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Gas Plant Troubleshooting: Assumptions Can Be Expensive – Follow the Data

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Thought Experiment

- You have fed your dog a certain food its whole life.
- One day, you switch brands, and that very night, your dog gets sick.
- **What is your first assumption?**

MISSION STATEMENT

To provide an overview of sound plant troubleshooting methodology through the use of a case study.

- Good data, and correct interpretation of that data, can be a compass that points you to the root cause, which, in this case, was far removed from the original suspect.
- Following the data, holding initial suspicions loosely, and having a willingness to pivot the focus in light of new evidence is critical in getting plants back to operating successfully.



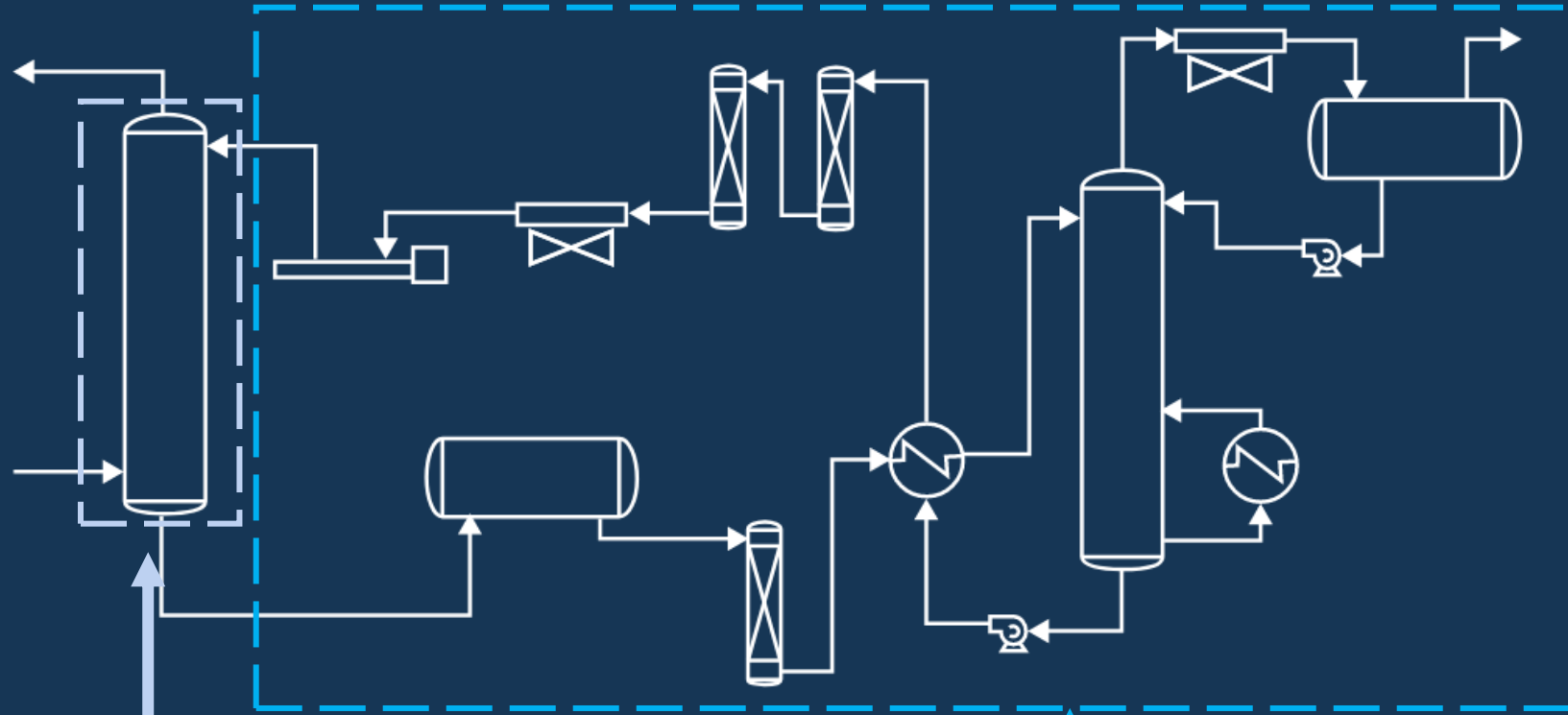


Wilfred Facility Overview

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2023
ROCKIN' ON! MOVING ENERGY IS OUR BUSINESS

- Inlet Conditions:
 - 20 MMSCFD
 - 50 ppm H₂S
- Treated Gas Specification:
 - 4 ppm H₂S
- New 20 GPM regeneration system provided by Enerflex.
- Existing Contactor sized for 40 MMSCFD remained in service.



