

Analysis of the Potential Fire and Explosion and Losses with Dow's Fire and Explosion Index of Primary Reformer 101-B in Pt Pupuk Sriwidjaja Palembang

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Abstract – PT Pupuk Sriwidjaja Palembang produce various kinds of fertilizers Ammonia one. Primary reformer 101-B is one of process equipment in the production of ammonia with the highest temperature and pressure as well as the most at risk of failure which could result in a fire or explosion. Primary reformer 101-B acts as one of the stages of purification of methane results in the form of hydrogen and carbon monoxide. This research is a qualitative descriptive approach that aims to analyze the potential for fires and explosions using Dow's Fire and Explosion Index. Informants in this study consisted of two key informants and 7 usual informants. Methods of collecting information by means of in-depth interviews, observation and document study. From the analysis of the potential for fires and explosions using Dow's Fire And Explosion Index showed that the Primary Reformer 101-B at the level of danger of "severe" with an area of 8954 m² exposure. The magnitude of Business Interruption received due to disruption of the ammonia production process for 196 days is predicted to reach Rp1.285.362.722.290.

Keywords: Primary Reformer, Dow's Fire and Explosion Index, loss analysis

PRELIMINARY

At this time the industry continues to grow at a very advanced to meet the needs and demands of the market. Increased nitrogen-based fertilizer needs of the world over the years demanded a greater ammonia production again (Nurmanto, 2004).^[1] According to the Fertilizer Industry Association (IFA) in the 84th IFA Annual Conference Moscow Russia (2016), world fertilizer requirements in 2015 is 245 mt and is predicted to increase in 2020 to 270Mt.^[2]

The petrochemical industry is one of the industries that have a high potential to cause major hazards that cause work accidents such as fires and explosions. This is because the petrochemical industry to use chemicals that are harmful in the production process such as gas methane (CH₄), hydrogen (H₂), nitrogen (N₂), carbon dioxide (CO₂), Ammonia (NH₃) and others (ILO, 1991).^[3] Fires and explosions that occur in the petrochemical industry due to the natural gas which is a raw material for making ammonia. Natural gas has a characteristic combustible (flammable) and in the ammonia production process uses machines that temperature and high pressure. Losses experienced a confirmed case of fire industry is huge because it involves high-value assets.

There are fires and explosions at West Fertilizer Company, which resulted in 350 houses damaged. Besides the house, there are schools, apartment complexes and nursing homes that also damaged as a result of this incident. And an estimated \$ 230 million for material loss (US Chemical Safety and Hazard Investigation, 2013).^[5] Recorded seven fires that occurred in 2011 to 2015 in PT Pupuk Sriwidjaja Palembang. The three of seven events including a work accident caused by the failure of some components of the machine, for example steam vapor valve or faucet is loose and there is also a cover flange connection on the tube or pipe that is leaking.

According to Ojha et al. (2010), the fertilizer industry which uses ammonia, stages of the production process of the most frequent failures are reformer process unit, particularly Primary Reformer. The failure of the primary reformer work caused by clogged tubes, union, or valve. In addition, tools that operate at high temperatures (600 - 1100°C) and pressure of 32 kg/cm²

- 35 kg/cm² so vulnerable to damage in case of errors in the operation which could result in leaks and fire. ^[6]

Therefore, the need for an analysis of the potential for fires and explosions as well as losses in the Primary Reformer 101-B PT Pupuk Sriwidjaja, considering PT Pupuk Sriwidjaja Palembang is one of the factories that produce the largest urea fertilizer in Indonesia. PT Pupuk Sriwidjaja Palembang location is also close to residential communities, public facilities such as schools and hospitals which in case of fires and explosions are great it will be potentially affected by the incident. Steps to be taken in the calculation of the potential risk of fire and explosion as well as losses in the Primary Reformer in PT Pupuk Sriwidjaja Palembang is as follows: determining an overview of Fire and Explosion Index, The Radius of Exposure, The Area of Exposure, Value of the Area of Exposure, Damage factor, Base Maximum Probable Property Damage, Loss Control Credit factor, Actual Maximum Probable Property Damage, Maximum Probable Days Outage, and Business Interruption.

METHOD

The research design used in this study is qualitative with descriptive approach. In calculating the amount of the potential danger of fire and explosion, this study using Dow's Fire and Explosion Index, which will obtain the value of the radius of exposure, area of exposure, the value of the area of exposure, susceptible to damage, loss value basis, the controlling factor value of the loss, the value of the actual damages, working days lost, and losses due to business interruption.

