Part III – Glycol Dehydration Systems Design

Darryl Mamrosh, PE
Trimeric Corporation
Buda, TX

TEG Dehydration Process Design

Topics

- Introduction
- Typical process
- Modifications to typical process
- Key design questions
- Design references

TEG Dehydration Process Design: Introduction

- Why worry about TEG dehy design?
  - Vendors often provide detailed design along with their equipment
  - Often not necessary to design your dehy

TEG Dehydration Process Design: Introduction

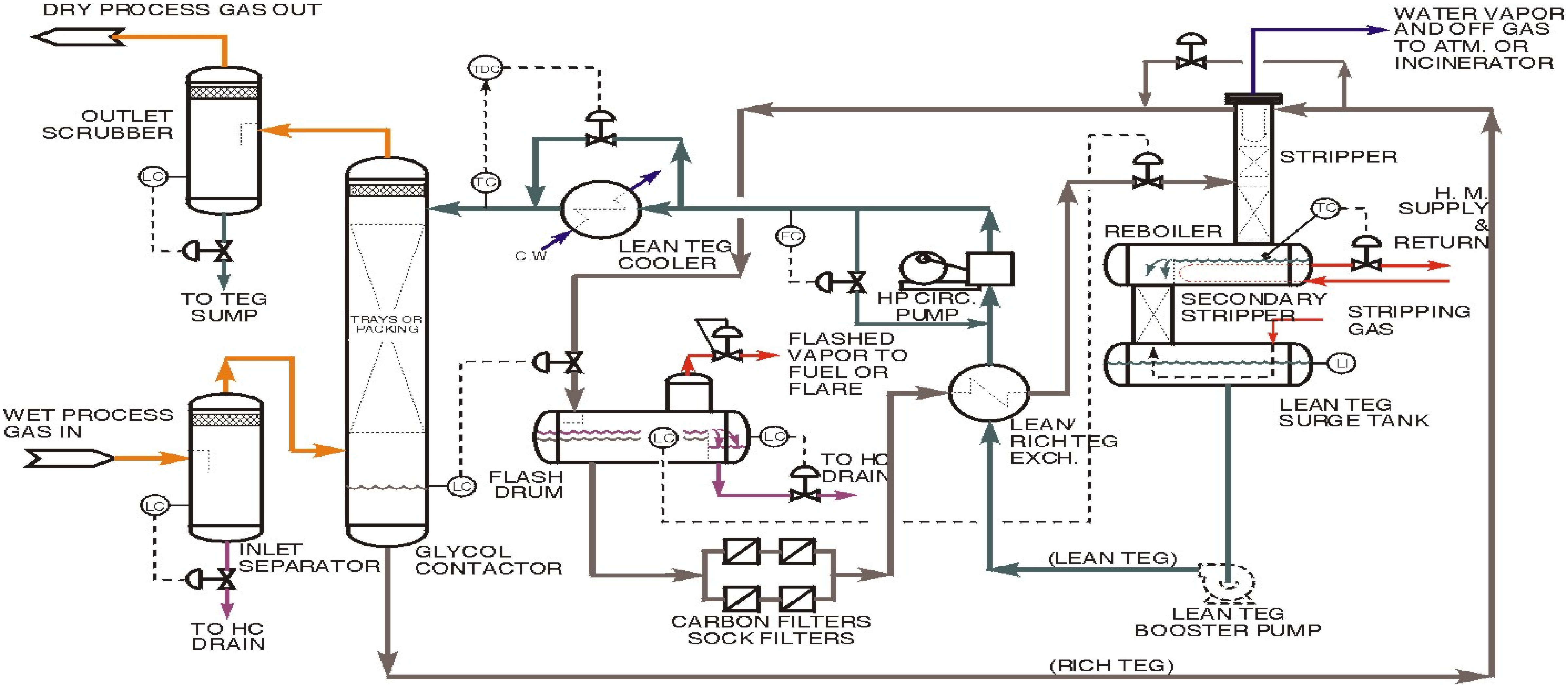
- Why worry about TEG dehy design?
- Knowledge of design practice is important anyway:
  - Troubleshooting
  - Debottlenecking
  - Early phase work / cost estimation
  - Guiding vendor designs
  - Evaluating design proposals

TEG Dehydration Process Design: Introduction

Dehydration Solvents

- MEG & DEG: primarily *inhibitors*
- Glycerol: Limited dehydration uses
- TEG: Most Common Process Solvent for Gas Dehydration
  - Low vapor pressure
    - Less solvent loss with treated gas
  - Thermal stability at high temperature
    - Required for lower dew points