EXISTING

NEW



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Start-Up and Troubleshooting

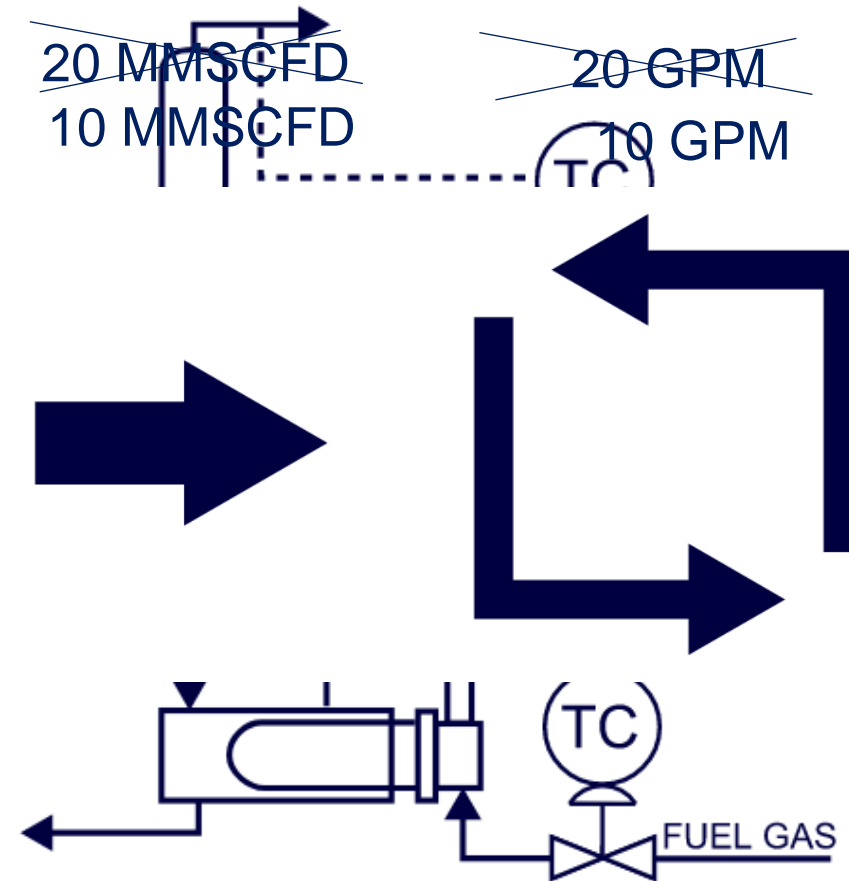
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2023

Initial Start-Up Results

- Enerflex's involvement in plant troubleshooting began at the end of 2022.
- At this point, H₂S spec in treated gas was NOT met (*plant reporting >4 ppm*).
- Enerflex provided heat and material balances at current operating conditions that predicted sufficient performance: <1 ppm H₂S content in treated gas.
- Solvent samples were taken:
 - *Lean loadings reported to be 0.0036 mole of acid gas per mole of amine (mol/mol). Note: Although these are low for MDEA based solvents, **this is much higher than historical values prior to the regen system swap out.***
 - *Rich loadings reported to ALSO be 0.0036 mol/mol.*

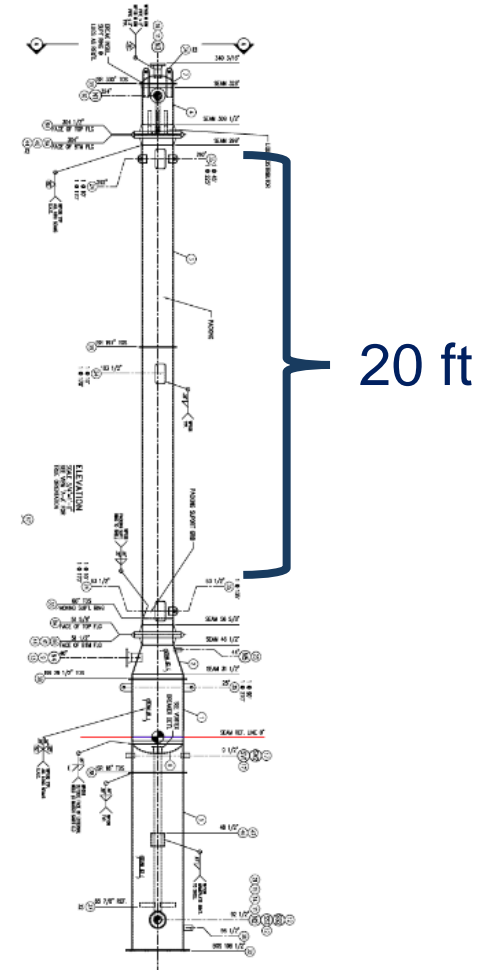
Operational Troubleshooting Steps

- High lean loadings? **Boil harder!**
 - Target: 235°F to 240°F in still overheads
 - Operations achieved 237°F to 239°F with capacity to spare.
 - H₂S concentration in treated gas unaffected.
- Turndown the plant: Both inlet gas and circulation rate.
 - H₂S concentration in treated gas unaffected.



Initial Suspect: Still Tower Packed Bed Height

- Still bed height = 20-foot of packing. The old still column that was replaced was reportedly taller.
- 20-foot bed heights were quoted by two independent internals providers during proposal stage.
- New feedback from the selected internals provider: *“We would like to see 30-foot of packed height.”*
- This would add ~5 stages of mass transfer.
- Alternatively, smaller packing could be provided to add ~2-stages, but limited to 70% of design flow.
- **Short term solution:** Add stripping promoter as suggested by solvent provider.



Tower Replacement? Really?

.....can be very costly!

