Overpressure Protection Design

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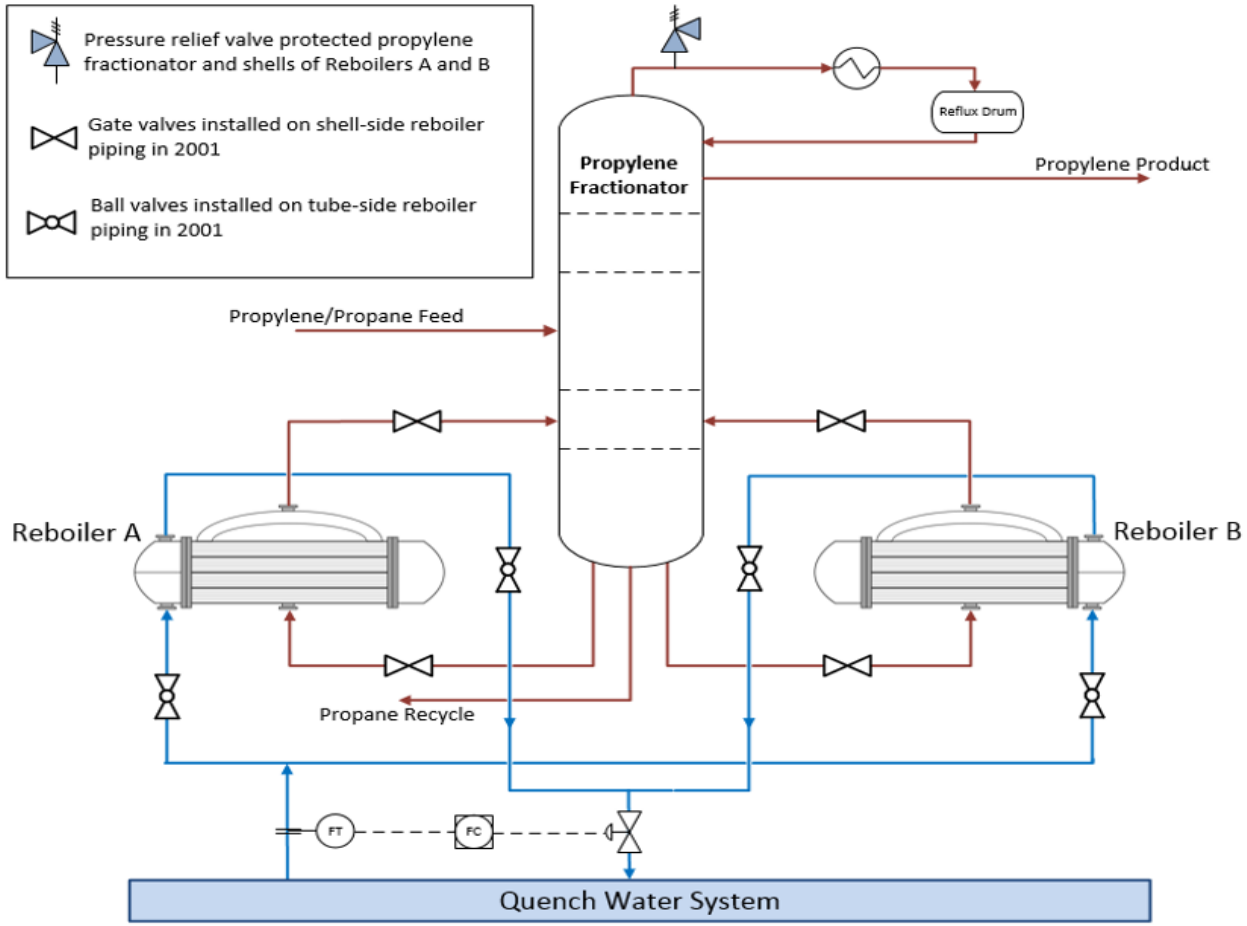
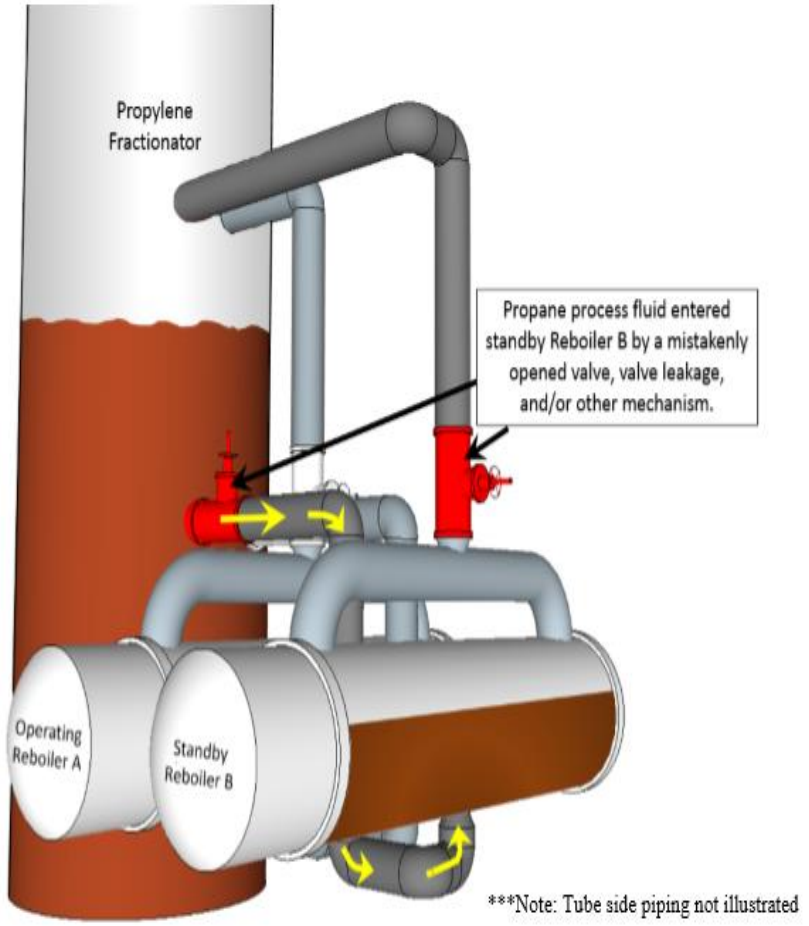
Williams Geismar Olefins Plant – Overpressure Incident

