

# Risk Control Analysis of Distribution Operations in LPG Storage Using Fault Tree Analysis Method

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## ABSTRACT

Risk is a probability of occurrence beyond the unexpected events in any human activities and could become a disadvantage. Distribution operational in LPG storage, various activities will cause danger and hazard that can inhibit the distribution operational. These hazards can have an impact on productivity, the risk of cost, time, and damage to the system. To decrease that impacts, a risk management system is required, including the identification, assessment, analysis, and control of possible risks. Risk management makes an effort to manage risk by using a combination of two tools, the risk assessment method, and the FTA. All risk potential from distribution operation is identified and analysed by using the risk assessment matrix, whereas the resulting risk prioritized outcomes have identified the source of the cause using the FTA method and described structurally. From the results of the analysis, 21 risk variables were classified into 1 type of activities with 5 sub- items of equipment used in the distribution activities. The most critical level of risk is the potential for fire, LPG leakage, pump components damage, and distribution obstructed.

**Keywords:** *risk control, LPG storage, FTA*

## 1. INTRODUCTION

There is always have risk of failure in every work activity. When work accident happened, no matter how small is it, it will give a loss effect. So, it must be prevented as much as possible and as early as possible, work accident must be prevented or at least reduced. Handling a safety issues in a company it must be done seriously to all company component, cannot be partial handled and treated just as marginal discussion in a company.

Work safety handling also applied in gas industry. In gas industry health and work safety is very high priority to guarantee all the company activity but the accident cannot be erased, for example, storage tank accident in Depot LPG Makasar that collapsed on august 2017, storage tank collapsed happened because the cantilever pillar was broken, that expected overloaded and its already aged accident like this can be minimalist if health and work safety assessment is greatly detail.

Company X is one company that engaged in oil and gas, LPG that sold by Company X marketed with trademarks LPG that used as house hold and industries fuel. Another Gas product that marketed is gas fuel, musicool (hydrocarbon refrigerant, environmentally friendly), HAP - Hydrocarbon Aerosol Propellant (Propellant environmentally friendly with basic material hydrocarbon that used as aerosol product booster), and Vi-Gas (LGV Fuel - Liquefied Gas Vehicle).

LPG storage have main activity just like reception, storage, and distribution LPG, they accept the supply through sea

transportation that used tanker, and storehouse LPG used storage tank Spherical and distribution used skid tank and tube truck in carrying out distribution and storehouse always have a risk and danger that can cause a loss. Based on those backgrounds, this study was conducted to Risk Control Analysis of Distribution Operations Using FTA (Fault Tree Analysis) Method.

## 2. METHOD

### 2.1. Risk Assessment

Risk based on Australian Standard New Zealand Standard (AS/NZS) 4360:2004 a chance that can be occur the incident that can gave an effect to an object. A risk calculates based on likelihood score (the possibility of an event) and Consequence. A risk can be calculated in qualitative, semi-quantitative or quantitative. General formula that used to do a calculation score risk in AS/NZS 4360:2004 is: "Risk (R) = Severity (S) x Probability (P)" [1].

Based on ILO, occupational Health and Safety it's a promotion, protection and a very high degree of health improvement including physical aspect, mental, and social welfare for all workers in all workplaces [2].

### 2.2. Risk Evaluation

Prediction the Risk Level through accurate evaluation is a crucial step in risk studies series, qualification and quantification risk, developed in the process. Risk evaluation method including: 1) Calculation the chance of incident (Probability). To specify the chance of incident in

workplaces we can use based on potential level (see on Table 1), 2) Calculate the Severity (see on Table 2), and 3) Combination chance score and consequence to decide the risk score. Level or risk level determined correlation

between the value of the identification of hazard opportunities and consequences this correlation, shown in Table 3.

