Tending towards operational excellence in Oil Terminals- Using Process Safety as a key tool

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Oil Terminals play a vital role in the business of handling and transportation of the final hydrocarbon liquid products. In October 2009, a major fire blazed for about a week in Jaipur terminal and in the wake of the accident many terminals have understood the sense of vulnerability and efficacy of the process safety. Though the terminal operations and requirements with respect to process safety widely remain similar, when process safety studies are conducted the observations and gaps found from each terminal are surprising and provide lot of inputs which when taken care would have prevented catastrophic accidents. Not deviating from the philosophy stated by Trevor Kletz idea that though two plants are mirror images, the hazards are not similar, this paper throws light on the top issues faced by the terminal industry with respect to hazards identification, consequence analysis, and facility siting.

Chola MS Risk Services having served the wide range of public and private company owned terminal clients in this business and in tribute to the Jaipur accident has developed the following case study analysing the different process safety studies with different objectives and focused improvement areas carried out for terminals in the last decade has analysed the following.

- Inherent design issues in the facility siting aspect of the terminals and resolutions. Example-Location of transfer pump rooms
- The limitations of the general safety studies and the way process safety studies like HAZOP and QRA are being articulated in becoming more instrumental for decision making of expansion activities, societal risk associated
- The common mistakes made in QRA assumptions for terminals, particularly the aged terminals
- The way recommendations are being explicitly understood and challenges faced by the terminals in closing the recommendations, particularly aged ones. On analysis, around 35 % of the recommendations refer to improvement in instrumentations.
- Lists down few of the best practices being followed in Terminals
- The way process safety studies are becoming integral part of life cycle of the terminals beyond the regulatory requirements

Using this paper, it is intended to share the minimum requirements needed to comply for a terminal to be on par with the international best practices, and this paper can act as quick source of information for the terminals to ensure that nothing is missed out

Introduction

Oil storage and handling terminals play a vital role in the business of handling, mobility and transportation of the final hydrocarbon liquid products. They form the vital final mile link in the supply chain in ensuring that the fuel reaches the ultimate retail customer. While an oil storage terminal does no “processing” there are minor operations like additive addition and refilling to tankers or inter terminal transfers. While general safety incidents are possible, what has been a major concern are the process safety incidents which though are of very low frequency, the consequences of which are catastrophic in nature.

India has witnessed one such major process safety incident in a storage terminal about a decade ago. A major fire broke out blazing all the storage tanks for about a week in Jaipur terminal killing about dozen and injuring more than 100 (TNN, 2009) was the trigger event emphasising the vulnerability of terminals. The incident led to the oil industry in India initiating and strengthening a number of process safety interventions including rigorously carrying out a number of PHA studies like HAZOP, QRA, SIL etc.,

The past incidents involving Oil Terminals were evaluated in many research papers (James I. Chang, 2006) and suggest at adopting good engineering practices.

Chola MS Risk Services, having a back ground of the two decades of rich experience of process safety studies has worked extensively with a wide range of public and private company owned terminals covering the range of operations from railway wagon receipt, pipeline receipt, tankage and truck dispatch and pipeline dispatch. After almost a decade, in tribute to the Jaipur accident this paper analyses value addition of process safety studies which can positively impact the operational excellence of the oil terminals.

Analysis of Process Safety Studies

Chola MS Risk had carried out a detailed analysis of 42 terminals which were in operational stage based on the HAZOP and QRA studies carried out for them. The life of terminals was ranging from more than 60 % of normal design life (greater than 20 years) and to the recently built terminals. This is a critical aspect in India, as exhaustive integration of process safety during detailed engineering stage is still a work in progress and many times the operating terminals are faced with engineering recommendations to mitigate risks, a perennial challenge as implementing these may require operational shutdown.

HAZOP Study

HAZOP study was conducted structurally and systematically for examination of an existing operation of terminal in order to identify and evaluate hazards and operability issues that may represent risks to personnel or equipment, or prevent operation. From the recommendations of the HAZOP, the key observations are provided in Figure 1.

