Semi Quantitative Risk Analysis of Onshore Receiving Facility

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Abstract: During the onshore receiving facility (ORF), a potential hazard that could cause an installation failure is found. Onshore receiving facility installation operator needs to do a risk analysis to identify hazards, determine the probability of Failure and consequence of Failure and conduct Semi-quantitative risk analysis due to knowing the risk profile at the onshore receiving facility and the consequence for the environment, people, assets/business, and company reputation. Based on the risk level, the ORF operator can determine a mitigation plan and recommend reducing risks such as inspection frequency, maintenance, and repairs related to internal corrosion and external corrosion. The result of risk analysis states that the overall risk of the ORF installation is at low risk.

1 INTRODUCTION

1.1 Background

The oil and gas business involves several stages, such as exploration, exploitation, and production. In general, the oil and gas business is an industry with high risks both from a business perspective and a safety/accident perspective, especially risks caused by fires and explosions.

Significant hazards in the oil and gas and chemical industries are related to fires, explosions, and toxic releases. Of the three hazards, the most common is fire, but the explosion has the most significant effect on mortality and loss of production. (Lees, 1994).

The Flixborough incident was the enormous explosion that occurred in Great Britain, which caused 28 fatalities and total damage to the vicinity of the NYPRO plant. The explosion on the Bombay High North Platform on 27 July 2005 was caused by a support vessel hitting the gas export riser platform, causing 22 fatalities and environmental damage, and loss of production of 120,000 barrels of oil and 4.4 million cubic meters of gas per day. One of the most significant accidents and the largest accident in the oil and gas industry occurred on July 6, 1988, at the Piper Alpha platform in the North Sea, which killed 167 people and totalled the US $ 3.4 billion business losses. This type of risk is a category of catastrophic events. Although these occurrences are rare, the repercussions can be enormous. Not only events that result in an unacceptable loss of life, large-scale environmental problems, the economy, poor community relations, civil litigation, and even criminal prosecution. These events also often have a major impact on the development of management systems and regulations. (Sutton, 2015).

In the oil and gas industry, risks cannot be avoided. However, these risks can be managed by referring to the concept of risk management. Risk management aims to increase opportunities and minimize losses. The risk management process based on ISO 31000: 2018 includes: Risk Identification, Risk Analysis, Risk Evaluation, and Risk Treatment / Control.

In the gas processing facility, there is a risk of fire and explosion due to the content of natural gas, most of which is mainly methane (around 70-90%) and is highly flammable. These risks can potentially cause harm to humans (serious injuries, minor injuries, and death), environmental damage, equipment damage, and company reputation. These losses can be controlled by carrying out a risk analysis.

1.2 Facility Description

Onshore Receiving Facility receiving gas and crude oil from Floating Production Unit (FPU). Gas and condensate from FPU are separated in the separator. The volume of the gas from the separator is measured and sent to the customer. Part of the gas is used to supply ORF fuel gas used to purge gas and pilot flare

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gas in the flare system. Meanwhile, condensate from the separator is combined with the crude oil from the FPU to be sent and stored in a storage tank.

2 METHODOLOGY

2.1 Hazard Identification

Hazard identification is carried out by understanding the equipment damage mechanism in the Onshore Receiving Facilities installation. It is crucial to make a proper plan to reduce the failure rate of the equipment and increase the safety of the plant operation. Table 1 shows the identification of hazards and damage that may occur during the operation of the installation.

