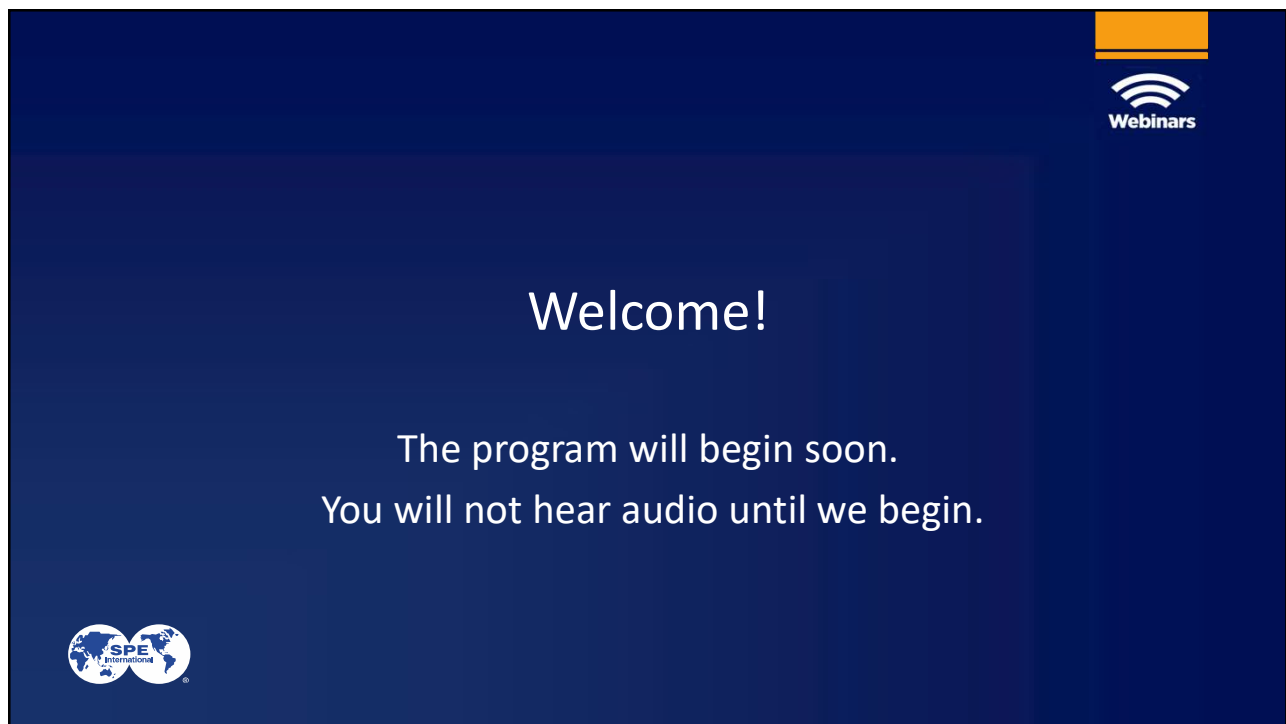




A dark blue rectangular slide with a lighter blue rectangular area in the center. In the top right corner, there is an orange square above a white Wi-Fi symbol and the word "Webinars". In the bottom left corner, there is a logo for SPE International, which consists of two globes with the text "SPE International" in the middle. The central text is white and reads: "Welcome!" followed by "The program will begin soon." and "You will not hear audio until we begin."

Webinars

Welcome!

The program will begin soon.
You will not hear audio until we begin.