ProTreat Analysis

Case 1: Match lean loadings

Case 2: Match overheads temperature

Case 3: Match overheads temperature, add stripping promoter

Summary Table		Case 1	Case 2	Case 3
Inlet Gas Rate	MMSCFD	13	13	13
Amine Circ Rate	USGPM	10	10	10
Outlet H2S Content	ppm	1.178	0.855	0.212
Still Ovhd Temp	F	224	231	231
Lean Loading (H2S Only)	mol/mol	0.0036	0.0028	0.0003

Sweet Gas

Sour Gas

6
13

CASE 3

ADD STRIPPING PROMOTER!

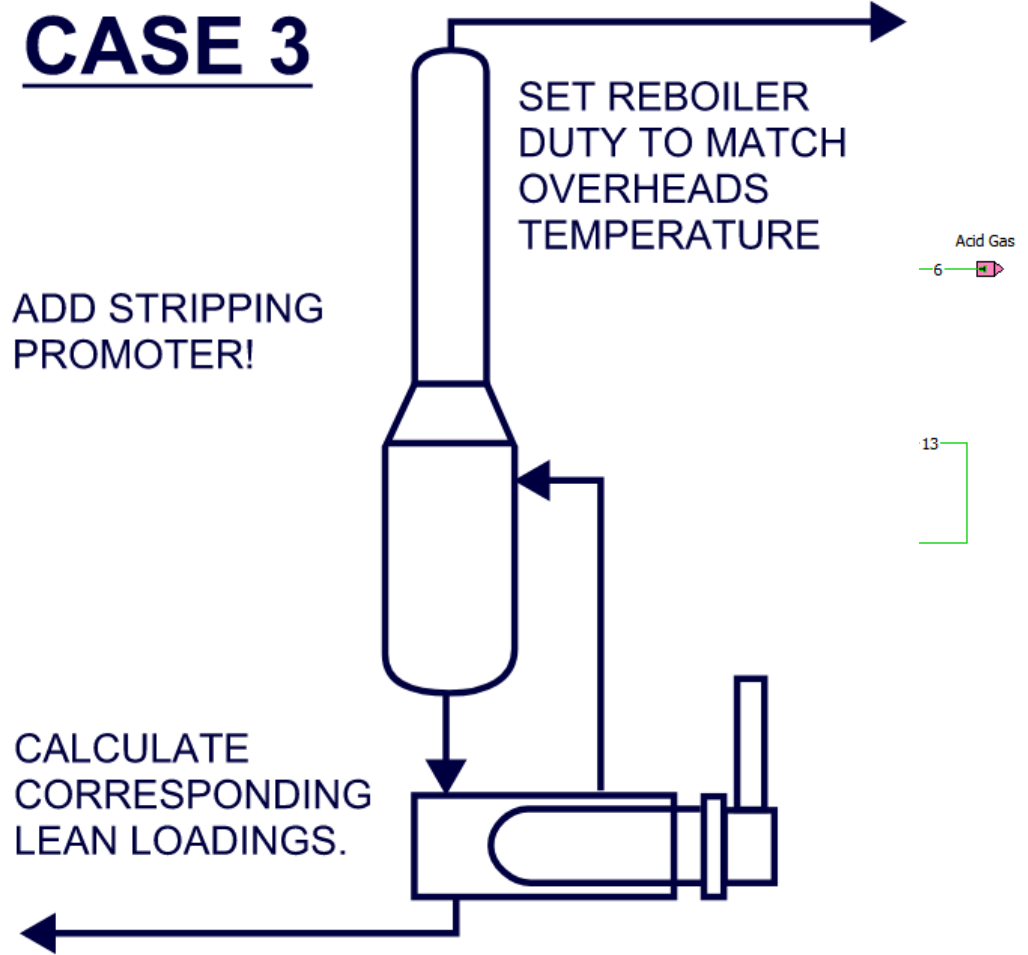
CALCULATE CORRESPONDING LEAN LOADINGS.

SET REBOILER DUTY TO MATCH OVERHEADS TEMPERATURE

Acid Gas

6

13



ProTreat Hydraulic Analysis

- **Still Column Hydraulics**

- Low DP's predicted in regenerator
 - A likely result of operating at 50% turndown.
 - Could there be maldistribution? Channeling?

