2
106	147.4	122.2	105.1	92.9	83.6	76.4	70.6	65.8	61.9
107	151.7	125.7	108.1	95.5	86.0	78.6	72.6	67.7	63.6
108	156.0	129.3	111.2	98.2	88.4	80.7	74.6	69.5	65.3
109	160.5	133.0	114.4	101.0	90.9	83.0	76.7	71.5	67.1
110	165.1	136.7	117.6	103.8	93.4	85.3	78.8	73.4	69.0
111	169.8	140.6	120.9	106.7	96.0	87.7	81.0	75.4	70.8
112	174.6	144.6	124.3	109.7	98.7	90.1	83.2	77.5	72.8
113	179.5	148.6	127.8	112.7	101.4	92.6	85.4	79.6	74.7
114	184.6	152.8	131.3	115.9	104.2	95.1	87.8	81.8	76.8
115	189.8	157.0	135.0	119.1	107.1	97.7	90.2	84.0	78.8
116	195.1	161.4	138.7	122.3	110.0	100.3	92.6	86.2	80.9
117	200.5	165.9	142.5	125.7	113.0	103.1	95.1	88.6	83.1
118	206.0	170.4	146.4	129.1	116.0	105.8	97.6	90.9	85.3
119	211.7	175.1	150.4	132.6	119.2	108.7	100.3	93.3	87.6
120	217.6	179.9	154.5	136.2	122.4	111.6	102.9	95.8	89.9

NOTE: The above values are based on Bukacek, R. F., (Equilibrium Moisture Content of Natural Gases), Research Bulletin No. 8, Institute of Gas Technology, Chicago, Illinois 1955.

TABLE D.5
ACTUAL TRAYS OR FEET OF PACKING
REQUIRED FOR DEW POINT DEPRESSION

RATIO TEG/WATER L_W (gal./lb.)	DEW POINT DEPRESSION °F	OPERATING PRESSURE, PSIG								
		400	500	600	700	800	900	1000	1100	1200
2	55	4	4	4	4	4	4	4	4	4
	60	5	5	5	5	5	5	5	5	5
	65	5	5	5	5	5	5	6	6	6
	70	6	6	6	6	6	6	6	6	6
	75	6	7	7	7	7	7	7	7	7
	80	8	8	8	8	8	9	9	9	9
	85	9								
3	55	3	3	3	4	4	4	4	4	4
	60	4	4	4	4	4	4	4	4	4
	65	5	5	5	5	5	5	5	5	5
	70	5	5	5	5	5	5	5	5	5
	75	6	6	6	6	6	6	6	6	6
	80	6	6	7	7	7	7	7	7	7
	85	8	8	8	9	9	9	9	9	9
4	55	3	3	3	3	3	3	3	3	3
	60	3	3	3	4	4	4	4	4	4
	65	4	4	4	4	4	4	4	4	4
	70	5	5	5	5	5	5	5	5	5
	75	5	5	5	5	5	5	5	5	5
	80	6	6	6	6	6	6	6	6	6
	85	7	7	7	8	8	8	8	8	8
	90	9								

NOTE: (1) This table is based on 33⅓% tray efficiency or three (3) feet of packing per theoretical tray required.

(2) The above values were obtained using an outlet gas dew point at 7 pounds of water per MMSCF, a lean glycol solution concentration of 99.1 weight percent, a 400°F reboiler temperature, and at an elevation of 1200 feet.

(3) Greater dew point depressions or parameters different from those given above require additional design considerations.

TABLE D.6
TYPICAL VERTICAL TWO PHASE GLYCOL FLASH SEPARATOR SIZES

Diameter	Length	Settling Volume, gallons
12¾″	x 4′ - 0″	8.2
16″	x 4′ - 0″	13.5
20″	x 4′ - 0″	22.3
24″	x 4′ - 0″	33.6

NOTE: Settling volume is based on level being 1′ - 0″ above bottom head seam.

TABLE D.7
TYPICAL HORIZONTAL THREE PHASE GLYCOL FLASH SEPARATOR SIZES

Diameter	Length	Settling Volume, gallons ½ Dia.	⅔ Dia
24″	x 3′ - 6″	39.3	56.0
24″	x 5′ - 0″	56.2	79.9
30″	x 5′ - 0″	90.1	128.3
36″	x 5′ - 0″	132.6	188.9
36″	x 7′ - 6″	196.9	279.9

NOTE: The settling volume is based on the vertical spill over baffle being 6″ from the outlet end head seam.

