



UNEXPECTED TWO-PHASE FLOW STALLING A DEMETHENIZER INTERCONDENSER

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SADARA CHEMICAL COMPANY

About Sadara

Sadara Chemical Company is a joint venture developed by Saudi Aramco and The Dow Chemical Company. Sadara is a multi- billion dollar world-scale chemical complex in Jubail Industrial City II in Saudi Arabia's Eastern Province.

Comprised of 26 world-scale manufacturing units, the Sadara chemical complex is the world's largest to be built in a single phase producing more than 3 million tons of plastics and chemicals annually and is the only chemical company in the Middle East to use refinery liquids, such as naphtha, as feedstock.

By using best-in-class technologies to crack refinery liquid feedstock, Sadara will enable many industries that either currently do not exist in Saudi Arabia or only exist through imports of raw materials.

INDEX

- Problem statement
- Aspen model hydraulic analysis
- Findings Substantial difficulty in getting C2R loop flow
- Proposed solution and challenges for new modifications
- Conclusion

E-2121 hydraulic and performance check

- Model developed in Aspen Plus
- Preliminary hydraulics for E-2121 circuit indicate NO pressure limitation, however C2R pressure at E-2121 shell outlet needs to be 0.5 barg (vs. 0.16 barg, Design case) to match IP21 data.
- Check control valve sensitivity with Temperature and Pressure.

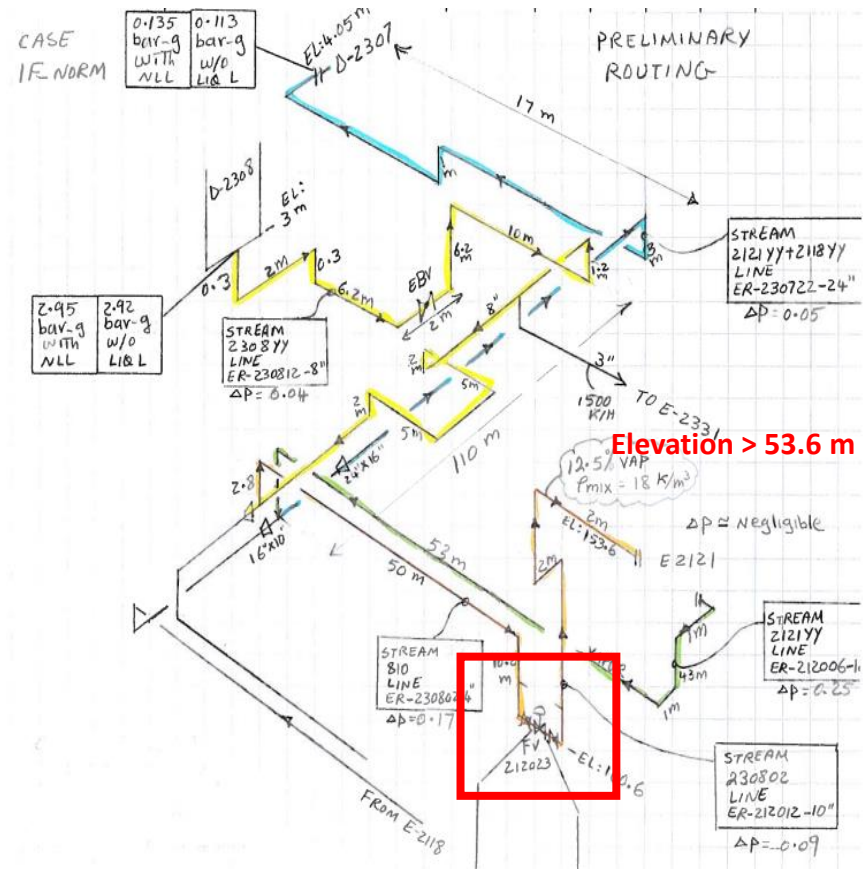
	FV-212023 % Open	E-2121 C2R, temp oC	D-2307 Pressure BARA
1	50	100.0	0.78
2	60	-99.1	0.95
3	61	-97.7	1.08
4	62	-96.4	1.20
5	63	-95.4	1.30
6	64	-94.4	1.40
7	65	-93.6	1.48
8	66	-92.9	1.55
9	67	-92.3	1.62
10	68	-91.7	1.68
11	69	-91.2	1.73
12	70	-90.8	1.78

Findings v.0

- Detail engineering hydraulic model not consider pressure drop impact on C2R temp at E-2121 outlet. Although small, DP impact could be critical and result in Ethylene loss in fuel gas.
- BUT WHY was it difficult to startup E-2121 loop? Operations had to change Pressure S.P. on Compressor / C2R drums to get flow started!

ELEVATION PROFILE IMPACT

- E-2121 elevation stands out.
- Not enough Pressure differential to flush vertical line filled with liquid
- FV cross check on control valve software against field ΔP matches above conclusion



Findings v.1

- Exchanger elevation and startup flows problematic. Need sufficient flow to generate substantial flash across FV and allow 2-phase mixture to rise.
- Yes, 2-phase ΔP is lower than only liquid phase in vertical line!
- Project initiated to route some flow from rundown ethylene to CTF into E-2121. No impact on C2R compressor performance. Project required stronger justification to proceed.