Glycol Dehydration – A Typical Process Scheme



Slide courtesy - Petroskills

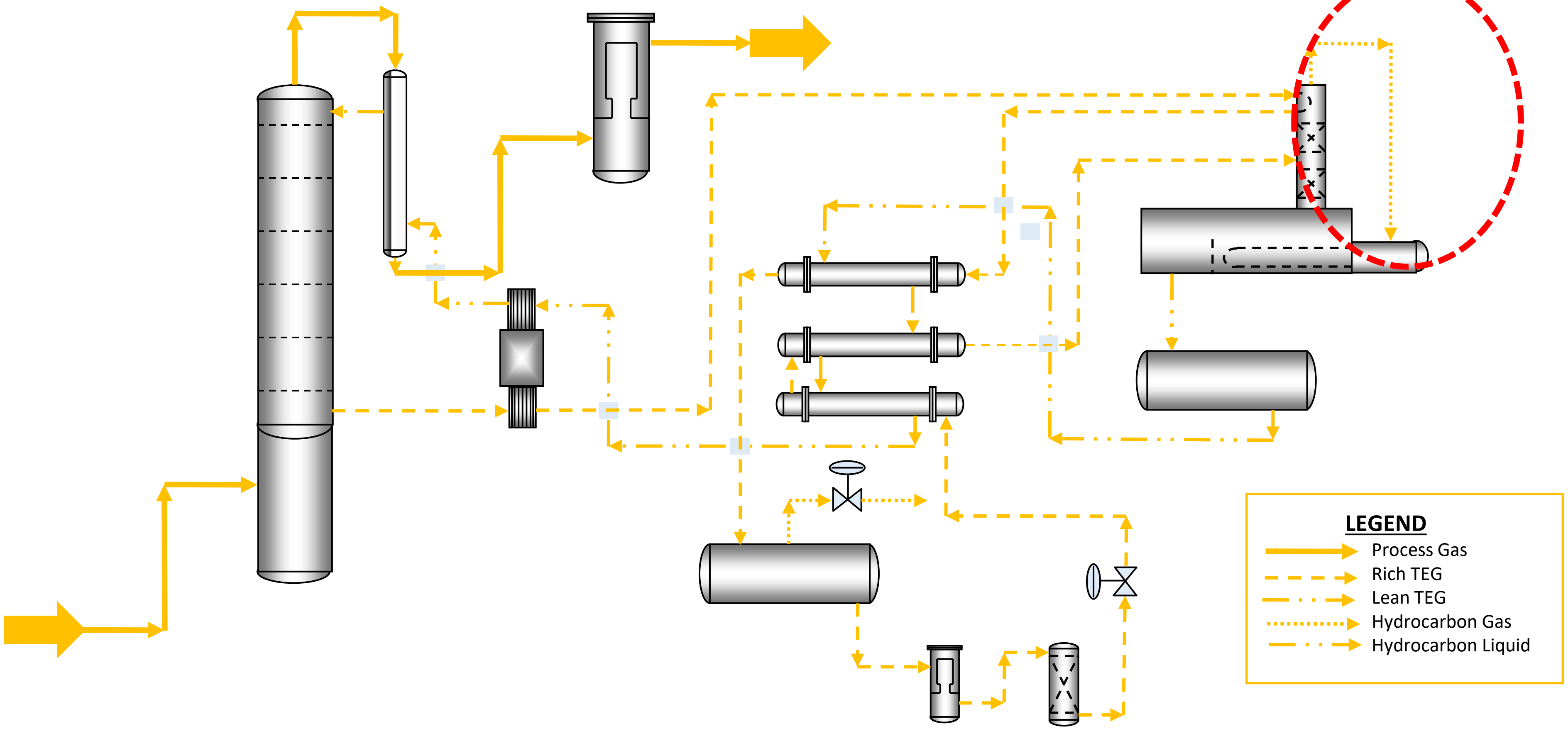
LAURANCE REID GAS CONDITIONING CONFERENCE
70
EST. 1951

TEG Dehydration Process Design

- Many variations, usually focus on:
  - “Enhanced purity” glycol for very dry gas
  - Environmental restrictions
  - Lower capital cost
  - Gas characteristics
  - Field unit versus plant (utility availability)
- Also:
  - Energy efficiency
  - Reducing solvent loss
  - Avoiding downstream problems

TEG Flowsheet Variations

ENVIRONMENTAL COMPLIANCE

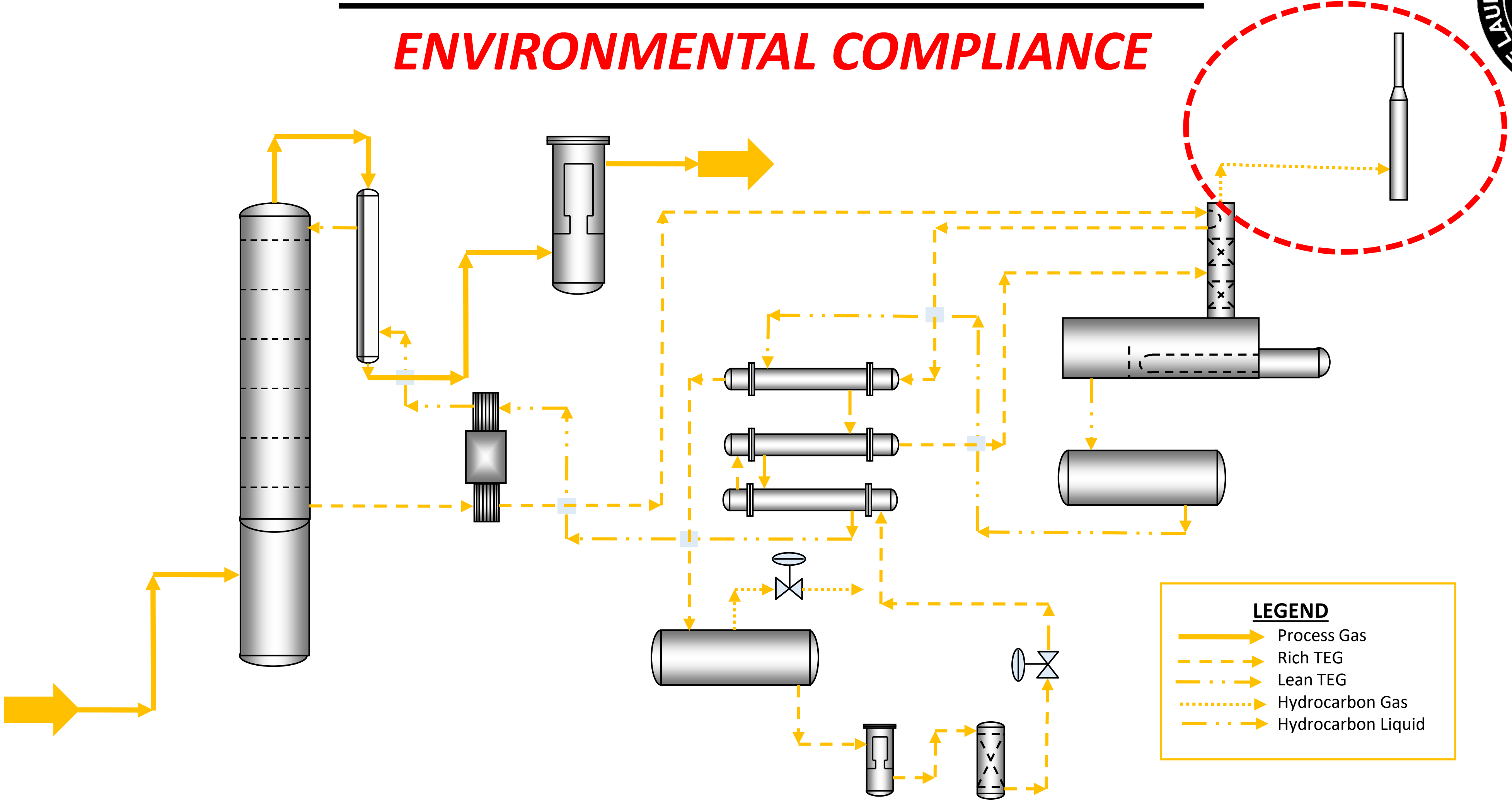


BTEX (Benzene, Toluene, EthylBenzene, Xylenes) AND VOC EMISSIONS - REBOILER BURNER

Control of BTEX and VOC's from TEG Reboiler vent stream. Smaller units often mix vent gas into fuel gas feed. Less common now (burner is often on/off design, can cause burner problems).