TABLE D.8
EMPIRICAL FACTORS FOR THE REBOILER HEAT DUTY
(BTU/gallon of lean glycol circulated)

Contactor Temperature, °F	Glycol/Water Ratio (gallons of glycol/lb. of water) 2	3	4
60	1770	1470	1320
80	1640	1340	1200
100	1510	1220	1070
120	1370	1080	940

NOTE: The above calculated values are based on 99.1 weight percent lean glycol, 400 °F reboiler temperature, 10 percent atmospheric heat loss, and a lean glycol from the heat exchanger of 200 °F.

TABLE D.9
TYPICAL REBOILER SIZES

Nominal Rating BTU/hr	Required Firetube Surface Area, sq. ft. 6,000 BTU/hr-sq. ft.	8,000 BTU/hr-sq. ft.	10,000 BTU/hr-sq. ft.
75,000	12.5	9.4	7.5
125,000	20.8	15.6	12.5
175,000	29.2	21.9	17.5
250,000	41.7	31.3	25.0
350,000	58.3	43.8	35.0
500,000	83.3	62.5	50.0
750,000	125.0	93.8	75.0
850,000	141.7	106.3	85.0
1,000,000	166.7	125.0	100.0
Efficiencies(1)(2) Percent	78-80%	73-76%	68-72%

NOTES: (1) The above calculated efficiencies are based on 0 % excess air and no fouling factors applied. Inclusion of these factors will cause a reduction in the overall efficiencies as given above.

(2) Reference: McAdams, W. H., "Heat Transmission," Third Edition, McGraw-Hill Book Co., Inc., 1954.

APPENDIX E
EXAMPLE CALCULATIONS

Size a glycol dehydrator for a field installation from the typical sizes given in Appendix D to meet the following requirements:

1. Gas flow rate: 10.0 MMSCFD
2. Gas specific gravity: 0.7 (air = 1)
3. Operating line pressure: 1000 psig
4. Maximum working pressure of contactor: 1440 psig
5. Gas inlet temperature: 100 °F
6. Outlet gas water content: 7 lb water/MMSCF

Select additional design criteria.

1. Glycol to water circulation rate: 3.0 gal. TEG/lb water
2. Lean glycol concentration: 99.1 % by weight TEG
3. Reboiler Temperature: 400°F.
4. Lean Glycol from Heat Exchanger: 200°F.
5. Heat Flux: 10,000 BTU/Hr-sq. ft.
6. Use a trayed type contactor.
7. Use 30 minutes retention time for a three phase horizontal flash separator.

Inlet Scrubber Size: The allowable gas flow rate is obtained from Table D.1 using the specific gravity, temperature and pressure of the gas. This value is divided into the standard gas flow rate to calculate the required cross sectional area of the scrubber.

$$A_S = (10.0) / (7.18) = 1.39 \text{ sq. ft.}$$

Using a working pressure of 1440 psig and a required cross sectional area of 1.39 sq. ft., Table D.3 gives a scrubber diameter of 20 inches.

Contactor Diameter: The allowable gas flow rate is obtained from Table D.2 using the specific gravity, temperature and pressure of the gas. This value is divided into the standard gas flow rate to calculate the required cross sectional area of the contactor.

$$A_C = (10.0) / (4.22) = 2.37 \text{ sq. ft.}$$

Using a working pressure of 1440 psig and a required cross sectional area of 2.37 sq. ft., Table D.3 gives a contactor diameter of 24 inches.

Dew Point Depression: The dew point of the outlet gas is determined using Table D.4. At the operating pressure and a 7 lb water/MMSCF water content, the dew point is read to be 32°F. Assuming a saturated inlet gas, the dew point depression is given by the following:

$$DP_{DEF} = 100°F - 32°F = 68°F$$

Number of Trays Required: From Table D.5 at 3 gal TEG/lb. of water and 68°F dewpoint depression, the actual number of trays required would be 5.

Glycol Circulation Rate: Table D.4 is used to determine the inlet water content at saturation. At the operating pressure and temperature, the inlet water is read to be 60 lbs./MMSCF.

The water removal rate from the inlet gas is determined by using the inlet and outlet water contents along with the gas rate.

$$W_R = (10.0)\ (60-7)/24 = 22.1 \text{ pounds of water/hr}$$

The circulation rate of the lean TEG solution is calculated using the water removal rate and the ratio of lean glycol to water removed.

$$L = (22.1)\ (3) = 66.3 \text{ gallons of lean solution/hr}$$

Glycol Circulation Pump: The manufacturer of the pump should be consulted for the exact sizing to meet the specific requirements of the glycol dehydrator.