SPE International



Experiences with TEG dehydration plants, from early to late life challenges

Erik Solheim Sr.Advisor Process Upstream, Equinor
November 2 2023



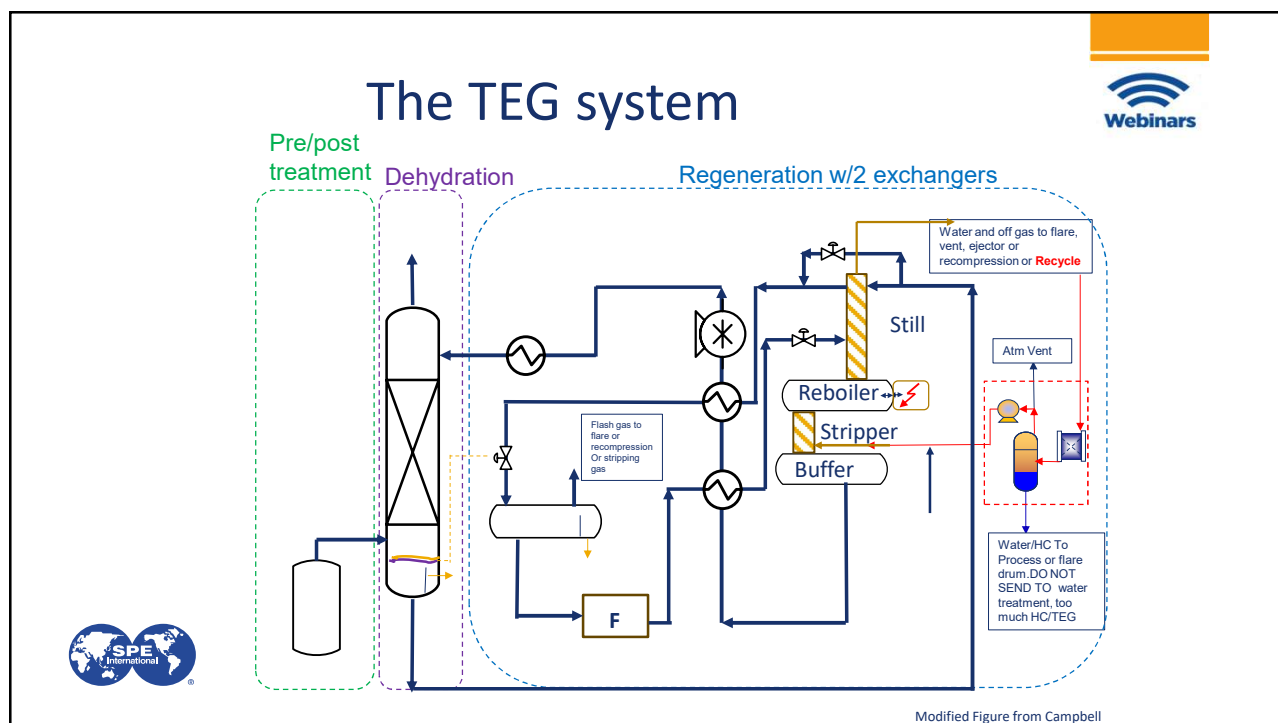


Presentation content

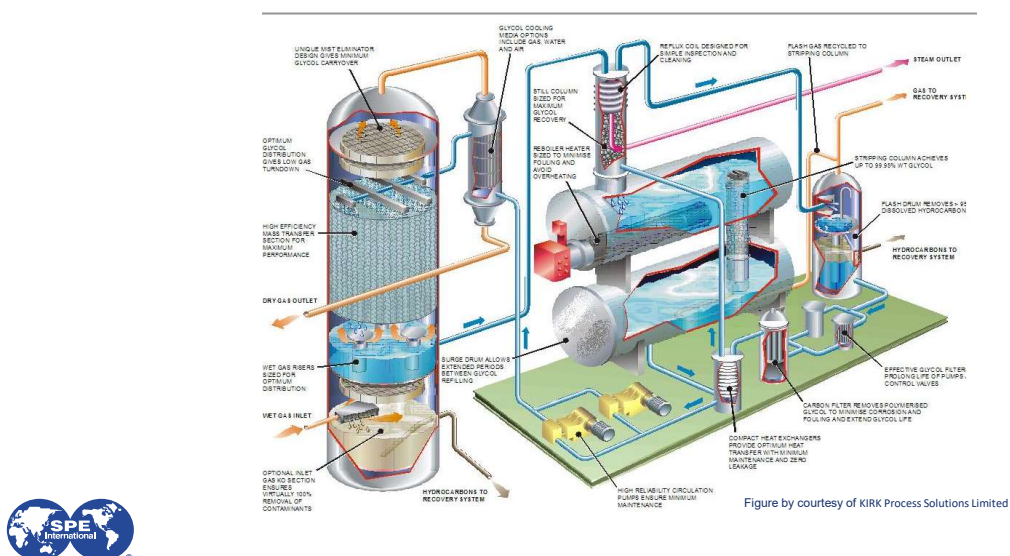


- TEG dehydration design
- The design phase
- Bottlenecks found in design/commissioning phase
- Bottlenecks in operational phase
 - Operational experiences
- Revamps and Low Pressure production bottlenecks
- Where are we going?





Water Absorption and Regeneration with TEG



Example of glycol regeneration skids



Figures by courtesy of Frames Group B.V

The design phase



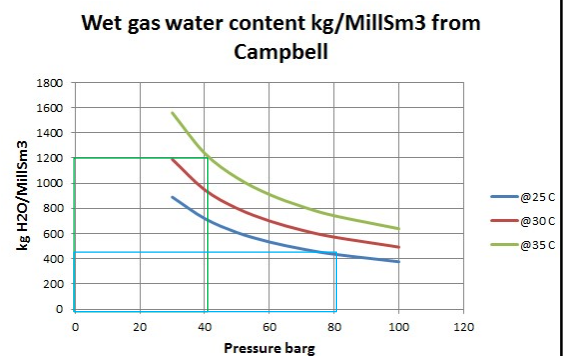
- What is your spec? -18C @69barg, or 36 ppm mol or 40 kg/MillSm3 ?
- Determines TEG purity requirement and circulation rate
- Design is iteration between tower height, TEG purity and circulation ratio(TEG/water)
- What is your wet gas water rate?