**Table 1** Probability, qualitative measures of likelihood

| Level | Descriptor     | Description                                 |
|-------|----------------|---|
| 1     | Almost certain | Is expected to occur in most circumstances  |
| 2     | Likely         | Will probably occur in most circumstances   |
| 3     | Possible       | Might occur at some time                    |
| 4     | Unlikely       | Could occur at some time                    |
| 5     | Rare           | May occur only in exceptional circumstances |

**Table 2** Severity, qualitative measures of consequence or impact

| Level | Descriptor    | Example detail description  |
|-------|---------------|---|
| 1     | Insignificant | No injuries, low financial loss   |
| 2     | Minor         | First aid treatment, on-site release immediately contained, medium financial loss                                     |
| 3     | Moderate      | Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss |
| 4     | Major         | Extensive injuries, loss of production capability, off-site release with no detrimental effects, major financial loss |
| 5     | Catastrophic  | Death, toxic release off-site with detrimental effect, huge financial loss  |

**Table 3** Risk analysis matrix—level of risk [3]

| Likelihood (P)     | Consequences (S)   |            |               |            |                   |
|--------------------|--------------------|------------|---------------|------------|-------------------|
|                    | Insignificant<br>1 | Minor<br>2 | Moderate<br>3 | Major<br>4 | Catastrophic<br>5 |
| 5 (Almost certain) | M                  | H          | H             | E          | E                 |
| 4 (Likely)         | L                  | M          | H             | H          | E                 |
| 3 (Possible)       | L                  | M          | M             | H          | H                 |
| 2 (Unlikely)       | L                  | L          | M             | M          | H                 |
| 1 (Rare)           | L                  | L          | L             | L          | M                 |

Legend: E : Extreme risk (very high); P : Probability; H : High risk; S : Severity; M : Medium/Moderate risk; L: Low risk

Based on matrix rank we can identify or decide the action that we will do in every risk. Definition as follow: a) Low risk, risk can be accepted, additional control is not necessarily needed. Monitoring is needed to make sure that control has been maintained and properly implemented, b) Medium risk, action needs to be taken to reduce risk, but the costs of prevention required must be carefully calculated and limited. Measurement of risk reduction must be applied within a specified time period, c) High risk, activities should not be carried out until the risk has been reduced. Need to consider the resources that will be allocated to reduce risk. If there is a risk involved in the implementation of work that is still ongoing, then action must be taken immediately, d) Extreme risk, activities cannot be carried out or continued until the risk has been reduced. If it is not possible to reduce risk with limited resources, work cannot be carried out [3].

**2.3. Fault tree analysis (FTA) Method**

It is a deductive approach so as to get the probability of top event. FTA is failure analysis in which undesired state is analysed using Boolean logic. FTA was developed in 1962 at Bell Laboratories by H.A Watson, under a U.S Air Force

Ballistics Systems Division contract to evaluate the Minuteman I Intercontinental Ballistic Missile (ICBM) Launch Control System. The concept of FTA was expanded by the reliability experts. Boeing and AVCO expanded its use to Minuteman II system in 1963-964[4]. FTA is useful not only in giving a visual representation of the system; it also provides a foundation for identifying and combining probabilities of different events impacting system failure through Boolean logic statements [5]. Fault tree analysis is a deductive method used to identify the casual relationship leading to specific system failure mode. Analytical tree is the graphical representation or picture of the event and it is called tree because their structure resembles a tree having top event as output event and having branches (basic event) as input event [6]. The initial step is to identify the system failure mode of concern which becomes the top event of the analysis. The top event is developed by several branches leading to various sub events which represents the possible cause of the event. The defined hazards can be analysed using many tools such as FTA and ETA (event tree analysis). FTA is a systematic and deductive approach that focuses on hazardous outcomes (top event) and develops further to the basic causes (bottom event) that lead to such unwanted outcomes [10]. FTA is

also used widely in hazard analysis of the various storage facilities [7-12].

### 3. RESULTS AND DISCUSSION

#### 3.1. Hazard Identification Risk Assessment and Risk Control (Distribution of LPG Storage)

Distribution activity in LPG storage has a significant share in supporting the smooth operations of the LPG storage. Identification of risks in distribution activities is intended so

that in its implementation can be known the types of hazards and risks contained in distribution activities, and will provide an overview of the risk control of such hazards.

The assessment of hazard risk in LPG industry distribution activities at the LPG storage is carried out using the multiplication between Probability and Severity based on a risk matrix. Probability (P) is a number obtained based on the level of frequency that occurs and Severity (S) is a number obtained based on the severity if the event occurs. This figure was obtained from interviews and literature study research conducted by the author during the research at the LPG storage. The identification and highest risk assessment table in distribution activities can be seen in Table 4.