Data used in this research is primary data and secondary data. The primary data of field observation and in-depth interviews with 2 key informants and 7 regular informant. Secondary data such as Standard Operating Procedure (SOP) in the Primary Reformer 101-B, Material Safety Data Sheets (MSDS), etc.

RESEARCH RESULT

Primary Reformer Unit 101-B are charged the amount of approximately 180 tons of material, which in its operation requires high temperatures around 780°C to 820°C and high pressure is about 32 kg / cm² to 39 kg/cm². Known fuel methane has a material value factor (MF) 21. From the results, the level of

potential danger (F & EI) fires and explosions in units of Primary Reformer 101-B Factory Pusri-1B has a level of potential danger of severe (severe) with a value of F & EI amounted to 168 . Based on the guidelines of Dow's Fire and Explosion Index F & EI value obtained by multiplying the Material Factor (MF) by Process Unit Hazard Factor (F3). Hazard Unit Process Value Factor (F3) is obtained by multiplying the results of the General Process Hazard Factor (F1) and the results of the Special Process Hazard Factor (F2).

Table 1. Values DF & EI

General Process Hazard Factor (F1)	Penalty
Base Factor	1.00
A. exothermic reaction	0.00
B. endothermic reaction	0.40
C. Displacement and Material Handling	0.50
D. Closed Process Unit	0.60
E. Access (Road)	0.00
F. Pembuangan channels and Spill Control	0.00
General Process Hazard Factor (F1) (Σ AF)	2.50
Special Process Hazard Factor	Penalty
base Factor	1.00
Hazardous materials	0.80
Under Atmospheric Pressure	0.00
Operating in or near Flammable Range	-
The tank containing flammable liquid	-
Contents of process equipment with flammable material close range	-
Process or operation that is always at or near flammable range	0.80
Dust explosion	0.00
pressure release	
The operating pressure of 14.7 psig / kPa gauge	0.55
Relief setting 14.7 psig / kPa gauge	
Low temperatures	0.00
Total Material	
Liquid / gas in the process	0.27
Liquid / gas in the process	
combustible solids The unit processes, the dust in the process	
Corrosion and Erosion	0.10
Leakage	0.30
Use of Equipment Burners	0.12
Hot Oil Exchange System	0.00
Rotating equipment	0.50
Special Process Hazard Factor (F2) Σ (AL)	4.44
Process Unit Hazards Factor (F1 x F2) = F3	8
→ 2.50 x 4.44 = 11.1 → 8 (max value)	
Process Unit Hazards Factor (F1 x F2) = F3	168
→ 2.50 x 4.44 = 11.1 → 8 (max value)	

In case of fire and explosion on Primary Reformer unit 101-B Factory-1B Pusri then all the equipment, process units or buildings that are in the 53,4 meter radius of the outer edge of the reformer unit will be affected by the fires and explosions. Regional widely exposed in case of fire and explosion on Primary Reformer unit 101-B-1B od Pusri Factory about 8954 m².



Figure 1. Total Area Radius Exposure and Exposure

Value loss or replacement value of the entire equipment and isisnya to be damaged or missing from the area of exposure in case of fire and explosion on Primary Reformer unit 101-B Factory-1B Pusri about Rp59.763.830.564 or US \$ 4,236,995.44. This value does not include the cost of land preparation. construction of roads, foundations, pipelines in the ground, engineering and so on. Value factor Primary Reformer damage to unit 101-B Factory-1B Pusri of 0.67 or 67% of the exposed area, the 8954 m² which means the area of the damaged area of 6000 m². Losses experienced in the area of 6000 m² are experiencing the impact of fires and explosions Rp 40,041,766,478 to US \$ 2,830,156.82.

The value of the loss controlling factor that has been done by the PT Pupuk Sriwidjaja Palembang is equal to 0,67. The value calculation results when compared with the best value for Loss Control Credit Factor is equal to 0.18, the efforts to control the company has done in the Primary Reformer 101-B-1B Pusri factory can still be improved.

