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How to Determine the Dangerous Potential of Accidents to Domino Effect Detonation in a Hydrocarbon Processing Area?

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Abstract

The crude oil industry has been developed in recent decades due to the uses of this product, as well as its derivatives. One of the worst consequences phenomena that can occur in the process industry is the called domino effect. The domino effect or cascade effect occurs when an initiating event, such as a pool of fire or a vapor cloud explosion, causes a new number of accidents. Moreover, due to the importance of avoiding this phenomenon, the European Commission considers the domino effect analysis as mandatory for industrial facilities. There are methodologies in the specialized literature focused on quantifying the existing risks in the storage and processing of hydrocarbons. However, there is a tendency to develop new procedures that increase the risk perception of these accidents. In addition, it is necessary to develop a method that allows visualizing clearly and concisely the dangerous potential of fire and explosion accidents for the occurrence of the domino effect. Precisely, this research aims to predict the dangerous potential of fire and explosion accidents for the occurrence of the domino effect. For this purpose, a methodology consisting of three fundamental stages is developed. Finally, hydrocarbon storage and processing area is selected to apply the proposed methodology. Overall, the development of graphs that summarize information and show the dangerous potential regarding the escalation of fire and explosion accidents is vital in risk analysis. For the case study, the effectiveness of the same was demonstrated, since after its realization it was possible to increase the risk awareness of workers, technicians, and managers of the area taken as a case study..

Keywords: Accidents, Domino effect, Fire explosion, Risk awareness, Industrial safety.

Introduction

Common accidents in the chemical industries include explosions, fires, and toxic emissions; however, the greatest consequences occur during the so-called domino effect. This phenomenon occurs when one accident leads to others, where the magnitude of the consequences of the chain of events is much greater than those of the single primary event [1-3].

The crude oil facilities are also exposed to the influence of accidents, mainly those caused by fire and explosion due to the hydrocarbon properties. Accidents can occur at different levels and areas in the chemical process industry, during

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the transport, storage, and manufacture of substances. In general terms, accidents in the process industry are divided into three main categories: fire, explosion, and toxic releases [4,5].

Moreover, there are risk analysis techniques that allow quantifying the consequences of fire and explosion accidents [2,3]. However, it is necessary to develop a method that allows visualizing clearly and concisely the dangerous potential of fire and explosion accidents for domino effect occurrence. Thus, the aim of this research is to predict the potential danger of fire and explosion accidents for the domino effect occurrence.

Materials and Methods

In order to predict the dangerous potential of accidents, the methodology shown in **(Figure 1)** is proposed, which consists of three fundamental stages. The first stage is related to the selection of the process units based on the equipment in the study area and a rigorous analysis of their potential to cause accidents. The second stage starts with the simulation of the fire and explosion scenarios with the ALOHA software. This software has been jointly developed by the North American agencies NOAA (National Oceanic and Atmospheric Administration) and EPA (Environmental Protection Agency) [6]. ALOHA is recognized by the Ministry of Science, Technology and Environment of Cuba (CITMA) as the most suitable simulator to express the behavior of toxic accidents, fire and explosion, with widely recommended use for the evaluation of consequences in the process of analysis of risks and with great international prestige [7]. To define the possible secondary units, a comparison is made of the different escalation vectors obtained with the threshold values established by Reniers and Cozzani [8] shown in **(Table 1).** Finally, in stage 3 the graphs are developed that show the dangerous potential of these accidents for the detonation of the domino effect.

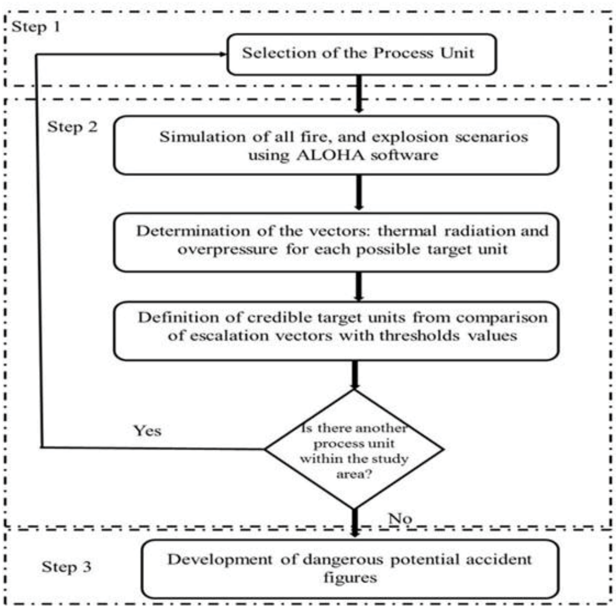

Figure 1: Methodology proposed in this research framework.