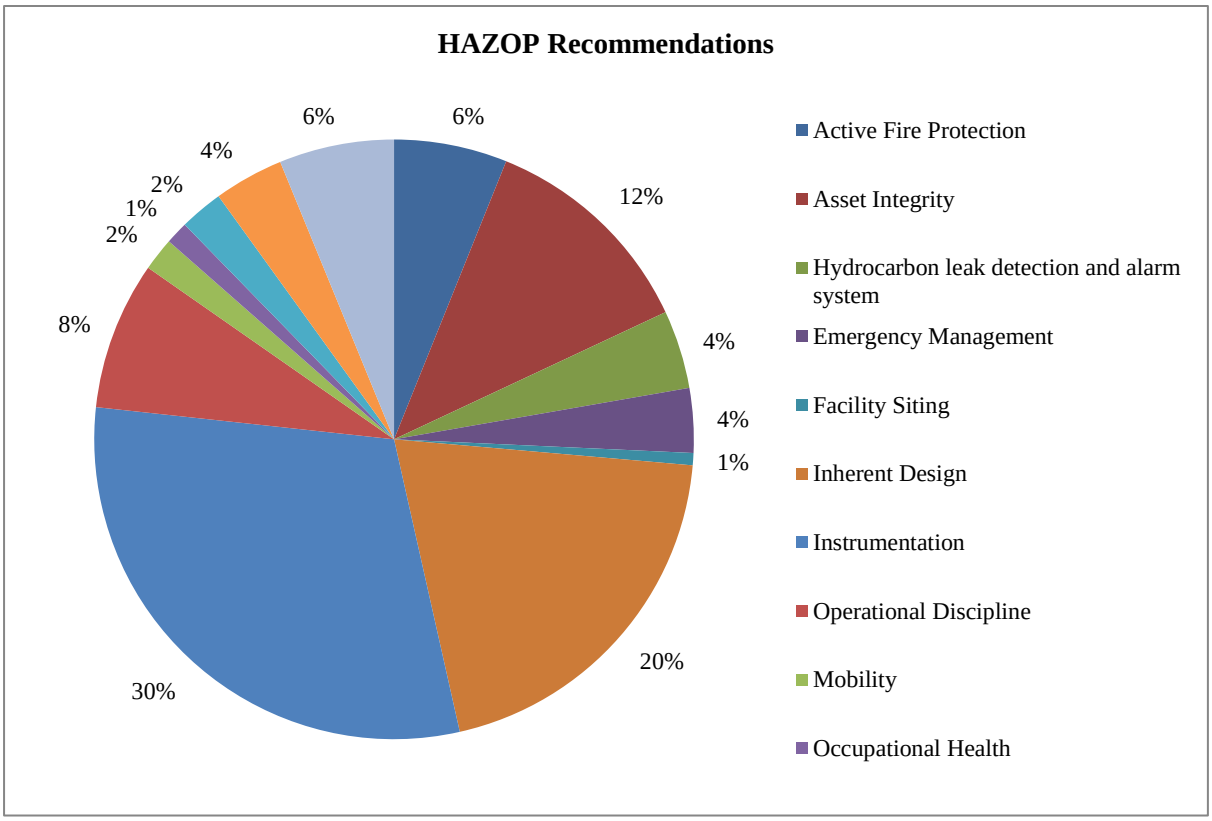

Figure 1: Analysis of HAZOP recommendations

QRA Study

QRA study was conducted with the following objective

- To identify locations within installation/depots where separation distances between units and/or boundary wall are non-compliant with the legal requirements. (The review also includes the requirement of design, layout, railway siding requirement etc).
- To conduct consequence analysis for various identified credible emergency scenarios covering all facilities within terminal like tank farm, tank lorry filling gantry, tank wagon decantation area, tank wagon filling gantry, product pump houses, oil water separator, transfer product pipelines, product pipeline exchange pit manifold, fire pump house, Tanker Lorry (T/L) parking area etc., including all catastrophic situations. Consequences are considered for onsite and offsite effects of the overall terminal including any new addition of facilities.
- To tabulate the consequences in terms of distances to radiation levels, Lower Flammability Limit (LFL) and explosion overpressure for different weather classes according to specific damage criteria and threshold limits.
- To verify and prevent risk of the facility in terms of individual and societal risk levels.
- To provide mitigation measures commensurate with the risk evaluated including action plan at terminal.
- Provide necessary mitigation measures for all credible and catastrophic emergency scenarios.

