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Fire and explosion consequence of analysis with the DOWS fire and explosion index method on diesel tank in a construction project in Indonesia: A case study

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Abstract

Introduction: Fire and explosion accident has enormous impact and difficult to predict. The Project X was a construction site that has a diesel tank of 5000 liters. The diesel tank has the potential to generate fire and explosion. Therefore, it was crucial to do a consequence analysis. This study aimed to analyze the fire and explosion consequences in the diesel tank in the Project X.

Methods: This research was a descriptive study using the value of Dows Fire and Explosion Index method. This study obtained the Fire and Explosion index value of 28.83, so it was included in the light category.

Results: The area of exposure was 171.018 m2. The loss control credit factor was 0.873. Even though the value of Fire and Explosion Index was light, the resulting impact still relatively large.

Discussion: The area of exposure was affected not only the project area but also affects the community area. The loss control credit factor in the project area has not been influential. It was suggested that the Project X improve their fire and explosion protection system.

1. Introduction

Fire is a catastrophic event that occurs due to the emergence of several interacting components, such as fuel, oxygen, ignition, and chemical reaction(Li & Huang, 2012). According to the Center of The data shows that there is a trend of increasing fire cases every year(Linawati & Purba, 2020).

Fire cases in construction sites in Indonesia have also occurred frequently. Based on that, the construction project has a potential fire hazard to appear in other project areas, including the Project X.

Based on the preliminary study observation at the Project X, it was found that the Project X had many sources of fire hazards such as electronic devices, lifting and transportation machines, electrical panels, material warehouses, and diesel tanks. Therefore the Project X is prone to fire and explosion hazards. The Dows Fire and Explosion Index method was used to calculate the impact of a fire and explosion in a processing unit(Suardin, 2006).

Based on the information above, it is essential to analyze the consequences of fire and explosion in the Project X because there is a large quantity of flammable storage in the work area. This study uses

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the Dows Fire and Explosion Index method because it can estimate the potential risk of fire and explosion, the location of exposure, and the loss control credit factor.

2. Methods

This is a quantitative descriptive study with an observational approach. Data collected in the form of primary and secondary data. Primary data were obtained from observations and interviews with the HSE officer and Warehouse officer. Secondary data were obtained from searching Safety Data Sheet (SDS) and Standard Operating Procedure (SOP). This study used a data collection instrument in the form of an assessment form derived from the Dows Fire and Explosion Index guidelines.

Abbreviations

Material Factor : MF

General Process Hazard Factor : F1

Special Process Hazard Factor : F2

Process Unit Hazard Factor : F3

Fire and Explosion Index : FEI

Area of Exposure : AOE

Process Control : C1

Isolation Process : C2

Fire Protection : C3

Loss Control Credit Factor : LCCF

3. Results

Based on the Dows Fire and Explosion Index guidelines, when selecting process unit there are some factor to be considered included:

a. Chemical energy potential
b. Quantity of material
c. Capital Density
d. Process pressure and temperature
e. History problem
f. Unit critical to plant operation(AIChE, 1994)

Based on the factors above the process unit selected for the Project X was a diesel tank with a capacity of 5000 liters. The diesel tank was located on the ground floor area. The diesel tank was essential for work operations in the Project X. The diesel tank serves as a large-scale storage container for fuel used daily by trucks to transport building materials. It was also used to run heavy equipment and generator engines. Therefore, the diesel tank was selected as the process unit to be analyzed with the Dows Fire and Explosion Index. The diesel tank in the Project X was considered as atmospheric tank. Atmospheric tank was a tank that operating slightly above atmospheric pressure, up to 0,5 psig(Pullarcot, 2019). Based on the observation that conducted on the diesel tank in the project, there are no sign of process of adding pressure or temperature on the tank.

Figure 1: A typical tank

In order to estimate the risk and consequences of fire and explosion in the process unit, the first step is to calculate the value of the material factor and the process unit hazard factor. Next step is finding the value of fire and explosion index, the area of exposure and the loss control credit factor.

Material Factor (MF)

The value of material factor for diesel material can be found at the Appendix A inside Dows Fire and Explosion Index Hazard Classification Guide. The material factor for diesel is 10.

Process Unit Hazard Factor (F3)

The value of process unit hazard factor can be found by calculating the value of general process hazard factor and the special process hazard factor.

Table 1: General Process Hazard (F1)

Base Factor	1,00
Material Handling and	0,25
Access	0,20
Drainage and Spill Control	0,50
Total	1,95

Table 2: Special Process Hazard Factor (F2)

Base Factor	1,00
Pressure	0,16
Quantity of Material	0,0189
Corrosion and Erosion	0,10
Total	1,4789

The value of process hazard factor can be calculated by multiplying between the value of general process hazard factor and special process hazard factor.

F3 = F1 x F2

F3 = 1,95 x 1,4789

F3 = 2,883

Fire and Explosion Index (FEI)

The value of fire and explosion index is product of material factor and process hazard factor. The value of fire and explosion index represent the degree of hazard. The value of fire and explosion index also would be used to determine the area of exposure.

FEI = MF x F3

FEI = 10 x 2,883

FEI = 28,83

Area of Exposure (AOE)

The area exposure can be estimate by calculating the radius of exposure and multiply it with the value of fire and explosion index. In order to determine the value of radius of exposure, use 0,84 x FEI.

AOE = π x Radius of Exposure2

AOE = π x (0,84 x FEI)2

AOE = 3,14 x (0,84 x 28,83)2

AOE = 3,14 x 24,217 (ft) x 24,217 (ft)

AOE = 3,14 x 7,38 (m) x 7,38 (m)

AOE = 171,018 (m2)

Loss Control Credit Factor (LCCF)

The value of loss control credit factor can be calculated by determine the value of process control (C1), isolation material (C2) and fire protection (C3).