Primary accident	Escalation vector	Target equipment	Damage threshold	Escalation threshold
Vapor Cloud Explosion (VCE)	Overpressure	Atmospheric	P>7kPa	P>22kPa
		Pressurized	P>20kPa	P>20kPa
Pool fire	Thermal radiation	Atmospheric	I>15 kW/m²	I>15 kW/m²
		Pressurized	I>45 kW/m²	I>45 kW/m²

Table 1: Threshold values for damage and escalation due to thermal radiation and overpressure.

Results and discussion

In order to demonstrate the effectiveness of the developed methodology, it is applied in a hydrocarbon storage and processing area. For a better organization of the simulations, the plant is divided into four subareas. **(Table 2)** shows this distribution.

Area	Technological Equipment	Rep.	Storage material	Volume (m^3)
Sub-1	Tank 7	TK 7	Crude oil	5000
	Tank 8	TK 8	Crude oil plus H_2S	5000
	Tank 15	TK 15	Crude oil plus H_2S	10000
	Tank 16	TK 16	Crude oil plus H_2S	10000
Sub-2	Tank 6	TK 6	Crude oil plus H_2S	2900
	Tank 14	TK 14	Crude oil	20000
	Separator vessel 1	B1	Crude oil plus H_2S	100
	Separator vessel 2	B2		100
	Separator vessel 3	B3		100
	Separator vessel 4	B4		100
Sub-3	Tank 701	TK 701	Naphtha	5000
	Tank 702	TK 702		5000
	Tank 703	TK 703		5000
	Tank 704	TK 704		5000
Sub-4	Tank 101	TK 101	Crude oil	200
	Tank 102	TK 102		200
	Tank 103	TK 103		200
	Tank 104	TK 104		200

Table 2: Studied area divided into four main subareas.

(Figure 2) shows the graphs developed to quantify the dangerous potential of the process units in the event of a pool fire in any of them. In the case of the pool fire occurrence, the intensity of the thermal radiation is the escalation vector responsible for the domino effect. In all cases, distances reached, include the rest of the process units, both for escalation on atmospheric and pressurized equipment. The process unit that represents the greatest danger is Tank 15 due to its position within the area. These results agree with those obtained by Dueñas Santana et al. [3].

Moreover, the most dangerous process units are the Tank 15, Tank 6, Tank 703 and Tank 101 in the subareas analyzed due to the thermal radiation generated from a pool fire in these vessels are enough for triggering other tank failures. In all cases the highest scope corresponds to the escalation on atmospheric equipment's due to the threshold value is just 15 kW/m^2, while for pressurized vessels is 40 kW/m^2.

(Figure 3) shows the graphs developed to quantify the dangerous potential of the process units in the event of a VCE. This phenomenon has been responsible for the escalation of accidents in many previous ones as in the case of Burchfield,

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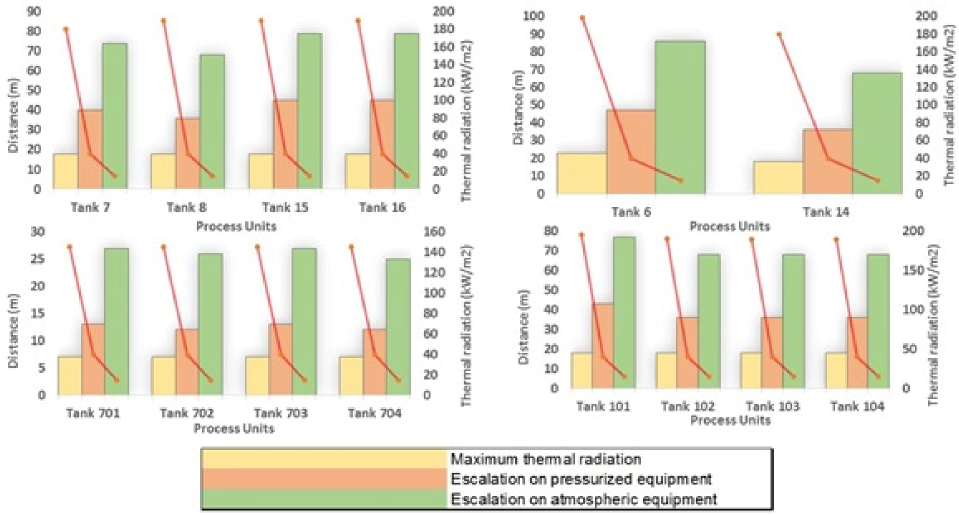

Figure 2: Dangerous potential due to the occurrence of pool fires.

