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THE MEASUREMENT OF POTENTIAL RISK OF FIRE AND EXPLOSION AT GAS STASION TO ANTICIPATE NON-MILITARY THREATS

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Abstract
Gas stations (SPBU in Indonesia) have the potency for fire and explosion hazards due to the storage and distribution of flammable liquids, one of which is Pertamax. This can be a non-military threat in the dimension of public safety because if it occurs, the resulting loss could be very large in terms of material or life. This study aims to determine the risk of fire and explosion at Indonesian gas station. This study uses Dow's Fire and Explosion Index in a simulated case method. The potential for fire and explosion or the value of the Fire Explosion Index (F&EI) in the simulated case is 111,24. The actual exposure radius is 29.62 m and the damage factor to the Pertamax storage tank is 63%. The results of the study have a risk level that is classified as Intermediate, so it is necessary to control risks such as increasing active protection and is expected to be an input in efforts to safeguard against non-military threats so as to reduce the impact of risks and losses that occur in the Pertamax storage tank.

Keywords: dow's fire and explosion index, gas station, storage tank, pertamax, non-military threat

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1. Introduction

Gas stations in Indonesia are places where motorized vehicles can buy fuel. There are various types of fuels with different octane ratings, such as Premium, Pertalite, Pertamax, Pertamax Turbo, Pertamax Dex, and Solar. This fuel is a flammable liquid that has a potential fire hazard. Therefore, gas stations are places with a large potential fire hazard, which can be followed by a risk of explosion[1].

Fire is an event or disaster caused by uncontrolled fire which is beyond human desire and ability, while explosion is an oxidation reaction, or a sudden decomposition that increases temperature or pressure, can even increase temperature and pressure. simultaneously[2]. These cases are included in non-military threats in the general security dimension[3] because if they occur, the losses incurred will be very large, both material and human. Many factors cause gas station fires such as unsafe behavior of gas station operators, sabotage or cans factors, gas station operational failures such as unloading (receiving and stockpiling) and loading (fuel distribution) activities pose a risk of fire risk[4]. In addition, the lack of adequate security equipment such as a grounding system for loading and unloading activities, gas/steam detectors to detect if there is a leak in the storage tank.

In calculating the potential for fire and explosion hazards, various methods can be used, such as the HIRADC method, FTA, ALOHA software, and the Dow's Fire and Explosion Index. In 2016, Permatasari conducted a study to analyze the effects of fires and explosions on LPG tanks using ALOHA software and obtained the results of the area affected and the possible number of victims affected[5]. Meanwhile, Lestari (2016) conducted a study to analyze the potential for fires and explosions in the primary reformer for Ammonia production using the Dow's Fire and Explosion Index method[6].

In this study, to measure the potential for fire and explosion in the Pertamax storage tank, the Dow's Fire and Explosion Index method was used. The difference with the previous research is in the form of calculated chemicals and the condition of the process unit in the form of a storage tank. Dow's Fire and Explosion Index

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is one of the process hazard analysis instruments, namely the process of evaluating the magnitude of the risk of fire, explosion, and the reactivity of process equipment and its contents objectively and realistically in a processing unit[7].

The Dow Fire and Explosion Index is widely used and has helped engineers to pay attention to hazards in every process unit when making critical decisions to reduce the severity and/or likelihood of a potential incident, this method is easier and requires less personnel to implement.

After identifying the problem at SPBU X, several conditions were found in the Pertamax storage tank that could trigger a potential fire such as excessive pressure in the holding tank if the vent valve is not functioning properly, possible hydrocarbon vapors, and heat/fire sources from equipment failure in the form of leaks. BBM due to poor inspection, installation and maintenance of equipment, Damage or malfunction of static electricity control equipment, namely the grounding system in disassembling or distributing fuel, other static electricity controllers that do not function, for example against lightning strikes.

2. Methods

This study uses qualitative and descriptive methods, with an approach of observation, interviews, and documentation of data sources related to the research. The location of this research is one of the gas stations located in East Jakarta, the company does not want to explain in detail the location.

