# Heat Integration and Relief Systems Design

**Jason White, P.E**
**Jason Spearow, P.E**

9TH GLOBAL CONGRESS ON PROCESS SAFETY

Smith & Burgess
Process Safety Consulting

# Overview

- Introduction
  - What is heat integration?
  - Common applications
  - Impact on relief systems
- Case studies
  - Crude Fractionator with preheat train
  - FCC Fractionator with gas plant integration
- Conclusion
- Questions

# What is heat integration?

- Process of utilizing energy already present in a system to minimize the utility consumption
- Becoming a more common practice in process optimization for both new and existing facilities

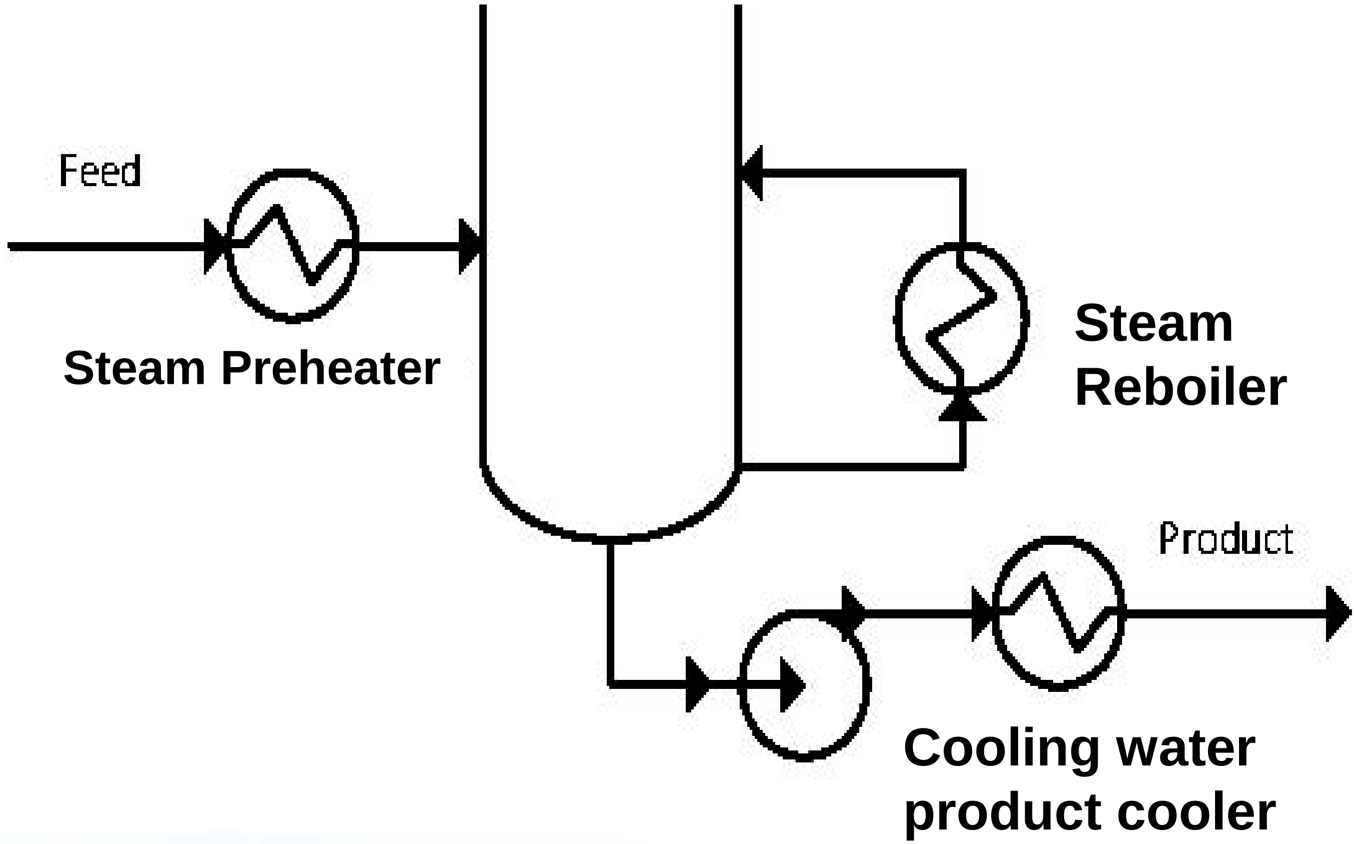



**Figure 1 – Example of process prior to heat integration**

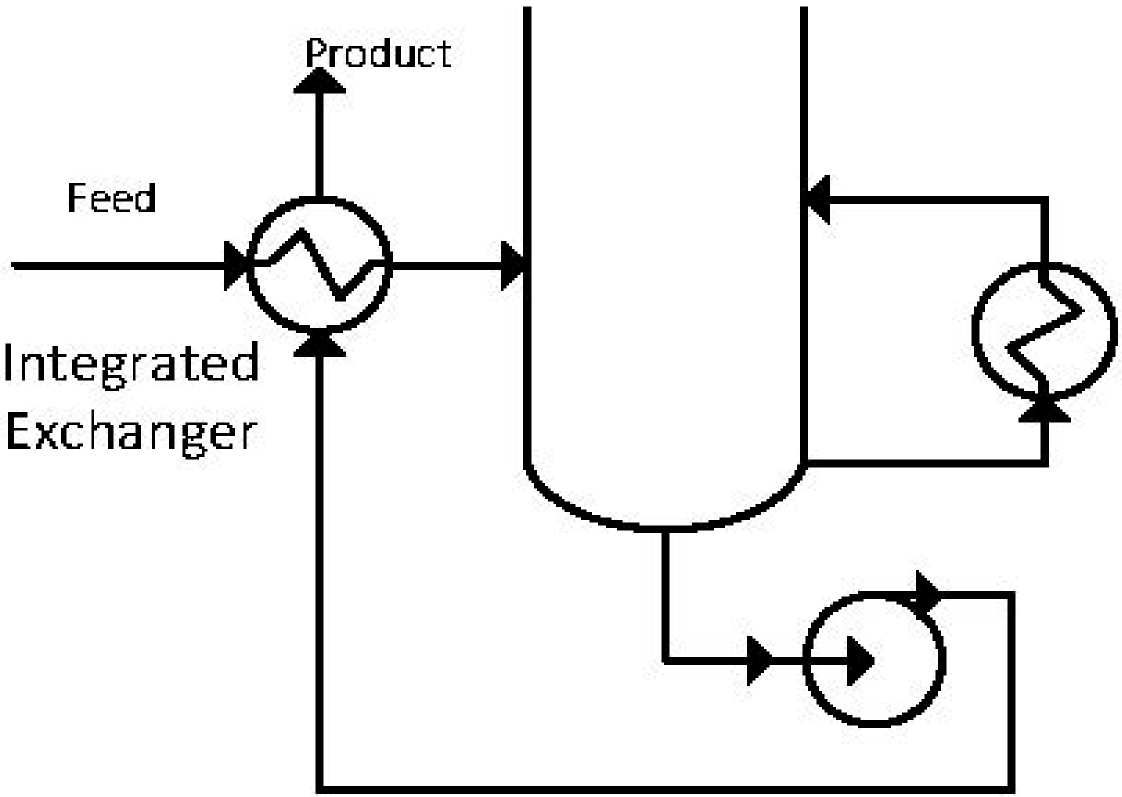



**Figure 2 – Example of similar process after heat integration**

# Impact on Relief Systems

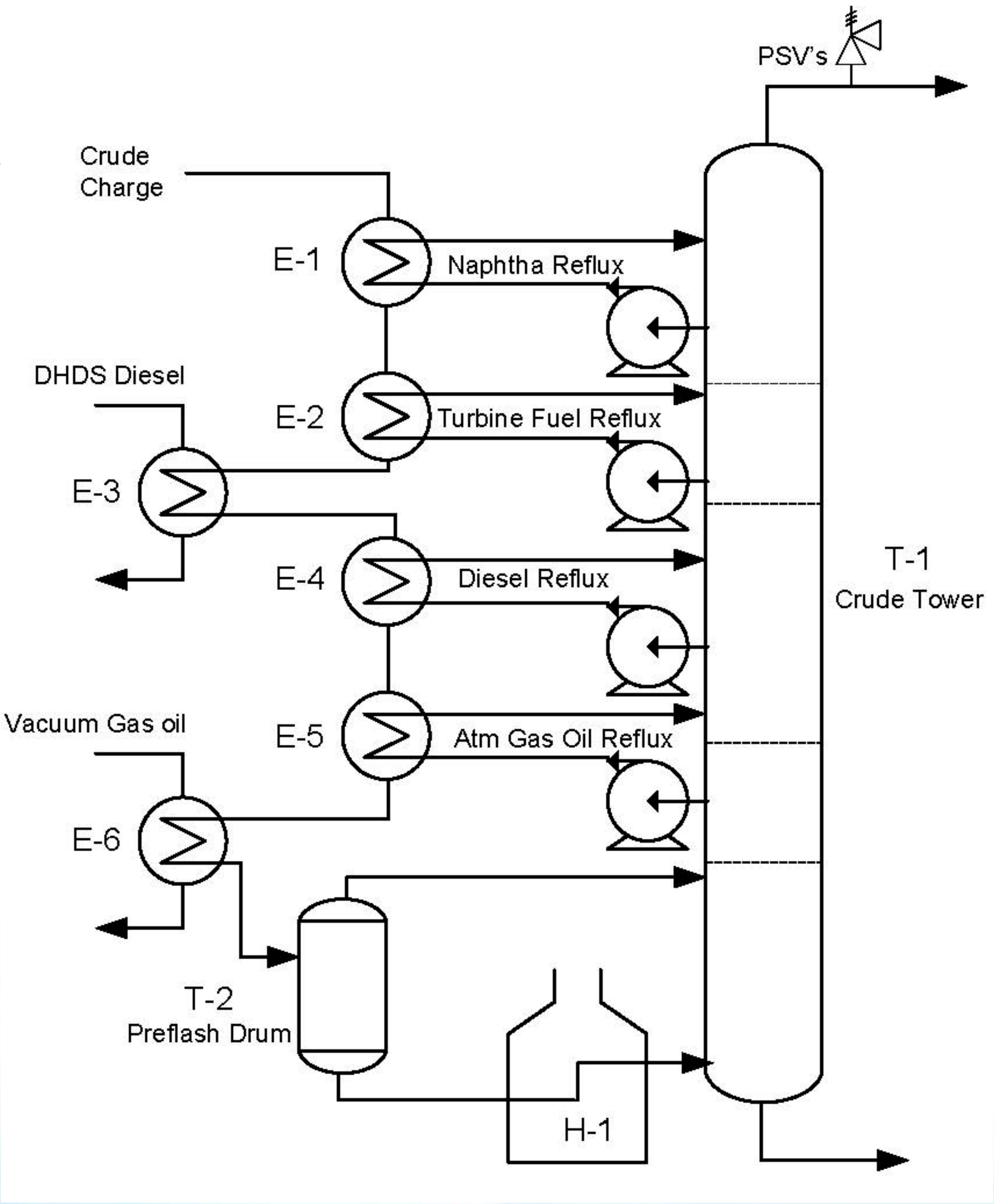
- Required relief loads are the imbalance of mass and/or heat
- Ignoring how heat is integrated artificially creates a heat imbalance
- This imbalance could result in over-predicting or under-predicting relief loads
- This could then result in unnecessary spending or unsafe design

# Staying Conservative

- Engineers are generally cautious about taking credits for what gives positive results
- It is important to recognize the physical limitations of the system
- By understanding the true limitations of a system, one can maintain conservatism while producing positive, more realistic results

# Case Study 1

- Refinery heat integration project aimed to increase feed temperature to crude fractionator
- A partial power failure scenario resulted in loss of pump-arounds with continued feed
- Initial relief calculations assumed normal tower feed temperature, and inadequate relief capacity
- Installing additional relief capacity with subsequent flare modifications was enough to warrant cancelling project