Table 1. Damage and Hazard Mechanism of Installation

Equipment	Damage Mechanism	Cause	Hazard
Pressure Vessel	Erosion Corrosion	Failure is characterized by metal loss or thinning of the pressure vessel caused by the abrasive material. The severity is determined by gas flow rate, pressure, type, and quantity.	Leak Rupture
	Atmospheric Corrosion	Atmospheric corrosion is caused by moisture in the air which can form a thin layer of liquid on the surface of the pressure vessel. This depends on the different atmospheric conditions of the particles and gases.	Leak Rupture
Piping	Mechanical Fatigue	Cyclic load processes and stress loss. Mechanical fatigue can cause failures that occur at relatively low stress levels.	Leak Rupture
	External Corrosion	Corrosion occurs due to contact between pipes and water/soil. There is a microscopic reaction between anodic and cathodic, triggered by coating records, differences in aeration, resistivity, soil acidity, and heterogeneity of soil acidity.	Leak Rupture
	Internal Corrosion	Corrosion is caused by gas content containing water, CO2, H2S, or a percentage of SRB.	Leak Rupture
	Erosion Corrosion	Failure is characterized by metal loss or thinning of the pressure vessel caused by the abrasive material. The severity is determined by gas flow rate, pressure, type, and quantity.	Leak Rupture

2.2 Determine of Probability of Failure (PoF)

Determination of the probability of Failure (Probability of Failure), is done by evaluating the parameters of the damage by considering the percentage of each possible hazard that occurs. The scoring system is carried out following the requirements of the installation system. Parameters and percentages used in the determination of PoF such as

2.2.1 Corrosion Factor (30%)

Corrosion factors can cause a reduction in thickness or a possible hazard to the walls of the installation equipment (pipes and pressure vessels). A reduction in thickness can be caused by the interaction of pipe walls and pressure vessels with the products/fluids contained in pipes and pressure vessels. To determine the value of the corrosion factor, there are several variables as follows: Inspection frequency (20%), equipment service life (20%), external protection (15%), equipment material (15%), fluid impact (15%), water impact (15%).

2.2.2 Operating Condition Factor (25%)

In operating conditions, some factors may allow the installation facility to fail. Factors that can cause Failure are leaks in the installation equipment. To determine the operating factor value, there are several variables as follows: Excess flow (25%), excess pressure (30%), pressure shift (15%), level shift (15%), and temperature shift (15%).

2.2.3 Electrical Failure (5%)

In addition to leading equipment such as pipes and pressure vessels, the ORF installation also includes electrical instruments. As for the possibility of damage that can occur to the electrical system caused by internal factors (electrical equipment inspection frequency) (55%) and external factors (history of being struck by lightning) (45%).

2.2.4 Leakage Factor (10%)

ORF installations have the highest design pressure of 2300 PSIG and an operating pressure of up to 1200 PSIG. Under these operating conditions, it can cause erosion-corrosion and lead to leakage failure. To determine the leakage factor value, there are several variables as follows: Leakage history (40%), flange management (30%), and valve inspection interval (30%).

2.2.5 Third-Party damage (10%)

On the third party, factors indicate the extent of activity or distraction from the third party to the ORF installation. Third-party interference, in this case, is the history and possibility of sabotage of the ORF installation operation

2.2.6 Equipment Design (10%)

In the equipment system design factor, an assessment is carried out on the suitability of the equipment design with applicable codes and standards both nationally and internationally.

2.2.7 Construction Factor (10%)

In the construction factor of the equipment, an assessment of the suitability of the equipment with the as-built drawing is also carried out and its supervision.

2.3 Determine of Consequence of Failure (CoF)

The consequences of Failure are determined based on the risk parameters applied by the company by considering the weight of each consequence factor on the possible events that occur during operational activities. The calculated consequence parameters described as below.

2.3.1 Safety Factor (30%)

The variable of the safety factor is the level of fatality that can occur in the Onshore Receiving Facility Installation in the event of an operation failure. The safety level is rated the size of the leak diameter. The safety variable weights 30% of the total consequences of installation failure.

2.3.2 Environmental Factor (25%)

The environmental impact variable is reviewed by the level of pollution or damage caused by the installation equipment if it experiences Failure or leakage. On the consequences of environmental damage, an assessment of the type of fluid service (40%), flammability (30%), and population density (30%) are carried out. The environmental damage variable weighs 25% of the total consequences of installation failure.

2.3.3 Assets Loss (35%)

The variable consequence of company asset loss is the variable that states the company's infrastructure damage caused by equipment damage to the ORF installation. The asset damage variable weighs 35%.

