FLUOR®

PRACTICAL LOPA
A BIOFUELS REVAMP STUDY

Katy Gerstner, Florin Omota – Fluor

With support from Preem Refinery

AGENDA

1. Who We Are
2. Our Partnership with Preem
3. Challenges We Faced
4. Key Learnings and Insights

ABOUT FLUOR

1,415
SUBJECT MATTER EXPERTS

9,000+
EMPLOYEES
IN EAME

ONE FLUOR EXECUTION MODEL

83 OFFICES IN **28** COUNTRIES ON **6** CONTINENTS

80 YEARS' EXPERIENCE IN THE REGION

110+year
LEGACY

27,000+
EMPLOYEES EXECUTING PROJECTS GLOBALLY

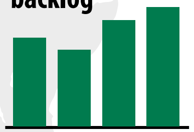
2
FABRICATION YARDS
Mexico | China

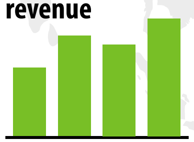
GLOBAL PROFESSIONAL AND TECHNICAL SOLUTIONS PROVIDER

#257
ON THE 2025
FORTUNE® 500 LIST

1,000+
PROJECTS IN ANY GIVEN YEAR

TRS staffing solutions℠
AGENCY ACCESS TRS - TO ANSWER MARKET DEMANDS

backlog

US$28.5 billion

revenue

US$16.3 billion

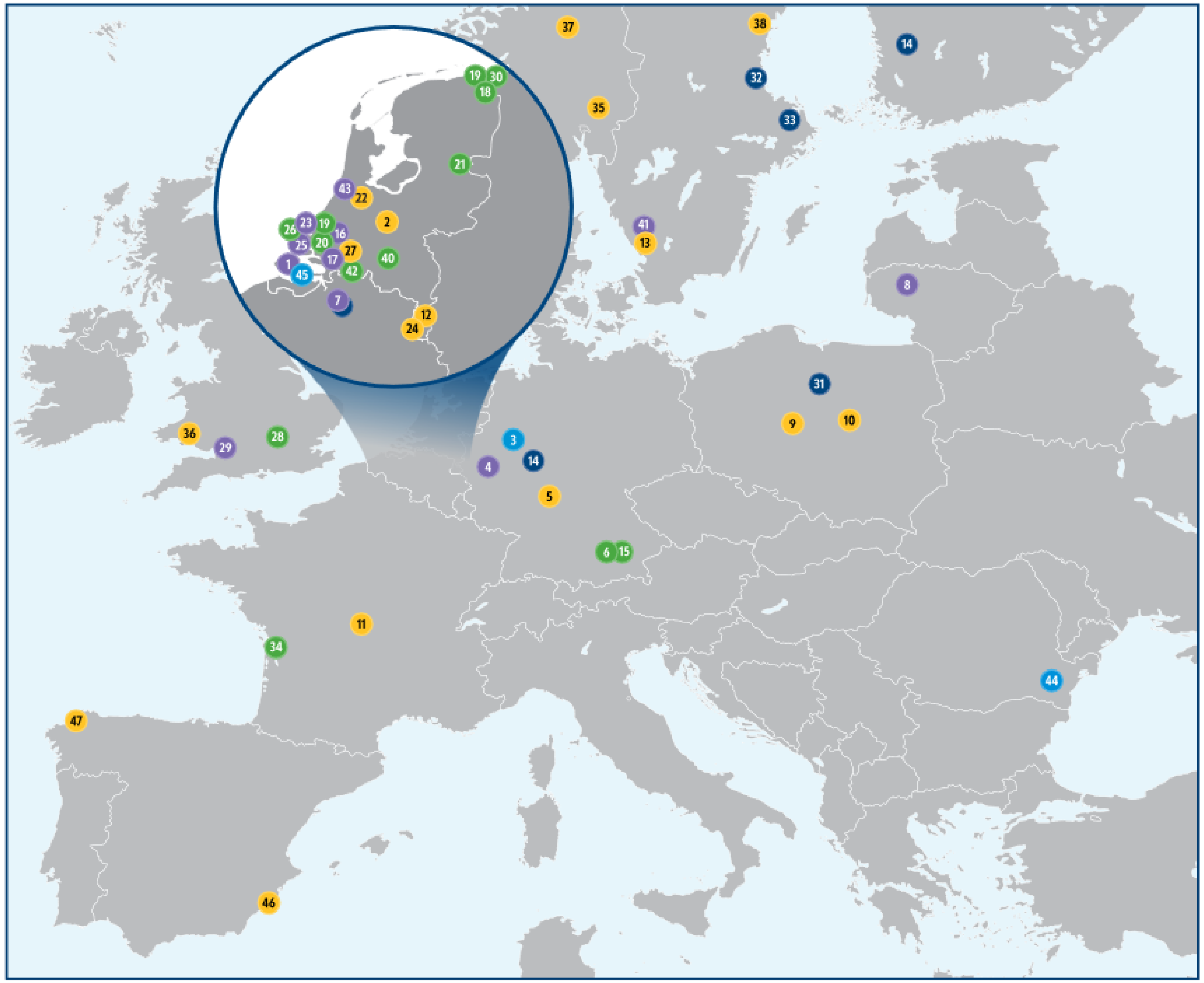
60
SPECIALISED INDUSTRIES SERVED

OUR AVERAGE ANNUAL SUPPLY CHAIN SPEND
$11.4B

HA20250002-049

FLUOR®

ENERGY TRANSITION PROJECT EXPERIENCE



1. **NSP Ghent** – CO_2 Liquefaction | Study | 2021
2. **BioConSepT** – Joint Study into bio-based Chemicals | Study | 2015
3. **RWE** – Compressed Air Energy Storage | Study | 2012
4. **RWE** – CO_2 Recovery | Various Studies | 2007-2010
5. **Confidential** – Plastics Recycling Plant | Technical Due Diligence | 2022
6. **BayernOil** – Wood Gasification into Hydrogen | FEL2 | 2024
7. **Fluxys** – CO_2 Liquefaction | Study | 2024
7. **Advario & Fluxys** – Footprint | Pre-FEED | Ongoing
7. **Umicore** – Metal Recycling Facility | Pre-FEED, FEED | Ongoing
8. **Orlen Lietuva** – Refinery Decarbonisation | Study | 2022
9. **Clariter** – Plastic Recycling plant | Estimate | 2024
10. **Clariter** – Plastics Recycling Plant | Technical Due Diligence | 2022
11. **Confidential** – PET Recycling Plant | Site Selection Study | 2021
12. **Itero** – Plastics Pyrolysis Recycling Plant | Pre-FEED | 2022
13. **Preem AB** – HCU+Isocracker Scoping | FEED, EPCM | Ongoing
14. **Johnson Matthey** – Cathode Active Materials | FEED | 2022
15. **Ventogene BayH$_2$** – 125MW Green Hydrogen | FEED | 2023
16. **Attero** – Carbon Capture Plant | Design | 2022
17. **ROAD** – Carbon Capture Storage | FEED | 2013
18. **Gasunie Zuidwending** – Natural gas compression and storage plant decarbonisation | Study | 2022
19. **Gasunie Eemshaven** – Hydrogen compressor station | Estimate | 2022
20. **Port of Rotterdam** – Ammonia Cracker Complex | Study | 2023