TEG Flowsheet Variations

ENVIRONMENTAL COMPLIANCE

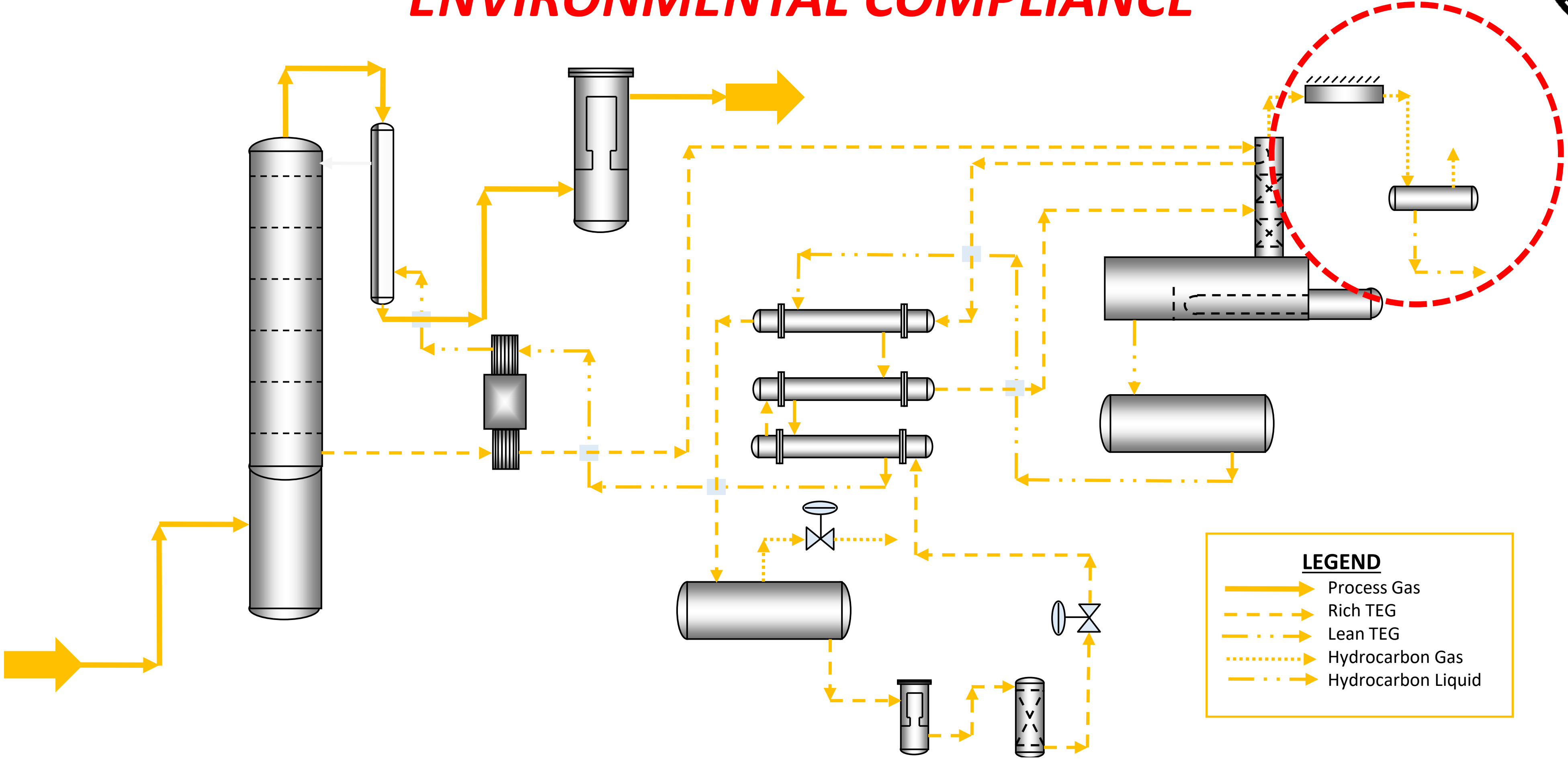


BTEX & VOC – COMBUSTOR

Vent gas may be routed to a flare or combustor. This often requires supplemental fuel gas to maintain a continuous flame -- the hot vent gas is usually mostly water vapor.

