https://doi.org/10.46335/IJIES.2022.7.7.2 e-ISSN: 2456-3463
Vol. 7, No. 7, 2022, PP. 6-11

International Journal of Innovations in Engineering and Science, www.ijies.net

Hazard Identification and Risk Assessment of Crude Oil Storage Tank

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***Received on**: 11June ,2022* ***Revised on**: 02 July ,2022,* ***Published on**: 04 July,2022*

***Abstract –** The major accidents in petrochemical facilities occur during storage processes. Many disastrous accidents occurred in the past, causing death or injury for workers, huge economic losses and massive environmental pollution. Thus, this work aimed to Review conduct profound and adequate hazard analysis in the oil storage facility. Firstly, the potential undesired accidents in the oil storage farm were identified using Hazard identification and risk assessment (HIRA). The qualitative analysis has shown that the most critical BEs for causing the tank fire and explosion are (formation of flammable cloud) and (Confinement between cloud and air). Additionally, it is found out that the occurrence frequency of pool fire is higher than other scenarios. Finally, based on the analysis, some preventive and mitigation measures have been given to reduce the consequence severity of tank accidents, which in turn improve the safety climate in the storage tank farm.*

.***Keywords-** Hazard Identification, Risk Assessment, Basic events, Fire and explosion, Safety measures.*

I- INTRODUCTION

Overview Risk Analysis is proven valuable as a management tool in assessing the overall safety performance of the chemical process industry and hazardous substance handling operations at a specific location. Although management systems such as engineering codes, checklists, and reviews by experienced engineers have provided substantial safety assurances, major incidents involving numerous casualties, injuries and significant damage can occur - as illustrated by recent world-scale catastrophes. Risk Analysis techniques provide advanced quantitative means to supplement other hazard identification, analysis, assessment, control and management methods to identify the potential for such incidents and to evaluate control strategies. Risk in general is defined as a measure of potential economic loss or human injury in terms of the probability of the loss or injury occurring and magnitude of the loss or injury if it occurs. Risk thus comprises of two variables; magnitude of consequences and the probability of occurrence.

II- RISK ASSESSMENT

Risk Assessment Is A Careful Examination Of Consequences Resulting From The Undesired Events That Could Cause Harm To People Or Property, So That Sufficient Precautions Can Be Taken. Workers And Others Have A Right To Be Protected From Harm Caused By A Failure To Take Reasonable Control Measures. Hydrocarbon operations are generally hazardous in nature by virtue of intrinsic chemical properties of hydrocarbons or their temperature or pressure of operation or a combination of these. Fire, explosion, hazardous release or a combination of these

https://doi.org/10.46335/IJIES.2022.7.7.2 **e-ISSN: 2456-3463**
Vol. 7, No. 7, 2022, PP. 6-11

are the hazards associated with hydrocarbon operations. These have resulted in the development of more comprehensive, systematic and sophisticated methods of Safety Engineering, such as, Hazard Analysis and Risk Assessment to improve upon the integrity, reliability and safety of hydrocarbon operations.

III- SCOPE OF REVIEW

The risk of tank accidents is affected by various factors, including but not limited to the amount of leaked materials, energy of initiation sources and the types of hazard-affected bodies. Even if the storage tanks comply with relevant laws and regulations, tank accidents still occur from time to time owing to hardware problems, maloperations and management flaws. Hence, storage tanks must be subjected to risk analysis in addition to compliance analysis. Operation accidents (e.g. falling and electric shock) and process safety accidents (e.g. fire, explosion, poisoning and suffocation) may occur during the construction, operation and maintenance of storage tanks. These accidents are attributable to various defects that are difficult to eliminate completely. The risk degree of tank accidents varies with the time, leak materials and operation conditions. Traditionally, the risk degree is assessed against the possibility of accidents and the consequence severity caused by the hazards. Considering the close correlation between the damages on hazard-affected bodies and the exposure, sensitivity, coping capacity and recovery capacity, it is necessary to expand the scope of risk assessment from accident possibility and consequence severity to the hazard degree and vulnerability of the hazard-affected bodies.