21. **Gasunie** – Hydrogen Drying | Study | 2020
22. **Vattenfall** – Power-to-Fuel | Study | 2021
23. **Cape Omega** – CO_2 Liquefaction | Study | 2022
24. **Ioniqa** – Plastics Recycling Plant | Engineering | 2022
25. **Porthos** – CO_2 Compression Station | FEED | 2021
26. **OCI Terminal Europoort B.V.** – Ammonia Bunkering Project | S/FEED/EPCM | 2022
27. **Shell Chemicals** – Electrification of process air compressor | EPCM | 2019
27. **Shell Chemicals** – Pyrolysis Oil Upgrader | FEED/EPCM | 2024
27. **Shell** – RedIIGreen | Execution Preparation Phase | Ongoing
28. **Confidential** – Hydrogen-fired furnace | FEED/EPCM | 2023
29. **Viridor** – Carbon Capture | Study | 2021
30. **HyCC H$_2$eron** – 40 MW Green Hydrogen | PMC/FEED | 2023
31. **Umicore** – Cathode Active Materials | FEED | Ongoing
32. **Confidential** – Li-ion Battery Facility | FEED, EPCM | 2023
33. **Altris** – Na-ion Battery CAM Pilot Plant | Pre-FEED, FEED | 2024
34. **TEPSA** – Green Flamingo Ammonia Storage | Pre-FEED | 2023
35. **LanzaTech** – Ethanol from Gas Fermentation | Pre-FEED, FEED | Ongoing
36. **LanzaTech** – Offgas to Ethanol | FEED | Ongoing
37. **CRI** – e-Methanol Project | Pre-FEED | 2024
38. **Orsted** – e-Methanol Project FlagshipOne | FEED | 2024
39. **H$_2$ Green Steel** – 2.5 Mtpa grassroot Steel production plant, powered by 800 MW Green Hydrogen production | FEED, EPCM | Ongoing
40. **Mitsubishi Corp./Repsol** – Hydrogen supply chain using LOHC | Study | 2024
41. **Preem AB** – Carbon Capture using EFG+ technology and CO_2 Liquefaction | Study | 2024
42. **Confidential** – 300 MW Electrolyser Capacity | Feasibility Study | Ongoing
43. **Tata Steel** – HeraCless (Decarbonisation) | FEED Verification | Ongoing
44. **EnergoNuclear S.A.** – Cernavoda Unit 3 and 4 | FEED | Ongoing
45. **Confidential** – New Nuclear Power Plant | Feasibility Study | 2024
46. 47. **Masol Iberia Biofuel, S.L.U.** – Biodiesel Project | S, BE, DE, FEED | Ongoing

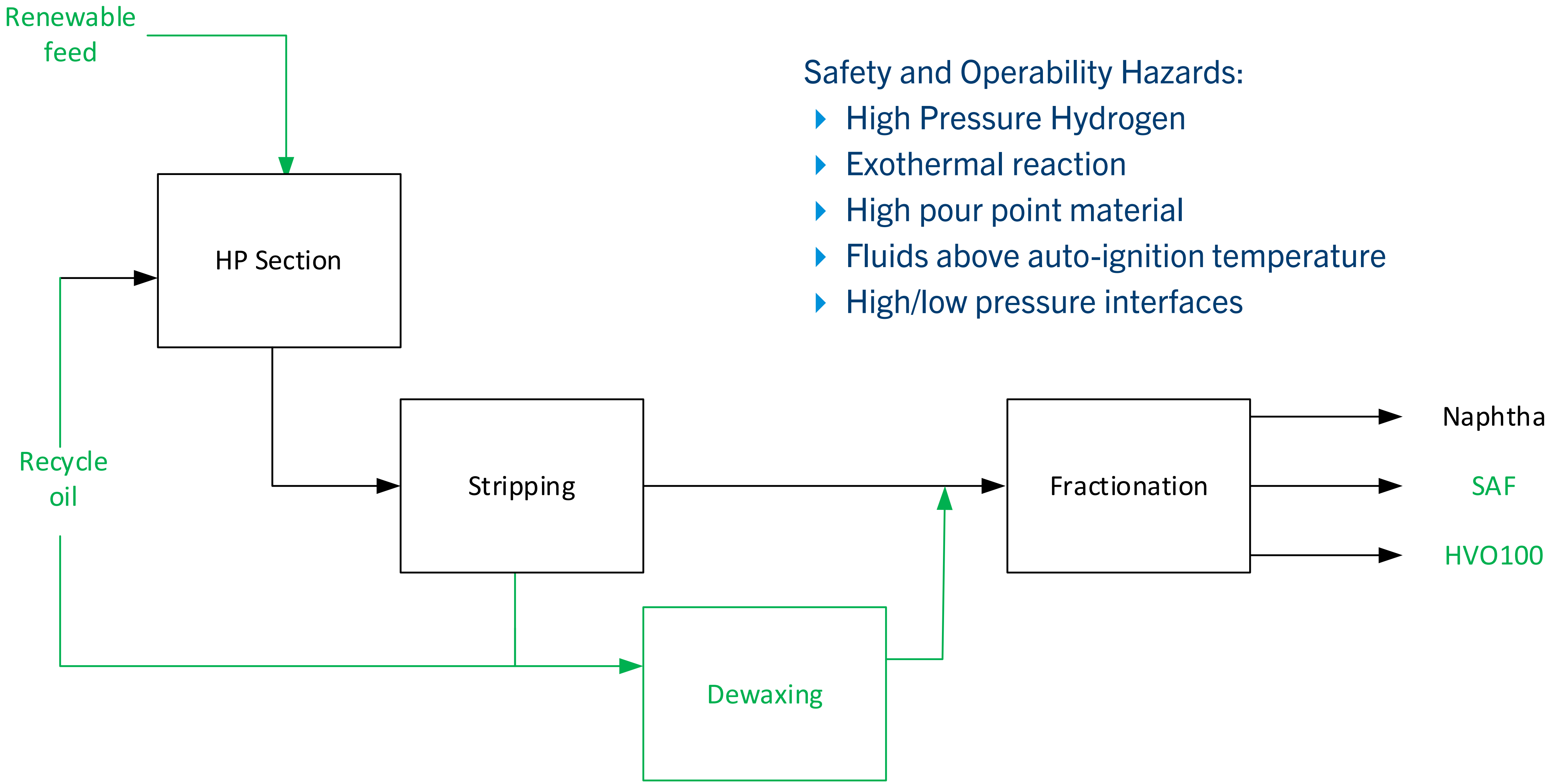
Renewable Fuels & Chemicals | Carbon Reduction | Hydrogen | Clean Power & Energy Storage | Battery Value Chain

PREEM ICR REVAMP PROJECT

Source: https://www.preem.com/en/about-us/our-facilities/

- Refinery: Lysekil, Sweden
- Plant: ICR (IsoCracker)
- Investment: ~400 MM eur
- Renewable production capacity:
  - SAF: 600 000 m3
  - HVO100: 600,000 m3
- Less emissions
  - (Scope 1-3): -2-3 million tons CO2e
  - Scope 1: -200,000 tons CO2e