Approaches were explored as alternate mitigating measures where the buildings/units in the existing layout within the terminal at fixed locations and it is not practical /feasible to provide the prescribed separation distances.

From the QRA recommendations, the key observations are provided in Figure 2.

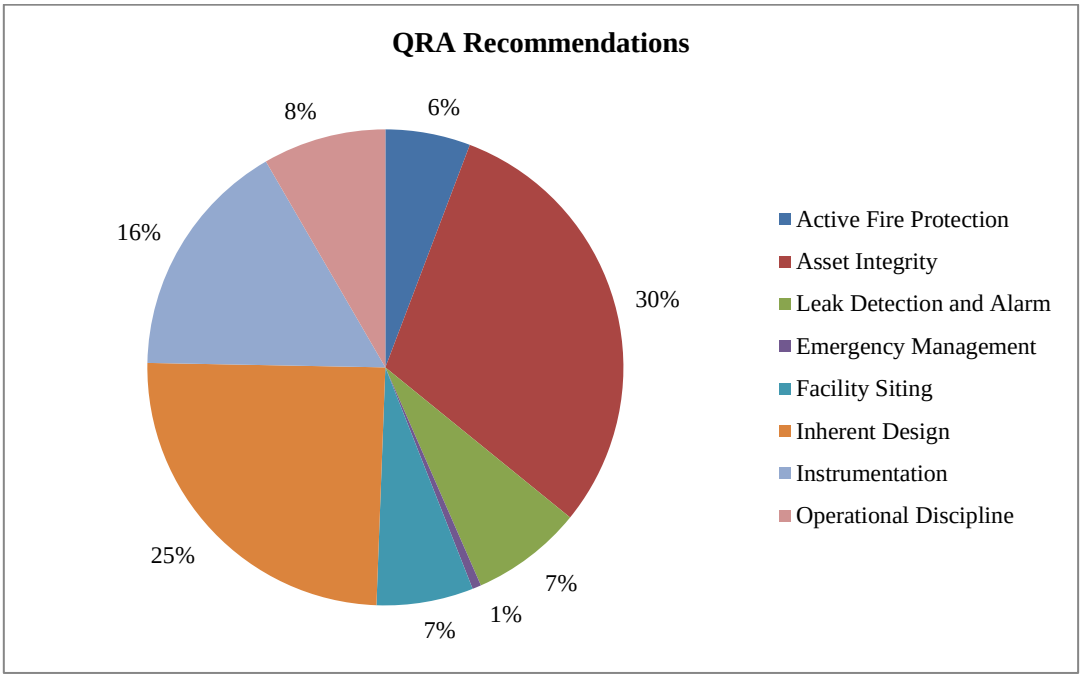

Figure 2: Analysis of QRA recommendations

Age of the terminals Vs Process safety aspects

Interestingly on observing the trends, the outcomes for old terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the aged terminals seem to have major gaps which if addressed during the conceptual stage of the project would have made the operations simpler and resulted in reduced efforts for achieving operational excellence. Trends with respect to age of terminals and process safety aspects are provided in Figure 3 and Figure 4.