IV- LITERATURE REVIEW

ZhuangWu, The time-to-failure assessment of large crude oil storage tank exposed to pool fire: In large crude oil tank farm, fire is a major primary event in domino effects according to past accidents. The quantitative risk assessment of domino fire accident is a key issue for the accident prevention of large storage tank farm. The most widely used equation for the estimation of the tank's time to failure (*TTF*) exposed to pool fire is not suitable for 100,000 m^3 external floating roof tank. The purpose of this study is to establish simplified models for the calculation of the tank *TTF* with respect to heat radiation intensity, filling level and the availability of safety protections under different fire conditions. The finite element transient heat transfer modeling of 100,000 m^3 external floating roof tank in the case of fire scenarios was performed. The quantitative assessment of safety protection performance in delaying the tank failure under fire conditions was performed according to the simulation results. The application of the *TTF* equation to case-studies of crude oil tank farm showed the importance of safety protection for the prevention and mitigation of the domino effect. The *TTF* model provides a basis to the risk management and emergency response in large tank farm [1].

Maria FrancescaMilazzo, A probabilistic approach for the estimation of the residual useful lifetime of atmospheric storage tanks in oil industry: Based on the prediction of the equipment residual useful life, important decisions are made in oil industry to ensure a safe and profitable management. Atmospheric storage tanks are particularly critical from the safety point of view as their bottom is affected by localised corrosion (pitting), which is not easy to be monitored. The prediction of the useful lifetime defines the time up to which the equipment can continue to be in-service before the formation of holes where the greatest thinning is observed. In this study, the thickness data collected in subsequent inspections of the bottom of twenty-three large storage tanks of petroleum products has been processed by adopting an improved probabilistic approach. The method is unconventional and combines the consolidated extreme value theory and Bayes' formula to quantify the probability of thinning below a fixed limit and, thus, predict the remaining useful lifetime, as well as the optimal time for the next full inspection. Data collected allowed the validation of the forecast model [2].

AnetaOlszewska, Using the acoustic emission method for testing aboveground vertical storage tank bottoms: This paper presents use of the acoustic emission (AE) method for diagnostic testing of aboveground vertical storage tank bottoms. This method allows evaluation and location of active corrosion damage of bottom material and micro-leaks in the tested object. To prepare a tank for AE testing, it is not necessary to drain the storage medium, which provides a high state of security with significant diagnosis and operational cost savings. The methodology and AE test results carried out on three storage tanks of crude oil are presented.

Data recorded during the measurements have been analyzed. The conclusions drawn from this analysis give the location of detected AE sources and an evaluation of the integrity of the tank bottoms. Assessment of detected acoustic sources allowed for classification of tank bottom surface conditions and estimation of the recommended operational time until the next required test [3].

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KazemSarvestani, Development of a predictive accident model for dynamic risk assessment of propane storage tanks: Investigation of past accidents has shown that LPG tank accidents cause significant damage to the industry due to the storage of large volumes of flammable materials in them. This study aimed for developing a predictive accident model for dynamic risk assessment of propane storage tanks of the refinery. Hazards and safety barriers were identified using MIMAH methodology. The basis of MIMAH methodology is Bow-tie method. To construct the Bow-tie diagram, first, accidents that occurred on LPG tanks were extracted from the databases of accidents and valid sources. The top events of the accidents were identified and analyzed by the fault tree. The Bow-tie diagrams were constructed and the barriers on the diagrams were identified and verified by refinery experts. According to the SHIPP model, safety barriers were categorized into seven main barriers. The failure rates of the fault tree basic events were extracted from reliable sources and the prior probability of barriers was calculated. Based on the failure or success of safety barriers, 6 levels of severity of consequences, safe, near miss, mishap, incident, and catastrophic accident were considered. Using the prior probability of failure of the barriers, the probability of occurrence of each level of severity of consequences was calculated with the event tree. In the next step, this paper employed LPG storage tanks past accidents to construct a likelihood function and update prior probability using the Bayesian equation. Finally, the posterior probability of occurrence of the consequences was calculated using the posterior probability of failure of the barriers. Because LPG accidents occur with low probability and high severity, predicting accidents dynamically helps people to always be prepared to prevent their occurrence [4].