# Figure 3 – Crude fractionator with preheat train

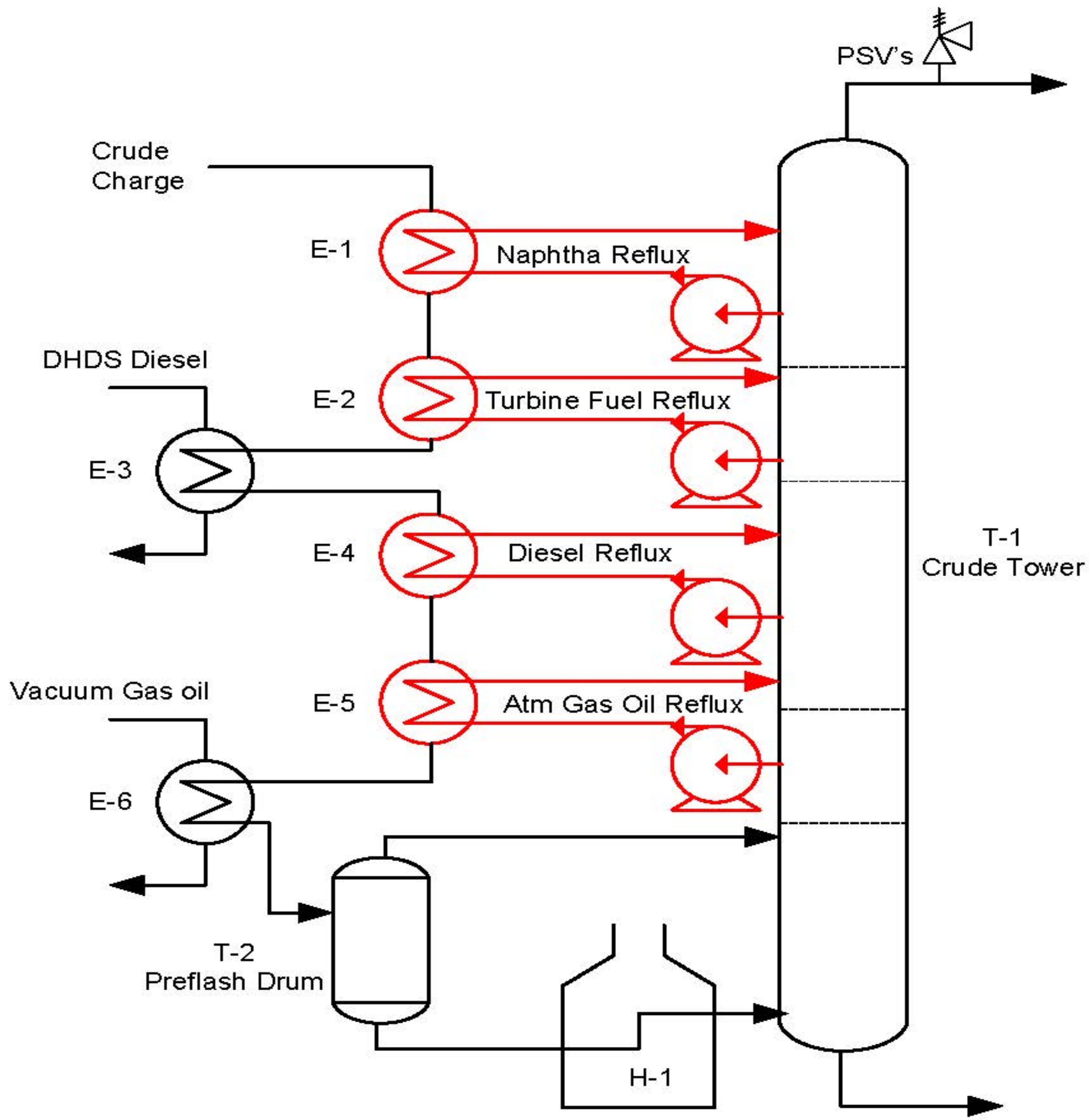
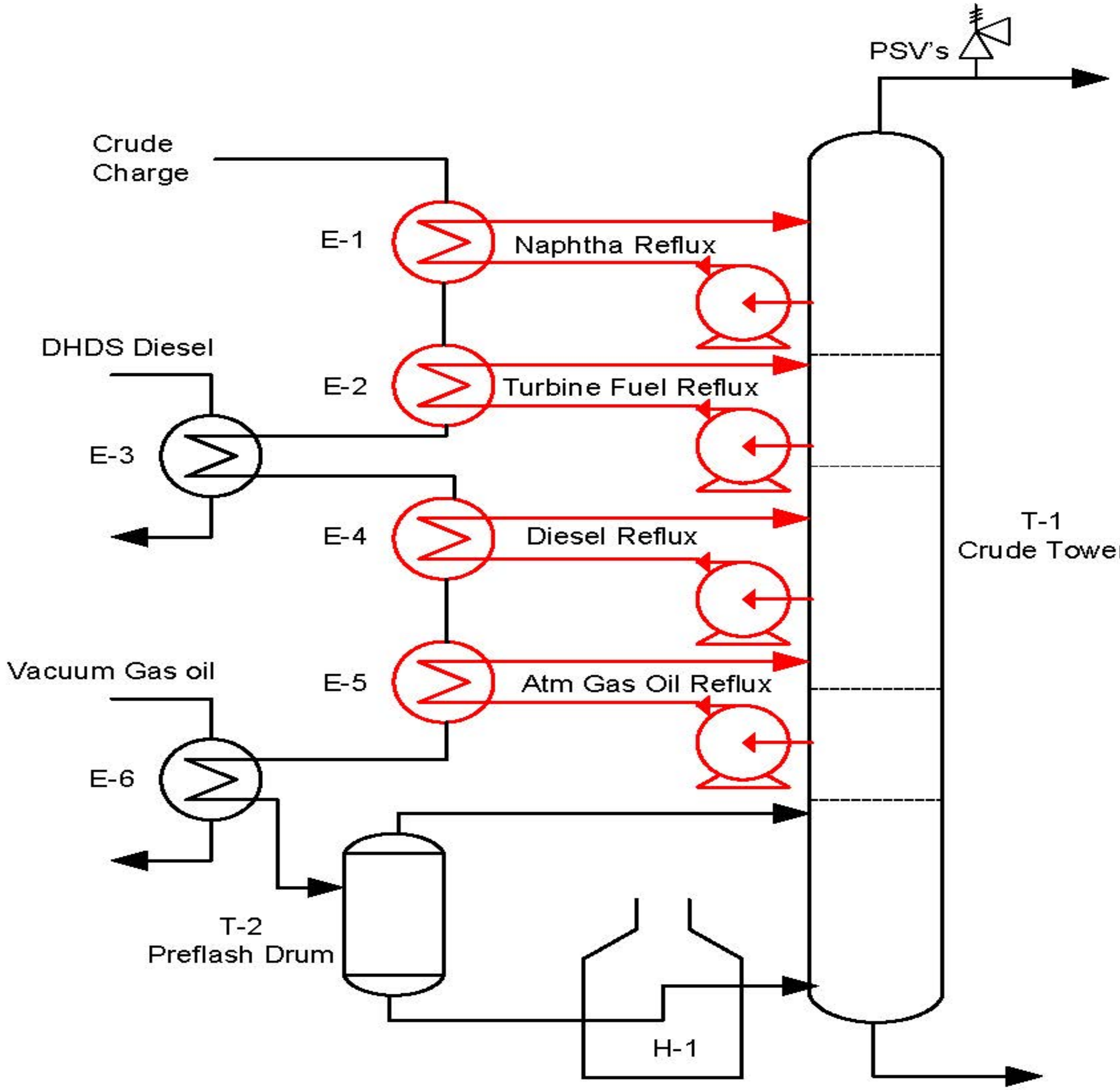