Glycol Flash Separator: The retention volume required is calculated using the retention time and the circulation rate of the glycol.

$$V = (66.3)\ (30) / 60 = 33.2 \text{ gallons}$$

Typical sizes of Glycol Flash Separators are given in Table D.6 and Table D.7.

Reconcentrator: Determination of the reboiler heat load is made by using the lean glycol circulation rate and the reboiler heat duty factors given in Table D.8.

$$Q_R = (66.3)\ (1220) = 80{,}886 \text{ BTU/hr heat duty}$$

Typical sizes of the Reconcentrators are given in Table D.9. Also, the firetube surface area for the various heat fluxes are contained in Table D.9.

Standard Size Unit Required:

Summary of Requirements:

Inlet Scrubber: 20″ O.D. separate or 24″ O.D. integral scrubber

Glycol-Gas Contactor: 24″ O.D. with 5 trays, 1440 psig W. P.

Glycol Pump: 66.3 gallons/hr

Reboiler: 80,886 BTU/hr

Standard Size Unit:

Inlet Scrubber: 20″ O.D. separate scrubber
24″ O.D. integral scrubber

Contactor: 24″ O.D., 1440 psig W.P. with 5 trays

Flash Separator: 24″ x 3′-6″

Glycol Reconcentrator: 125,000 BTU/hr reboiler
12.5 sq. ft. minimum surface area

APPENDIX F
STRUCTURAL DESIGN GUIDELINES

F.1 Saddles. The saddles for cylindrical shells should be designed in such a manner that excessive stresses are not induced in the shell. Some useful guidelines and references may be found in Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code. No more than two saddles should be used on a cylindrical shell. Caution is advised when angle legs are used to support the shell, because they may over stress the shell. The saddles or legs shall be adequate to support the vessel under normal operating conditions.

F.2 Skids. The skids should be designed to support 150% of the dry weight of the entire assembly with the skid supported at its ends and the deflection should be limited to L/400, where L is the length of the skid. It should also support the assembly under normal operating conditions. The user should inform the manufacturer how the skid will be transported, unloaded, and supported under normal operating conditions.

F.3 Lifting Lugs. Vessels that are furnished with insulation shall also be furnished with two lift lugs unless lifting lugs are furnished on skid mounted units. Each lug should be designed for 75% of the empty weight of the entire assembly. A maximum lift angle of 30° with the vertical shall be assumed. The effect of the lugs on the shell should be investigated and reinforcement should be provided if required. The lugs should be designed for double shear tear-out and tension on the net section at the pin hole. The lifting lugs on skid-mounted assemblies if furnished, should be designed as above, except that each lug should be designed for 50% of the empty weight of the entire assembly. Many manufacturers attach lift lugs to various components of the assembly that are intended for lifting that component only; however, they may not be suitable for lifting the total assembly.

F.4 Stacks. Wind forces on the stack can cause a moment on the cover plate which should be considered in the design.

F.5 Firetube. The firetube becomes buoyant when immersed in a reboiler bath and must be restrained from floating.

APPENDIX G
COMBUSTION EFFICIENCY

G.1 General. Proper operation of any dehydrator depends on efficient burner performance and adequate firetube design and is commonly expressed as combustion efficiency. Good burner performance depends on proper adjustment of fuel gas pressure, primary and secondary air and the gas orifice size. Good firetube design depends on heat flux, heat density, temperature and firing.

G.2 Efficiency. Dehydrator performance can be easily determined by an analysis and temperature of the flue gas taken from the base of the stack. Fig. G.1 is a convenient chart for estimating combustion efficiency in a dehydrator based on residual oxygen (O_2) content and exit temperature of the stark gas, employing a methane-rich fuel gas with a high (or gross) heating value (HHV) of approximately 1050 BTU/SCF. This chart assumes the residual level of combustibles in the flue gas is below 0.1% which is the maximum level for safe and efficient operation. While this chart is limited to natural gas, there is no intent to preclude other fuels.

G.3 Example Calculation. Determine estimated fuel consumption for a dehydrator with a firetube rating of 250,000 BTU/hr fueled with natural gas of 1050 BTU/SCF heating value (HHV), operating with flue gas of 4 volume % residual oxygen and 900°F stack gas temperature.

From Fig. G.1 read the following:

a. 4 volume % oxygen in flue gas corresponds to approximately 22.5% excess air for combustion.

b. Combustion efficiency = 69% for 1050 BTU/scf fuel gas.