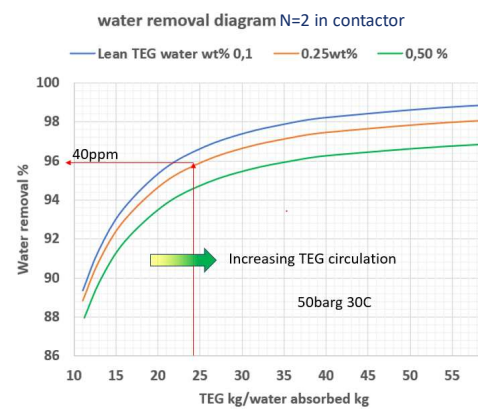
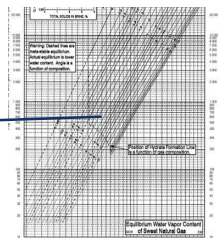
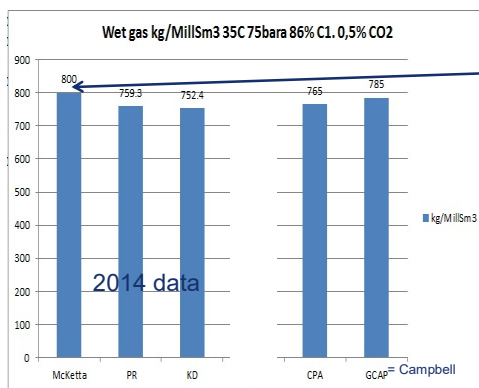
The design phase. Temperature



- Our design method:
 - Design for +3C
 - Have extra cooling capacity for feed gas
- If you design for a low temperature , but cannot achieve it, performance may be off spec/fail
- If gas cannot be cooled more, more stripping gas in the only other parameter to improve operation/performance since the TEG rate is given from design.
- Your still and stripper column must be able to handle sufficient extra stripping gas
- Being able to lower feed gas temperature is the most effective way to improve dehydration performance in operation.



The design phase...water load



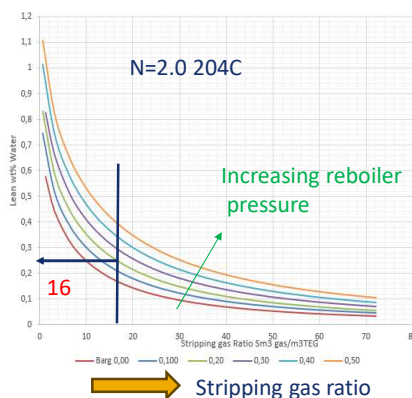
Effect of gas feed inlet temperature
+5C on feed gas gives 30% more water and may give +40-100% increase in TEG rate circulation.

Stripper/Still & Lean TEG water%



- In operation the stripper degrades and seldom exceed 2 theoretical stages regardless of internals. 1.5-2 stages are typical. Note theoretical stages will differ between simulation models/EOS.
- If designed (only) for high efficiency/dense packing the hydraulic capacity will suffer (smaller ID), and compensating for a stripper degradation in operation by increasing stripping gas can become impossible.
- Stripper and still must have sufficient extra hydraulic gas capacity (ID) to operate with a fouled stripper with degraded efficiency ($N=1.5-2$) even if it on paper/when clean had more efficiency

Lean TEG
Water%



Make sure the stripper/still can handle
sufficient stripping gas
Reboiler pressure must be known



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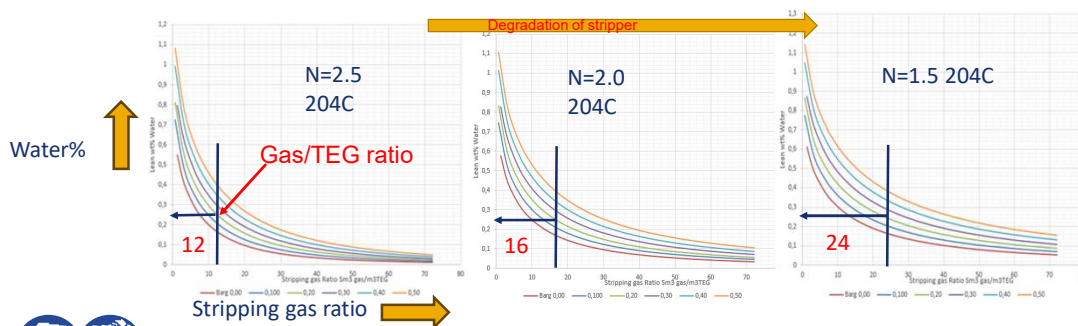