2.3.4 Company Reputation (10%)

The company reputation variable shows the degree of damage to the company's reputation that can be caused by failure or damage to the ORF installation. A company's reputation is determined by media exposure of failure or damage; this variable weights is 10%.

2.4 Risk Calculation

After all the parameters of the probability of Failure (PoF) and Failure (CoF) have been determined, then the risk calculation is carried out as follows

Total PoF $= \sum PoF_{(i)} = 0{,}3\ PoF_{(1)} + 0{,}25\ PoF_{(2)} + 0{,}05\ PoF_{(3)} + 0{,}1\ PoF_{(4)} + 0{,}1\ PoF_{(5)} + 0{,}1\ PoF_{(6)} + 0{,}1\ PoF_{(7)}$ ……………………….(1)

Total CoF $= \sum CoF_{(i)} = 0{,}3\ PoF_{(1)} + 0{,}25\ PoF_{(2)} + 0{,}35\ PoF_{(3)} + 0{,}1 PoF_{(4)}$ ……………...(2)

Risk = Total PoF x Total CoF…..(3)

From the total probability and consequence, multiplication is then performed to obtain the ORF installation risk value. The results of the risk value calculation are then inputted into the risk matrix used. The risk matrix used is shown in Figure 1

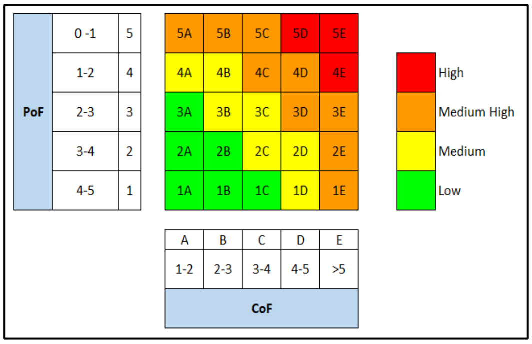

Figure 1 Risk Matrix

In this study, the Monte Carlo equation is used. Calculations are used with the simulation program to generate risk values according to the risk matrix. The certainty level that used on this simulation is 80-85%.

The risk matrix is divided into four main areas, namely the low-risk level, medium risk level, medium high-risk level, and high-risk level.

Table 2 Probability Category

Probability Level	Description
5	It happens several times per year in the company
4	It happens several times per year in the industry
3	Has occurred in the company
2	Has occurred in the industry
1	Never heard the industry

Table 3. Consequence Category

Conse quence Level	People	Environment	Property	Repu tation
E	Multiple fatalities	Massive effect	Extensive damage	Internatio nal impact
D	Fatality	Major effect	Major damage	National impact
C	Major injury potential	Localized effect	Localized damage	Considera ble impact
B	Minor injury potential	Minor effect	Minor damage	Limited impact
A	No health effect	No effect	No damage	No impact

3 RESULTS AND DISCUSSION

3.1 Probability of Failure Calculation

3.1.1 Corrosion Factor

Based on the assessment, the corrosion factor score is 3.60. The result is obtained from the following scoring results: Inspection frequency score 4.00, equipment service life 2.00, external protection score 5.00, equipment material score 3.00, fluid impact score 4.00, and water impact score 4.00. The following figure is the simulation result of Crystal Ball for the corrosion factor.

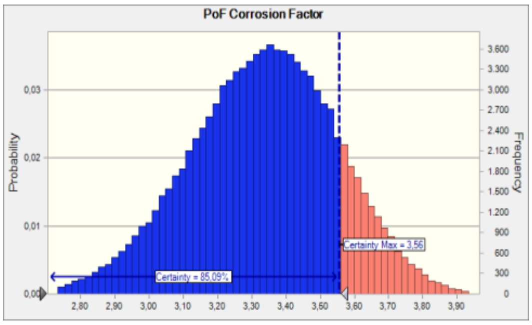

Figure 2 Corrosion Factor Simulation

Based on Figure 2, the total PoF value of the corrosion factor is 3.56, with a certainty level of 85%.