- **Contactor Hydraulics**

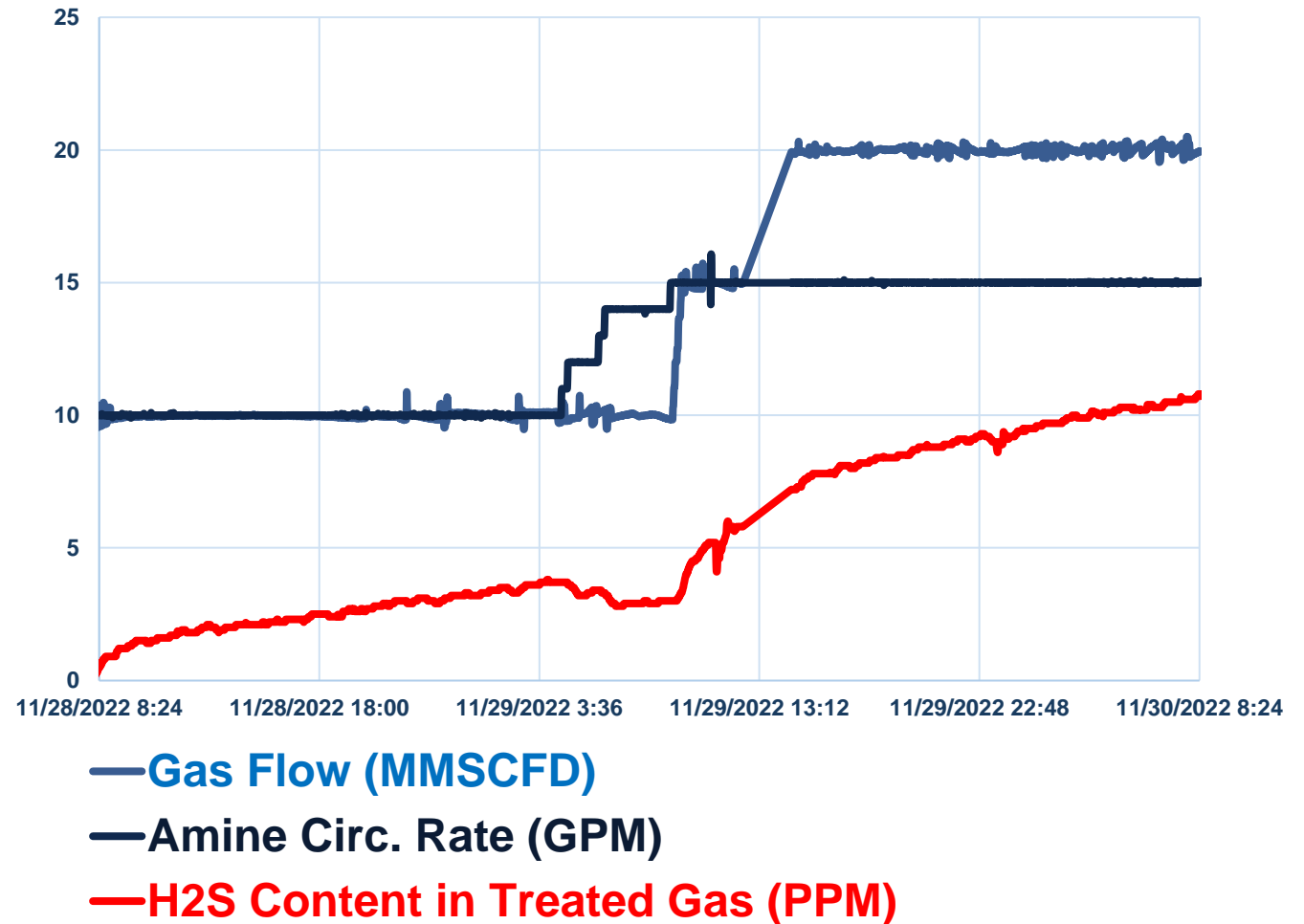
- Percent vapor flood <20%.
 - However, bubble cap trays were installed – weeping was not of great concern.
- Weir loads < 0.5 GPM/in. Target is 1 GPM/inch.
 - Could have impact on selective treating of H₂S vs. CO₂. Uneven flow of amine across tray deck leading to mass transfer inefficiencies due to liquid pooling.
 - Impossible to model / predict impact.
 - Addition of picket weirs would only marginally help this situation.

First Official Lab Data

- Lean and rich amine samples were taken when operating at the high still overheads temperature operating point.
- Lean Loading:
 - Local Lab: 0.0002 mol/mol, or 29 ppm H₂S
 - Solvent Provider Lab: No detectable H₂S
- These samples were taken before adding the stripping promoter.

Performance Data After Adding Stripping Promoter

- Stripping promoter added just a few days away from our deadline.
- Over two days, plant slowly stepped up flow from 10 MMSCFD to 20 MMSCFD. H₂S content in treated gas slowly crept up.
 - Day 1 – 2:00 PM: 2 PPM H₂S
 - Day 2 – 5:30 AM: 3.7 PPM H₂S
 - Day 3 – 6:00 PM: 8.3 PPM H₂S
 - Day 4 – 8:00 AM: 10.8 PPM H₂S



Why the Slow H₂S Creep?

Instrument error?

- Site confirmed proper calibration of GC.

Channeling/fouling in the amine still?

- No reports of amine discoloration or high amounts of suspended solids content.

L/R exchanger leak?

- This ended up not being the case because the pressure on the lean side was reported to be higher than the pressure on the rich side.

Reboiler issue?

- Some burner troubleshooting commenced to ensure the heat output was adequate. (Fuel gas pressure, orifice plate readings, etc.) There was no issue found with the fired equipment.

What About the Contactor?