**Table 4.** The identification and highest risk assessment (distribution operations)

| Operation    | Equipment         | Description                    | Risk Process  | Another Risk   | Score |   |       | Level of Risk |
|--------------|-------------------|--------------------------------|---|--|-------|---|-------|---------------|
|              |                   |                                |   |  | P     | S | P × S |               |
| Charging     | Pumping           | Mechanical seal/thin broken    | Gas Leak  | Fire Possibility   | 3     | 4 | 12    | H             |
|              |                   | Impeller broken                | Decreased pump performance, damaged pump components | Noisy // Hearing Disorder/Vibration//Discompartment                                  | 3     | 4 | 12    | H             |
|              | Valve             | No circulation during charging | Distribution blocked/vapor stuck//Explosion//fire   | Crossing/Crash Skid tank//Accident MT Pinched/Crashing//injury/Die, Fire Possibility | 3     | 4 | 12    | H             |
| Filling Shed | Truck Loading Arm | Seal joint TLA broken          | Gas Leak  | Gas Exposure // Skin irritation/Respiratory disorders/dizziness                      | 3     | 4 | 12    | H             |
|              |                   | Overflow                       | Gas Leak  | Land Pollution, Fire Possibility   | 3     | 4 | 12    | H             |

(/= Or; // = Consequence)

Based on the assessment obtained, there are three hazards that have the highest risk of danger, namely LPG leakage, LPG distribution to the skid tank is obstructed, damage to pump components, this risk will then be analysed using the Fault Tree Analysis method.

#### 3.2. Control the High Risk Of Distribution Operations Using FTA Method

Based on identification and risk assessment, there are four risks that are considered to have the highest level of risk from the results of the risk assessment using a risk matrix. Then three of these types of risk are analysed using fault tree analysis to determine the main problem, see on table 5, 6, and 7.

**Table 5** W3 analysis LPG leak risk

|       |   |
|-------|---|
| What  | LPG Leak  |
| Where | Filling operational and filling shed LPG distribution in LPG storage  |
| When  | Leak Gas on:<br>-Mechanical seal in pump thinned /broken<br>-Leakage on pipe<br>-Loading arm leak<br>-Mechanical seal quick coupling broken |

The result of the Fault Three Analysis of LPG leak, in this case LPG leak occurs if one of the causes occurs, the causes of the occurrence are as follows: a) mechanical seal in pump thinned /broken (intermediate event), b) leakage on pipe (intermediate event), c) loading arm leak (intermediate event), and d) mechanical seal quick coupling broken (intermediate event).

**Table 6** W3 analysis distribution obstructed

|       |   |
|-------|---|
| What  | Distribution obstructed   |
| Where | There are LPG distribution activities for industry at the LPG storage   |
| When  | Distribution obstructed on:<br>-Flow up and down<br>-Vapor not came out |

The result of the Fault Three Analysis of the obstruction of distribution events. In distribution activities, it is expected that all systems and equipment related to distribution activities can run as functions, but does not rule out the possibility of errors can still occur. The causes of the occurrence are as follows: a) pump failed start (intermediate event), b) flow up and down (intermediate event), and c) no circulation.

**Table 7** W3 Analysis Pump Component Damage

|       |   |
|-------|---|
| What  | Pump Component Damage   |
| Where | LPG distribution pumps for industry at the LPG Storage                                    |
| When  | Pump Component Damage on:<br>-Strainer broken down<br>-Cavitation<br>-Excessive vibration |

The result of the Fault Three Analysis of damage to pump components. Damage to the pump component is a top event because it can cause losses for the depot or the industry. In this case pump component damage occurs if one of the reasons occurs, based on pump Literature, the causes of the occurrence are as follows: a) Strainer broken down, b) Cavitation, and c) Excessive vibration.

#### 4. CONCLUSIONS

Controls that can be carried out to prevent risks, namely compliance with work procedures (SOP), employee training, periodic maintenance of facilities, and repair or replacement of damaged equipment. Reduce and minimize the danger potential that were 21 danger potential on distribution LPG storage, for reduce and avoid the risk that will have an impact in all distribution process or impact on environment.

The company can carry out further related risk assessments about process or safety risk in all activity in LPG storage. Do the preventive action and control based on priority order risk, start from the highest risk using FTA method, that is LPG leak, obstructed channelling, pump component damage, and fire possibility.

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