ICR UNIT – EXISTING / FUTURE SITUATION

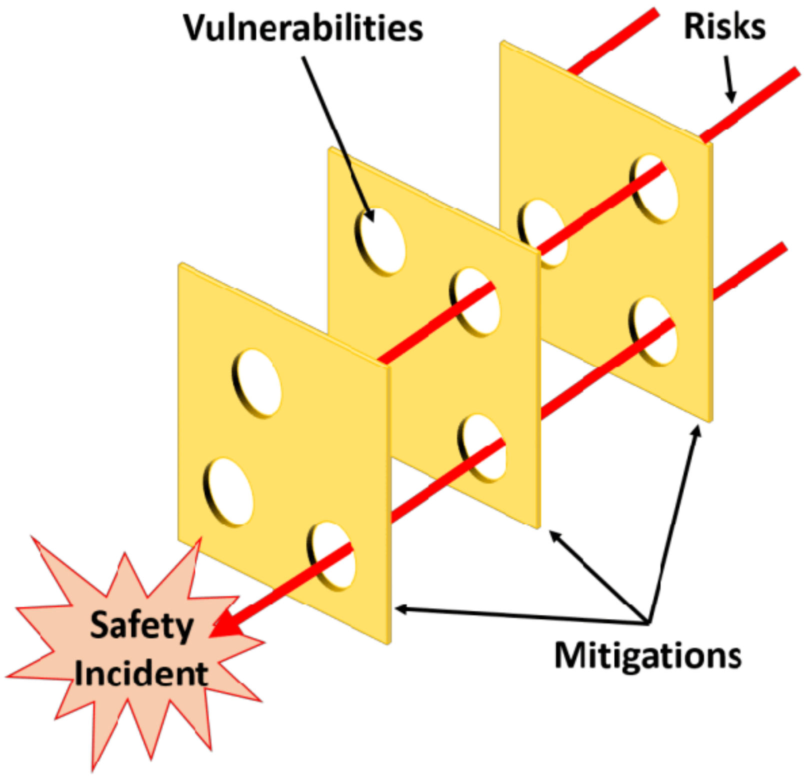


Safety and Operability Hazards:

- High Pressure Hydrogen
- Exothermal reaction
- High pour point material
- Fluids above auto-ignition temperature
- High/low pressure interfaces

PROCESS SAFETY APPROACH

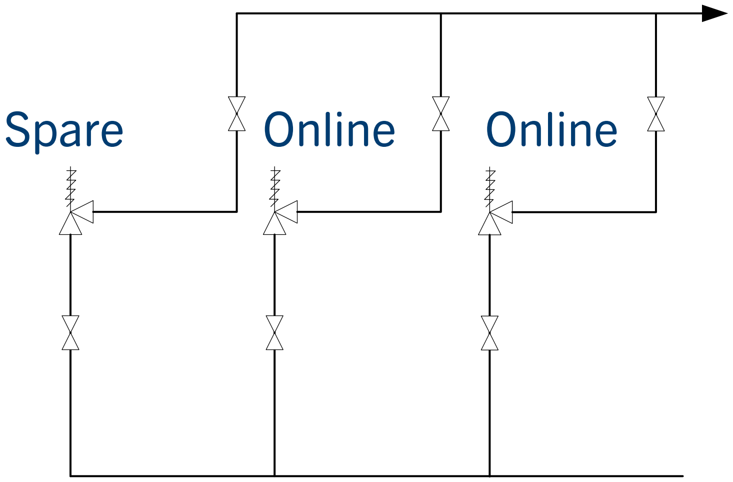
- HAZOP / LOPA for entire plant
  - Systematic review
  - Modifications and existing design
- Challenges:
  1. PSV redundancy calculation
  2. Excessive protection
  3. Balancing operability and safety
  4. Impacts of a revamp on design

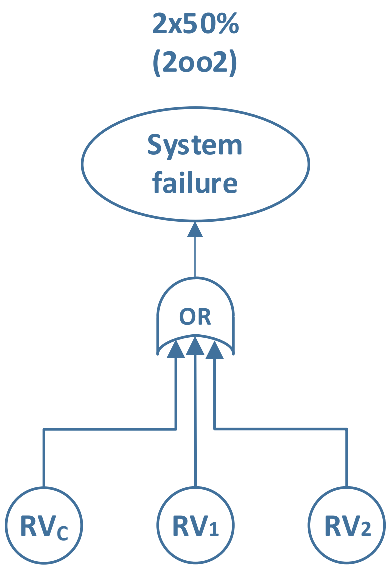


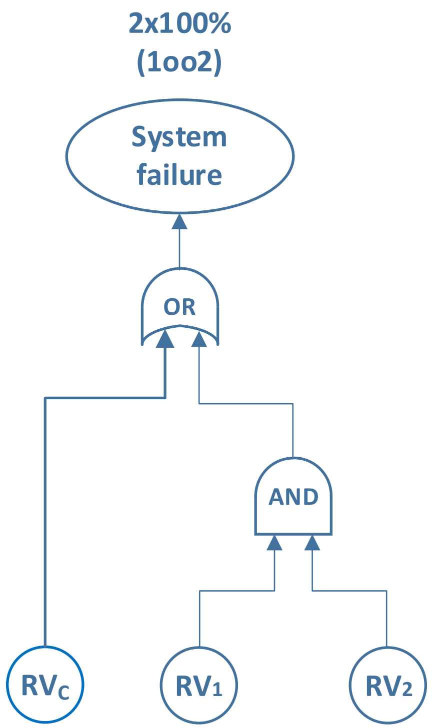
Reason's Swiss Cheese Model (Source: Reason (1997)).

First Challenge:

RELIABILITY CALCULATION FOR MULTIPLE PSVS



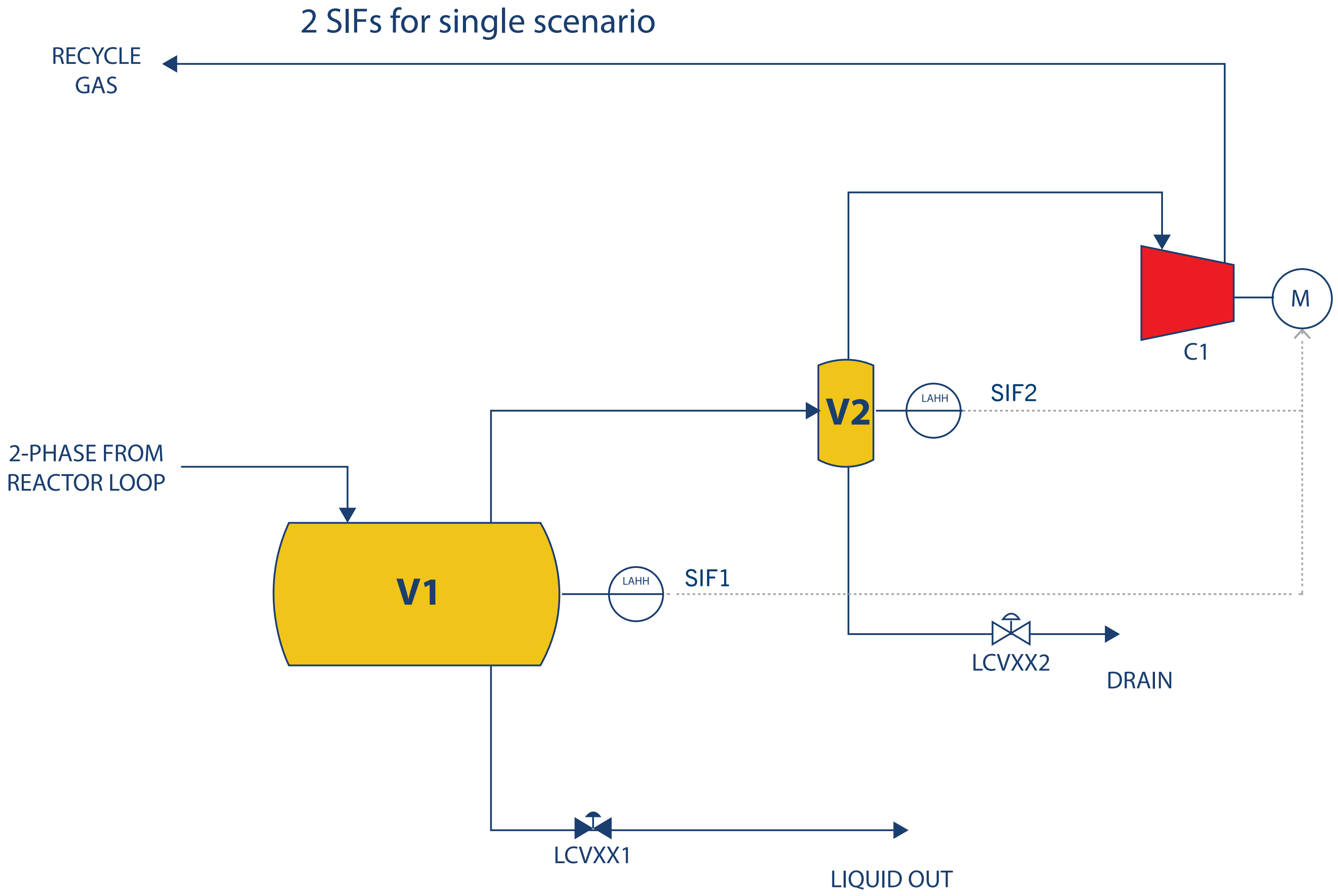




Single PRV:	PFDavg = 0.01
Common cause:	$\beta = 10\%$
Multiple PRVs 2oo2:	$0.01 \times 0.1 + 0.01 + 0.01 \approx 0.02$
Multiple PRVs 1oo2:	$0.01 \times 0.1 + 0.01 \times 0.01 \approx 0.001$

Second Challenge:

EXCESSIVE PROTECTION



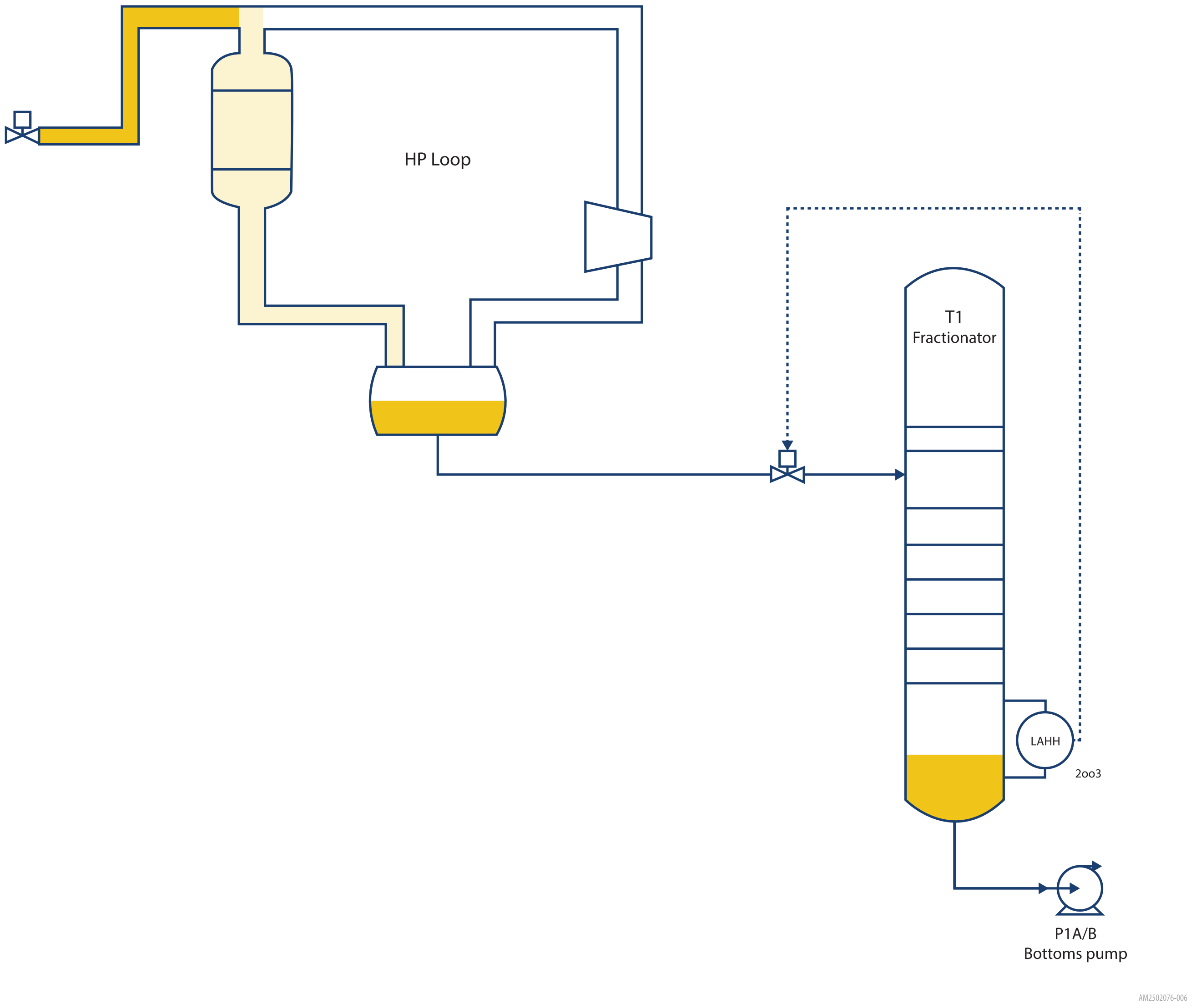
Can the SIFs be considered together?

- Is time sufficient for SIF2?
  - Yes
- Are scenarios the same?
  - Not always

Required reliability is a combination

Third Challenge:

OPERABILITY VS. SAFETY



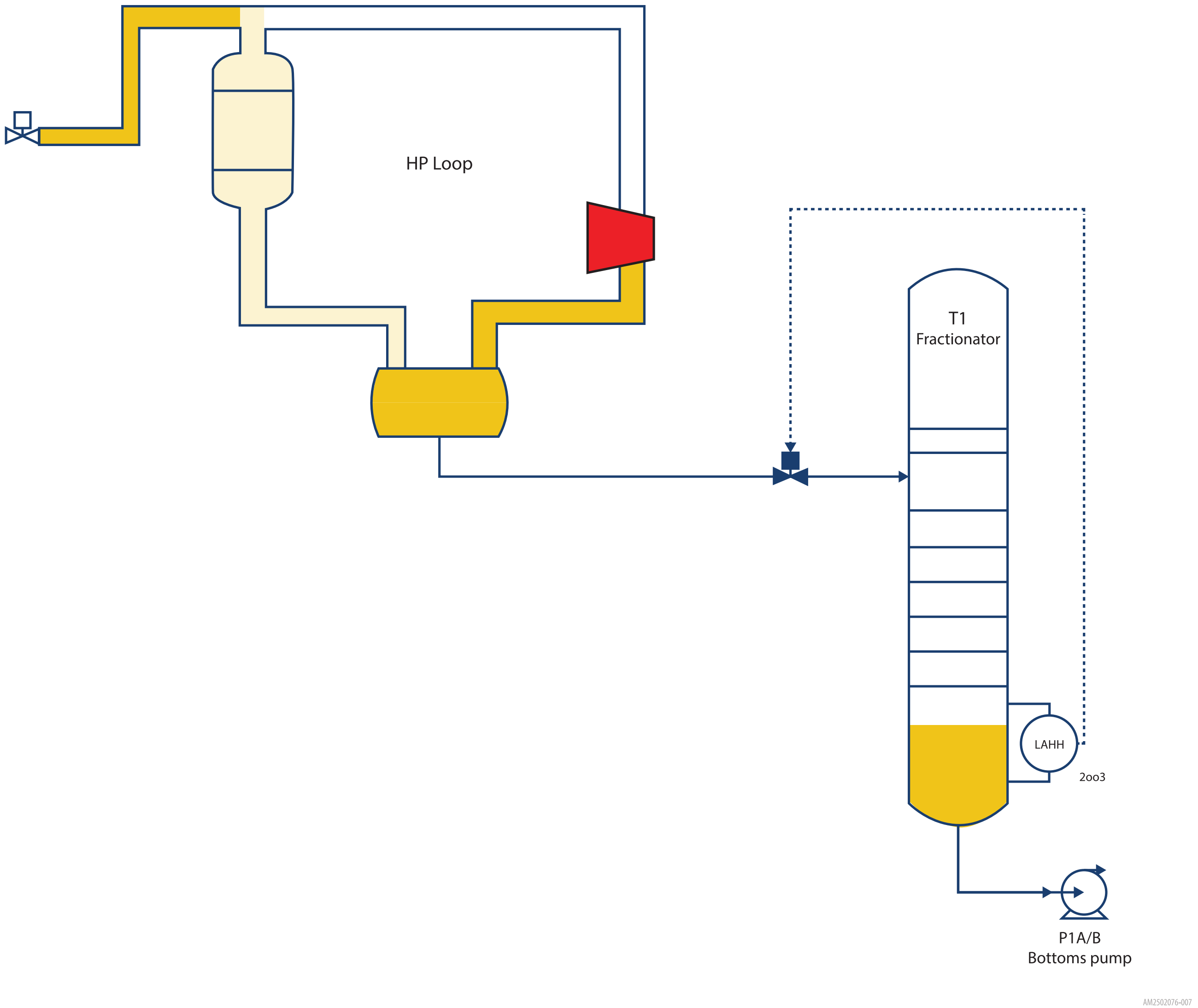
Original design alarm only

Additional protection for overfill

- PSV
  - Consider foundations and supports
- *Or* overfill protection

Third Challenge:

OPERABILITY VS. SAFETY

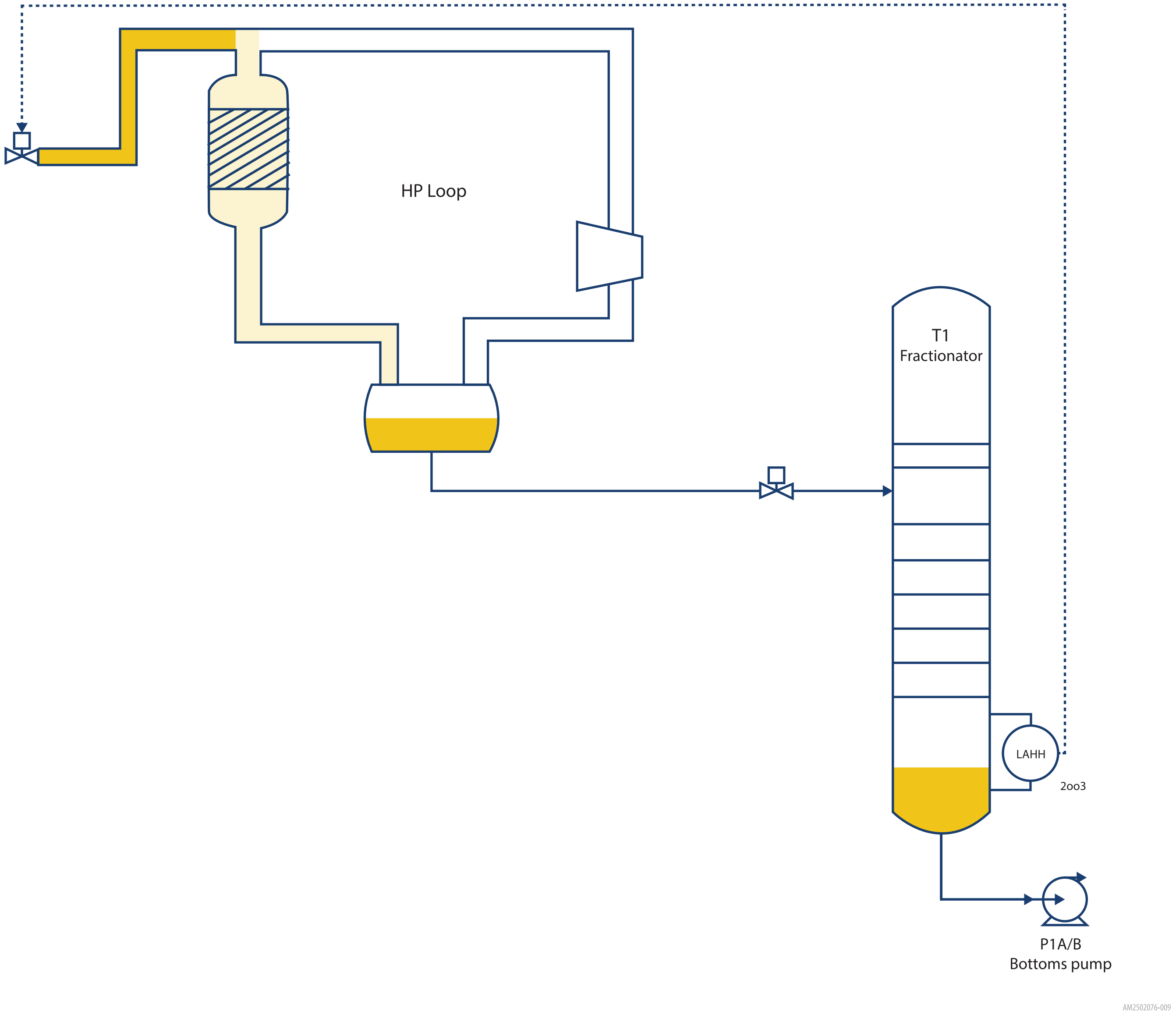


Close feed – safe?

- LAHH protects the fractionator
- Level increases slightly
- Issues upstream
  - Additional demand on trip
  - Recycle compressor will stop