TEG Flowsheet Variations

ENVIRONMENTAL COMPLIANCE

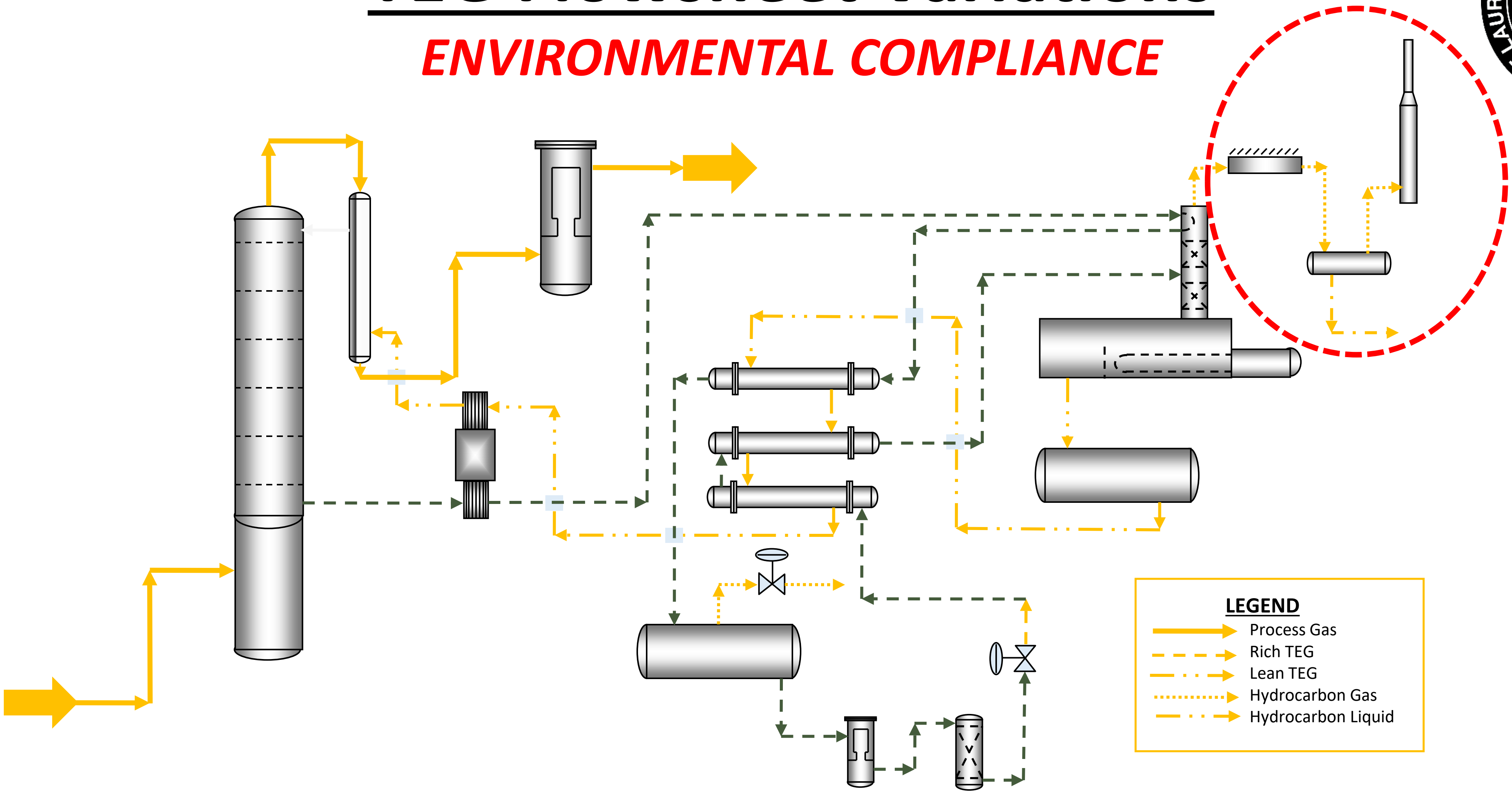


BTEX & VOC – CONDENSER

Many newer BTEX Units include condensing and liquids collection. Both air coolers and cross exchangers common. Air coolers require careful control in cold locations.

TEG Flowsheet Variations

ENVIRONMENTAL COMPLIANCE



BTEX – CONDENSER & COMBUSTOR

Larger BTEX Units may not reduce BTEX/VOC enough with one technology. May have condenser and combustor. Fuel gas is not required as this cooled vent gas is usually combustible.

TEG Flowsheet Variations

ENCHANCED PURITY PROCESSES

- Purify glycol beyond what can be achieved by temperature alone
  - ***Purify = remove water***
  - Big difference between 98 wt% and 99.99 wt% TEG
- Roughly 98-99% for non-enhanced processes
- Purity limited by reboiler temperature
  - 400 F typical reboiler temperature
  - 404 F considered a limit (Thermal Degradation)
  - Approximate Equilibrium: 98.6% TEG at 400 F / 1 atm

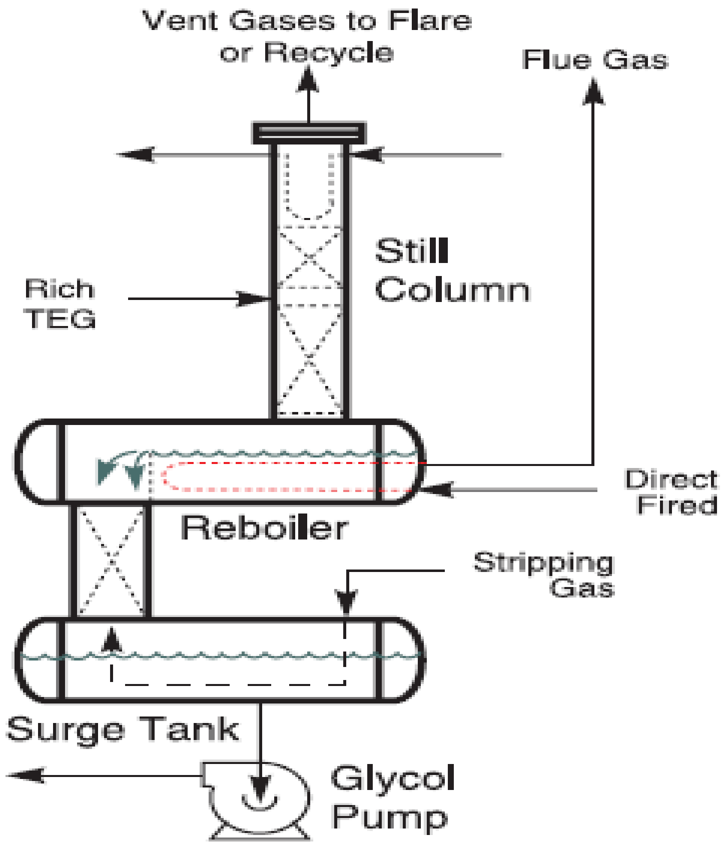
TEG Flowsheet Variations

ENCHANCED PURITY PROCESSES

- Vacuum
- Stripping gas
- Stahl column
- Cold finger
- Drizo
- And New this week Tall Stahl – Paper on Tuesday afternoon introduces a new method to achieve ultra pure glycol that could compete with molecular sieves