Stripping gas ratio

Examples



- Example 1: 0.2barg/204C: Base stripping gas rate requirement and hydraulic design on 2 stages and 150% stripping gas.= Stripper can then degrade from 2 to 1.5 stages (or from 2.5 to 2) without consequences.
- Do not assume that you will have more than 2 stages in operation, and make sure the design can handle that.
- Example 2: Designed for 2.5stages efficiency and hydraulically(ID) with no margin = When degraded to N=2.0 stripping gas cannot be increased= water in lean TEG increase from 0.25 to 0.35wt% and may give offspec gas



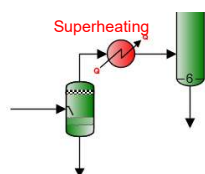
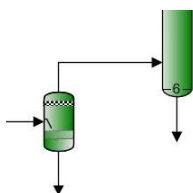
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Make sure the stripper/still can handle sufficient stripping gas

Pre-treatment: inlet separation

Inlet Separation

Without a doubt, most operating problems with glycol dehydration systems are a direct result of inadequate inlet gas conditioning upstream of the contactor. The upstream separator should remove liquid hydrocarbons, liquid water, solids, corrosion inhibitors, etc., prior to the glycol unit. John Campbell Sr. said, "You cannot afford the dehydration unit if you cannot afford to place an effective separator on the gas inlet."

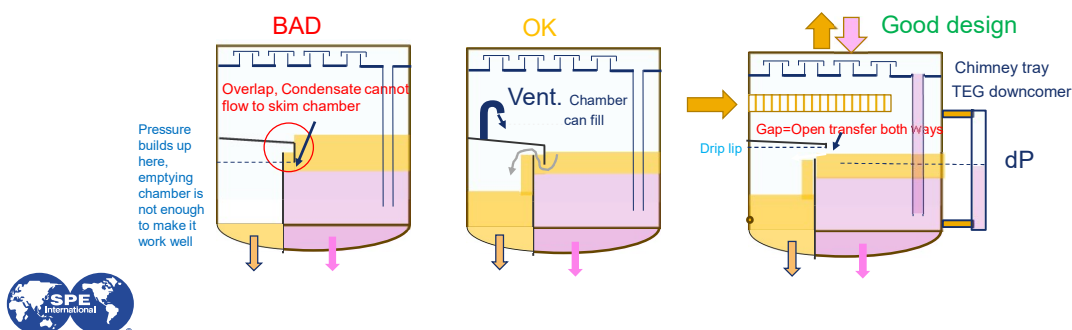


- A separate scrubber with robust design is recommended. Recommend to use 20% design margin here.
- Possible retrograde condensation add to condensate drop out in/to contactor.
- Carry-over liquid will always reach contactor and HC skimming in contactor bottom is required. See next slide. Skimming frequency can vary from 1/hr to 1/day
- Superheating of gas feed by 3-5C can eliminate carry-over/condensate, but still wise to have a skimming arrangement, you may not always have superheating. But poorer dehydration at increased temperature

Contactor skimming



- Use ONLY dP cells for level control of TEG in vessel with skimming- This will result in a self-regulating skimming system not requiring any logic or operator intervention. (Trip level can be non-dp cell...)
- Example: Calibrate for 100% TEG and set SP 100mm lower than chamber edge. Condensate will accumulate on top and flow over edge. $1\text{m TEG} = 0.8\text{m TEG} + 0.3\text{m Condensate} = 1.1\text{m}$
- Skimming chamber should be inside contactor, and have a roof. It MUST ventilate freely to the TEG side gas phase= avoid any overlap (under-over weir) effects that can prevent gas to escape the chamber as condensate flows into chamber.



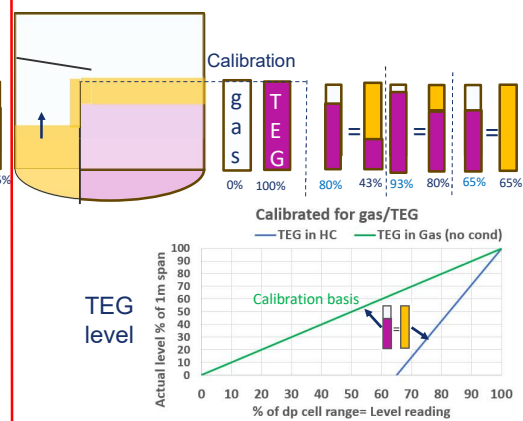
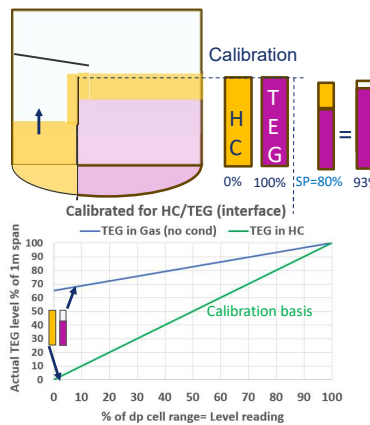
TEG level control (self study)