Estimated fuel gas consumption:

$$\text{Fuel, SCFH} = \frac{250{,}000 \text{ BTU/hr}}{0.69 \text{ eff.} \times 1050 \text{ BTU/scf}} = 345 \text{ SCFH}$$

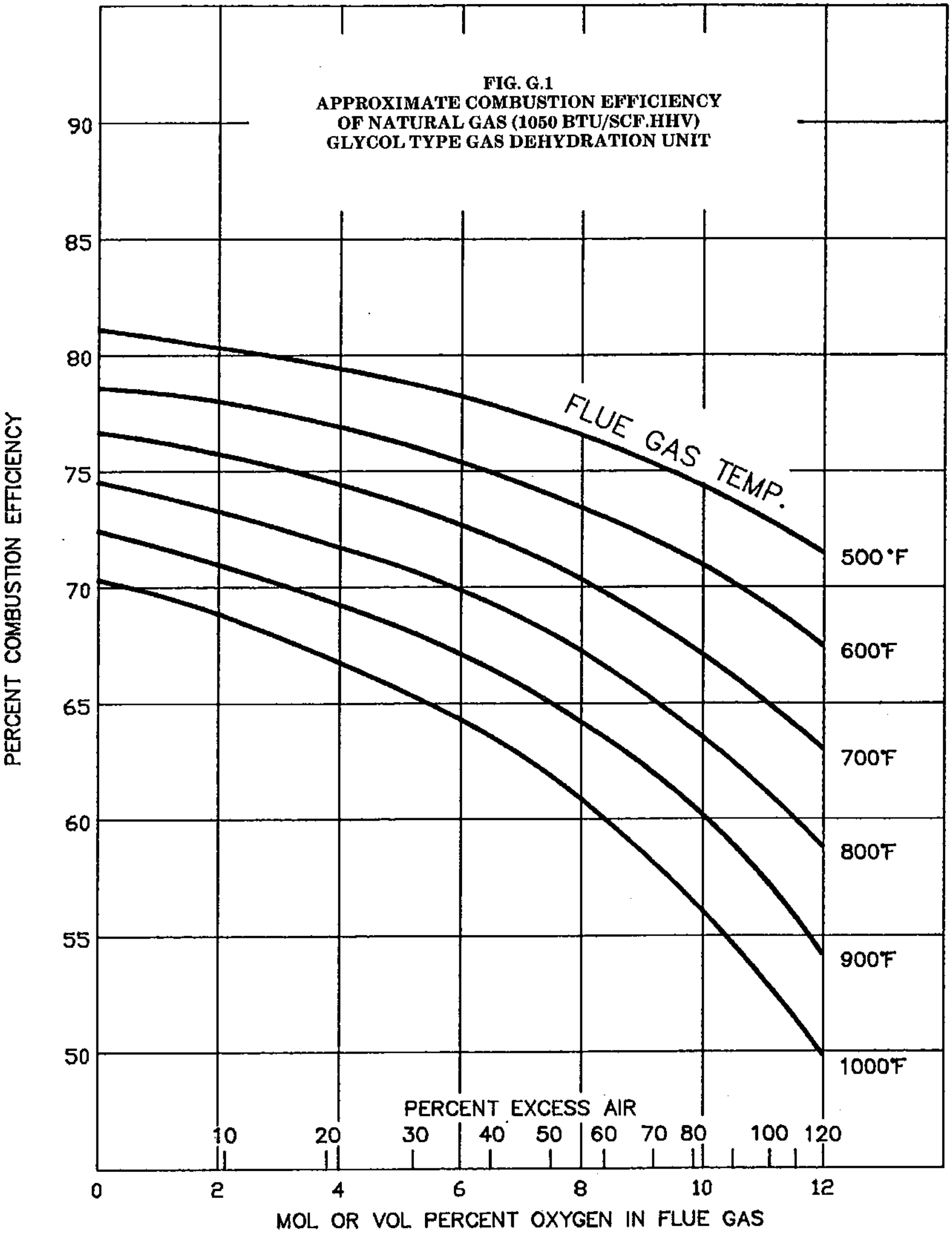


FIG. G.1
APPROXIMATE COMBUSTION EFFICIENCY
OF NATURAL GAS (1050 BTU/SCF.HHV)
GLYCOL TYPE GAS DEHYDRATION UNIT
FLUE GAS TEMP.
500°F
600°F
700°F
800°F
900°F
1000°F
PERCENT COMBUSTION EFFICIENCY
90
85
80
75
70
65
60
55
50
PERCENT EXCESS AIR
10
20
30
40
50
60
70
80
100
120
0
2
4
6
8
10
12
MOL OR VOL PERCENT OXYGEN IN FLUE GAS

APPENDIX H
INSTALLATION, START-UP, OPERATION AND MAINTENANCE

H.1 Installation. All equipment must be installed on an adequate foundation. The equipment should be as level as possible for the most efficient operation.

