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Fire Protection Integrity and Optimization

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Abstract

The greatest challenge to fire protection engineering is the gap between codes and optimized facility design. Fire code and industrial practices provide prescriptive guidelines to mitigate the risk and control hazards. However, within the past decade new processes or methods of construction have been used and their associated hazards have not been foreseen in the current guidelines or standards.

Atkins Consulting Canada Ltd. has developed a means to link process safety methods (PHA, Consequence Modeling, QRA, Facility Siting etc.) and the deterministic approach to optimize the design while also maintaining integrity of fire protection elements. This methodology focuses on risk-based (probabilistic) and performance-based (deterministic) assessment to select the most appropriate active and passive fire protection system and optimize the design.

This presentation demonstrates a practical application of process safety to assess fire hazard scenarios and implementing the results in design to meet both the prescriptive legislative requirement as well as the goal of optimal safety in design.

Introduction

A growing oil and gas industry, advancing technology and process complexity requires development in safety engineering. Most engineers are keen to use codes and standards such as NFPA or API for designing fire protection systems, but there is always some ambiguity within these standards that can cause further confusion for the engineer. In fact, codes and standards cannot catch up with advancements in technology or construction methodology. These grey areas in standards will result in over-investment in a project or uncertain decision-making, which eventually compromise safety. Safety studies could assist fire protection engineers to realize the risk and reduce it to ALARP (As Low as Reasonably Practicable) with optimum investment.

Fire Protection Engineering

Fire protection engineering applies engineering principles to analyze fire hazard and design mitigation measures. Engineering principles applied in fire protection engineering are:

- Hydraulic calculation
- Material properties
- Transfer phenomena

The key to success in fire protection engineering is to maintain integrity between the fire protection elements (Figure 1):

- Passive Fire Protection
- Active Fire Protection
- Detection System
- Emergency Response Time

Figure 1. Fire Protection Elements

Fire protection engineering in process safety is the last layer of defense. Although fire protection is not an independent protection layer (IPL), it is considered as a safeguard and is a safety critical element (SCE).

Design Approach

There are two different approaches to fire protection engineering:

- Prescriptive Approach

- Performance-Based Approach

The prescriptive approach appears very conservative but sometimes creates gap in the design. The performance-based method is an alternative to prescriptive design with more flexibility and could obtain functional objectives of the system. In addition, it could provide opportunity for optimization. An example of prescriptive approach is the pipe rack failure in propane deasphalting unit McKee Refinery [1]. The pipe rack was designed according to API-2218; however, the jet fire in the unit disrupted beyond the estimated fire zone and the unprotected steel structure collapsed, resulting in catastrophic incident (Figure 2).