- Level control on TEG with dP cell can be done 2 ways. Both will result in "self-skimming"

A: Calibrated TEG level to indicate/control Interface. Set interface SP, HC will flow over edge

B: Calibrated only TEG liquid for level control
Set TEG SP below edge, HC will accumulate and flow over edge

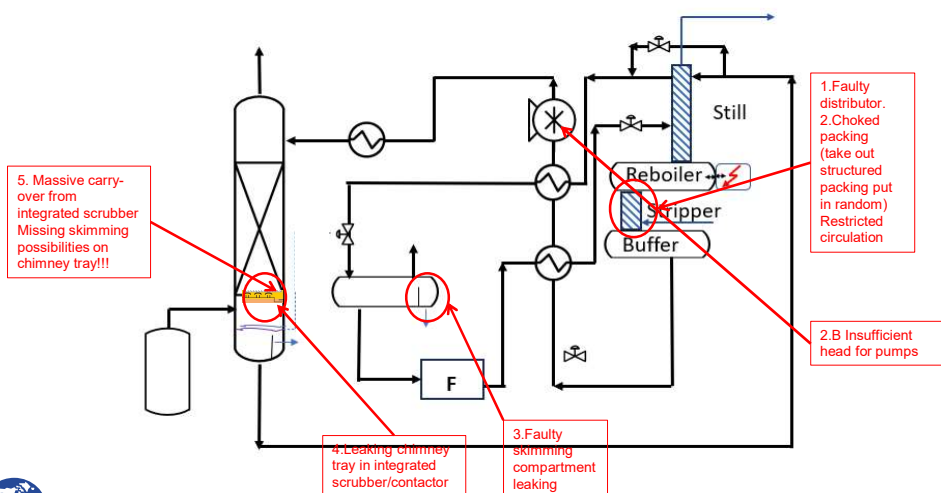


TEG level

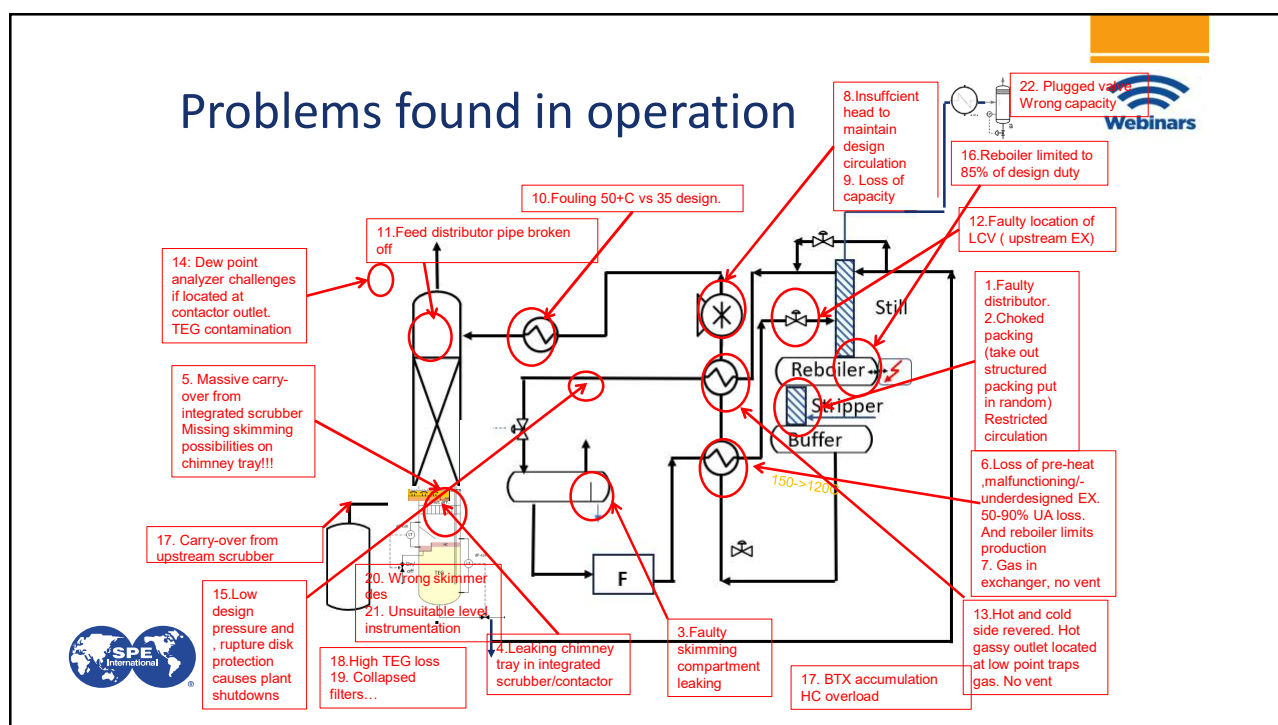


24V8001 nivåmåling

Bottlenecks found in commissioning/startup



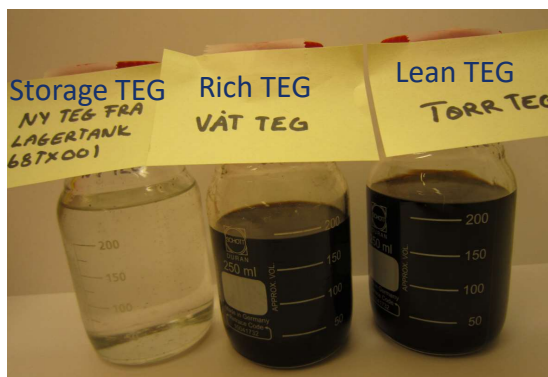
Modified Figure from Campbell



Glycol in/out



- In operation the glycol becomes contaminated, and degrades
 - This is what is circulating



Stripping/Still column limitations



- Less suitable distributor design/plugged distributor



Stripping/Still column limitations



- Fouled and plugged packing. Limits TEG circulation



Packing weight 6kg when new, 24 kg when fouled