All items shipped loose should be installed on the unit. This may include the stack, still column, piping between the regenerator and contactor, and the vent line from the still column. Normally the still column vapors are vented directly to the atmosphere. Vent piping should be kept to a minimum. It should be remembered that these vapors contain combustible hydrocarbons, corrosive components, and water which may condense and freeze. Therefore, consideration must be given to the location and manner in which these vapors are vented, piped, drained, etc. After the unit has been completely assembled, all screwed and bolted connections should be checked for tightness.

H.2 Start-Up. The unit should be inspected before start-up to make certain that all valves are closed and all regulators are backed off. All relief valves and critical shutdown devices should be operational. Admit supply gas to the system and open isolation valves under all pressure gauges.

The contactor should be purged with natural gas to eliminate air. It then should be brought up to line pressure and checked for leaks. Maintain the contactor pressure, but do not flow gas at this point. The flash tanks and piping should also be purged to eliminate air.

Open the cocks on the glycol surge tank level gauge and the valve in the line between the surge tank and the glycol/glycol heat exchanger. Fill the reboiler with glycol until the level comes about half way up in the surge tank gauge. Allow approximately 25% of the surge tank for thermal expansion of the glycol. Set all regulators in accordance with manufacturer's recommendations.

The glycol circulation, including the return to the reboiler from the contactor, should be fully established prior to ignition of the main burner.

Light the pilot light and main burner as recommended by the manufacturer. Heat the glycol until it reaches 390°F and set the temperature controller. Continue heating the glycol until it reaches 400°F and set the high temperature shutdown. These temperatures are typical; however, some manufacturers and operators prefer somewhat different temperatures. Operating conditions can also sometimes require different operating temperatures. It is highly recommended that the glycol never be heated above 400°F because it starts decomposing at 405°F.

The glycol level in the surge tank should be brought to normal after circulation has been established. All gauge cocks should be open and level controls set at this time.

Gas flow may now be started through the contactor. The flow rate should be increased slowly to prevent losing liquid seals and damage to the trays.

The unit is now ready for final adjustments. This includes checking the reboiler temperature setting, circulation rate, burner adjustment, valve function, level controller function, and glycol level in the sure tank. It is very important to make sure that steam is coming out of the vapor outlet of the still column. The circulation rate should be in accordance with the manufacturer's recommendations.

H.3 Operation. Routine operation of gas dehydration units primarily involves periodic visits to determine if everything is operating properly. As a minimum, the following items should be checked:

a. inlet gas temperature and flow rate

b. contactor pressure

c. reboiler temperature

d. pump operation

e. steam from still column

f. level of glycol in surge tank

g. burner flame pattern and firetube appearance.

It is necessary to periodically add glycol to the surge tank because a certain amount of glycol loss is normal. Other than that, the units are designed for unattended operation as long as everything is functioning properly. If the unit is designed for manual dumping of distillate from the reboiler and/or the glycol flash separator, it will be necessary to check these levels during the periodic visits.

There are numerous operating problems that can be encountered with these units. Some of the most common will be discussed here.

Two factors which greatly affect the ability of a unit to dehydrate gas are gas pressure and temperature. Small changes from design in these variables can have a large effect on the water content of the gas. Gas flow rate has a somewhat smaller effect on equipment performance. The manufacturer should be consulted for turndown capability.

Cold outside air temperatures can render a unit inoperable. It can freeze instruments and controls, and can cause hydrates to form in scrubbers. If a unit is located in an area where this is a problem, precautions should be taken. Examples are heating coils in scrubbers, heating jackets on liquid discharge lines, cold weather shrouds on glycol/glycol heat exchangers, and housing the entire regenerator.

Proper operation of a unit depends on the cleanliness of the gas being processed. Many times, it is necessary to install a coalescing filter separator immediately ahead of the unit. This will remove compressor lube oil fog, small solids, distillate, salt, etc. These impurities can plug equipment, coat packing, render the glycol less effective, and coat the firetube which will cause it to burn out. Plugging in the still column or vent line can cause pressure to build up in the reboiler and surge tank. This pressure should be checked periodically. Caution should be used when opening connections: for example, to add glycol.