Sabarethinam Kameshwar, Chapter 29 - Flood risk assessment of storage tanks in the Port of Rotterdam: My research goal for the PIRE program was to understand and quantify the flood risk to above ground storage tanks (AST) in the Port of Rotterdam since consequences of AST failure can be catastrophic for the surrounding environment and communities, and the economy. Furthermore, I also wanted to understand the flood risk mitigation approach adopted in the Netherlands to gain insights on how AST flood risk can be managed in the Netherlands. For hurricane risk assessment of ASTs, I used physics-based fragility to estimate the vulnerability of ASTs subjected to inundation depths corresponding to different return periods. The NSF PIRE program components such as meetings with experts and stakeholders helped me understand the flood risk management philosophy in the Netherlands. Site visits and other interactions with experts and students from various disciplines also helped me broaden my perspective on flood risk management using a holistic multidisciplinary approach [5].

LipinLi, A new small leakage detection method based on capacitance array sensor for underground oil tank: The early detection and discovery of small leakages from underground storage tanks (USTs) is an effective means for preventing the spread of contamination to deep soil and groundwater, which is of great significance to the process safety and risk management of oil tanks. In the previous studies, the soil sample collecting by these boreholes near the oil tank, the detection results have a certain degree of randomness and non-timeliness due to the sampling affected by the distribution of the boreholes, which would result in failure to catch small leakages of UST in time. According to capacitance sensor having a sensible capacity for relative permittivity of the soil, we propose a new small leakage detection method that employs the full-coverage three-dimensional capacitance array sensor with optimized parameters and higher sensitivity and our established measurement function of oil leakage to realize early detection of small leakage. Such a method can effectively solve the problems of incomplete sampling and easy to miss small leaks in borehole sampling detection. In addition, the experimental results show that the absolute error is less than 0.110% when selecting the small oil leakage in the range of 0.068~3.261%. Therefore, our method has higher measurement accuracy and could offer an efficient way for early discovery and quantitative estimation of small oil leakages from UST, which would provide a reliable basis for process safety and risk prediction [6].

FavourIkwan, Safety evaluation of leak in a storage tank using fault tree analysis and risk matrix analysis: The work presented in this paper used a quantitative analysis of relevant risks through the development of fault tree analysis and risk analysis methods to aid real time risk

https://doi.org/10.46335/IJIES.2022.7.7.2 **e-ISSN: 2456-3463**
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prediction and safety evaluation of leak in a storage tank. Criticality of risk elements and their attributes can be used with real time data to predict potential failures likely to occur. As an example, a risk matrix was used to rank risk of events that could lead to a leak in a storage tank and to make decisions on risks to be allowed based on past statistical data. An intelligent system that recognizes increasing level(s) and draws awareness to the possibility of additional increase before unsafe levels are attained was used to analyse and make critical decisions. After a visual depiction of relationships between hazards and controls had been actualized, dynamic risk modelling was used to quantify the effect controls can potentially have on hazards by applying historical and real-time data into a probabilistic model. The output of a dynamic risk model is near real-time quantitative predictions of risk likelihood. Results from the risk matrix analysis method mixed with RTD and FTA were analyzed, evaluated, and compared [7].

RongshuiQin, Multi-hazard failure assessment of atmospheric storage tanks during hurricanes: Hurricane as one of the most destructive natural hazards can make a devastating impact on the industrial equipment, especially atmospheric storage tanks, leading to the release of stored chemicals and disastrous safety and environmental issues. These catastrophic consequences are caused not only by strong winds but also by the torrential rainfall and inundating floods. The objective of this study is to present a risk-based methodology for assessing and reducing the vulnerability of atmospheric storage tanks to hurricanes. Considering the shell buckling, flotation, sliding, and roof sinking as dominant failure modes of atmospheric storage tanks during hurricanes, Bayesian network (BN) has been employed to combine the failure modes while considering their conditional dependencies. The probability updating feature of the developed BN was employed to indicate that the flood is the most critical hazard during hurricanes while the impact of wind and rainfall cannot be neglected. Extending the developed BN to an influence diagram, the cost-benefit filling of storage tanks with water prior to the advent of hurricanes was shown as a viable measure for reducing the damage probability. The results show that the proposed methodology can be used as an effective decision support tool for assessing and reducing the vulnerability of atmospheric storage tanks to natural hazards [8].