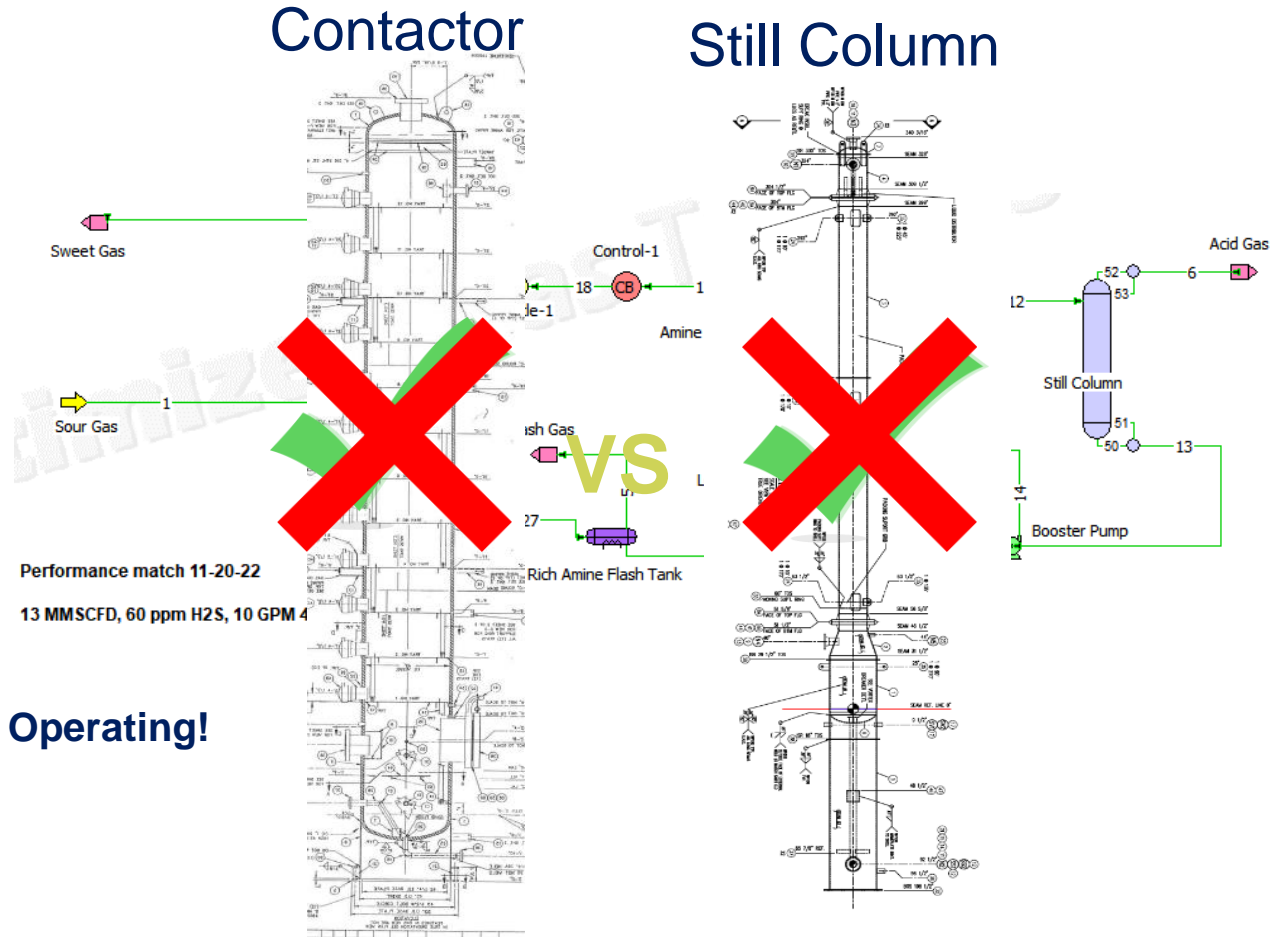


ProTreat Analysis Part II

- Case 1: No deration in Still Columnn or Contactor
- Case 2: Still column issues
- Case 3: Contactor issues

Summary Table		Case 1	Case 2	Case 3
Lean Loading (H2S)	mol/mol	0.0002	0.00682	0.00186
Still Ovhd Temp	F	225.24	181.2	225.24
Still Bottoms Temp	F	240.67	212.4	240.37
Reboiler Duty	MMBTU/hr	1.1	0.3	0.47
Trays in Contactor		12	12	2
Outlet H2S Content	ppm	0.19	10.14	14.27