There are ways of removing distillate once it gets into the regeneration system. The surge tank may have a skimmer valve on it by which the distillate can be manually drained. If the glycol flash separator is designed as a three phase vessel, distillate may also be removed from the system at this point.

H.4 Maintenance. It is necessary to check the pH of the glycol periodically. It should be a neutral solution. Values that vary from neutral can lessen the ability of the glycol to absorb water, and may cause foaming or corrosion.

The elements in all filters (coalescing, charcoal, sock, regulators, etc.) need to be checked periodically and replaced as necessary.

Pumps require routine maintenance and overhauling. Pump manufacturer's recommendations should be followed.

Dehydration units may become plugged and packing may get a coating buildup. When this happens, it is necessary that the system be thoroughly cleaned.

APPENDIX I
USE OF API MONOGRAM*

I.1 Nameplates. Manufacturers of glycol type dehydration units furnished to this specification shall identify each of the following components with a separate corrosion resistant nameplate.

I.1.1 Reboiler

I.1.2 Contactor

I.1.3 Inlet Scrubber (if not integral with contactor)

I.1.4 Gas-Condensate-Glycol Separator (if furnished)

I.1.5 Glycol/Glycol and Gas/Glycol Heat Exchanger (if not identified by the respective manufacturer)

I.1.6 Glycol Pump (if not identified by the respective manufacturer)

I.2 Reboiler. A nameplate shall be attached to the firetube flange end of the reboiler above the flame cell opposite the stack and shall bear the following information:

I.2.1 API monogram

I.2.2 Manufacturer's name

I.2.3 Manufacturer's serial number

I.2.4 Year built

I.2.5 Weight empty, lbs

I.2.6 Firetube rating, BTU/hr at ____ BTU/hr/ft²

I.2.7 Firetube area, sq. ft.

I.2.8 Shell sizes, O.D., in. x length, feet

I.2.9 Design Pressure, psig

I.2.10 Additional markings such as firebox diameter, length, thickness, material; turbulators installed; still column material desired by the manufacturer or requested by the purchaser are not prohibited.

I.3 Contactor. A nameplate shall be attached to the side of the vessel at about eye level (5 to 6 ft above skid level if practical) and shall contain the information required by the ASME Code plus:

I.3.1 API monogram

I.3.2 Number of trays (for tray tower)

I.3.3 Tray spacing (for tray tower)

I.3.4 Type of packing (for packed contactor)

I.3.5 Height of packing (for packed contactor)

I.3.6 Type of mist extractor

I.4 Inlet Scrubber. A nameplate shall be attached to the side of the vessel at about eye level and shall contain the information required by the ASME Code plus:

I.4.1 API monogram

I.4.2 Type of mist extractor

I.5 Gas-Condensate-Glycol Separator. A nameplate shall be attached to the side of the vessel at about eye level and shall contain the information required by the ASME Code plus:

I.5.1 API monogram

I.5.2 Type of mist extractor (if applicable)

I.6 Glycol/Glycol and Gas/Glycol Heat Exchanger. A nameplate shall be attached to each component and shall contain the information required by the ASME Code (if applicable) and the following information:

I.6.1 Manufacturer's name

I.6.2 Manufacturer's serial number

I.6.3 Year built

I.6.4 Design Pressure, psig

I.6.5 Design Temperature, °F

I.6.6 Either type or model number that can be traced to the heat exchanger manufacturer's engineering data or it shall include enough information so that heat transfer calculations can be made.

I.7 Glycol Pump. The glycol pump shall have a nameplate attached in a visible location with the following information:

I.7.1 Manufacturer's name

I.7.2 Manufacturer's serial number

I.7.3 Manufacturer's model number or type that may be traced to the pump manufacturer's engineering data or it shall include enough information to allow calculations to be made for glycol rate.

I.8 Valves and Controls. It is the manufacturer's responsibility to assure that valves and controls necessary to the operation of the unit have proper identification markings so that traceability to a manufacturer can be accomplished for future information.

I.9 ASME Code Marking. ASME components furnished to this specification shall have a nameplate affixed to the vessel as required by the latest edition of the ASME Code. In lieu of separate API nameplate and at the discretion of the manufacturer, the information required by Appendix I may be included on the ASME Code nameplate below the Code required markings.

I.10 Stamping. Stamping directly on the vessel shell may be injurious to the vessel and should be avoided.

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