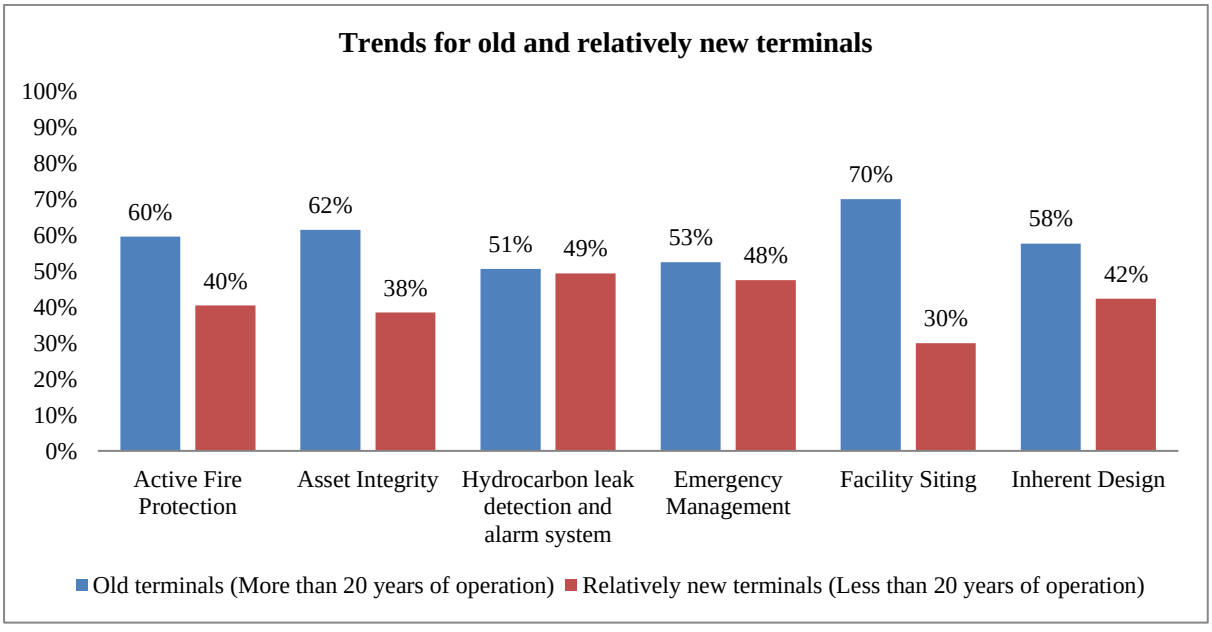

Figure 3: Trends with respect to age of terminals and process safety aspects

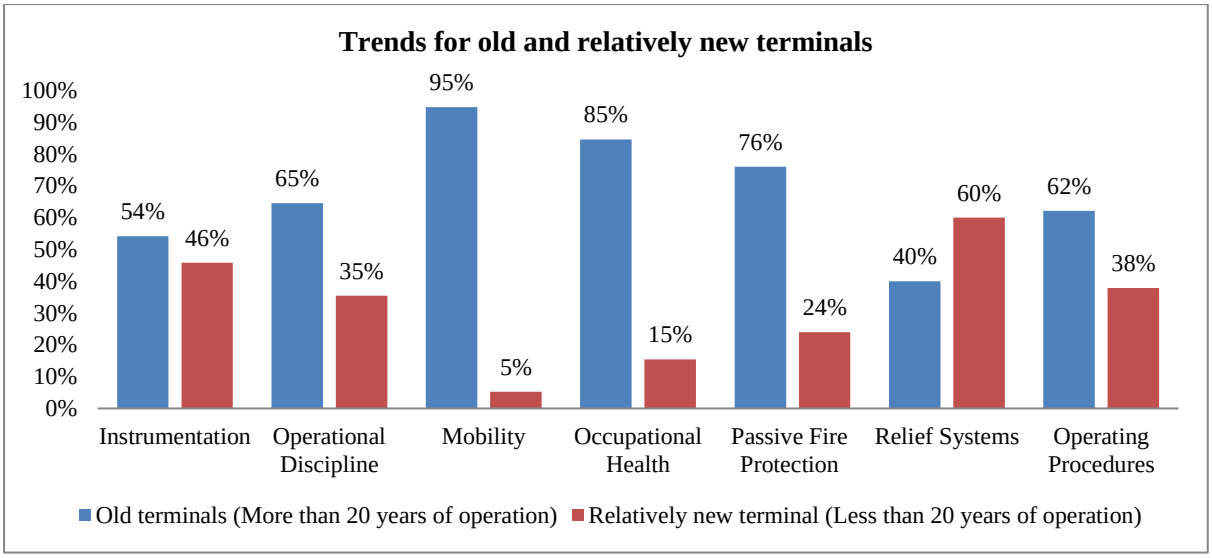

Figure 4: Trends with respect to age of terminals and process safety aspects

It can be observed that the older terminals have challenges in active and passive fire protection, facility siting, asset integrity and operational discipline aspects. Detailed analysis and interpretation as presented in the subsequent sections.

Process Safety Areas impacting Operational Excellence

A closer look at about 1600 recommendations arising from the process safety studies from the 42 terminals gives insight into the top 10 areas that emerge as the critical success factors for ensuring operational excellence. In this section of the paper we analyze each of these factors and establish the learning and mitigation measures.