TEG Flowsheet Variations

ENCHANCED PURITY PROCESSES: STRIPPING GAS

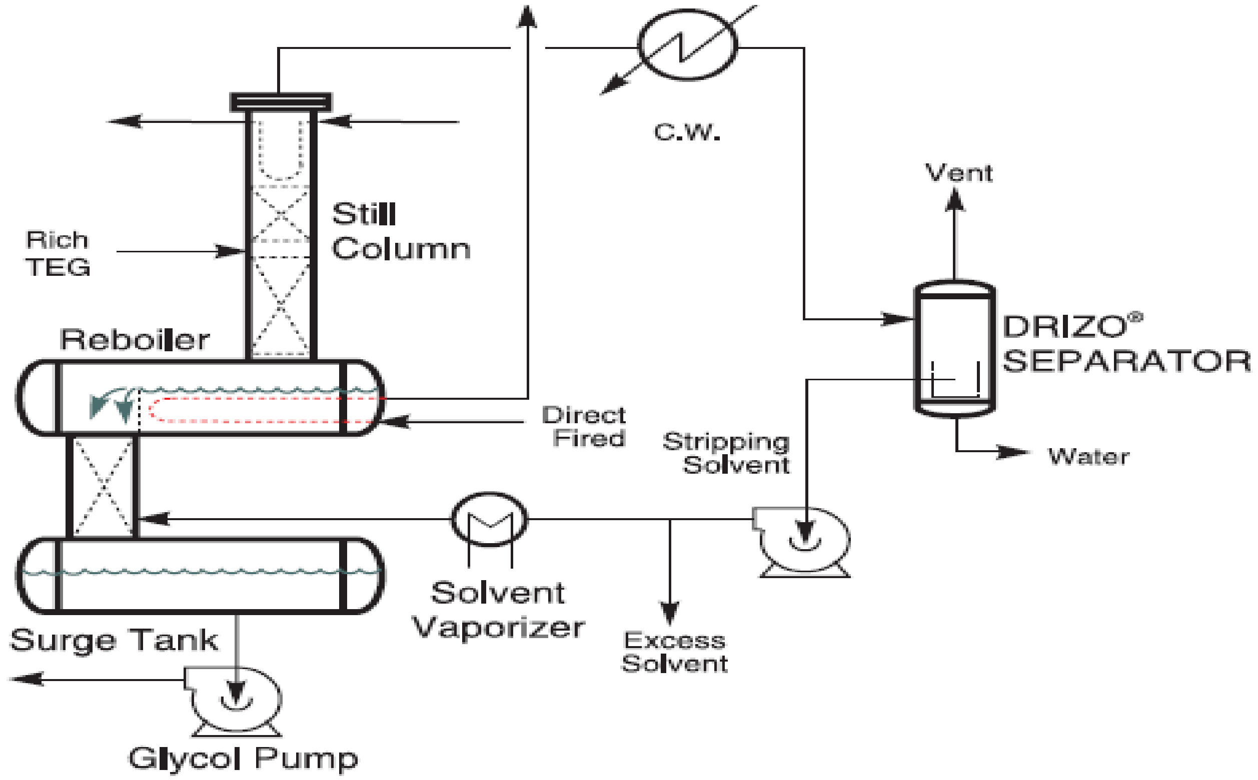


a) Stripping gas

Slide courtesy - Petroskills

TEG Flowsheet Variations

ENCHANCED PURITY PROCESSES: DRIZO

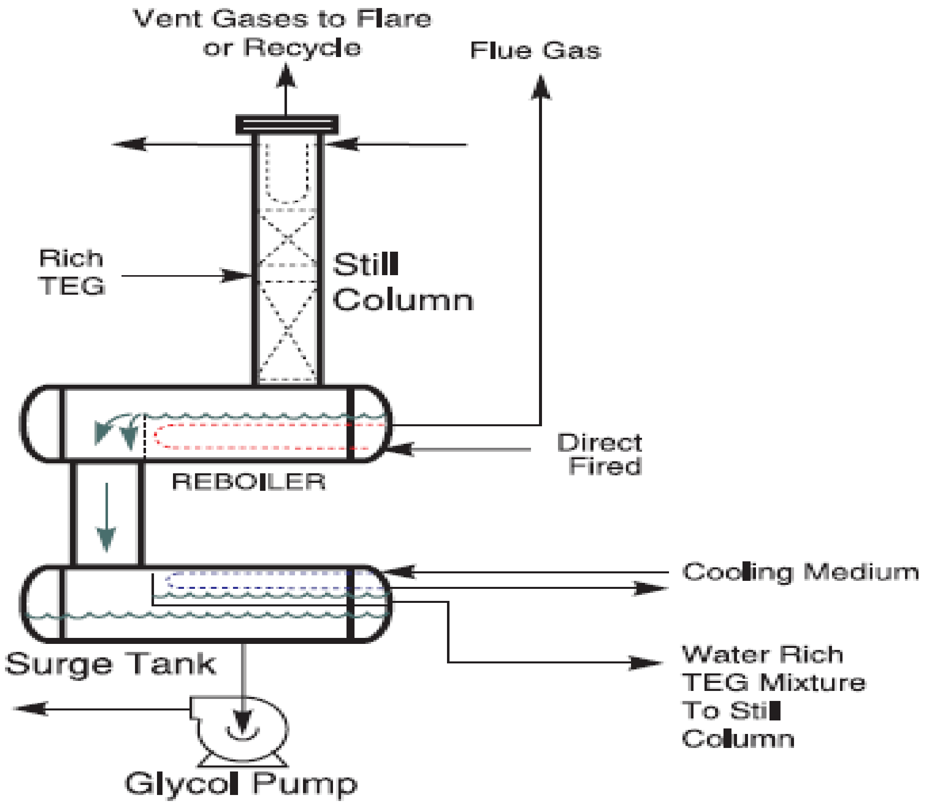


b) DRIZO®

Slide courtesy - Petroskills

TEG Flowsheet Variations

ENCHANCED PURITY PROCESSES: COLDFINGER

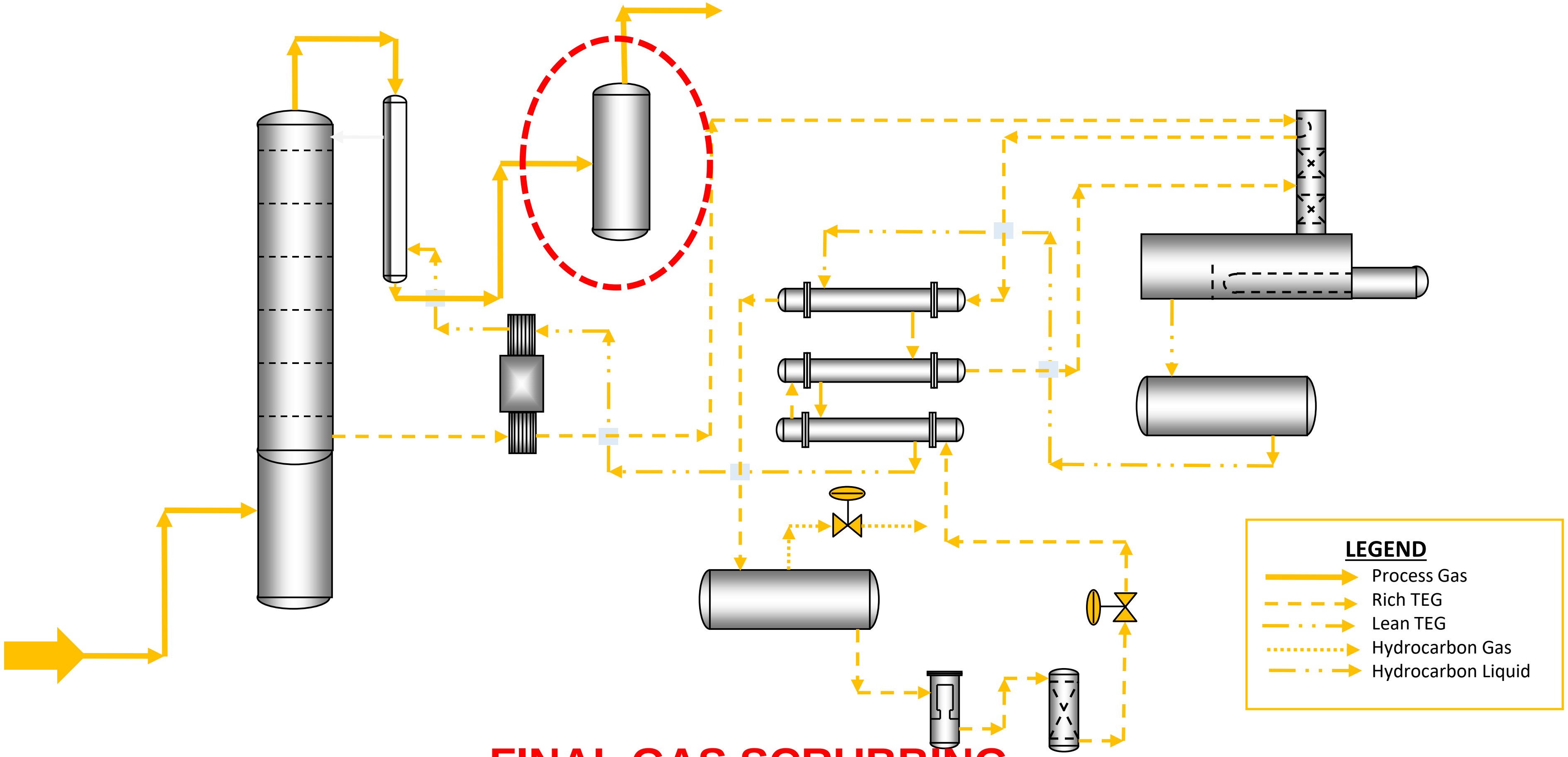


c) COLDFINGER®

Slide courtesy - Petroskills

TEG Flowsheet Variations

AVOIDING DOWNSTREAM UPSETS & EXCESSIVE SOLVENT LOSS