Table 2. Value Loss Control Credit Factor

No.	variables	Penalty
A.	1. Emergency Power (Power Emergency)	1.00
	2. cooling (Air)	1.00
	3. Explosion Control (Control Explosion)	1.00
	4. Emergency Shutdown (Terminator Emergency)	0.99
	5. computer Control (Computer Control)	0.97
	6. inert Gas	0.96
	7. Operating Instruction / Procedures (Procedures or Operation Instructions)	0.95
	8. Reactive Chemical Review (Overview Against Reactive Chemicals)	0.91
	9. Other Process Hazard Analysis (Process Hazard Analysis Else)	0.94
Process Control Credit Factor		0.75

B.	1. Remote Control Valves (Valve Controlled From Far)	0.98
	2. Dump / Blowdown (Storage Tank)	1.00
	3. drainage (Drainage)	1.00
	4. interlock	0.98
	Isolation Material Credit Factor	0.96
C.	1. Leak Detection (Leak Detection)	1.00
	2. structural Steel (Structural Steel)	1.00
	3. Fire Water Supply (Fire Water Supply)	0.97
	4. special System (Special System)	0.91
	5. sprinkler System (Sprinkler Systems)	1.00
	6. Water Curtain (Veil Water)	1.00
	7. Foam (Foam)	1.00
	8. Hand Extinguisher / Monitors (APAR / Monitor)	0.98
	9. Cable Protection (Cable Protection)	0.94
Credit Fire Protection Factor		0.81
Loss Control Credit Factor (C1 x C2 x C3) → (0.75 x 0.96 x 0.81)		0.59

Results of calculation of actual damages in case of fire and explosion on Primary Reformer unit 101-B Factory Pusri-1B is about Rp 32,559,691,729 or US\$ 2,301,322.89. Estimation of working days lost due to fire and explosion in an ammonia plant that is over 192 days. Given the length of working days lost and losses will be received by the company in case of fire and explosion, the company will make every effort to abolish the working days lost in case of fire and explosion on Primary Reformer unit 101-B Factory Pusri-1B.

DISCUSSION

General Risk Assessment Fire and Explosion On Primary Reformer 101-B PT Pupuk Sriwidjaja

Based on the results of the study, the rate of incidence risk of fires and explosions in the Primary Reformer unit 101-B is obtained by calculating the value of Dow's Fire and Explosion Index of 168 is located on the severe category. This value indicates the overall magnitude of the potential hazards of fire and explosion-owned unit of the process. Based on the analysis of the FTA, a potential source of fire and explosion hereinafter that of equipment such as arch burner burner, rotating equipment such as ID and FD Fan Fan, and leakage tube, union or valve. Other potential sources of leakage that is associated with the operating pressure and temperature. Pressure on Primary Reformer unit 101-B high-pressure production process which ranges from 32 kg /cm² to 39 kg/cm²,

operating temperatures required in the Primary Reformer unit 101-B was high, ranging from 790oC to 820oC can even reach 900oC at

hotspotnya. According Bashita (2013) on the primary reformer catalyst tube operates at temperatures between 700-900 ° C so it is prone to failure creep and oxidation which could potentially lead to overheating and ledakan.7 addition, Turi (2011) suggested that the failure of the primary reformer also caused by corrosion of the tubes reformer who do not do maintenance for two years. ^[8]

According to the American Institute of Chemical Engineers (1994), the danger of the damage and loss due to fire and explosion risks contained in the F & EI value, is a form of informative results and realists against the risk of fire and explosion. The results of F&EI calculations and this may be a consideration for companies to control and preventive measures so that the risk of fires and explosions can be prevented and minimized. ^[9]

The Radius of Exposure

Radius exposure in case of fire and explosion on this research that is as far as 53.4 meters. According to Sukma (2017), the radius of exposure is the radius or distance where there is the possibility of working or processing units other exposures directly from fire or explosion of air that impact on workers or people who are on the radius, as well as equipment and units within its radius to the possibility exposure can be affected directly by the fire, or exposed to the air blast effect and in the distance workers must give attention more. ^[10]

In case of fire and explosion on Primary Reformer unit 101-B-1B Pusri plant, equipment, machinery and workers who are in a radius of 53.4 m on the outside area of the reformer will be affected. The more equipment and machinery that is at this radius the greater will be the damage as well as losses incurred by the company. If at the time of the incident there were workers or operators who are working, then it will be exposed to fires and explosions. The larger the radius of exposure the greater the losses are obtained. The equipment is located in the Primary Reformer unit 101- B in the method of the Dow's Fire And Explosion Index, the whole will be affected and the damage in case of fire and explosion.