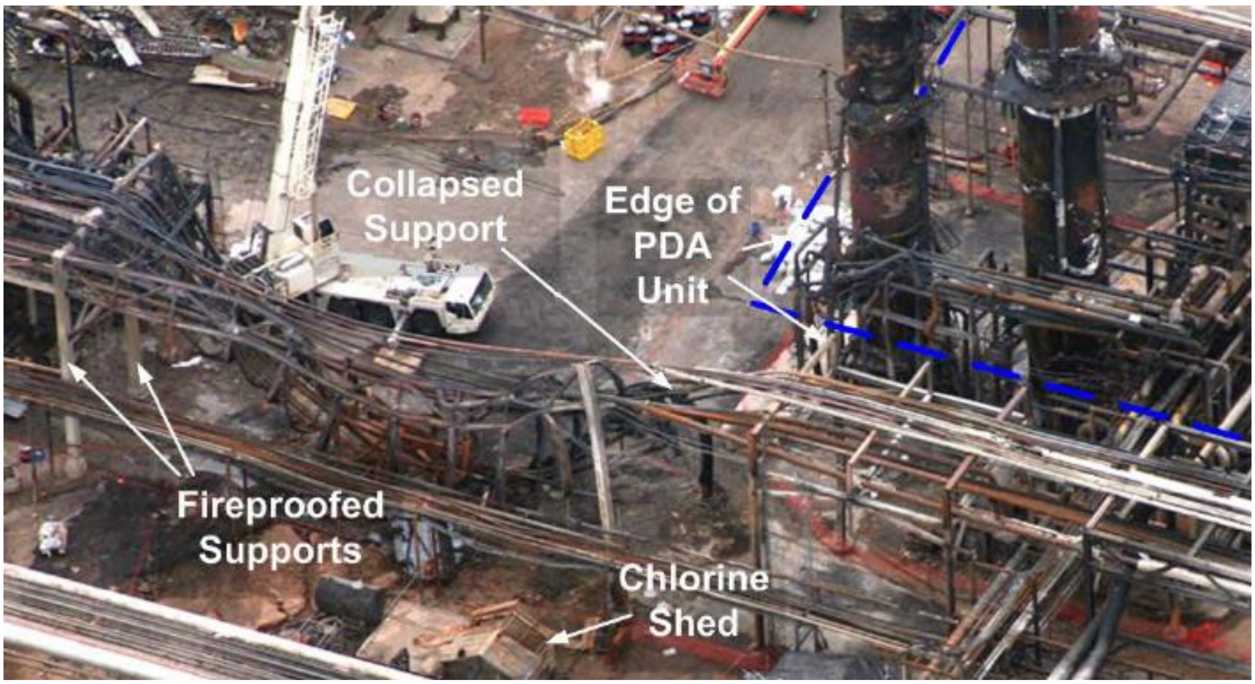
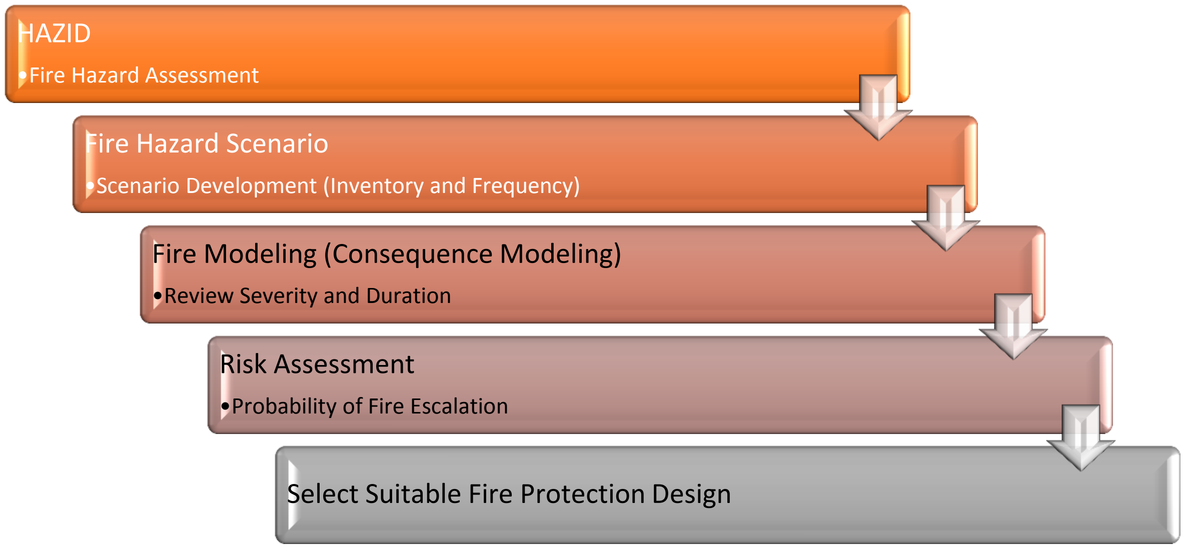


Figure 2. Propane Deasphalting Unit Incident

Performance Design Approach

In order to apply performance-based approach in fire protection design, the following process is recommended:



This analysis will be conducted to identify the most probable potential losses of containment and subsequent fire types, sizes and effects for the subject facility. The objective of fire hazard analysis is to reduce the frequency and the magnitude of hazardous events as long as economically practicable. As an outcome of fire scenario, fire zones could be developed and play a great role in fire protection optimization from different perspectives such as size of fire water header, fire separation, location of deluge valve house, etc.

Fire modeling will help to revisit locations of firefighting equipment and access to them. It will also give an idea of potential escalation to other process units and identify activation of two or more firefighting systems simultaneously. In order to make full use of the advantages of performance-based regulations, the design should be based on risk analysis methods. Developing exceedance curve (Figure 3) and Event Tree Analysis (Figure 4) could assist fire protection engineers to realize the risk and frequency of a fire scenario.