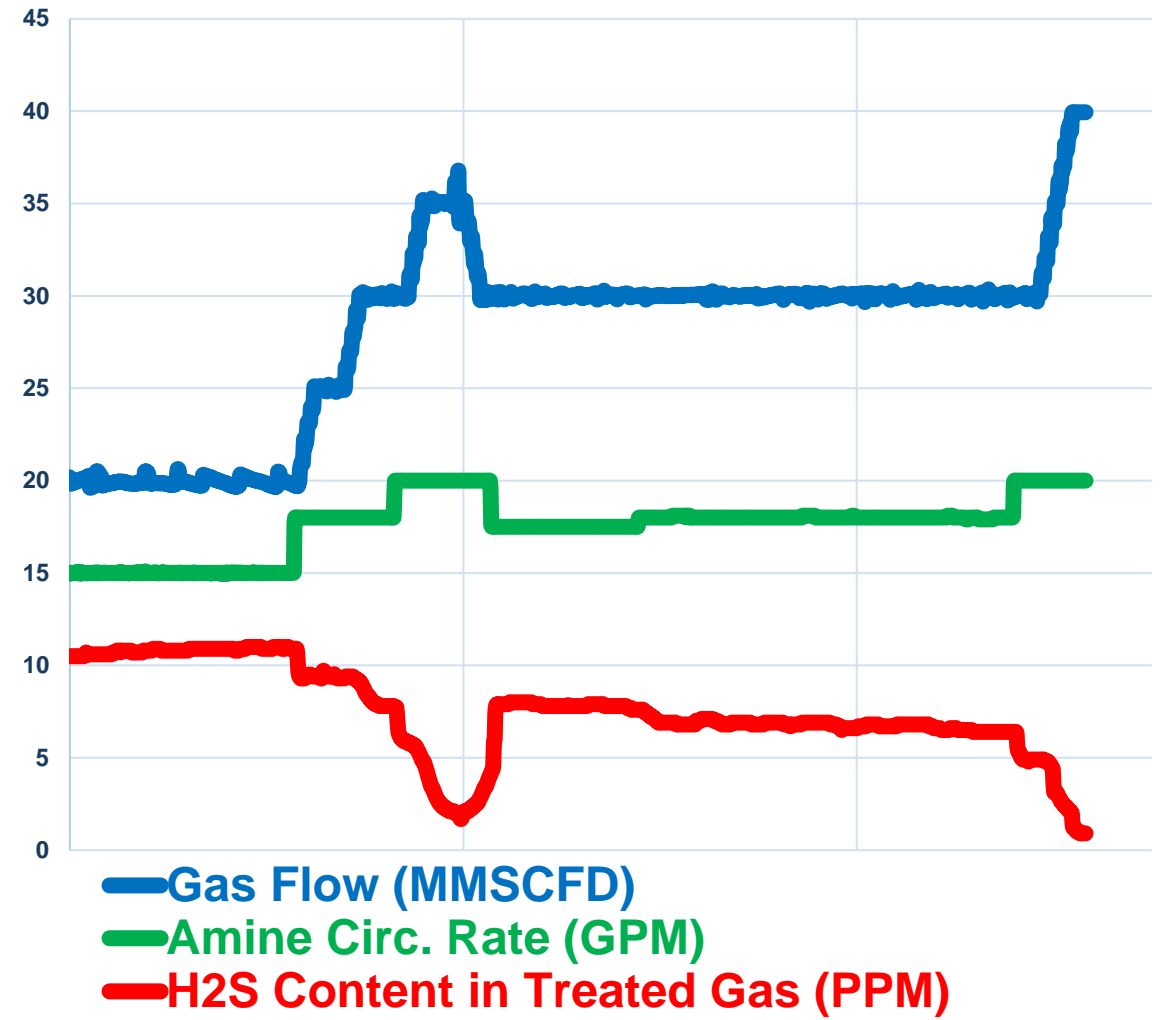
*All cases assume 20 MMSCFD, 60 ppm inlet H2S, 15 GPM circ. rate.



225.24 F Operating!

Performance Data During Turnup

- Operations continued to increase the flowrate throughout the three days. Interesting things then started to happen.
- H₂S content in the treated gas was observed to drop off significantly at inlet gas rates greater than 34 MMSCFD!