The Area of Exposure

The area of exposure in case of fire and explosion on Primary Reformer unit 101-B

Factory Pusri-1B that is equal to 8953.9 m². Based on research Jatisari (2012), area of exposure is an area where all the equipment inside the exposure area, will be exposed to the effects or impacts in the event of fire and explosion. The area of exposure associated with exposure radius, the farther the radius of exposure is experienced, the more exposure the area. ^[11] Case of fire and explosion unit area outside the Primary Reformer 101-B are included in the exposure area will be affected in case of fire and

explosions that are within the exposure area namely units in Ammonia Plant-1B whole, affected the overall control room, cooling tower exposed to the whole,

Value of The Area of Exposure

Value-exposed area is the replacement value or value in the form of money which is issued by the company to make the turn of all the equipment that may be damaged in case of fire and explosion on Primary Reformer unit 101-B

Factory Pusri-1B. Value-exposed areas in a study of Primary Reformer unit 101-B Factory-1B Pusri is about Rp 59,763,830,564 or US\$ 4,236,995.44. The research result Lanin A. (2009), obtained the value of the area exposed to the crude oil storage tank Chevron namely Rp 31.237.281.261,90. ^[12]

This value is in the form of the number of values in the form of rupiah entirety of equipment, tools, and other infrastructure that is within the area of exposure and the amount of the costs incurred by PT Pupuk Sriwidjaja Palembang to replace and repair equipment, infrastructure, tools and others who located in the entire area exposed in the event of fire and explosion. Value Exposure area is proportional to the area of exposure, meaning the area of exposure, the greater the value of the exposure area will be the more spending PT. Pupuk Sriwidjaja Palembang in performing repairs and replacement of equipment damaged in exposed areas.

Damage Factor

Damage factor is defined as the value of damage and losses incurred as a whole when there is a release of energy from the process unit in case of fire and explosion (Agustin, 2014). ^[13] The result of the calculation of the value of the damage in a study of Primary Reformer unit 101-B Factory Pusri- 1B of 0.67. This damage factor value is determined

based on the value of Material Factor (MF) and the value of the calculation result F3. So that the equation used to calculate the damage factor is devoted to the Material Factor value of methane is 21. F3 value included in the value of X in the equation. In this study, the F3 value of 11,1. The area of exposure cause damage to affected on research in the Primary Reformer unit 101-B is equal to 67% from the calculation of the area exposed.

Base Maximum Probable Property Damage

Loss value is calculated and determined based on the value of the area exposed to the pre-computed by a factor of damage, because the magnitude of the value of this basic losses depending on how much the value of the damage factor. In Jatisari research (2012) the results of the calculation of the basic loss in case of fire or explosion which amounted to US \$ 6,039,630.751. There is a difference between the value of the basic losses to the value of the area of exposure, due to the damage factor of 27% so that the value of the basic loss of US\$ 22.369.002,78^[11]

Based on the results of the calculation of the basic loss value in the process unit Primary Reformer unit 101-B Factory Pusri-1B, in this study, the basic losses about Rp 40,041,766,478 or \$ 2,830,156.82. The loss value is fewer than the value of the area exposed due to the basic loss value is 67% of the exposed area. From the previous statements it can be concluded that the basic value of the losses that occurred in the exposed area of 6,000 m² is about Rp 40,041,766,478 or \$2,830,156.82. Basic loss value into the image of the value of losses on exposure area, the loss on the equipment being dijangkau unit processes and value factors influencing damage.

Loss Control Credit Factor

The amount obtained controlling factor in the value of losses (LCCF) in the Primary Reformer unit 101-B Factory-1B Pusri of 0,59. Best Value in Loss Control Credit Factor of 0,18 so compared to LCCF value of 0,59 results of this study the control measures taken by the company can still be improved. According to Agustin (2014), the controlling factor in this loss can prevent and limit the losses incurred by the company in case of fire and ledakan. ^[13] In calculating the value of the

controlling factors of loss, there are three credit variables associated with the production process control system. These variables namely Process Control (C1), Isolation Material (C2), Fire Protection (C3). For the value of Process Control (C1) in the Primary Reformer unit 101-B is 0,75. In the unit there are pembangkit emergency power, cooling system (cooling), and controlling the explosion. For value Material Control (C2) in the Primary Reformer unit 101-B is 0,96. In the unit there are tanks and drainage. For the value of Fire Protection (C3) in the Primary Reformer unit 101-B is 0,81. There is no leakage detector, sprinkler, water curtain and foam systems in the reformer unit.