JianShuai, Risk-based inspection for large-scale crude oil tanks: Periodic Internal Inspection Method often results in under-inspection or over-inspection for large-scale crude oil tank. Therefore, how to determine reasonable internal inspection interval (INTII) has great significance on balancing the safe operation requirement and inspection cost for crude oil tanks. Here, RBI (risk-based inspection) technology is used to quantitatively assess the risk of crude oil tanks in an oil depot in China. The risk comparison between tank shell and bottom shows that the risk of tank depends on the risk of tank bottom. The prediction procedure of INTII for crude oil tanks is also presented. The INTII predicted by RBI method is gradually extended with the increasing of the acceptable risk level. The method to determine the acceptable risk of crude oil tanks is proposed, by which 3.54E+04 are taken as the acceptable risk of the oil depot. The safety factor of 0.8 is proposed to determine the final INTIIs for 18 crude oil tanks. The INTII requirement in China code SY/T 5921, 5–7 years, is very conservative and lower than predicted service life of tanks. The INTIIs predicted by Gumbel method are smaller than by RBI method for tanks with short INTII. Therefore, this paper recommends RBI method to predict the INTII for crude oil tanks [9].

Shilpi Shrivastava, Life cycle sustainability assessment of crude oil in India: Integrating sustainability into the process of the supply chain is a paramount challenge for every industry aiming to thrive or survive in this ever-changing world. Sustainability is more relevant for the oil industries because oil is one of the leading sources of energy in India. The demand for fuels is increasing at a fast rate even though it is one of the non-renewable resources. The main focus of this study is to carry out the Life Cycle Sustainability Assessment (LCSA) of the crude oil in India and to assess its performance from well-to-tank, i.e., from the extraction of crude oil till the dispatch of finished fuel from storage. The LCSA is considered to be an appropriate tool for accessing the three aspects of sustainability which are environment, economic, and social. According to the study, the majority of emissions are from the oil refining phase and transportation phase. For performing the Life Cycle Costing (LCC) a new economic method has been developed for this study. As far as the social aspect is concerned, it was found that the industries have established a strong relationship with their stakeholders but there is the scope of improvement in various subcategories. An integrated framework model for LCSA of crude oil is presented based on the outcomes of this study. Sustainability measures are also suggested which can lead to environmental, economic, and social sustainability [10].

Pablo.G.Cirimello, A major leak in a crude oil tank: Predictable and unexpected root causes: A

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A 2000 m^3 washer tank at a crude oil treatment plant suffered a structural collapse, involving total loss of integrity. A fast fracture initiated in a sector of the shell with a severe thickness reduction due to combined internal and external corrosion. The fracture bent and propagated horizontally, at the shell-roof intersection and at the joint between second and third courses, causing the almost instant opening of a large window. Due to the large initial leakage flow, the containment enclosure wall could not hold the spilled mixture of water and crude oil. The fast leaking wave damaged the breakwaters at the top of the wall, overpassed the enclosure and pushed out a sliding gate, thus causing total liquid leakage. Fracture and computational fluid dynamics models were developed to understand the origins of the failure, as well as to reconstruct the sequence of events. Deficiencies in tank construction, maintenance adequacy, and corrosion prevention were found to be the main root causes of the failure [11].