A fire and explosion occurred on June 13 2013 and **fatally injured** two workers due to an overpressure caused by hydraulic expansion in a tower reboiler

Williams Geismar Olefins Plant – Overpressure Incident





Overpressure Protection Design Objective

- The objective is to **prevent** a loss of containment in an equipment / piping due to an overpressure to protect people, environment and property
  - Loss of containment events can have a **catastrophic consequence**
  - Potential for a **major accident** (e.g. vapor cloud explosion, toxic exposure)
- The objective is typically achieved by
  - Designing the equipment / piping to withstand the maximum source / possible pressure and / or
  - Installing a **mechanical** pressure relief device of adequate size

Overview on Singapore Acts and Regulations

- Workplace Safety and Health (WSH) Act requires the duty holders to take so far as is reasonably practicable measures as necessary to ensure the safety and health of persons at work
  - The requirement is **applicable to pressure vessels, machinery and piping**
- WSH (General Provisions) Regulations directs the owners of pressure vessels to ensure that the equipment is designed and fabricated to relevant **internationally recognised codes and standards** and properly inspected and maintained
  - Statutory Inspection (SI) pressure vessels require registration and regular inspection

Some of the International Codes

- ASME Boiler and Pressure Vessel Code
  - Section I – Power Boilers
  - Section VIII – Pressure Vessels
- ASME Piping Code
  - B 31.1 – Power Piping
  - B 31.3 – Process Piping
- Pressure Equipment Directive (PED)
  - Not a design code but provides guidelines for the pressure vessel overpressure protection design requirements

Some of the International Standards

- API RP 520: Sizing, Selection, and Installation of Pressure-relieving Devices
  - Part I – Sizing and Selection
  - Part II – Installation
- API RP 521: Pressure-relieving and Depressuring Systems
- HSG 176: The Storage of Flammable Liquids in Tanks

Overpressure Protection Design Requirements (critical few)