This X gas station has six storage tanks that have the same storage tank volume of 21,000 liters containing fuel such as bio diesel, Pertamax, Pertamax turbo, Pertalite, Pertamax dex and Vigas. The object of this research is the Pertamax fuel storage tank with a total capacity of 21,694 liters. This research was conducted from October 2019 to January 2020. This study uses the assumption of fires and explosions that occurred with observations during the unloading of Pertamax fuel to the storage tank.

In assessing the level of risk of fire and explosion that occurs using the Dow's Fire and Explosion Index method. The advantage of using this method is that the assessment includes an assessment of the fire and explosion protection system, company management policies and can provide an estimate of the impact and losses that will result from fire and explosion events. In addition, this method is relatively easy and does not require much effort in its implementation. This method has weaknesses such as the need for professional judgment in awarding penalties and credit scores, besides that the fire and explosion risk assessment does not take into account the wind direction at the location and at the time of the fire and explosion[8].

2.1 Hazard Identification

Data was collected by direct observation or observation of storage conditions and the surrounding environment, including fire protection systems, interviews were conducted for data that could not be obtained from observations or observations, and literature studies as other supporting data obtained from browsing the internet as well as related books and journals.

2.2 Fire and Explosion Risk Analysis

This study uses a risk assessment method, namely the Dow's Fire and Explosion Index method to determine the level of risk, the area affected by fire and explosion, the number of days affected, to calculate the actual potential loss experienced by the gas station. X.

The results of observations, interviews, and literature studies were then recorded into the Data Collection Sheet as an instrument to facilitate data analysis. Furthermore, the data in the form of 'penalties' from the assessed factors are then entered into the Fire & Explosion Index (F&EI) form, Loss Control Credit Factors and Process Unit Risk Analysis for calculations according to the instructions contained in the Dow's Fire & Explosion index guidelines.

The penalty value in this study is determined by reviewing secondary data and conducting field checks (observations or observations) directly. Then the results are discussed with experts (central officers and gas stations) and academics. Therefore, the results of this study are quite valid and objective.

Calculations are done manually and with Microsoft Excel. After the data was analyzed, the results of the F&EI values were interpreted descriptively according to the Dow's Fire and Explosion Index guidelines, and from the loss values obtained, recommendations for controlling the risk of fire and explosion were given as consideration for company owners, take precautions to reduce or avoid the possibility of fire and explosion.

3. Results and Discussion

3.1 Hazard Identification in Storage Tank

The Pertamax tank is located underground with the main hole located on the side of the vehicle entry

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and exit access road. The storage tank location is next to the Premium tank.

The size of the tank diameter based on the ATG monitor is 2.46 meters, and for the height of the tank using the assumption of 2 meters. The Pertamax storage tank is made of steel plate which is coated with a layer of Asphalt Coating and is placed in a concrete bunker as protection

This section contains the results of research submitted in the form of narration, tables, and or images and statistical test results with explanation without discussion. Table title is written on it while the title of the image is written underneath it.

Fig 1. Pertamax storage tank

Some of the hazards around Pertamax tank are as follows:

1) Work involving burning, welding, or similar operations that can trigger a fire or explosion
2) Wild currents, for example equipment that can conduct electricity such as hoes or automatic lawn mowers to clean bushes or grass with these tools.
3) Lightning strike.
4) The formation of static electricity in the flow of the pipe which can cause a fire if the soil is not given to neutralize the flow of electricity, or the pump is damaged which triggers the formation of overheating/sparks.
5) The use of cellphones that emit radiation such as LED lights on cellphones will cause flares or sparks in the antenna coil which can cause fires or explosions.
6) Grass and shrubs around the ground level of the storage tank area. If the grass is dry and not scrubbed it can be used as fuel for fires in the area.

3.2 Fire and Explosion Risk Analysis

3.2.1 Value of Fire and Explosion Index

Based on the Dows Fire and Explosion Index Guidelines, in determining the process unit to be studied, the selected process unit is a process unit that is estimated to have a large potential for danger and can cause large losses in the event of a fire and explosion. In addition, the process unit must be at least 5,000 pounds or about 600 gallons of flammable, combustible, or reactive materials[7].