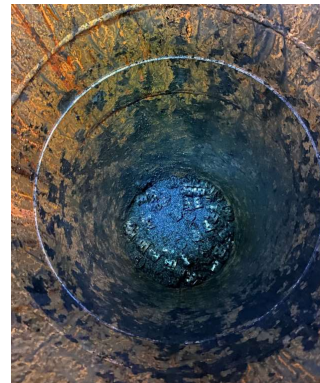


Design should not depend on a high assumed efficiency of “fine” packing in stripper
Stripping gas design rate and stripper/still diameter must consider loss of stripping
packing efficiency and demands for increased stripping gas

Stripping/Still column limitations



- Also random packing can become plugged. This is stripping column AFTER chemical cleaning.

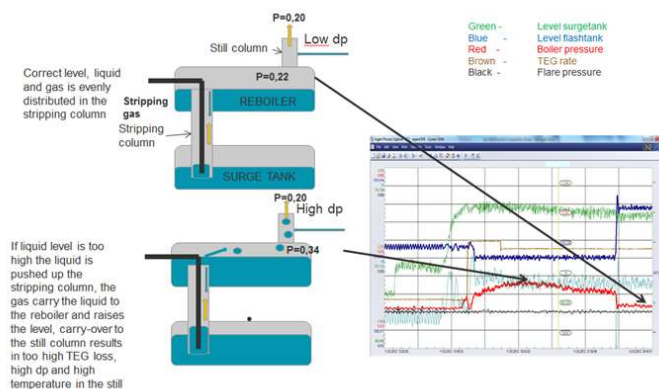


Stripper (and still) design diameter must allow for fouling

Interactions



- Restricted TEG circulation, due to design and level interactions



Problem could be avoided if stripper did not extend into liquid pool

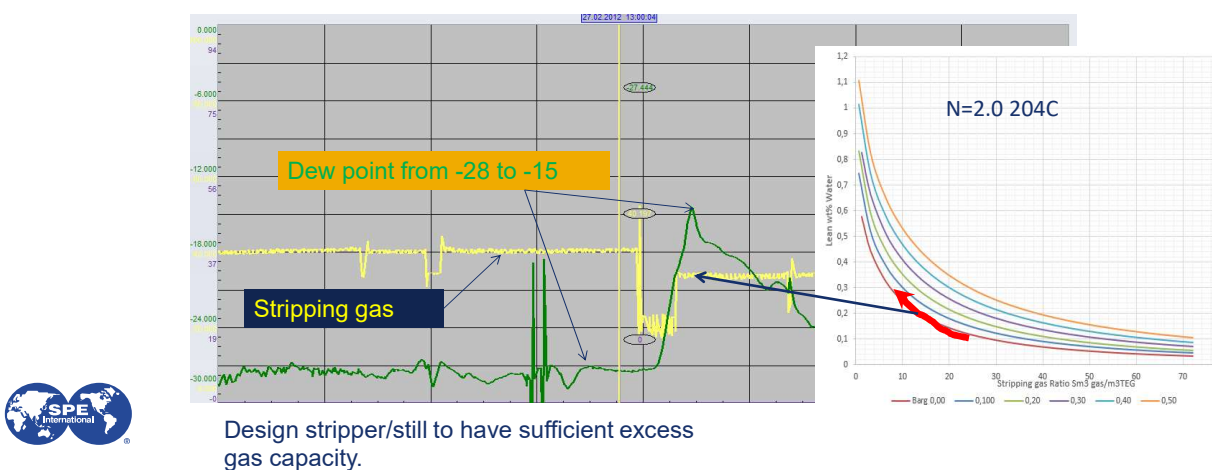


Figure 5-17: Level effects in surge drum and reboiler cause increased reboiler pressure and TEG loss (Train B Data)

Stripping gas sensitivity.