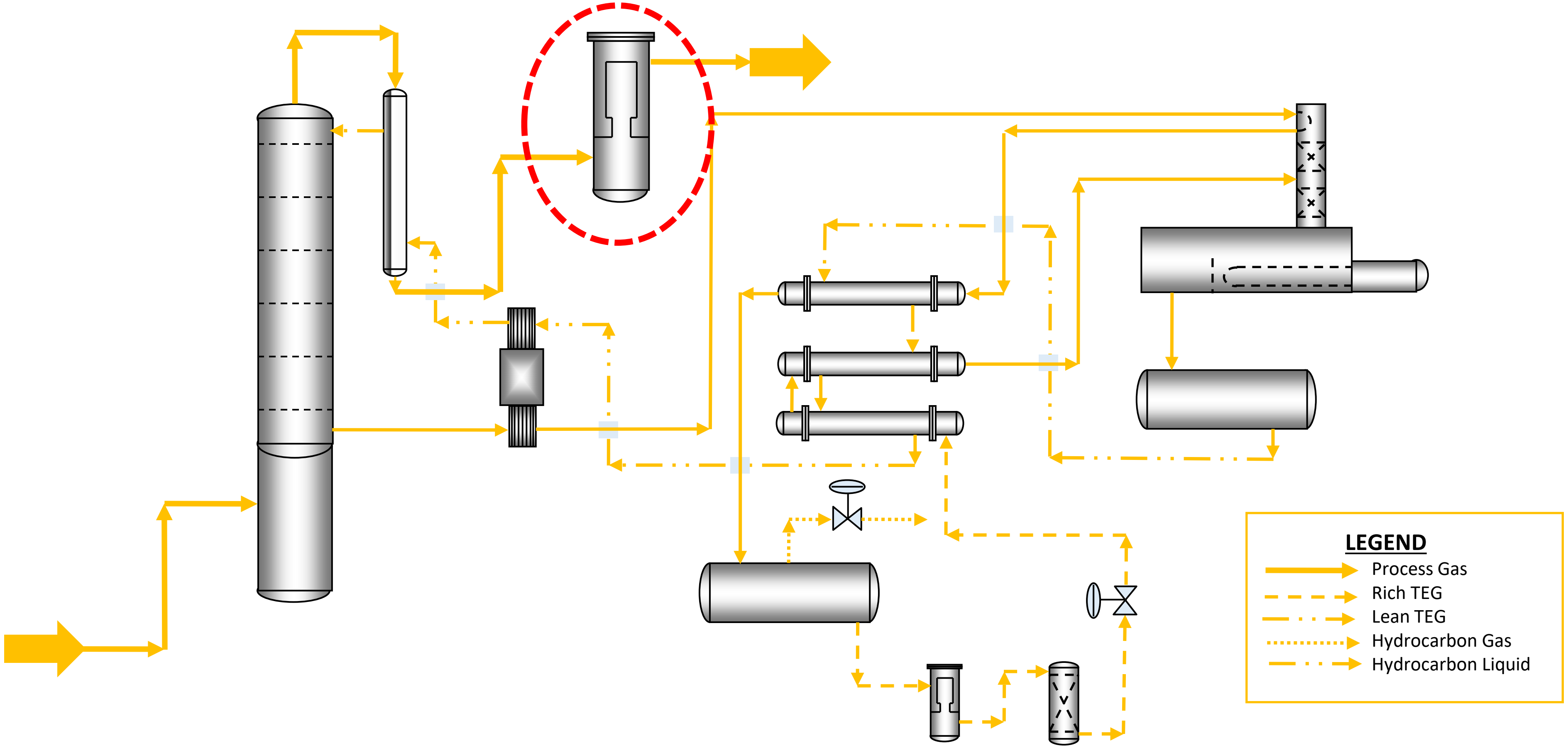


FINAL GAS SCRUBBING

***All** designs should end with an Outlet Scrubber to remove TEG carried over from the Contactor. Normally low volumes are caught. But can catch larger volumes from foaming or other issues.*

TEG Flowsheet Variations

AVOIDING DOWNSTREAM UPSETS & EXCESSIVE SOLVENT LOSS



FINAL GAS SCRUBBING – COALESCING FILTER

An option to an outlet scrubber is an outlet coalescer. Also can have both (scrubber followed by coalescer).