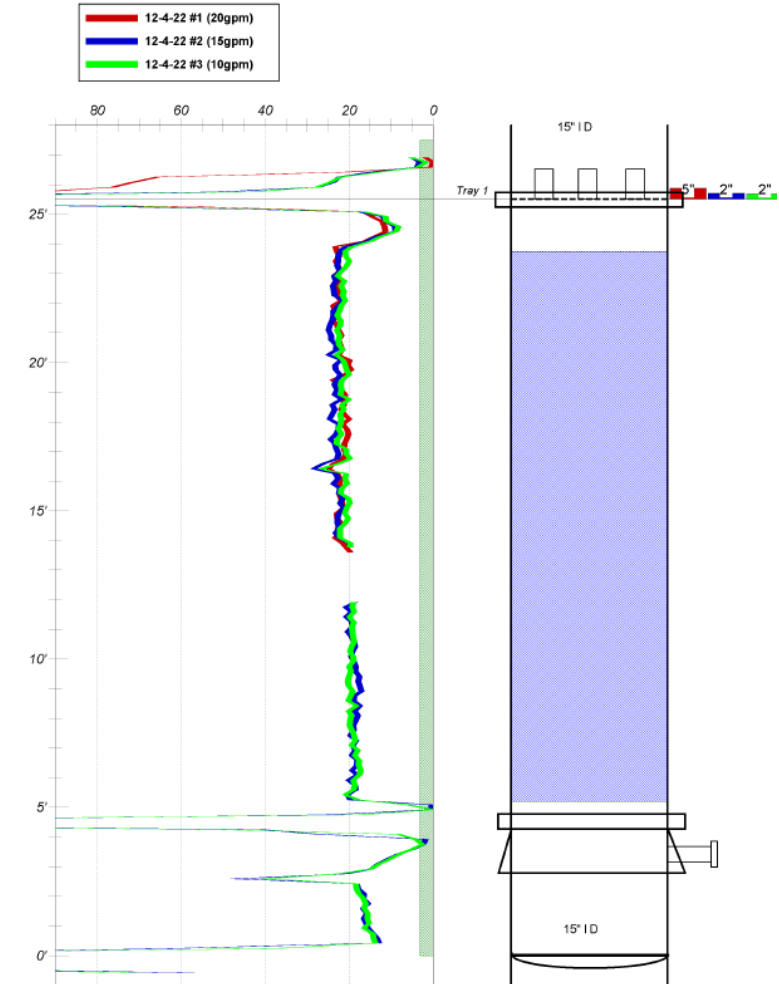
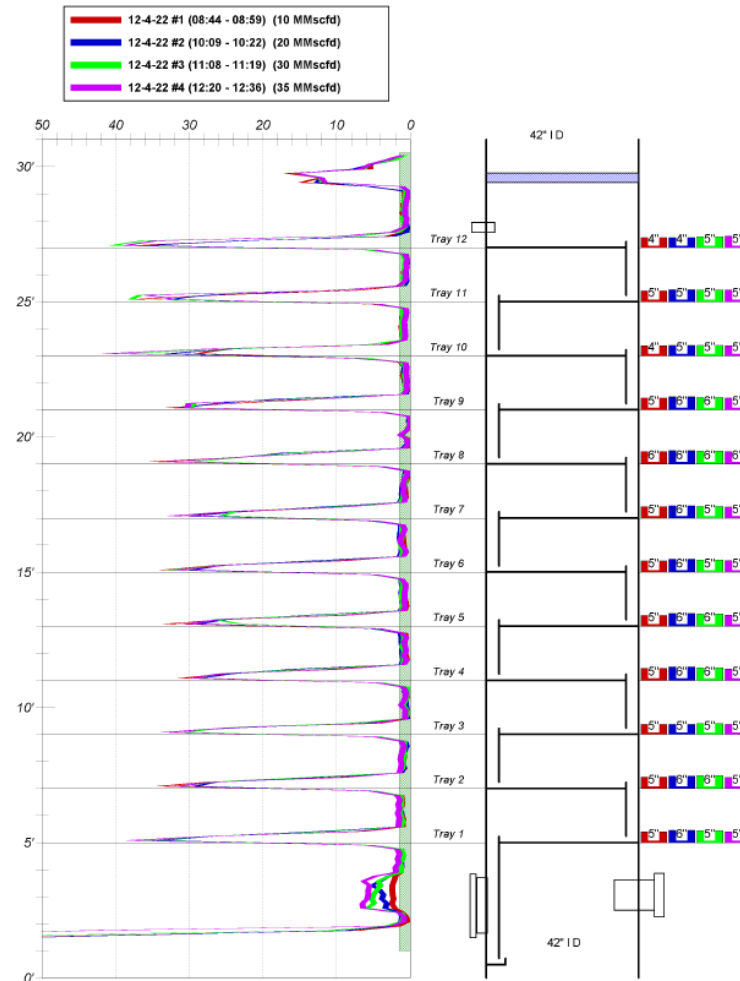


Next Steps

- By this point, the prevailing theory was that the Contactor was underperforming, but only at lower rates.
- This was odd because the Contactor has historically operated successfully at rates much lower than this. Add in the fact that it has bubble cap trays, which are extremely good at handling turndown.
- Customer noted that prior to the installation of the new regen unit, these bubble cap trays were removed, cleaned, and reinstalled.
- This prompted a gamma scan one week later to see if the trays had been reinstalled correctly.

Gamma Scan Results

- Both Contactor and Still Tower were scanned.
- Neither scan revealed anything noteworthy.
- The hydraulics in both towers appeared to be normal and there was no indication that anything was knocked out of place.



Visual Inspection

- The Contactor was opened for visual inspection.
- No liquid level was visible on the tray decks. For bubble cap trays, liquid level should remain up to the riser.
- A leak test was performed by circulating water through the Contactor.
- The trays that were tested were unable to hold a level.