FLUID FLOW ANALYSIS

- Why is FV inlet single phase?
- Software(s) use phase equilibria. Head gain allows 2-phase to become single.
- Process engineering analysis
 - Consider 2-phase at FV inlet > upsize valve.
 - Vapor pocket can develop at high point
 - Recommend to proceed with C2 new 16 barg rundown stream option

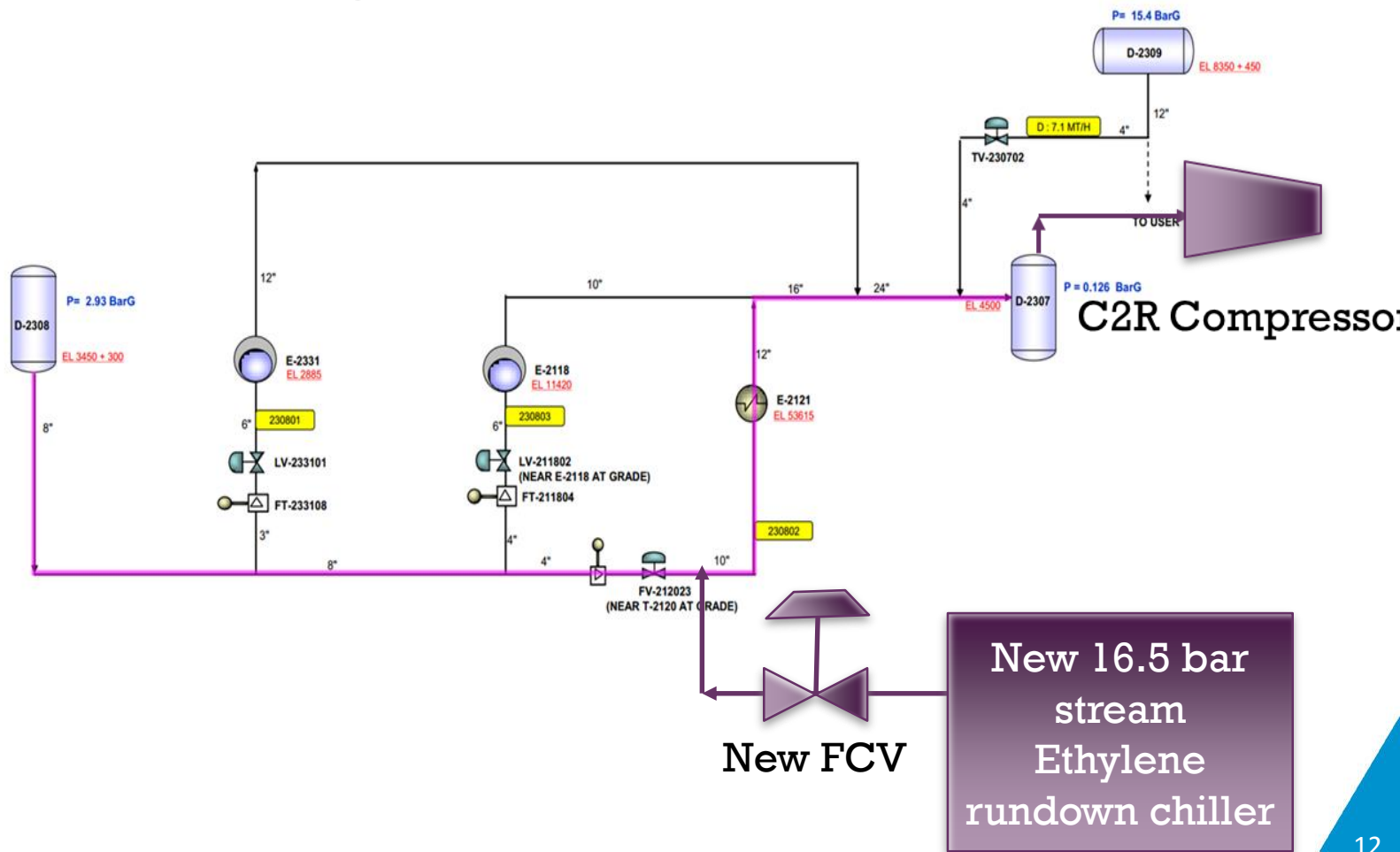
Findings v.2

- Head gain doesn't ensure thermodynamic equilibrium (phase split) will be re-established. Straight length requirements for 2-phase can be $>100 D$
- Aspen model modified to include this effect, but mismatch still existed. Closer match with control valve software with 2-phase option.

Findings v.3

1. 2-phase fluid at Valve inlet, while control valve design for single phase inlet condition.
2. Not obvious even with modeling. Cross-check with right tool at right time
3. Understand sensitivity
4. For a HX with close approach, slight change in temperature will severely impact performance.
5. Startup requirements can be different than steady state operation
6. Pressure measurements done in field depend upon location and can be misleading

Proposed new modification & Challenges



Conclusion

- All possible scenario including startup scenario need to be check sensitivity of the system during design phase
- Two phase flow analysis flow regime shall be indicated in the P&ID with different possible scenarios
- Transient load calculation required for slug flow & special piping design support consideration
- Valve inlet phase fluid sensitivity must be considered during design phase
- Valve elevation profile hydraulic impact must evaluate for piping and control valve design