MinHuang, Multi-hazard coupling vulnerability analysis for buckling failure of vertical storage tank: Floods and hurricanes: As one of the typical multi-hazard natural disasters, floods and hurricanes have caused destructive damage to the process equipment, especially vertical storage tanks, leading to a large number of severe technological accidents in chemical industrial parks. In the present study, aiming at the buckling behavior under the coupling effect of floods and hurricanes, the wind load, flood load, and wave load are analyzed, and the limit state equation of storage tank buckling failure under the coupling effect of floods and hurricanes is established. Then, the load distribution on the tank wall is verified by FLUENT software and the rationality of FLUENT simulation is shown by laboratory experiments of vertical storage tanks. The fragility curves and surfaces are plotted by Monte Carlo Simulation under different wind speeds, considering the effects of flood velocity, flood inundation height, and liquid filling level. The results show that with the increase of wind speed, the influence of flood inundation height on the vulnerability of storage tanks gradually increases, while the influence of flood velocity and filling level on the vulnerability of storage tanks gradually decreases. Flood inundation height is the main disaster parameter affecting the vulnerability of storage tanks. Compared with the case of floods or hurricanes alone, the buckling failure probability of storage tanks under the coupling effects of floods and hurricanes increases by 17.67% and 80.50%, respectively. Moreover, the damaging effect of the coupling of floods and hurricanes is greater than that of the direct superposition effect, and the failure probability increases by 17.57%. The research aims to analyze the failure mechanism of vertical storage tanks, accident prevention, and control under the coupling effects of multiple hazards [12].

YiLiu, Firefighting Emergency Capability Evaluation on Crude Oil Tank Farm: Firefighting emergency capabilities absorb more and more attention due to the sharp expansion of crude oil tank scale and frequent accidents of tank fire. An emergency capability evaluation model was developed towards crude oil tank farm based on the data of crude oil tank fire accidents and the concept of layers of protection analysis (LOPA). The model consists of four first-grade-index, fifteen second-grade-index, and fifty-eight third-grade-index. The analytic hierarchy process (AHP) was used to achieve the weight of each index at the different levels. The fuzzy evaluation was integrated to construct the emergency capability evaluation model. The model was validated in a petrochemical plant to identify the weaknesses of firefighting emergency system of the tank farm, and the countermeasures were provided based on the results to minimize the risks of the tank farm [13].

XinZhou, Crude oil hierarchical catalytic cracking for maximizing chemicals production: Pilot-scale test, process optimization strategy, techno-economic-society-environment assessment: Crude oil direct catalytic cracking can effectively promote the production of chemicals. However, the heterogeneity of cracking depth of various distillates seriously restricts its industrialization. This study proposed a novel crude oil hierarchical catalytic cracking process for controlling the catalytic cracking depth. The key operating parameters were investigated and optimized using a multi-objective optimization strategy. A quantitative assessment for the life cycle techno-economic-society-environment of the novel processes was then conducted and compared with the conventional process. Results show that the optimized first and second flash unit temperatures are 187 °C and 251 °C. The optimized first and second riser outlet temperatures are 644 °C and 682 °C, respectively. The conversion rate and olefin yields of the novel process are increased by 1.47% and 1.46%. The hydrogen and carbon atoms efficiency in the novel process is 63.17% and 76.21%, which could raise 0.97% and 1.62% compared with the conventional process. Moreover, the novel process could increase 14.3% and 1.61% in the net present value and internal rate of return. Meanwhile, it decreased by 2.1%, 8.2%, and 2.2% in greenhouse gas emissions, wastewater generation, and non-renewable energy consumption, compared with

https://doi.org/10.46335/IJIES.2022.7.7.2 e-ISSN: 2456-3463
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conventional crude oil-to-chemicals processes. These findings in this work could promote engineering application, process intensification, and key operating parameters optimization of crude oil direct catalytic cracking [14].

RongchenZhu, Risk analysis of terrorist attacks on LNG storage tanks at ports: In recent years, with the increasing demand for liquefied natural gas (LNG) worldwide, a large amount of LNG is stored, processed, and transported in ports. The port's LNG storage tanks may become a hot target for terrorist attacks because the failure or destruction of these facilities will put markets, cities, and the environment at high risk. This article presents a new risk analysis method of terrorist attacks on the port's LNG Storage tanks. The steps are as follows: (1) Identify risk factors from a multidimensional perspective. (2) Analyze the risk using the Bayesian network and event tree. (3) Evaluate and quantify the accident consequence. (4) Use knowledge graph to store risk knowledge. We verify the effectiveness of the method through case studies. The defence capabilities of the police and different prevention strategies were studied. The results show significant differences in accident consequence between different defensive and emergency response forces. We also conducted nine scenario analysis, which could provide a theoretical basis and method support for public security and urban risk management departments' security prevention decisions [15].