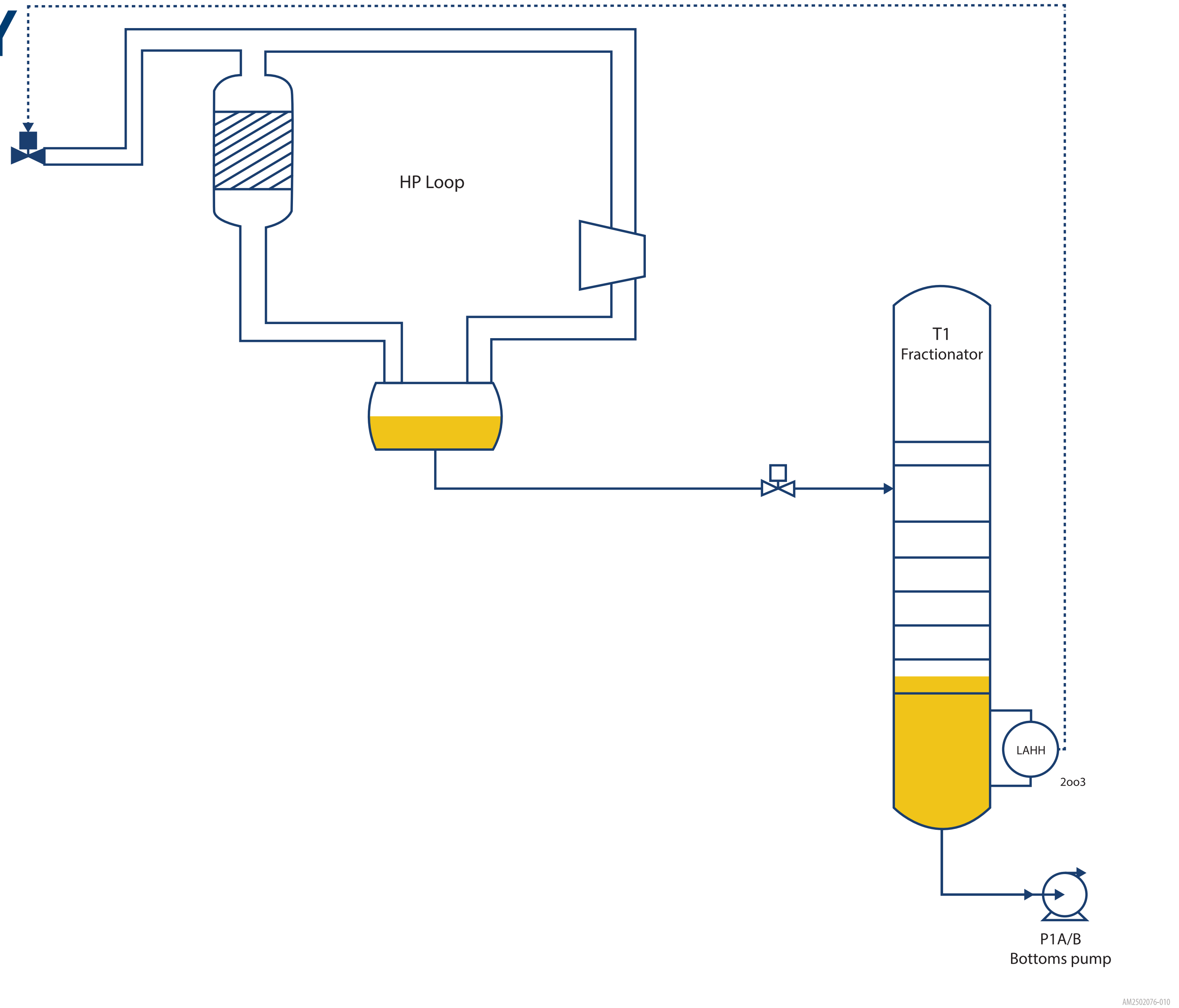
Third Challenge:

ALTERNATE SETUP



Third Challenge:

ENHANCED OPERABILITY

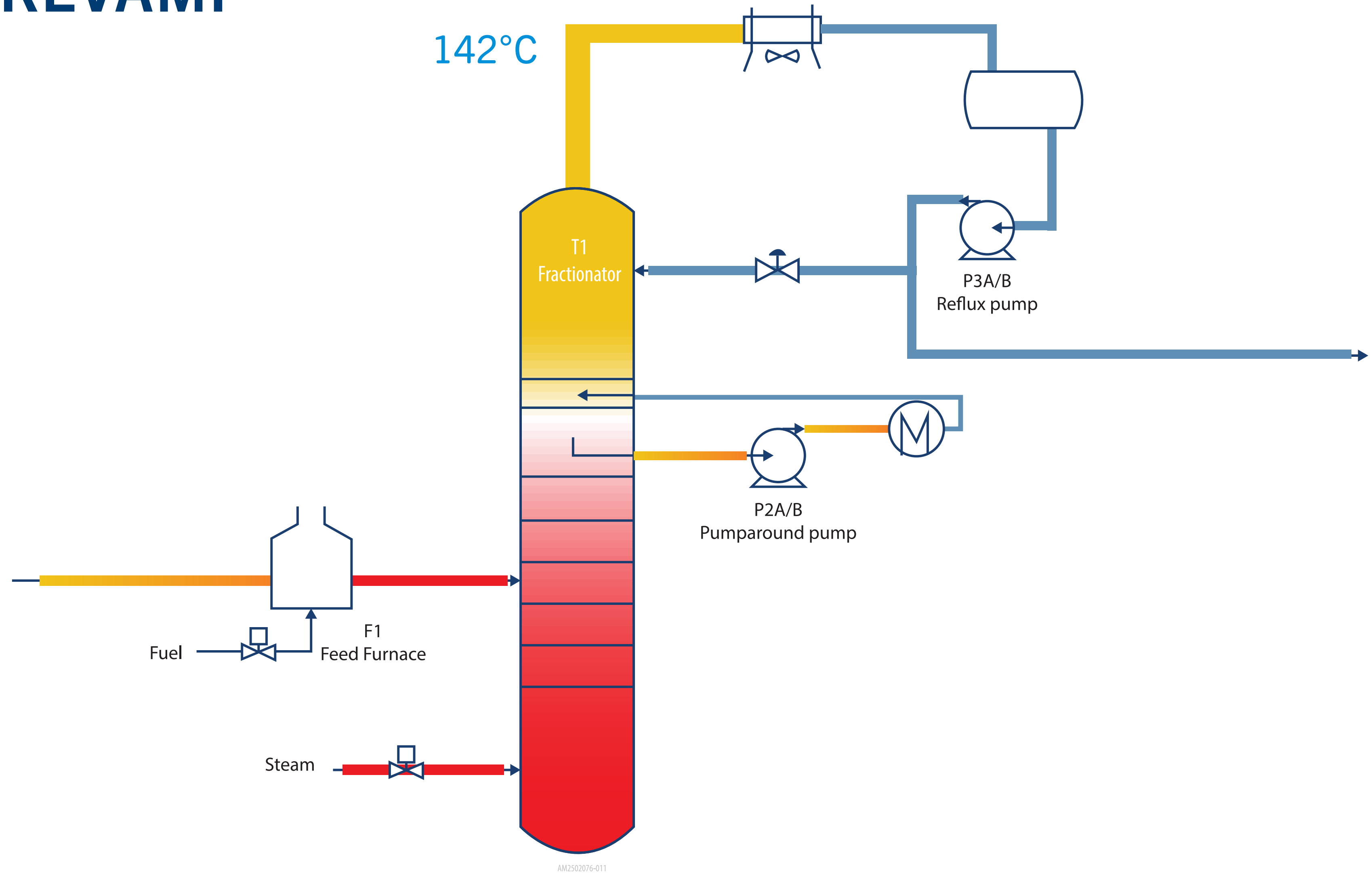


- HP loop stabilises
- Compressor continues
- Increased level in fractionator

Feasibility dependent on volumes

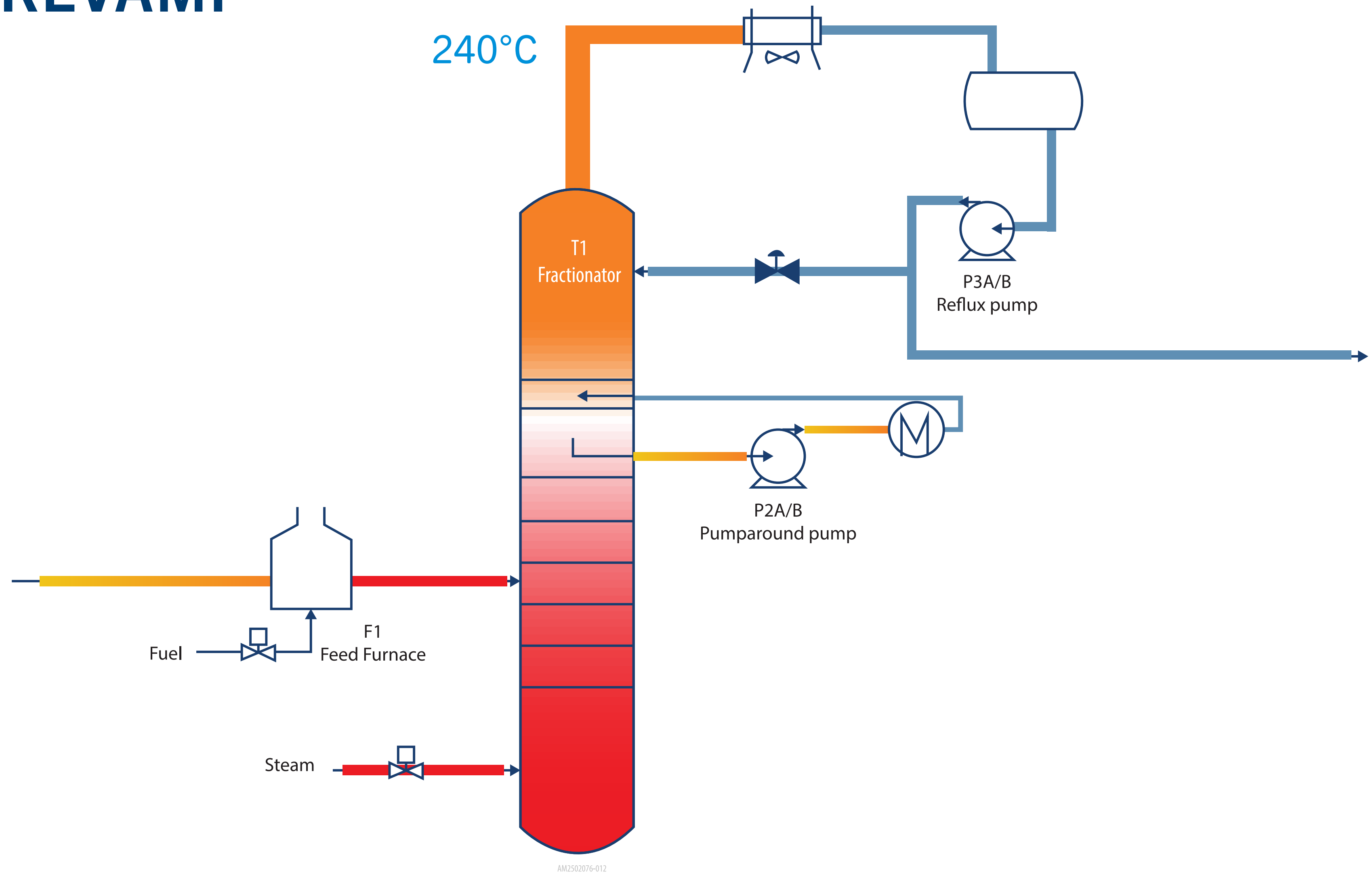
Fourth Challenge:

THE IMPACT OF REVAMP



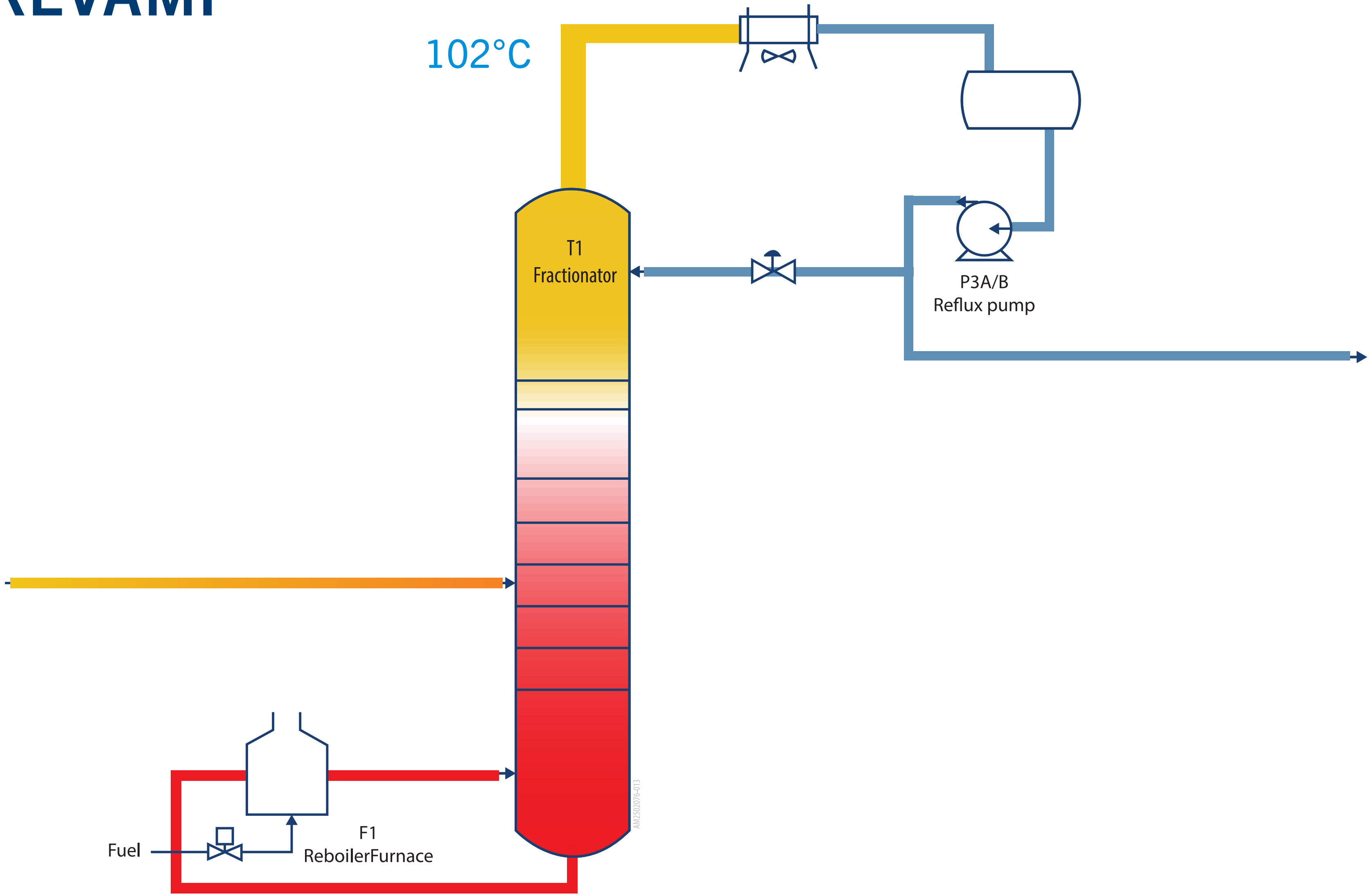
Fourth Challenge:

THE IMPACT OF REVAMP



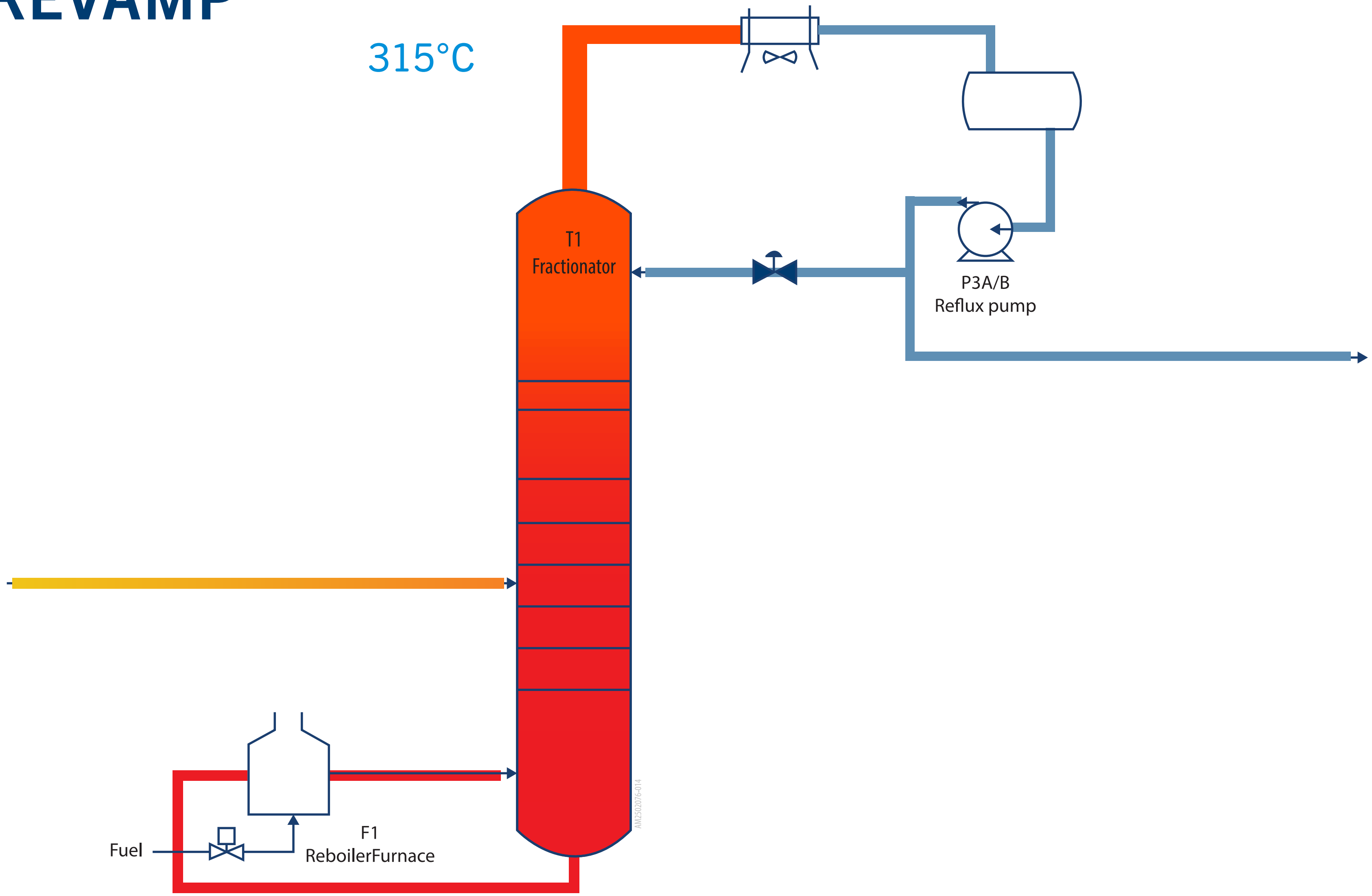
Fourth Challenge:

THE IMPACT OF REVAMP



Fourth Challenge:

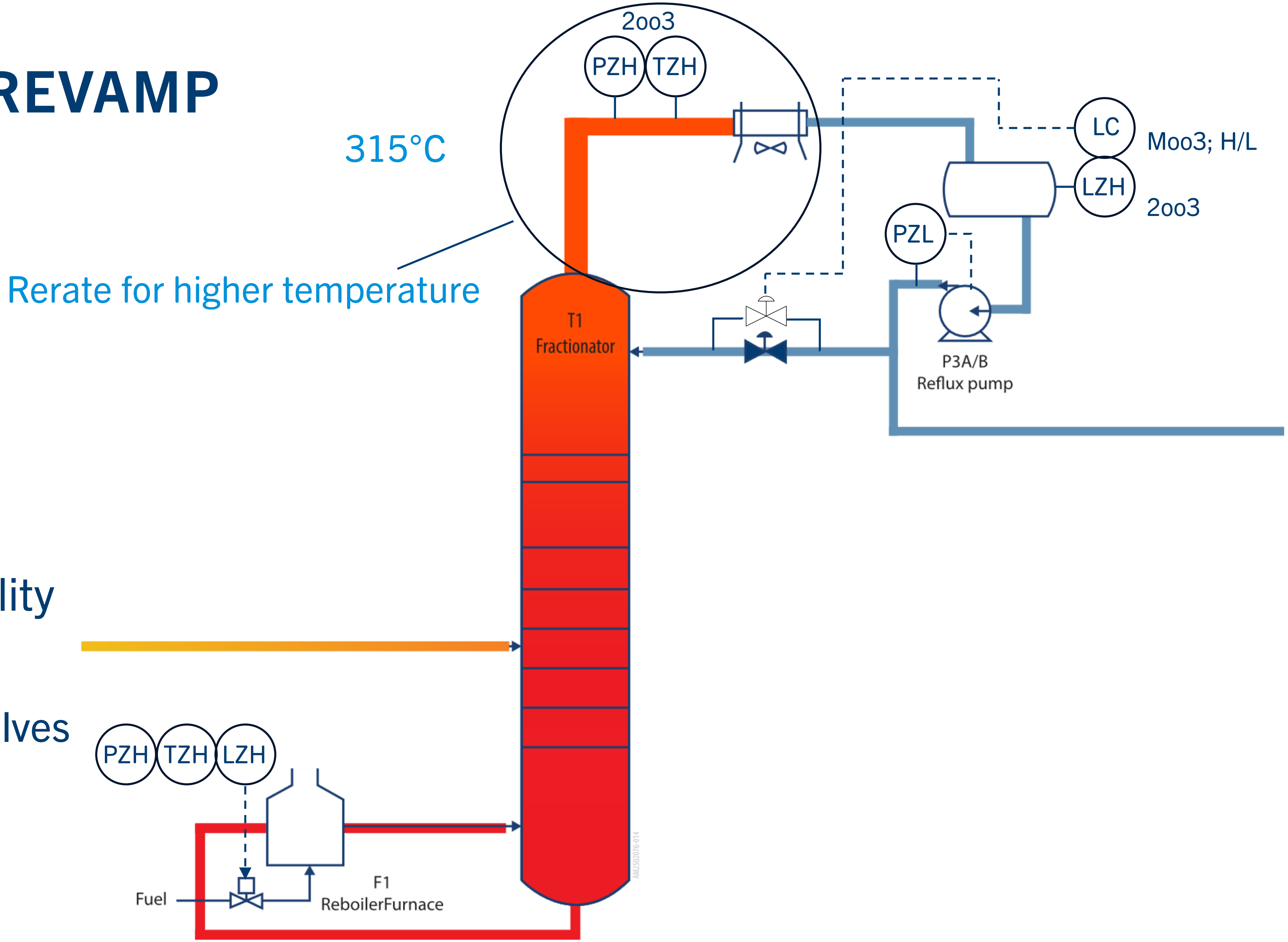
THE IMPACT OF REVAMP



Fourth Challenge:

THE IMPACT OF REVAMP

- Furnace trip
  - Hot refractory
  - Consider lag time (30 mins)!
- Rerate of overhead system
- Enhance reflux reliability
  - Pump autostart
  - Redundant control valves
  - Additional level instruments



KEY TAKEAWAYS

Early Establishment of LOPA Principles	Align early to prevent debate during the review
Balance Safety and Operability	Design SIFs to protect without compromising reliability or operational efficiency
Think System-Wide	Adopt a holistic approach to identify subsystem interactions and hidden risks in revamp projects

THANK YOU

FLUOR®

Energy Transition

Clean Water

Renewable and Biofuels

Katy Gerstner

Process Engineering Manager

katy.gerstner@Fluor.com