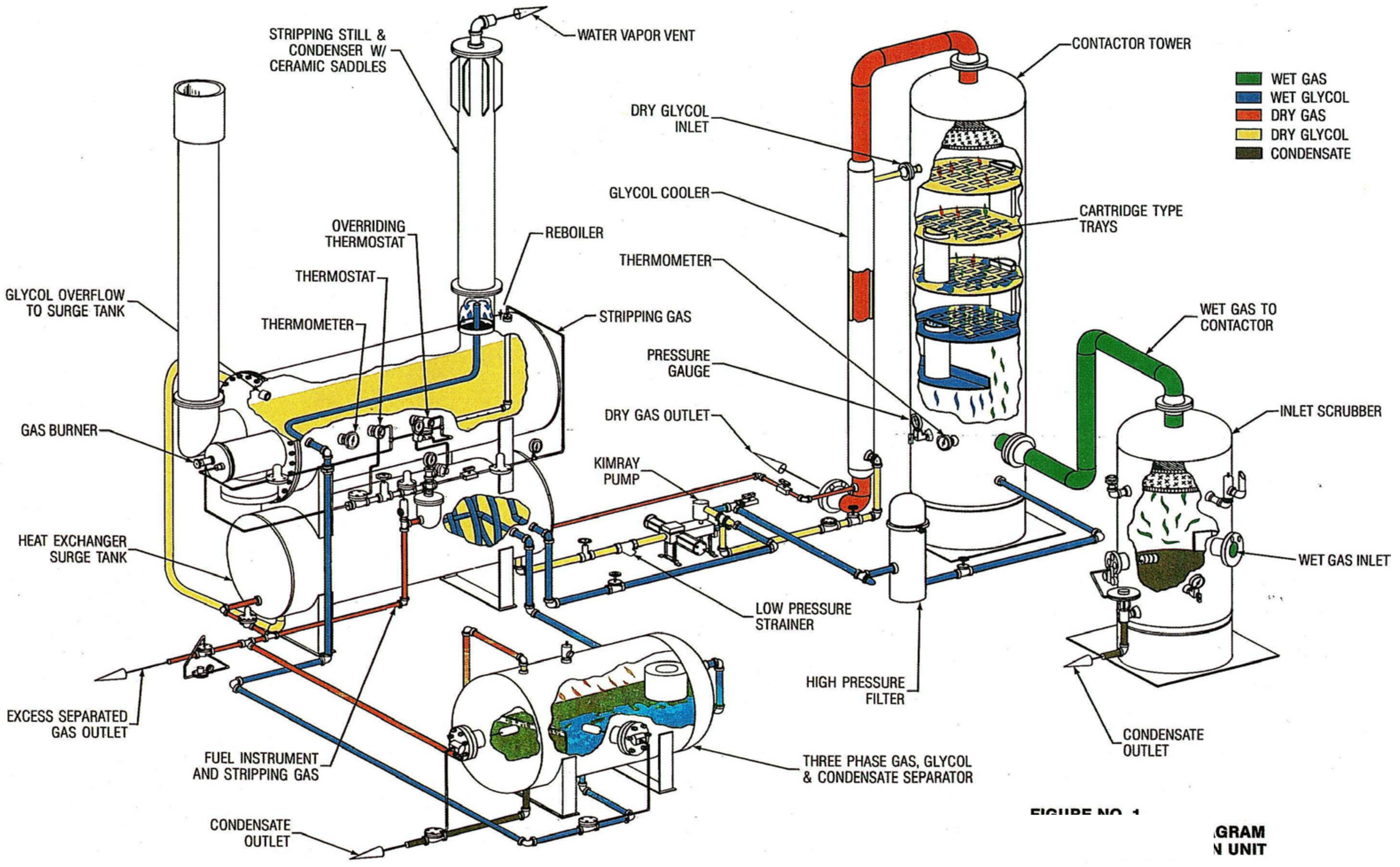


FIGURE NO. 1
GRAM
N UNIT

Defining the Design

- Design Basis
- Define Basic Design Parameters

Key Design Questions: Design Basis

- How much water must be removal from feed gas?
  - Glycol recirculation rate
- What is the specification for water in the treated gas?
  - Glycol purity
  - Absorber column height

Key Design Questions: Parameters

- What glycol rate is required?
  - 2-6 gal TEG / lb water typical range
  - Size of the unit
  - Reboiler size, energy usage
- What glycol purity is required to achieve the treatment?
  - “Enhanced design” required?

Design References

Reference #1

Gas Processors Suppliers Association, Engineering Data Book, Volume 2, 14th Edition, Section 20 – “Dehydration”

- *Comprehensive design overview with excellent updated data for special design circumstances*
- *Physical property and chemical equilibria*
- *Rules of thumb for approximate / early phase design*

Design References

Reference #2

Campbell, John M. et al, Gas Conditioning and Processing, Volume I & II, 8th edition, John M. Campbell & Co., Norman, OK, 2004, Chapters 6 & 18

Good general reference with detailed methods and data for units of all sizes

Design References

Reference #3

Sivalls, C. Richard, “Glycol Dehydration Manual”, 2001 Laurance Reid Gas Conditioning Conference, February 25-28, 2001, Norman, Oklahoma

Practical basic general reference with typical design procedure

Design References

Reference #4

Manning, W.P., and Wood, H.S., “Guidelines for Glycol Dehydrator Design, Part I & II”, Hydrocarbon Processing, Jan-Feb, 1993

Typical of a series of articles and presentations on glycol units from sources rich in field experience

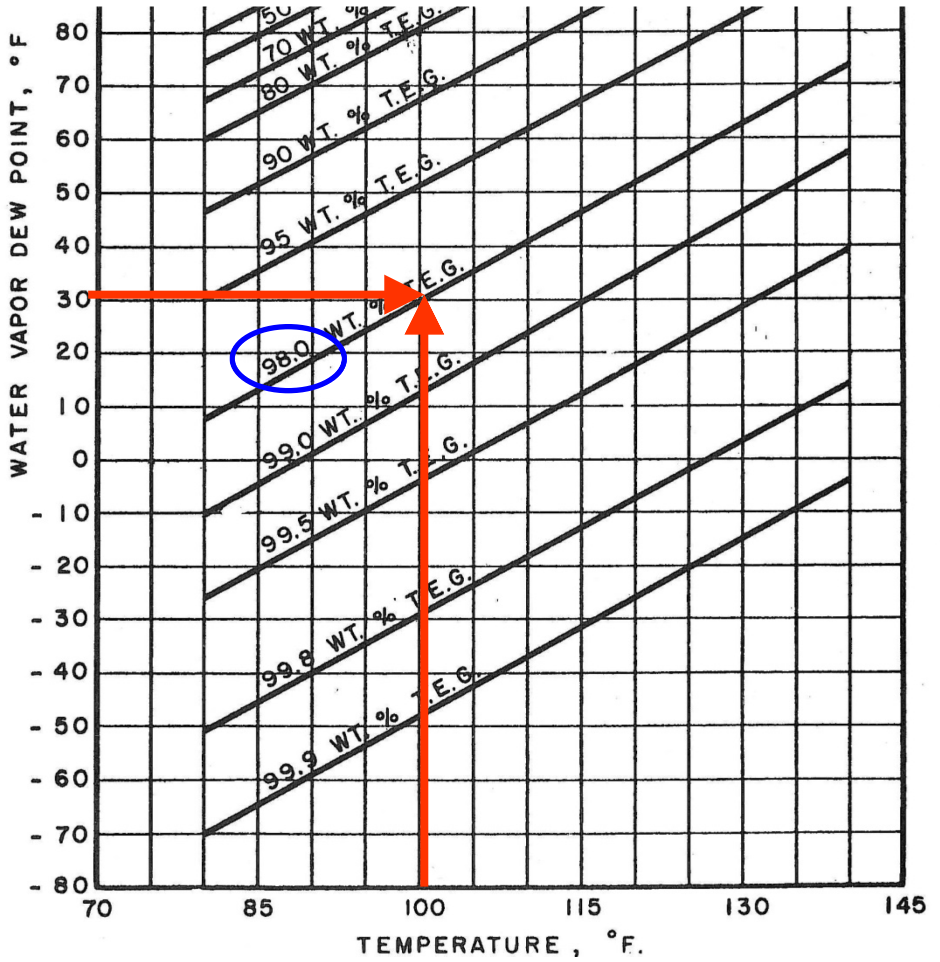
Key Design Questions

- The methods in the References have been used successfully for many years to build glycol units large and small
- Use charts and rules of thumb such as
  - Approach to equilibrium in the top tray
  - Number of trays or height of packing to achieve 1 equilibrium stage
- **Example: determine glycol purity required for a given water dew point requirement in dry gas…**