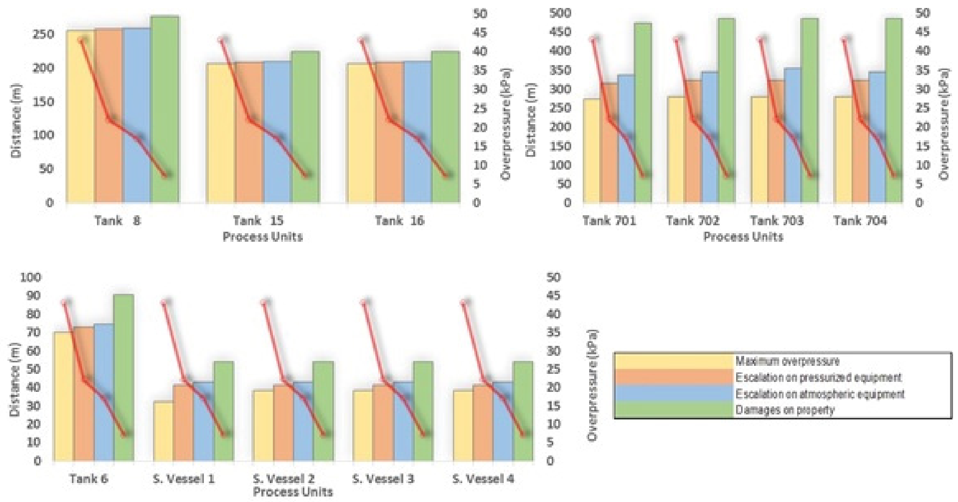

Figure 3: Dangerous potential due to the occurrence of vapor cloud explosions.

England due to the overpressure as the escalation vector [9]. As the main results, high overpressure values are reached in the event of the detonation of a vapor cloud over long distances, therefore, if this scenario occurs, the domino effect is highly probable. Similar results were obtained by Dueñas Santana et al. [3] and Zhou and Reniers, [10].

Furthermore, the process units most dangerous for VCE generation are the Tank 8, the Tank 703 and the Tank 6 in each area respectively. Notwithstanding, it is vital the consideration of the occurrence of this phenomena on Vessels 1-4 due to the position of these pressurized separators into the area. If a VCE occurs in any of the aforementioned process units, there is very likely the escalation on pressurized and atmospheric equipment and damages on property as well because of the high overpressure peaks.

Overall, the scope of thermal radiation due to fires and overpressure due to explosions is high and allows the occurrence of the domino effect. Additionally, the development of these graphs allow to a better safety management in the hydrocarbon processing area.

Conclusion

The graphs development that summarizes information and shows the dangerous potential regarding the escalation of fire and explosion accidents is vital in risk analysis. These figures allow showing the intensity of the radiation or overpressure as appropriate, the distance they reached, the expected damage at these distances, and the comparison between the process units within each analyzed subarea. For the case study, the effectiveness of the same was demonstrated, since after its realization it. was possible to increase the risk awareness of the workers, technicians, and managers of the area taken as a case study.

References

1. Clark I, De Groeve T, Marin FM, et al. Science for Disaster Risk Management 2017: Knowing Better and Losing Less. EUR 28034 EN, 2019.

2. Dueñas Santana JA, Orozco JL. Febles LD, et al. Using Integrated Bayesian-Petri Net Methodology for Individual Impact Assessment of Domino Effect Accidents. J Clean Prod.2021.

3. Dueñas Santana JA, Orozco JL, Furka D, et al. A New Fuzzy- Bayesian Approach for the Determination of Failure Probability Due to Thermal Radiation in Domino Effect Accidents. Engineering Failure Analysis. 2021.

4. Abbasi SA, Abbasi T, Pandey S, et al. Pool Fires in Chemical Process Industries: Occurrence, Mechanism, Management. J Fail Anal Prev.2018;5:1224-1261.

5. Ding L, Ji J, Khan F. Risk-Based Safety Allocation to Prevent and Mitigate Storage Fire Hazard. Process Saf Environ Prot. 2020;135:282-293.

6. www.epa.govcameoaloha-sotware.

7. Orozco JL, Caneghem J, Hens L, et al. Assessment of an Ammonia Incident in the Industrial Area of Matanzas. J Clean Prod. 2019;222:934-941.

8. Antonioni G, Cozzani V, Khakzad N, et al. Quantitative Assessment of Risk Caused by Domino Accidents. Domino Effects in the Process Industries Modeling. 2013;pp:208-228.

9. Atkinson G, Coldrick S, Cusco L, et al. Flammable Vapor Cloud Generation From Over filling Tanks: Learning the Lessons from Buncefield. J Loss Prev Process Ind. 2015;35:329-338.

10. Zhou J, Reniers G. Petri-Net Based Cascading Effect Analysis of Vapor Cloud Explosions. J Loss Prev Process Ind. 2017;48: 118-125.

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