Pertamax is a vehicle fuel that is in great demand by consumers, in addition to Premium and Pertalite. The choice of the Pertamax tank as the process unit because almost every day gas station X places an order for Pertamax to the Pertamina Depot. In one day, the Pertamax order is carried out in two shifts or two times for unloading Pertamax fuel, the timing of the order is made with the assumption that the supervisor shifts 1 x 8000 liters per day, and the next day orders 2 x 8000 liters so that the Pertamax inventory is in the stockpile. not empty. Thus, tank cars often fill the Pertamax tank (unloading process) which is considered to have a large potential risk of danger in the event of a failure in the tank filling process.

Based on the Dow's Fire and Explosion Index Guidelines, the steps for assessing the potential for fire and explosion hazards are starting from selecting the process unit, determining Material Factor (MF), determining F3 by calculating F1 and F2, to determining F&EI.

MF is a value that describes the potential energy released during fires and explosions, resulting from combustion or other chemical reactions. MF is obtained from FV and RV, each of which describes the value of flammability and reactivity.

According to the Pertamax Safety Data Sheet [9], the specifications for Pertamax or Gasoline 92 fuel are as follows:

1) Flash Point (FP) : -45°F or -43°C
2) Lower Flammable Limit (LFL) : 1.4 %
3) Upper Flammable Limit (UFL) : 7.6 %
4) Healthy Value (HV) : 2
5) Flammability Value (FV) : 3
6) Reactivity Value (RV) : 1

Therefore, from the picture above, it can be seen that the Material Factor (MF) value on Pertamax is 16.

Next is to calculate the value of F1 (General Process Hazard Unit Factor) and F2 (Special Process Hazards Factor). These two values are important factors that can trigger a potential fire, the value is given by penalizing the factors listed in the Dows' Fire and Explosion Index. In awarding the penalty value, it is carried out jointly with the authorities from the gas station with direct observation and joint discussion.

After obtaining the values of F1 and F2, it can calculate the value of F3 (Process Unit Hazards Factor)

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to further calculate the value of the potential for fire and explosion.

Table 1. Fire & explosion index

MF		**16**
General Process Hazard (F1)	**Penalty Range**	**Penalty**
Base factor	1.00	1.00
Exotherm reaction	0.30 to 1.25	0
Endotherm reaction	0.20 to 0.40	0
Material handling and transfer	0.25 to 1.05	0.85
Enclosed or indoor process unit	0.00 to 0.90	0.225
Access	0.20 to 0.35	0
Drainage and spill control	0.25 to 0.50	0.5
F1		**2.575**
Spesial Process Hazard (F2)		
Base factor	1.00	1.00
Toxic material	0.20 to 0.80	0.4
Sub-atmospheric pressure	0.50	0
Operation in or near flammable range		0.5
Dust explosion	0.25 to 2.00	0
Pressure		0.16
Low temperature	0.20 to 0.30	0
Quantity of flammable/unstable material		0.34
Corrosion and erosion	0.10 to 0.75	0.2
Leakage - joints and packing	0.10 to 1.50	0.1
Use of fired equipment		0
Hot oil heat exchange system	0.15 to 1.15	0
Rotating equipment	0.50	0
F2		**2.7**
Process Unit Hazards Factor (F1 x F2) = F3		**6.9525**
Fire and Explosion Index (F3 x MF = F&EI)		**111.24**

F1 is the main factor that plays a role in determining the magnitude of the loss from the incident. From Table 1, it can be seen that F1 in the Pertamax storage tank is 2,575. This value is obtained from the sum of all penalty values for each item in general process hazards and penalties from the base factor (1.00), as follows:

a. Exotherm Reaction
   There is no penalty (0.00) because the tank is only a place for storing fuel, there is no exothermic reaction and the unit process is not a reactor.
b. Endotherm Reaction
   There is no penalty (0.00) because the tank is only for fuel storage.
c. Material Handling and Transfer
   Received a penalty of 0.85 for Pertamax which is a flammable liquid material with a value of FV = 3.
d. Enclosed or Indoor Process Unit
   Received a penalty of 0.225 because when filling/unloading Pertamax fuel was almost complete, the temperature gradually decreased to the initial temperature at the start of filling, which was 41˚C. Pertamax is a flammable liquid which has a flash point of -43°C. Thus, if the material is handled above the flash point, the penalty value is 0.45. In the process of the unit there is an open vent as ventilation that is designed and works well, so the penalty is reduced by 50%
e. Access
   There is no penalty (0.00) because the gas station area X has more than two access roads which are sufficient for tank extinguishing operations.
f. Drainage and Spill Control
   Received a penalty of 0.50 because there was an embankment designed around the unit process area in the form of a temporary storage container to anticipate spills during loading and unloading of fuel

F2 is a factor that can increase the probability of a potential incident. From Table 1, it can be seen that the F2 in the Pertamax Storage Tank is 2.7. This value is obtained from the sum of all penalty values for each item in special process hazards and penalties from the base factor (1.00), as follows:

a. Toxic Material
   The HV for Pertamax is 2. The penalty is determined by using the formula:
   Penalty = 0.20 x HV Material
   = 0.20 x 2 = 0.40
   Then the penalty value is 0.40
b. Sub-Atmospheric Pressure
   There is no penalty (0.00) because the Storage Tank is operated at a pressure of 1 atm or 0 psig (14.7 psi or 760 mmHg, maximum pressure in the storage tank is 2 bar (29 psig).
c. Operation In or Near Flammable Range
   Received a penalty of 0.50 because the storage tank is a place to store Pertamax fuel which has FV = 3.

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When filling Pertamax into the tank, some of the steam will be pushed out through the vent hole or PV Valve. This is because the incoming pertamax will push the steam above it so that the higher the liquid and the less steam space, and when the pertamax is almost exhausted in the storage tank, the steam will be more and the open vent opens the steam to come out.

d. Dust Explosion
There is no penalty (0.00) because the process unit is a Pertamax storage tank that is not associated with solids or processes that generate dust

e. Pressure
The unit process stores Pertamax with a flash point below 60ºC and has a normal operating pressure of 1 atm (0 psig) due to atmospheric tank conditions meaning the fluid in the tank is at its vaporizing pressure. While the pressure is regulated by a relief device or pressure release of 1.5 bar (7.34 psig). The penalty is awarded by entering operating pressures of 0 psig and 7.34 psig into the equation contained in the Dow's Fire and Explosion Index Guidelines. Based on the calculation, the result is 0.15. then the penalty given is 0.15.

f. Low Temperature
There is no penalty (0.00) because the penalty applies only if the unit process operating temperature is at or below 50ºF or 10ºC. The storage tank uses steel construction with a transition temperature (ductile/brittle) -20–0ºC, while the process temperature in the unit process is 32–49ºC.

g. Quantity of Flammable/Unstable Material
The penalty is 0.34. value is obtained through the following calculations:
Net volume = 21,694 liters
Pertamax density = 0.742 kg/liter
Mass = Density x Net volume
= 21,694 liters x 0.742 kg/liter
= 16,096.95 kg
(1 kg = 2.2046 lb), hence = 35,487.33 lb
Gasoline has energy (Hc) = 18.8 x 10^3 BTU/lb

Total energy = 35,487.33 lb x 18.8 x 10^3 BTU
= 667,161,833.36 = 0.667 x 10^9 BTU
In BTU = 0.667
Pertamax is a flammable liquid material with a flash point of less than 100ºF included in Class I Flammable Liquid, so the formula used to determine the penalty is as follows in accordance with the guidelines for dow's fire and explosion index.

h. Corrosion and Erosion
The penalty given is 0.20 because the storage tank has a coating with a coating, namely Asphalt Coating to prevent corrosion

i. Leakage - Joints and Packing
The penalty given is 0.10 because there is a possibility of a small leak in the pump, pump gland seal and distribution pipe.

j. Use of Fired Equipment
There is no penalty (0.00) because there is no burning activity around and does not use incendiary equipment,

k. Hot Oil Heat Exchange System
There is no penalty (0.00) because penalties are only given for combustible liquid materials, while Pertamax is not a combustible liquid, but a flammable liquid because the flash point is below 100˚C.

l. Rotating Equipment
There is no penalty (0.00) because The distribution of Pertamax from the storage tank to the dispenser uses a pump with one pipe line. The pump has a power of 1.5 PK or 1.479 hp, so it is less than 75 hp

F3 is a measure of the degree of hazard exposure of the process unit with a value range of 1–8. F3 is obtained from the product of F1 and F2. From Table 2, it can be seen that the value of F3 is 6.9525. Therefore, it can be said that the degree of hazard exposure of the Pertamax storage tank is quite high.