- The **size** of the pressure relief device must be adequate to relieve the required relief flow rates for all the credible overpressure scenarios
- The **set pressure** of the pressure relief device is such that it protects the equipment / piping considering the potential liquid static head and backpressures
- The **pressure relief path** between the interconnected equipment / piping is of adequate size and the valves on the relief path are either lock open or car seal open per the applicable codes, standards and regulations

Potential Challenges in Existing Operating Facilities

- Capital projects typically do not have a concern in complying with the overpressure protection design requirements
- If a **design variance** is identified in the **existing operating facilities** (e.g. through Safety Case assessments or through due-diligence initiatives), there may be some challenges in complying with the requirements
  - Pressure relief devices may be connected to the closed relief system (e.g. flare) which operates continuously
  - On-stream retrofit may not be technically feasible in some equipment (e.g. equipment nozzle size is smaller than the required size)
  - May involve reasonable engineering resources, engineering time and cost

How to Handle Design Variances? (one of the approaches)

- **Categorize** the facilities, identify the higher priority ones and work on them followed by the rest
  - Facilities governed by regulations and facilities with the potential to create a major accident are the candidates for the higher priority ones
- Focus on the **mandatory** design requirements from the codes and standards followed by the non-mandatory design requirements
  - Some of the design requirements are non-mandatory in nature
- **Prioritize** using risk assessments
- Close the gaps on the **higher risk** variances followed by the rest
  - Risk based approach

International References for Managing Variances

- Welding Research Council Bulletin
  - Guidance on the Application of Code Case 2211-Overpressure Protection by Systems Design, Bulletin 498, January 2005
- ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, 2017
  - UG-140 Overpressure Protection by System Design
- EEMUA 236:2018, Risk Management of Legacy Systems with Potential for Excess Overpressure

How to Close the Gaps?

- The first consideration should be given to meeting the design requirements using **conventional mechanical** pressure relief devices
  - Proven, reliable and easy to maintain
- If it is technically feasible, consider providing a **High Integrity Pressure Protection System** (HIPPS)
  - It is a Safety Instrumented System (SIS) designed to give an overpressure protection equivalent to the conventional mechanical pressure relief devices
- Leverage on **System Design** control measures, reduce the risk and demonstrate the risk is at ALARP
- Any other appropriate methods that are **acceptable** to the codes and regulatory agencies

What is meant by System Design?

- System Design refers to the **engineering control measures** that are included in the process design for reducing the overpressure risk in an equipment / piping
  - For example, a high level SIL rated Safety Instrumented Function (SIF) that closes the inlet valve on a high liquid level and prevents a liquid overfill
- In the event of using System Design features, the control measures may have to be designated as **Safety Critical** and their integrity needs to be tested and maintained in accordance with the required risk reduction

Potential Challenges with System Design

- Acceptability with respect to the codes and an alignment with the **insurers and regulatory agencies** may be required prior to adopting the System Design approach
- The adoption of the System Design approach may place a **burden** on the organization resources and it should not be underestimated
  - Typically requires detailed risk assessments and evaluation against the code requirements
- The **physical condition** of the equipment / piping may not suitable in some situations (e.g. due to corrosion)

Summary

- Overpressure protection design objective
- Regulations
- Methodologies
- Technologies

Quote from www.mom.gov.sg

Pressure Vessels that don't need to be registered

You do not need to register the following types of Pressure Vessels:

- Pressure vessels that only process chemicals and other substances, not with air, steam or water (when being used as a refrigerant).
- Pressure vessels that operate under vacuum or negative pressure.
- Air receivers, steam receivers or refrigerating plant pressure receivers where the safe working pressure does not exceed 0.5 bar or the product of its safe working pressure and volume does not exceed 100 bar litres.
- Steam boilers where the maximum permissible working pressure does not exceed 0.5 bar.

> **Note**
>
> Regulations, in accordance with the Workplace Safety and Health (WSH) Act, still apply **even if your Pressure Vessel is exempted from registration requirements**.
>
> Owners of pressure vessels still need to ensure that the equipment is designed and fabricated to relevant internationally recognised codes and standards and properly maintained – WSH (General Provisions) Regulations, Reg 33.

Overpressure Protection Design

Thank you!

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