Instrumentation

Around 30% of the HAZOP outcomes and 16% of the QRA outcomes point out gaps in the instrumentation. When analyzed by the age of the terminals, older terminals have higher issues on instrumentation (54%) when compared to relatively new age terminals (16%). With the advancement in technology and automation forming the basis for process design, dependence on the redundant systems for the feedback seems to be a major focus area for the terminals. Key aspects for operational excellence with respect to instrumentation in terminals are

- Redundant level controls for the storage tanks (H, HH, HHH), provision of radar gauge and servo gauge (SIL rated). Ideally the tank level control system to be SIL rated.
- Automation system for terminal based on the ullage selected, involving the tank gradient along with the parcel logic
- Provision of low pressure switch for the transfer pumps suction and high pressure switch at pump discharge, interlock mechanism to trip pump and shut off discharge valve
- Provision of differential pressure indicators on strainers/ filters in transfer pump suction/ discharge
- Provision of overfill protection system to stop TLF pumps
- Monitoring of the storage tank dyke valve positioning

Inherent Design

Around 20% of the HAZOP outcomes and 25% of the QRA outcomes point out gaps in the inherent design. For the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (58 %). Examples of inherent safe design which were missed during the detailed engineering design of the studied terminals were:

- Selection of type of transfer pumps (API, double mechanical seals) and availability of stand by pumps
- Selection of electrical fittings based on the Hazardous Area Classification (HAC) and the practice of updating the HAC, when any expansion or modification takes place
- Configuration of storage tank inlet/outlet piping valves like Remotely Operated Solenoid Valve (ROSOV), Motor Operated Valve (MOV). Operability of the ROSOV being limited only to close from the control room and having open, close and stop operation from local panel outside storage tanks

- Collection sump/pit for wagon siding, transfer pump houses and tank farm, which is then routed to Oil Water Separator (OWS)
- Provision of online density meters for improving the reliability during changeover of product, mass flow meters for pipeline transfer operations
- Provision of double isolation valves for the gauges, transmitters, sample points in the transfer pump houses
- Requirement of surge study analysis to understand the sudden closure of manual/ automated valves in the pipeline transfer operations
- ESD pushbuttons integration in wagon siding, transfer pump house, tank farm area where gantry stops all the electrical system in case of emergency

As it may be observed, implementation of any of these during the operational stage of a terminal not only results in shut down of the terminal but also is extremely cost and time intensive, forcing the terminal operators to operate the terminals with mitigation measures.

Asset Integrity

Around 12% of the HAZOP outcomes and 30% of the QRA outcomes point out gaps in the asset integrity. Comparing the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (62 %). They key aspects for operational excellence with respect to Asst Integrity in terminals are

- Selection of metallic braided loading and unloading hoses, increasing the frequency of inspection for based on the usage and practice to discard the hoses after 2 years
- Inspection of pipelines, storage tanks when there is change in service
- Development of corrosion management program, Long Range Ultrasonic Test (LRUT) for all the underground storage tanks
- Identification of dead legs (particularly for Class-A handling piping) and provision of Thermal Shut-off Valve (TSV) to prevent over pressurisation
- Adoption of flange management practices as per best practices like American Society of Mechanical Engineers (ASME) B31.4/31.3
- Post Weld Heat Treatment (PWHT) for pipes/ piping welding where Ethanol is handled
- Adoption of practices like gasket management, spare valve philosophy (particularly for OWS dyke)
- Predictive maintenance (like vibration test) of transfer pumps

Ensuring asset integrity practices not only ensures that the assets are “available”, “reliable” and “maintainable” the adequate care of assets also ensure that failure rates are within limits thereby ensuring that risks are within acceptable or ALARP region.

Operational Discipline

Around 8% of the HAZOP and QRA outcomes point out gaps in the operational discipline. Comparing the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (65 %). Adoption of non standard practices seems to be of major concern for the terminals. Key aspects for operational excellence with respect to operational discipline in terminals are

- Opening of expansion valves after wagon decantation operation
- Capping of Ethanol handling hoses to avoid ingress of moisture
- Periodic sampling of OWS for oil, grease, Volatile Organic Compounds (VOC), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)
- Effective communication practices (recording) with other stake holders when combined operations need o be carried out
- System of valve tagging and display of desired valve positioning in field for reference
- Minimising the presence of operators at the transfer pump houses