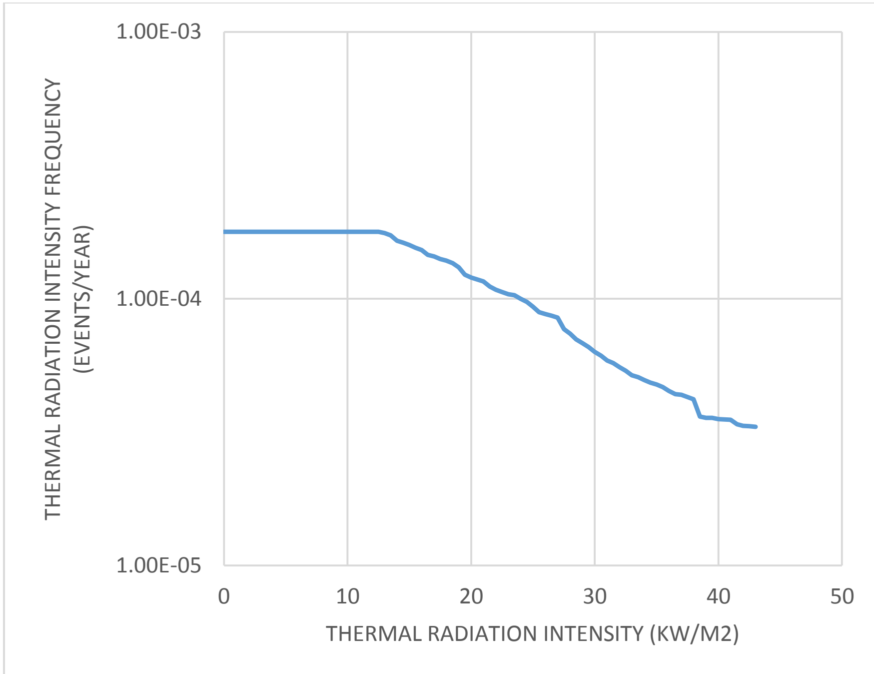


Figure 3. Exceedance Curve

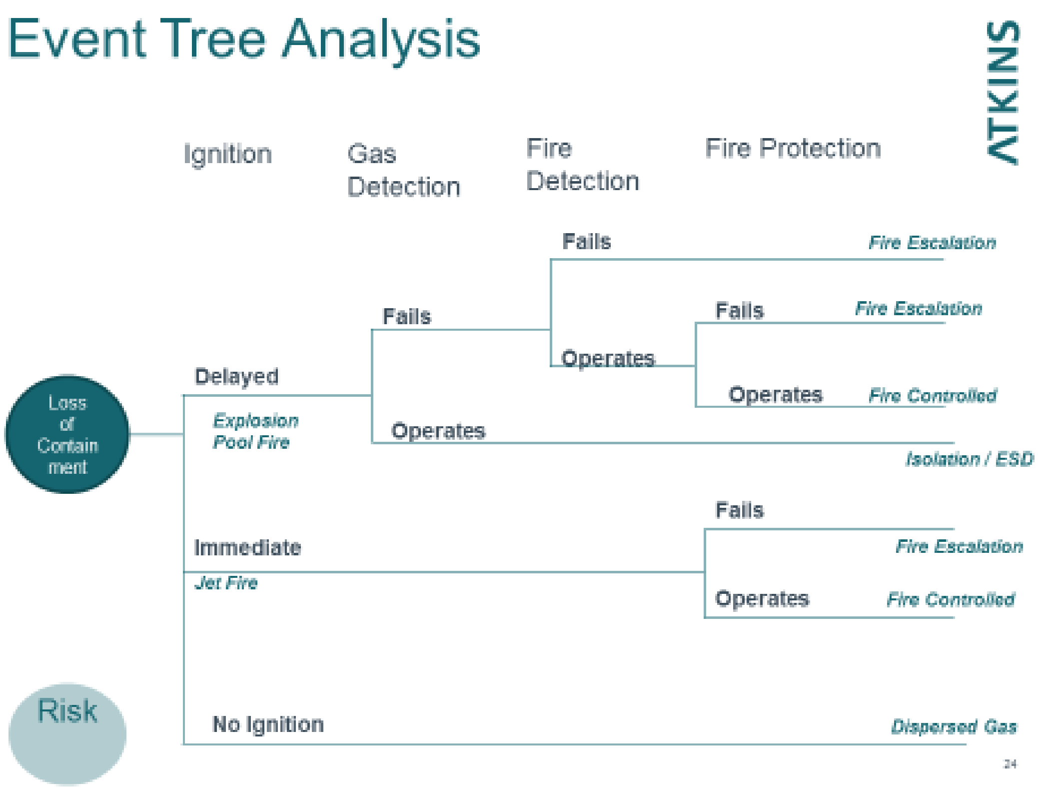


Figure 4. Fire Protection Event Tree Analysis

Optimization

By using only codes and standards that require minimum investment, a facility might not be entirely optimized, while a complicated luxury facility design is not economically desirable. By investing more in safety systems, the cost of the plant may also increase. However, safety studies could assist fire protection engineers to realize the risk and reduce it to ALARP with optimum investment. Overall, safety optimization involves several parameters such as cost, risk, integrity and performance that the organization will value depending on their own level of safety tolerability. For optimization of fire protection systems, the following performance parameters shall be taken into consideration:

- Suitability: Select a suitable extinguishing agent
- Reliability: Reviewing manual vs automatic active fire protection
- Accessibility : Access to plot plan with considering consequence analysis report
- Integrity: Detection, fireproofing, active fire protection and coverage
- Timing: Time for emergency responder from time of detection to complete suppression.

Challenges

Challenges for fire protection design and optimization are expected during debottlenecking or revamping projects or design dire protection system for a modular structure.

The concerns for modular structure are:

- ➢ High congested area
- • Adequate detection coverage
- • Deluge system
- ➢ Housekeeping underneath the module
- • Drainage
- • Fire underneath the module

Also, debottlenecking projects have hidden constraints within them. Limited spaces, limited fire water system capacity, capacity of drainage system, old and new systems integration, etc. are examples of such challenges. Process safety studies such as SIMOPS and ALARP demonstration are highly recommended to resolve any concern or uncertainties. Nevertheless, these challenges and optimization do not have severe impact if safety engineering is applied at the early stages of a project. Following risk reduction hierarchy is strongly recommended. The following process safety measures could significantly reduce cost of fire protection system:

- Depressurizing
- Isolation
- De-inventorying
- Drainage
- Special Flanges

According to API 581 inventory blowdown, coupled with isolation system reduces consequence area by about 25% [2].

References

[1] "U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD :INVESTIGATION REPORT LPG FIRE AT VALERO – MCKEE REFINERY".

[2] API-581: Bases Resource Document on RBI.