- Reduced stripping gas by 50%

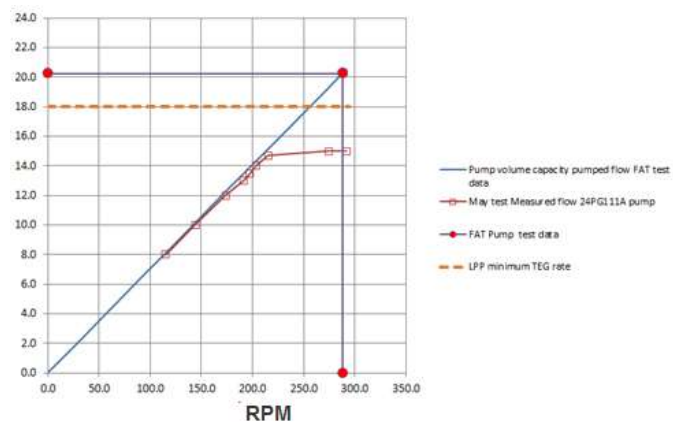


Circulation limitations. Pump limitation



- Too low head on suction side, suction dp limits reciprocating pump capacity

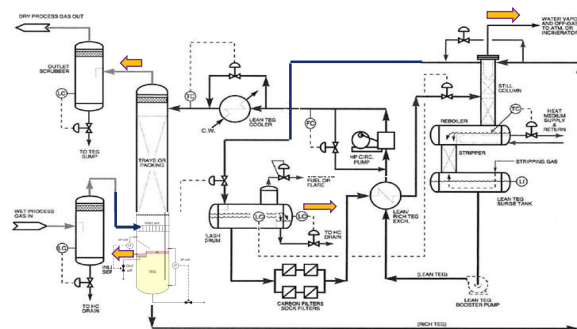
If you have variable rpm/stroke, you can save the pump by reducing flow... but with fixed speed/rate??



Glycol losses



- In our experience a stable plant has TEG losses from 10-30 liter/MillSm3
- With condensate carry over from scrubber TEG losses may be 10x higher
- With improper skimming levels/routine the losses may be 10x higher
- Undersized stripper/too much str.gas 10X higher loss
- Fouled packing in still: 10X more TEG loss

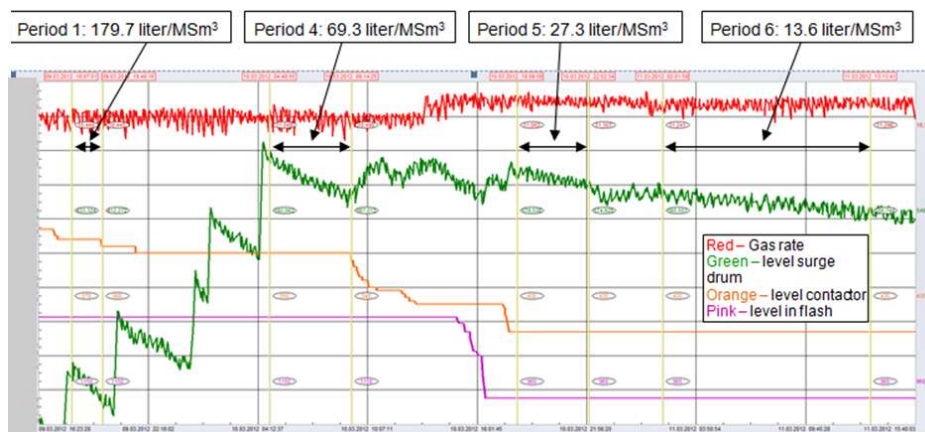


Modified Figure from Campbell

Glycol loss example



- Glycol losses minimized by adjusting skimming levels properly



Overall operating experience



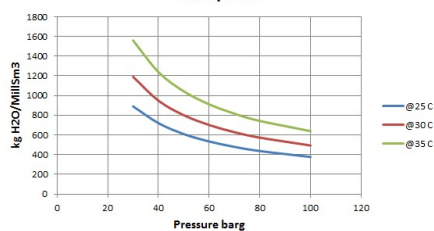
- Apart from the notes in the previous slides, TEG units works fine
- “Never” any complaints about off-spec gas. (well,,, once in my 25years)
- Many of our plants has passed their peak production and operate at reduced loads
- Units are left alone with little attention, as long at it does its job.
- Seldom limits production rates
- But Low Pressure production and tie ins requires a boost in capacities
- Design margins and debottlenecking technology allow this (High capacity packing installed originally by default)



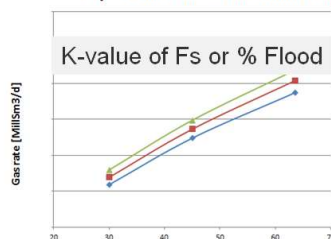
Low Pressure operation: Hydraulic and chemical limitations