**Figure 3 – Crude fractionator with preheat train**

# Considerations

- Relief load is due to more heat input than heat removal; however,
  - Heat removal comes from pump-around preheat exchangers
  - Heat input comes from feed furnace AND preheat exchangers
- The only valid heat input comes from feed furnace and preheat exchangers not associated with column pump-arounds




# Figure 3 – Crude fractionator with preheat train

# Considerations Cont'd

Preheat Exchangers

- Not all the preheat exchangers are from the Crude Tower pump-arounds
- The other exchangers will have ***higher*** duties than normal, as the temperature difference increases
- Use the UA $\Delta T$ to determine max duty at relief conditions

Feed furnace

- Fuel gas to furnace will increase in attempt to maintain constant temperature
- The max duty is determined by burner limitation with efficiency of furnace

# Case 1 Results

**Table 1 – Comparison between normal and relief duties when accounting for heat integration (MMBtu/hr)**

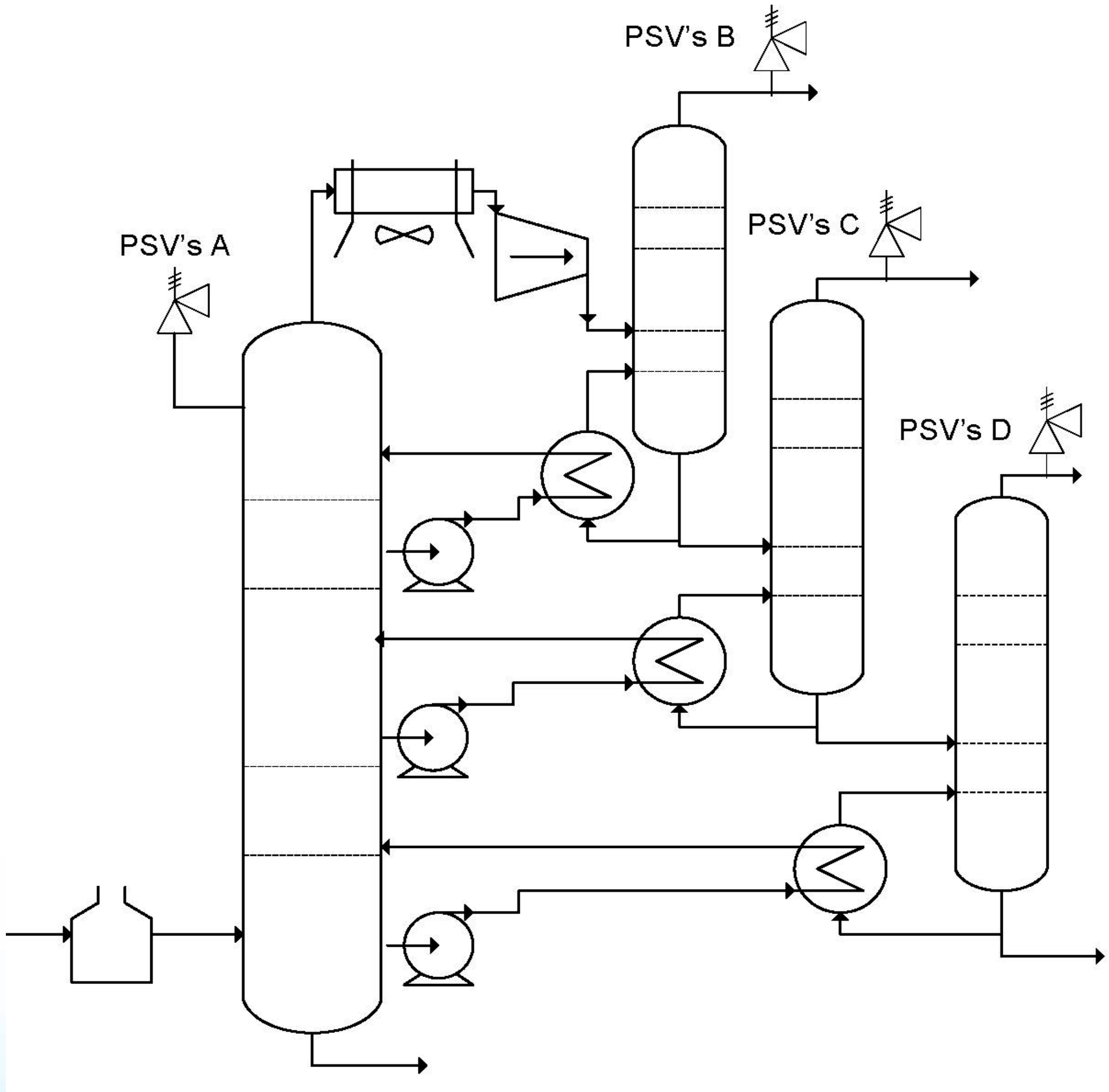
| Case | E-1, E-2, E-4, E-5 | E-4, E-6 | H-1 | Total |
|---|---|---|---|---|
| Normal | 214 | 75 | 236 | 525 |
| Relief | 0 | 152 | 318 | 470 |
| Difference | - 214 | + 77 | + 82 | - 55 |

**Table 2 – Required relief load with and without heat integration**

| Case | Tower Feed Temp (ºF) | Required Relief (lb/hr) |
|---|---|---|
| Without considering heat integration | 680 | 719,900 |
| Considering heat integration | 610 | 622,800 |

# Case Study 2

- Refinery was working to resolve concerns associated with flare radiation
- System in question is Fluidized Catalytic Cracking (FCC) fractionator with its pump-around exchangers fully integrated with distillation column reboilers in Gas Con unit




# Figure 4 – FCCU and Gas Con Integrated Exchangers

# Case Study 2 Cont'd

- Previous analysis used loads generated from individual relief systems reports that didn't account for heat integration

**Table 3 - Load summary prior to heat integration analysis**

| Valves | Location | Load (lb/hr) |
|---|---|---|
| PSV's A | FCCU Fractionator | 454,123 |
| PSV's B | Gas Con De-Propanizer | 151,400 |
| PSV's C | Gas Con De-Butanizer | 433,700 |
| PSV's D | Gas Con De-Isobutanizer | 148,900 |
| Total | FCCU and Gas Con | 1,188,123 |

# Considerations

- Because most pumps are set up with a spare (some steam driven), the pump in question may or may not fail

- The conservative assumption of which is spare at the time of the power failure is made for sizing each individual system

- For analyzing the flare, the sizing loads from the individual systems are not additive