Table 2: Loss Control Credit Factor

Process Control (C1)	0,91
Isolation Material (C2)	0,98
Fire Protection (C3)	0,98

LCCF = C1 x C2 x C3

LCCF = 0,873

Based on the table above, it was found that the Fire and Explosion Index value in the processing unit in the Project X was 28.83. The area of exposure to fire and explosion is 171 m2 with a damage factor of 0.115 and a loss control credit factor of 0,873.

4. Conclusion

Fire and Explosion Index Analysis

Based on the result, it was found that the Fire and Explosion Index value in the process unit in the Project X was 28.83. According to the Dows Fire and Explosion Index guidelines, this value falls into the category of light hazard. The special control is required if the Fire and Explosion Index value reaches points above 128 or is in the moderate to severe typ(Nedved & Imamkhasani, 1991). Because the Fire and Explosion Index value of the processing unit is in the light category, no special control is needed, but it is necessary to improve the existing fire protection system if the company wants to reduce the impact of losses due to fire and explosion.

Analysis using the Dows Fire and Explosion Index method must consider the quantity of material stored and processed in the process unit. The process of materials is very influential in determining the value of the Fire and Explosion Index. The Fire and Explosion Index value tends to be higher in the process unit that processes the material than the process unit, which functions only as a storage container(Etowa, Amyotte, Pegg, & Khan, 2002).

In the research conducted in a diesel tank in a steam power plant in 2012. The results of this study showed Fire and Explosion Index value of 75,24(Jatisari, 2012). Even though the selected process unit only functions as a storage container, the Fire and Explosion Index value remain high due to large quantity of material in processing units. In contrast to quantity of material in the process unit in the project, Project X has a quantity of material that is almost close to the minimum requirement for using the Dows Fire and Explosion Index method, so value of Fire and Explosion Index was small.

In 2012, Li and Huang's research in the LNG ship process unit showed the value of the Fire and Explosion Index in the processing unit was 168. This is because each item in the general process hazard factor and the particular process hazard factor are filled so that the Fire and Explosion Index value becomes large(Li & Huang, 2012). In contrast to the analysis results on the diesel tank processing unit in the Project X, not all items were filled, so the Fire and Explosion Index value was small.

Area of Exposure and People at Risk

Based on the results, the area of exposure was 171.018 m2. The area of exposure consisted of two-part, the first part is Project X area, and the second part is the community area around the project. The area exposure is located in the tower C area. Around the Tower C area, there is a construction work tool like a tower crane. In the event of a fire and explosion in the diesel tank, it will impact work equipment and workers around the exposed area.

Workers at risk of being affected in the event of a fire and explosion in the area of exposure are tower crane operators and construction workers. The flat surface of the area around the diesel fuel tank can cause diesel to spread in all directions if a leak occurs. Thus, in the event of a fire and explosion, the impact can apply easily.

In the research carried out at the processing unit in a fertilizer factory in Palembang in 2019. The study results found that if fire and explosion occurred, it would impact the factory area of 8,954 m2(Linawati & Purba, 2020). Although the area of exposure in the fertilizer plant is much greater than the area of exposure in the research in the Project X, when viewed from the perspective of potential casualties, the incidence of fires and explosions in the Project X is much greater. This is due to the possibility of losses from the community around the project area and not just from workers inside the project area.

The Project X is built around the community area. The event of fire and explosion from the diesel tank will impact the residents around the Project X. Based on data from the Central Statistics Agency of Depok City, there were around 60,218 residents living in the area near Project X. Thus, some of the

residents who live around the Project X site have the potential to be affected by fire and explosion from the diesel tank.

Offset Fire and Explosion Index Value

Based on the results, the loss control credit factor in the diesel tank is 0.873. The loss control credit factor does not affect the Fire and Explosion Index's value but can only affect the value of losses generated by fires and explosions. The Dows Fire and Explosion Index method does not consider the importance of the loss control credit factor, resulting in the Fire and Explosion Index value in the processing unit being large and seemingly out of control. Thus, it is necessary to know the Fire and Explosion Index Offset value in the processing unit. The Fire and Explosion Index Offset Value is the Fire and Explosion Index value modified by considering the loss control credit factor in the processing unit(Gupta, Khemani, & Mannan, 2003).

In calculating the Fire and Explosion Index Offset value, use the following methods:

Offset FEI = (LCFF)/2 x FEI

Offset FEI = (0,873)1/2 x 28,83

Offset FEI = 26,93

The value of the Fire and Explosion Index Offset in the diesel tank is 26.93. Thus it can be concluded that the loss control credit factor is still not optimal because its effect on the Fire and Explosion Index value is still small, only 6.5% of the previous total Fire and Explosion Index value. Although the Fire and Explosion Index value in the diesel tank process unit is in the light category, the company's resulting impact is still felt.

In the research conducted at the styrene process unit in 2012. The results of this study show the Fire and Explosion Index value of 192 and the offset value of the Fire and Explosion Index of 112.85. Thus, the effect of loss control credit factor on value of Fire and Explosion Index is quite significant around 41.22%(Wang & Wang, 2012). When compared with loss control credit factor in project x, loss control credit factor on project x was still not effective in reducing the value of the Fire and Explosion Index.

The Fire and Explosion Index value in the Projects X process unit is 28.83, so it is included in the light category. The area exposed to fire and explosion is 171 m2, with the exposed area from the project area and the community area around the project. The loss control credit factor value is only 0.873, so the effect on reducing the Fire and Explosion Index value is small. The Dows Fire and Explosion Index method not only can be used in big or complicated process unit inside a factory or plant, but also can be used in small process unit inside a construction site. Although the quantity of material is so small, the calculation with Dows Fire and Explosion Index still bring meaningful result.

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