Design Recommendations – Setting Glycol Purity

Typical Water Dew Point Vs Temperature Chart

See Sivalls Reference Figure 7



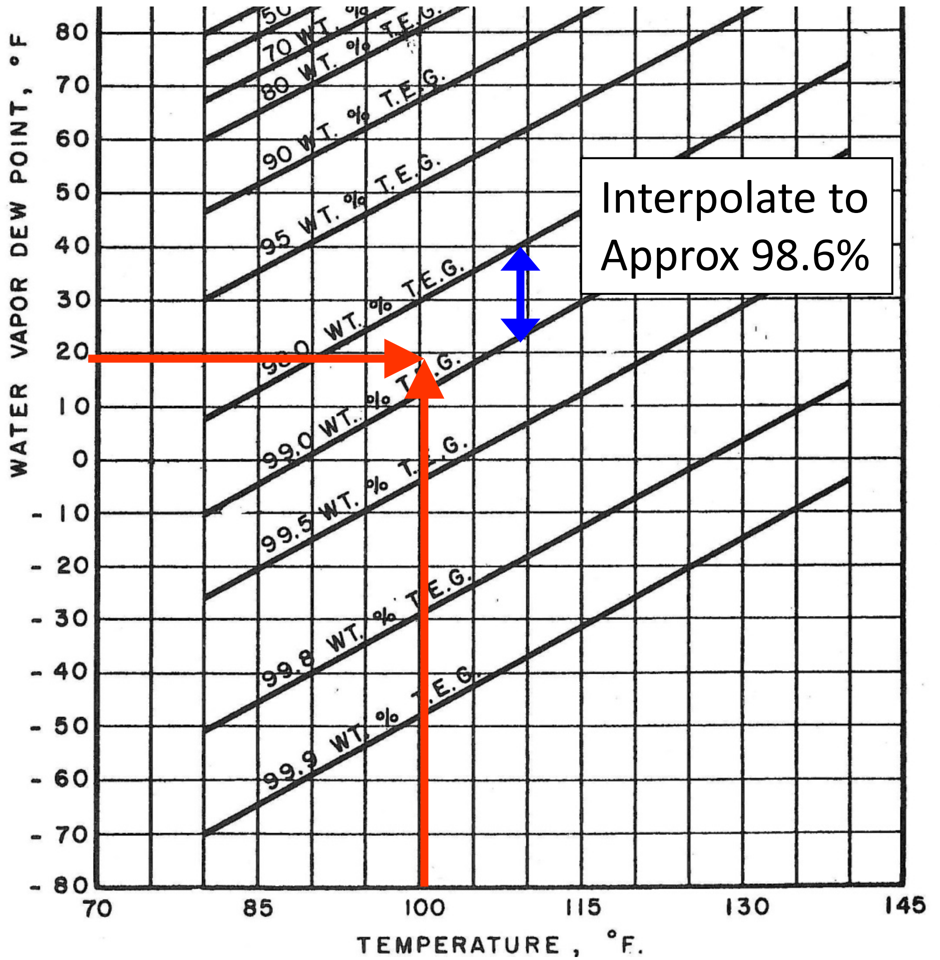
Design Recommendations – Setting Glycol Purity

- Consider “approach to equilibrium” for:
  - Non-equilibrium actual operation
  - 10 - 20 ^oF margin recommended

Design Recommendations – Setting Glycol Purity

Typical Water Dew Point Vs Temperature Chart

See Sivalls Reference Figure 7



Another Approach: Process Simulations

- The graphical methods are still quite useful
  - May be quicker (especially rules of thumb)
  - Always useful for early phase design estimates
- Most simulation software used for gas processing have a thermo package for glycol dehydration modeling
  - Consult with software vendor help desk
- Use rules of thumb from literature as starting point of simulation

Process Simulations

- Glycol absorption is mass-transfer-rate limited
- Trays and packing are inefficient
- Beware of equating trays directly to simulation theoretical stages
  - ~20 – 35% tray efficiency in absorber
- Use rate-based model if available
- Apply tray efficiency data from literature

Design Recommendations – Contactor Design

- Trays and packing are used
- Minimum 24” spacing for trays
- Structured packing can reduce column size
- Packing heights requirements from vendors
- Leave disengaging room at top

Design Recommendations – Contactor Design

- Apply a “system factor” to de-rate capacity
  - Accounts for foaming-type behavior
  - Applies a factor to make column diameter larger to reduce vapor velocity
- Literature references and vendor software

Design Recommendations – Glycol Regenerator Reboiler

- Large kettle reboiler
  - Drains to lean surge
- Still mounted on top of shell
- Special internals/outlet for enhanced purity
  - Stahl column

Design Recommendations – Glycol Regenerator Reboiler

- Heat input affected by losses to ambient / degree of insulation
- Typical operation is 400 ^{o}F
- Limit flux in high temperature operations

Design Recommendations – Glycol Flash Tank

- Reduce pressure (50-75 psig) of Rich Glycol to remove
  - Dissolved acid gas
  - Dissolved hydrocarbon gas
  - Entrained hydrocarbon liquid
- May not be needed for low pressure treatment, treatment of inert gases

Design Recommendations – Glycol Flash Tank

- 5-10 minute liquid residence time for "normal" circumstances
- When liquid hydrocarbons may form:
  - 20-30 minute residence time
  - Heating can help phase separation: Lean-Rich exchanger variations

Design Recommendations – Heat Exchange Options

- Lean glycol cooling
  - Rich-lean exchange for initial cooling
    - External or internal
  - Trim cool within 10-20 ^{o}F of gas temp
    - External coolant: air, cooling water
    - Gas-glycol exchange

Design Recommendations – Pumps and Filtration

- Kimray-type gas-driven
- Low speed reciprocating pumps
- Rich glycol filtration/carbon treatment
- 5 micron **full flow** solids filter (sock/cartridge)
- Coal-based carbon filter for removal of impurity chemicals (well-treating chemicals, hydrocarbons, etc)

TEG Dehydration Process Design: Conclusions

- There are many resources for designing glycol dehydration units
  - Proven literature references and charts
  - Simulations
  - Even if you're not designing and building, it is still important to be familiar with the technology

TEG Dehydration Process Design: Conclusions

- Acknowledgement: Mike Conder for developing the original slide pack

- Thanks for Listening

Fundamentals - Dehydration

- Part I – Dehydration Overview & Molecular Sieves
- Part II – Molecular Sieves Operations
- Part III – Glycol Dehydration Design
- Part IV – Glycol Dehydration Operations/Performance Monitoring

- *Part V* – Time and interest permitting we will field questions this afternoon or of course during the **ROUND TABLE** on Thursday morning