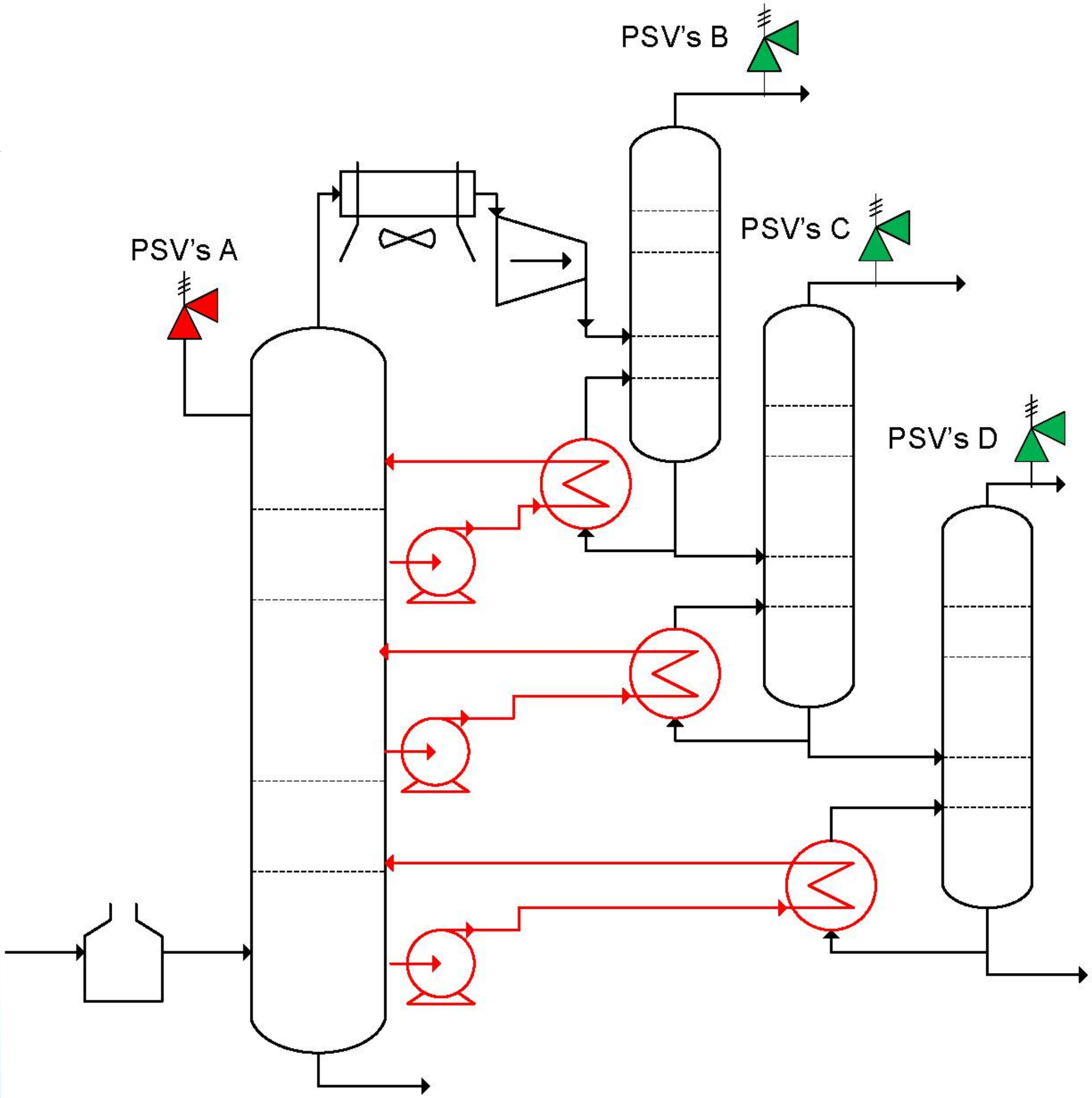
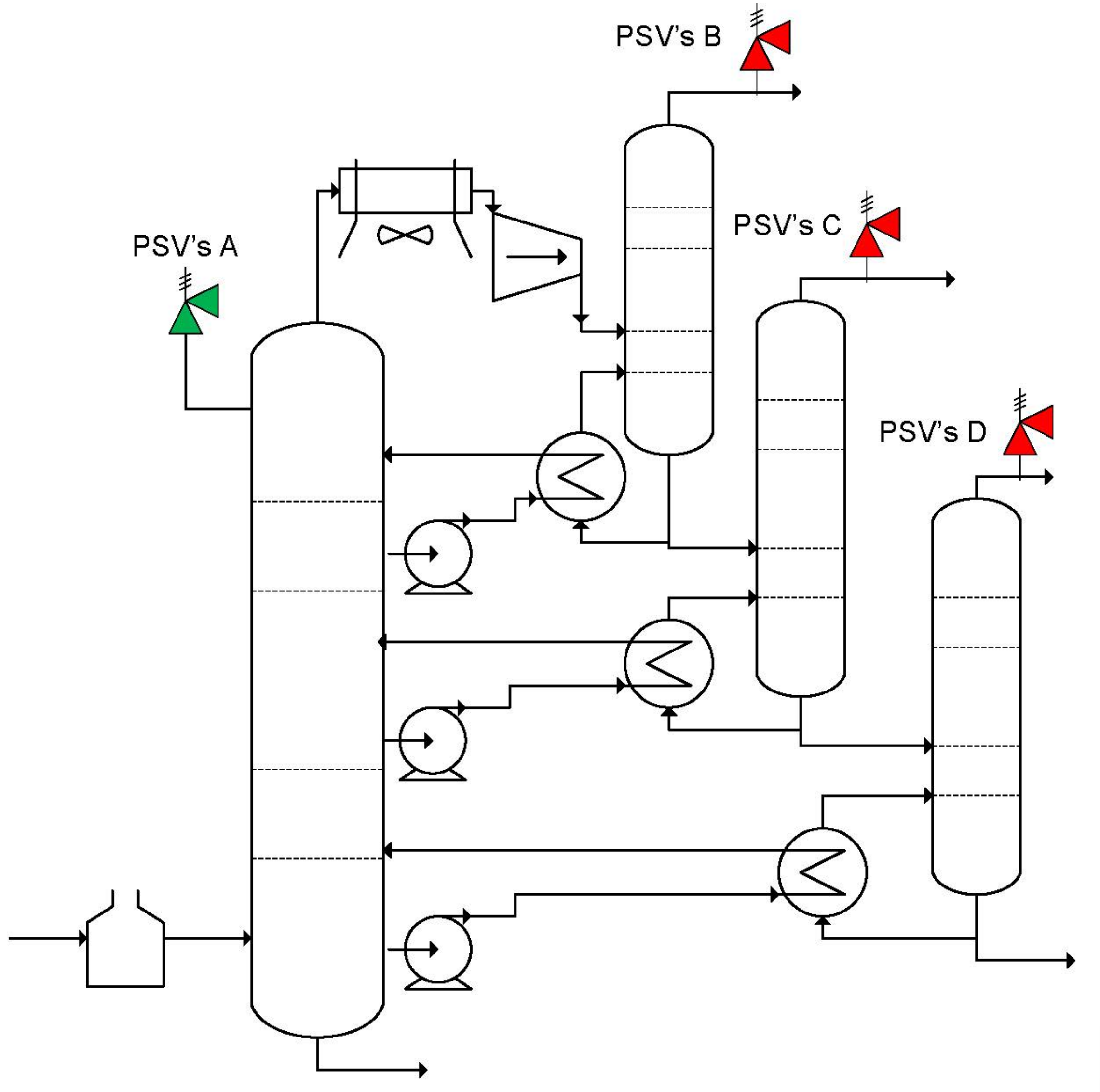



**Figure 4 – FCCU and Gas Con Integrated Exchangers**




# Figure 4 – FCCU and Gas Con Integrated Exchangers

# Case 2 Results

- During a power failure, the loads from the FCCU and Gas Con cannot both relieve
- Note that one case results in a worse result for radiation study, while the other case is worse for the subheader

**Table 4 - Load summary after heat integration accounted for**

| Valves | Location | Case 1 Load (lb/hr) | Case 2 Load (lb/hr) |
|---|---|---|---|
| PSV's A | FCCU Fractionator | 454,123 | 0 |
| PSV's B | Gas Con De-Propanizer | 0 | 151,400 |
| PSV's C | Gas Con De-Butanizer | 0 | 433,700 |
| PSV's D | Gas Con De-Isobutanizer | 0 | 148,900 |
| Total | FCCU and Gas Con | 454,123 | 734,000 |

# Conclusion

- Understanding how heat is integrated is **important** in analyzing relief systems
- One can avoid over-predicting relief loads that can have significant financial impact
- One can avoid under-predicting relief loads that can make a system unsafe
- Accounting for limitations due to heat integration does not require significant time or rigorous modeling software
- Save time, save money, save lives

# Questions?