Active Fire Protection

Around 6% of the HAZOP and QRA outcomes point out gaps in the active fire protection. Comapring the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (60 %). Not considering active fire protection systems as safety critical components, ensuring the maintenance, availability seems to be of major concern for terminals. Key aspects for operational excellence with respect to active fire protection in terminals are

- Reviewing the adequacy of the fire water network when major changes occur in the terminal
- When thermal radiation is impacting the public, provision of water curtains to minimise the thermal impact to public
- Water sprinkler system for wagon siding, gantry areas
- Provision of Medium Expansion Foam Generators (MEFG) for the OWS collection pits
- Replacement of fire stench with fixed sprinkler system around the storage tanks
- Provision of automatic actuated rim seal failure detection and extinguishing system for floating roof tanks

In addition to the fire protection installations, it has been observed in terminals that inter distances between fire water storage tank and product storage tanks, distance between fire water pump house and product areas have also been non-compliant to standard layout design.

Hydrocarbon leak detection and alarm system

Around 4% of the HAZOP outcomes and 8 % of the QRA outcomes point out gaps in the hydrocarbon leak detection and alarm system. Comparing the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are slightly more in aged terminal (51 %). Key aspects for operational excellence with respect to hydrocarbon leak detection and alarm system in terminals are

- Provision of point type detection at the drain sumps, dyke
- Provision of open path detector at the manifold area
- Annunciation of Hydrocarbon detector panel
- Integration of detectors with the transfer pumps

Operating Procedures

Around 6% of the HAZOP outcomes point out gaps in the Operating Procedures. Comparing the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (62 %). As the terminal ages, the emphasis is more on the administrative controls and criticality in adaption, practice of operating procedures increases. Key aspects for operational excellence with respect to operating procedures in terminals are

- Incorporation of valve sequencing and operating conditions in the Operating Procedures
- Use of sign off checklist to ensure proper sequencing of valve operations in the transfer pump house

An emerging trend in Indian context and globally is the use of contract employees in assisting operations. Compliance to defined standard operating procedures assumes significance in this context and it directly impacts operational discipline.

Emergency Management

Around 3% of the HAZOP and QRA outcomes point out gaps in the Emergency Management. Comapring the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (53 %). Key aspects for operational excellence with respect to emergency management in terminals are

- Developing the response procedures when the operations needs to be carried out with the neighbouring facilities
- Conducting of public awareness programs for the public about products being handled at the terminal and emergency evacuation procedures
- Provision of emergency shutdown valves at strategic locations like transfer pump houses for ease of isolation

Facility Siting

Around 1% of the HAZOP and 7 % of QRA outcomes point out gaps in the Facility Siting. Comparing the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in aged terminal (70 %). As the terminal operations expand, ignoring the principles of facility siting seems to be of major concern for the terminals. Key aspects for operational excellence with respect to facility siting in terminals are

- Checking the occupancy of occupied buildings and ensuring the minimum occupancy for building being affected by thermal radiation or over pressure
- Analysing the impact of fire water pump house and fire water storage tanks after any major expansion
- Blast proofing the control room

This assumes significance especially in terminals where the layout is congested and when public facilities are nearby . As part of the cyclic HAZOP and QRA the areas where separation distances are not met, suitable engineering controls are to be initiated to mitigate the risk arising out of the facility siting issues.

Relief Systems

Around 4% of the HAZOP outcomes point out gaps in the Relief Systems. Comparing the aged terminals (more than 20 years of operation) and relatively newer terminals (less than 20 years of operation) the gaps are more in relatively newer terminals (60 %). Key aspects for operational excellence with respect to relief systems in terminals are

- Reviewing the sizing of the relief valves as design standards gets updated for assurance
- Provision of silica gel in the vents for Ethanol storage tanks
- Adequacy of the relief valves for emergency vent also as per American Petroleum Institute (API) 2000

Conclusion

Respecting the philosophy of Trevor Kletz that though two plants operations are similar, the issues faced are not always the same (Kletz, 2009), an attempt has been made to identify the process safety focus areas for terminals which can help in striving for operational excellence. It may also be noted that these areas not only help in ensure excellence in operating terminals, but also act as a lesson learnt document while designing new terminals or carrying out brown field expansion.

References

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