Based on the above discussion, the increase in the controlling factor in the Primary Reformer unit 101-B is required to minimize loss, such as installing a leak detection system, flame detectors and smoke detectors. The need for emergency power generation supplied to a power supply in case of emergencies, especially when

I.D. Fan and F.D. Fan. For now all the power in the reformer unit is derived from utility plants so that electricity at the time of emergency is limited causing less optimal working appliances and could cause damage due to low power.

Actual Maximum Probable Property Damage

Results of calculation of actual losses in the Primary Reformer 101-B Factory Pusri-1B is about Rp32,559,691,729 or US\$ 2,301,322.89. The value obtained by multiplying the value of the basic loss where the calculation results about Rp 40,041,766,478 with the controlling factor loss (LCCF) that is equal to 0,67. There are differences between the results of calculation of loss basis with the calculated value of the

actual losses, the difference in nominal occur due to the influence of the controlling factor losses if there are items LCCF diunit process can reduce the amount of loss from fires and explosions due to the mill has been equipped with the system protection of both protection in the production process, the protection system materials and fire proteksi system.

In the study Ramzaan, et al. (2011) on the calculation value of the actual losses on the primary reformer in the petrochemical industry and the pipeline of US \$ 3,900,000, which is more than 70% confidence level with a duration

probability of a system failure. In this study, the controlling factor in the loss of 67% where the value of the actual losses of Rp 32.559.691.729.^[14] value is reduced from the value of the basic loss due to the Primary Reformer unit 101-B has done considerable control which can suppress and reduce the losses arise in case of fire and explosion. If all the elements in a controlling factor value of the loss is applied then the value of the actual losses can be reduced.

Maximum Probable Days Outage

Working days lost value calculation to be assumed that after the explosion, the company would rise and rebuilding of the ammonia production process. Oginawati research results (2016) states that the primary reformer concerning estimates of lost work days in the amount of 138 days.^[15] estimates of lost work days in case of fire or explosion Primary Reformer Unit 101-B is equal to 196 days. Value 196 working day is a day in which the company takes in repairing and replacing machines, equipment, piping and other infrastructure before it resumed operations, the company needed time to organize and prepare the filling catalysts in equipment operation, the time required PT Pupuk Sriwidajaja to start up the plant.

Business Interruption

The results of calculation of losses due to business interruption in case of fire or explosion Primary Reformer Unit 101-B which amounted Rp1.285.362.722.290 or the equivalent of US \$ 90,849,590.17. In calculating the value of losses due to business interruption involving an amount of ammonia production for a month, the amount of ammonia production at the factory-1B Pusri which amounted Rp280.500.000.000. According to the guidelines of Dow's Fire and Explosion Index (1994) the value of losses due to business interruption using the equation of value of production for a month divided by the number of days in a month later koefisien multiplied by 0.7. Value loss due to business interruption losses illustrate the loss of production during the working days lost.^[9] There are three losses will be experienced in case of fire and explosion that damages the basis of which is influenced by the radius of exposure and damage blasting, the actual damages suffered from the loss of

the base that has been influenced by factors controlling and losses due to interruption of business describe the loss due to the value of lost production 196 days. The other disadvantage is environmental damage, insurance, injured workers and others.

CONCLUSIONS

Based on calculations using Dow's Fire And Explosion Index, the potential danger of explosion and fire at the unit at PT Pupuk Sriwidajaja Palembang included into the category of "severe" or worse by F&EI value is 168. The area of 8954 m² exposure. The magnitude of Business Interruption received due to disruption of the ammonia production process for 196 days is predicted to reach Rp1.285.362.722.290. Advice can be given for further research is the study can be used as guidelines for the development of assessment of potential fire and explosion on units at the factory area of PT Pupuk Sriwidajaja Palembang particularly Primary Reformer unit. Furthermore, it is expected that such provision of leak detection systems, flame detectors and smoke detectors. Importance provided emergency power generators as the power supply in case of emergencies, especially when I.D. Fan and F.D. The purpose is to minimize the potential for fires and explosions as well as losses.

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