F&EI is a description of the potential hazards that exist in the process unit that can be categorized based on the level of danger. F&EI is obtained from the product of F3 and MF.

Table 2. Relation of F&EI and danger level[7]

Degree of Hazard for F& EI	
F&EI Index Range	**Degree of Hazard**
1–60	Light
61–96	Moderate
97–127	Intermediate
128–158	Heavy
159–up	Severe

From Table 1, it can be seen that the F&EI value is 111.24. Based on the Dow's Fire and Explosion Index Guidelines, it can be seen in Table 2 that the process unit with an F&EI range of 97–127 is classified as an

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intermediate hazard level. Therefore, the level of danger in the Pertamax storage tank is classified as an intermediate hazard level.

The results of the study have a risk level that is classified as Intermediate, it is necessary to control the risk in order to reduce the losses or impacts caused in the event of fire and explosion in the Pertamax storage tank. Risk control as an effort to increase security that can be done is to increase active protection such as the availability of hydrants with sufficient water capacity and the addition of other fire extinguishing media, namely foam according to the classification of fire types for fuel oil. In addition, there are automatic emergency stops and detectors that support remote automatic monitoring.

3.2.2 The Radius of Exposure

The radius of exposure is the distance from the equipment that may be reached and the distance that the equipment and structures around the tank can be exposed in the event of explosions and explosions.

The exposure radius is obtained from the calculation of the multiplication between F&EI with 0.84. The value of the exposure radius is obtained by the equation:

Exposure Radius (ft) = F&EI Value x 0.84
= 110.82 x 0.84
= 93.10 feet (28.39 m)

This value is the exposure radius calculated from the edge of the tank. Meanwhile, for larger unit processes, it is necessary to calculate the actual exposure radius starting from the center point of the tank. In the Pertamax submersible tank unit process has a radius of 4.03 feet. Then the actual Exposure radius is calculated by the following equation:

Actual Exposure Radius = Exposure Radius + Radius
= 93.10 ft + 4.03 ft
= 97.13 ft = 29.62 meters

3.2.3 Value of Damage Factor

The Damage Factor is the overall effect of the fire plus the explosion damage resulting from the release of fuel or reactive energy from the Unit Process. Based on the Fire and Explosion Index guidelines in determining the damage factor value, it is based on the MF value to determine the equation used. So, for MF with a value of 16, to find out the damage factor value, use the following formula:

$$Y = 0.256741 + 0.019886X + 0.011055X^2 - 0.00088X^3 \quad (1)$$

where X = F3.
Therefore

$$Y = 0.256741 + 0.019886 \times 6.9525 + 0.011055 \times 6.9525^2 - 0.00088 \times 6.9525^3 = 0.63 \rightarrow 63\%$$

The damage factor value for this pertamax storage tank is 0.63. The interpretation of these results will cause a damage rate of 63% in the event of a fire and explosion hazard in the Pertamax storage tank.

4. Conclusions

Based on the results of research and calculations using the Dow's Fire and Explosion Index, the F&EI value of 111,24 is obtained. From Table 2, the F&EI value of 111,24 indicates that the level of potential fire and explosion hazard in the Pertamax storage tank with a capacity of 21.694 liters at gas station X is classified as Intermediate. The risk obtained from calculations using the Dow's Fire and Explosion Index is the Actual Exposure radius of 29.62 meters and the damage factor of the Pertamax storage tank of 63%.

The results of the study are expected to be input in efforts to safeguard against non-military threats so as to reduce the impact of risks and losses received in the event of a fire.

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