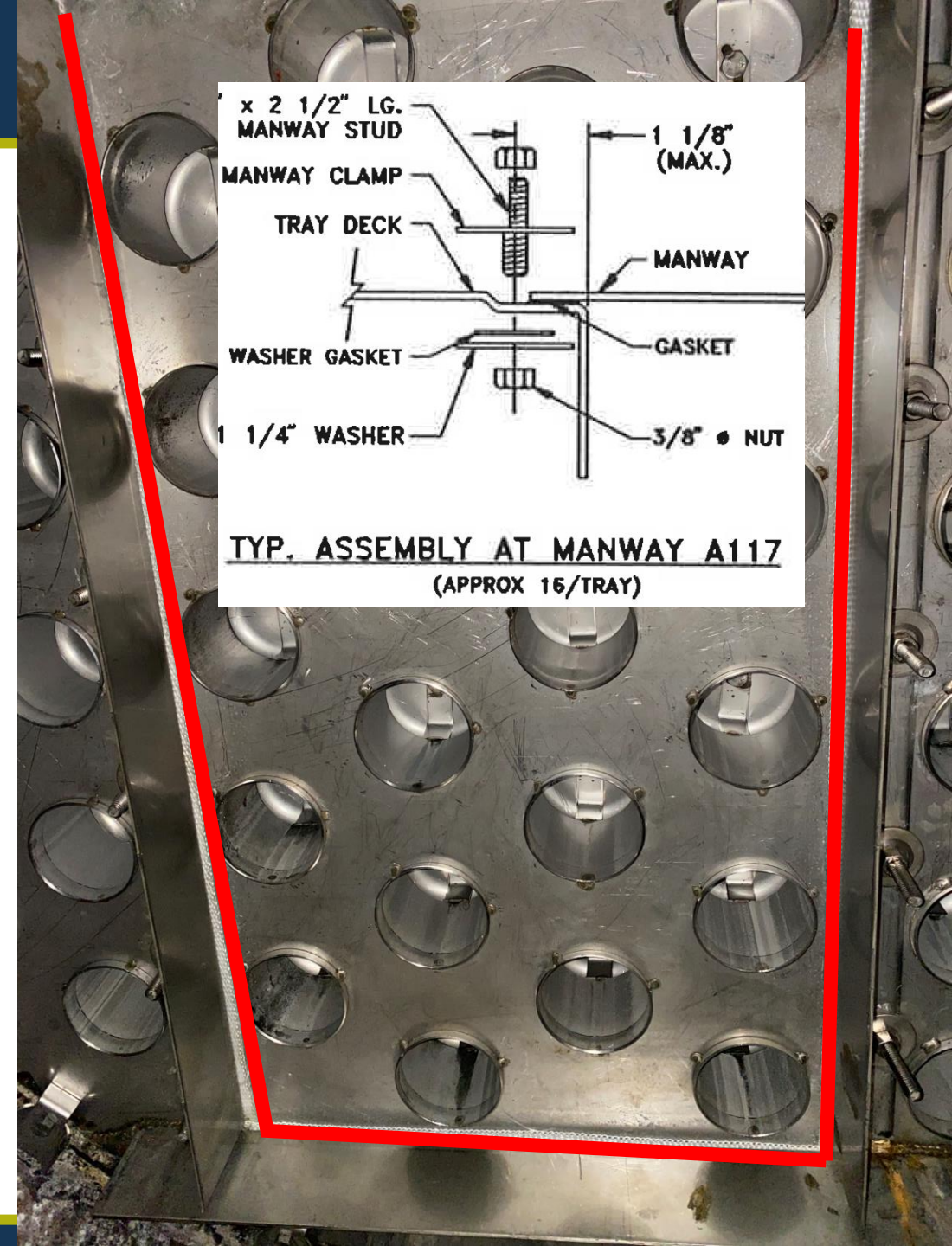
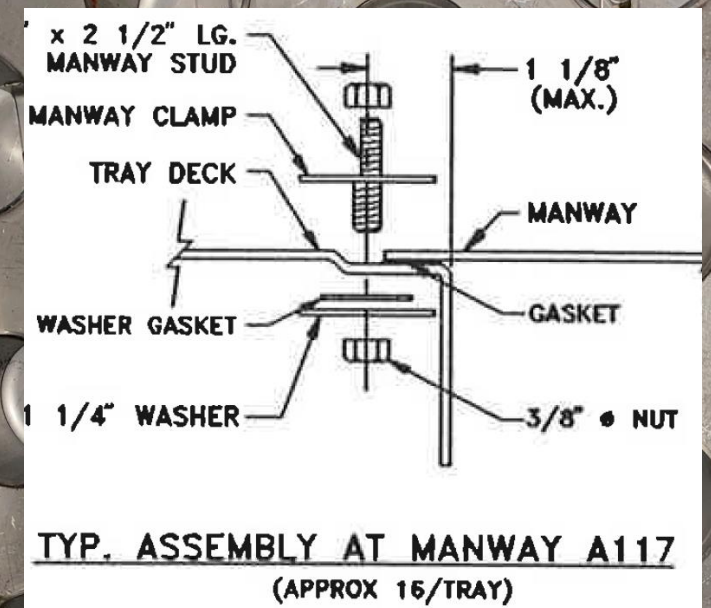
Contactors Tune Up

- Earlier that year, a third-party had replaced the contactor's mist pad. In order to gain access to the mist pad, bubble cap tray manways were removed.
- Tray decks were cleaned and manway gasketing was replaced with a combination of rope style gasketing and ePTFE joint sealant.



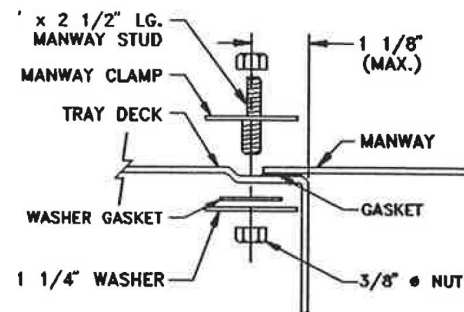
The Diagnosis

- It was confirmed that the leakage was pervasive through the manway gaskets.
- This is mostly due to wear and tear on old hold down clamp assemblies which were unable to provide a tight seal.
- This likely caused internal weeping of amine at turndown conditions.
- At rates >34 MMSCF/D, it is believed that weeping was precluded by the upward flow of gas.



The Fix

- Contractor worked the process tower internals provider to select appropriate gasket material for replacement: A fiberglass tape style.
- Clamp assemblies repaired / replaced / modified to provide proper clamping pressure, ensuring good liquid seal.
- After the re-gasketing efforts were concluded, the plant performance was reported to be on spec at all flowrates.



TYP. ASSEMBLY AT MANWAY A117
(APPROX 16/TRAY)

CONCLUSION

- Root cause may seem obvious in hindsight.
- Discovering that root cause is often an exercise in elimination.
- False assumptions may lead to fixing problems that don't exist – costing valuable time and money!
- Data led troubleshooting is critical.

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Questions?

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Thank You

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