Wet gas water content kg/MillSm3 from Campbell

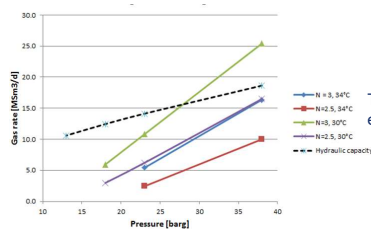


Glycol contactor Gas load limitation



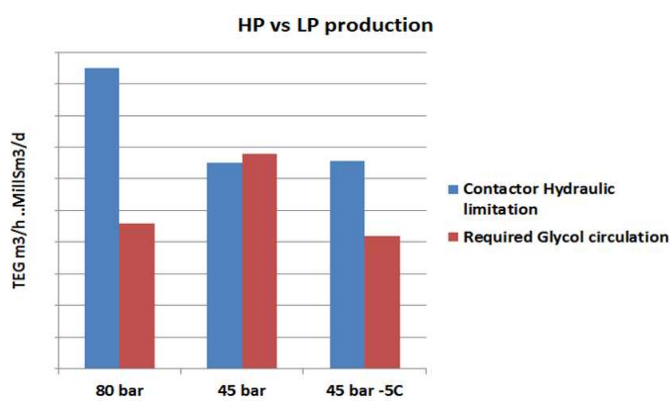
$$F_s = V_s \sqrt{\rho g}$$

$$K\text{-value} = V_s \sqrt{\rho g / (\rho l - \rho g)}$$



Tower stages and operating temperature effect dehydration capacity

Late life Low pressure production. A case study.



- Demand for glycol circulation increase despite gas rate reduction due to hydraulic capacity @temp
- Design should consider LP cases, utilize existing margins
- Lower feed gas temperature can debottleneck system
- Increase stripping gas to provide higher lean TEG %

Actual plant test for LP production:



- Identified limitations in TEG regeneration vs design. Running high gas temperature to emulate future regeneration load.
- 6 months after cleaning the system:
 - Pumps deliver 75% of design capacity
 - Low suction pressure/ high suction dp
 - 30-40 degree C lower preheating to reboiler than in design
 - Poor exchanger performance
 - Reboiler limited at 85-90% duty due to hot heating elements
 - TEG regeneration quality on spec at 75% of design rate
 - Original startup strainer never removed on stripping gas recycle blowers, removed after 20+ years!!
- Verify the design/paper capacity before you need it ..
- This is a plant with robust original design margins and extra circulation capacity included in original design, and will therefore meet the LP production rates after some improvement.
- If it had been an more "optimized" design, the LP production capacity would be much lower than desired.



How to minimize operational challenges?



- Have some fat in design
 - (But avoid adding margins on margins)
- Sufficient stripper and still column capacity to allow for some fouling/plugging
- Spare/ excess stripping gas capacity to compensate for efficiency loss
 - Assume max 2 theoretical stage stripper efficiency and add a margin to that stripping gas rate.
- Sufficient reboiler heater duty margin to allow for loss of preheat. 2*100% el. heaters
- Exchanger fouling factors?
- Self draining glycol liquid head may not be sufficient to overcome dp in equipment, especially when fouled
 - Booster pump may be needed
- Contactor design with margins, install High capacity packing by default
 - Use vertical support ring for mesh demister to maximize useful area
 - A 6cm flat support ring blocks 12% area in a 2m ID contactor!! Avoid this bottleneck...



Capacity extensions, debottlenecking, LP production



- Dehydration Contactor Tower
 - Change from bubble cap trays to structured packing
 - Change from standard packing to high capacity packing
 - More efficient packing (more area) if glycol rate is limited
 - Capacity penalty..
- Regeneration
 - Utilize design margins on circulation
 - Increase stripping gas to make higher TEG purity
 - Improve pre-heating
 - TEG Exchanger must be designed for presence of vapor and HC gas.
- Improve upstream scrubber performance
- Lower feed gas temperature as far as possible



Where are we going in TEG design?



- Contactor towers:
 - Taller with more packing and denser packing(more area per volume)
 - Higher capacity structured packings are utilized to put in more area.
 - But designers/company seems not to optimize for shorter towers.
- Regeneration: Module built vs skid built
- Variation in TEG water/ratio used by vendors, but generally higher circulation rates are used.
- Module size and weight differ significantly compared to capacity pre 2005..
 - We see 50% or more difference in weight for similar regeneration capacity
 - We see similar new weight modules that gives only 30-50% of gas capacity compared to old designs
- Design choices, specs, margins and requirements, construction and lay-out are important. A more lean design requires valid case definition to cover future operations.
- Example: Complete TEG package spec for 1990: 29 pages.... 2020: 200 pages from Eng company to vendor



The end



Thank you!
Any questions?



Erik Solheim