V- CONCLUSIONS

The conclusions of the study can be summarized in the following points:

- Hazard analysis study has been conducted for the crude oil storage tank farm.
- Hazard operability study has identified all possible deviations in parameters from design intent which could finally lead to oil leakage or extra pressure and consequently result in undesirable events such as fire and explosion.
- We are using job safety analysis method where we are identifying the potential hazards associated to the job and give the control measures to minimize the hazard.
- The identified critical causes must be given more attention to minimize the probabilities and mitigate the severity of the accidents.
- Through risk matrix we are evaluate the risk and its correspondence risk level and note it down in HIRA Register.

REFERENCE

[1] *ZhuangWu, The time-to-failure assessment of large crude oil storage tank exposed to pool fire, Fire Safety Journal, Volume 117, October 2020, 103192.*

[2] *Maria FrancescaMilazzo, A probabilistic approach for the estimation of the residual useful lifetime of atmospheric storage tanks in oil industry, Journal of Loss Prevention in the Process Industries, Volume 77, July 2022, 104781.*

[3] *AnetaOlszewska, Using the acoustic emission method for testing aboveground vertical storage tank bottoms, Applied Acoustics, Volume 188, January 2022, 108564.*

[4] *KazemSarvestani, KazemSarvestani, Development of a predictive accident model for dynamic risk assessment of propane storage tanks, Process Safety and Environmental Protection, Volume 148, April 2021, Pages 1217-1232.*

[5] *SabarethinamKameshwar, Chapter 29 - Flood risk assessment of storage tanks in the Port of Rotterdam, Coastal Flood Risk Reduction The Netherlands and the US Upper Texas Coast, 2022, Pages 397-409.*

[6] *LipinLi, A new small leakage detection method based on capacitance array sensor for underground oil tank, Process Safety and Environmental Protection, Volume 159, March 2022, Pages 616-624.*

[7] *FavourIkwan, Safety evaluation of leak in a storage tank using fault tree analysis and risk matrix analysis, Journal of Loss Prevention in the Process Industries, Volume 73, November 2021, 104597.*

[8] *RongshuiQin, Multi-hazard failure assessment of atmospheric storage tanks during hurricanes, Journal of Loss Prevention in the Process Industries, Volume 68, November 2020, 104325.*

[9] *JianShuai, Risk-based inspection for large-scale crude oil tanks, Journal of Loss Prevention in the Process Industries, Volume 25, Issue 1, January 2012, Pages 166-175.*

[10] *ShilpiShrivastava, Life cycle sustainability assessment of crude oil in India, Journal of Cleaner Production, Volume 283, 10 February 2021, 124654.*

[11] *Pablo.G.Cirimello, A major leak in a crude oil tank: Predictable and unexpected root causes, Engineering Failure Analysis, Volume 100, June 2019, Pages 456-469.*

[12] *MinHuang, Multi-hazard coupling vulnerability analysis for buckling failure of vertical storage tank: Floods and hurricanes, Process Safety and Environmental Protection, Volume 161, May 2022, Pages 528-541.*

[13] *YiLiu, Firefighting Emergency Capability Evaluation on Crude Oil Tank Farm, Procedia Engineering Volume 211, 2018, Pages 506-513.*

[14] *XinZhou, Crude oil hierarchical catalytic cracking for maximizing chemicals production: Pilot-scale test, process optimization strategy, techno-economic-society-environment assessment, Energy Conversion and Management, Volume 253, 1 February 2022, 115149.*

[15] *RongchenZhu, Risk analysis of terrorist attacks on LNG storage tanks at ports, Safety Science Volume 137, May 2021, 105192.*