3.1.2 Operating Condition Factor

Based on the assessment, the operating condition factor score is 4.10. The result is obtained from the following scoring results: Excess flow score 5.00, excess pressure score 3.00, pressure shift score 4.00, level shift score 4,00, and temperature shift score 5.00. The following figure is the simulation result of Crystal Ball for the operating condition factor

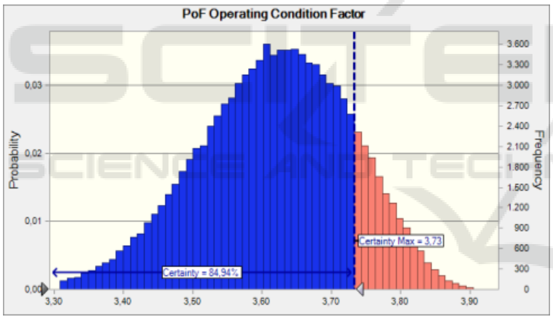

Figure 3 Operating Condition Factor Simulation

Based on Figure 3, the total PoF value of the operational factor is 3.73 with a certainty level of 85%

3.1.3 Electrical Failure

Based on the assessment, the electrical failure score is 3.35. The result is obtained from the following scoring results: Electrical equipment inspection frequency scores 2.00 and history of being struck by lightning score 5.00 The following figure is the simulation result of Crystal Ball for the electrical failure.

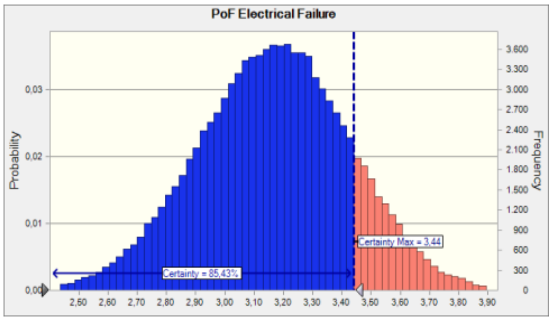

Figure 4 Electrical Failure Simulation

Based on Figure 4, the total PoF value of the electrical failure is 3.44, with a certainty level of 85%

3.1.4 Leakage Factor

Based on the assessment, the leakage factor score is 5.00. The result is obtained from the following scoring results: Leakage history score 5.00, flange management score 5.00, and valve inspection interval score 5.00. The following figure is the simulation result of Crystal Ball for the leakage factor

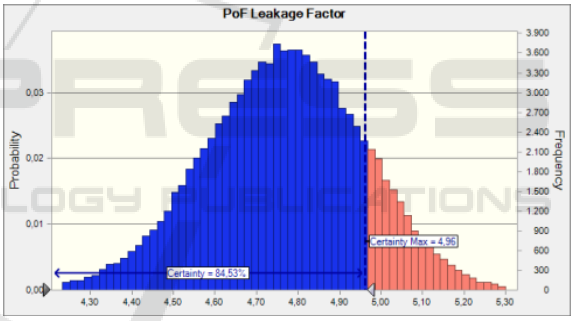

Figure 5 Leakage Factor Simulation

Based on Figure 5, the total PoF value of the electrical failure is 4.96 with a certainty level of 85%

3.1.5 Third Party Damage

Based on the assessment, the third-party damage score is 5.00. These results are based on the situation surrounding the installation being stable, and there is no history of sabotage. The following figure is the simulation result of Crystal Ball for the Third Party Damage.

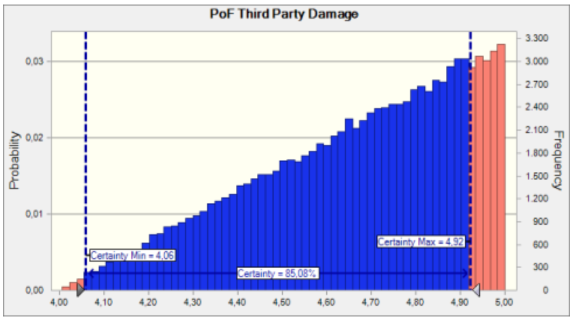

Figure 6 Third-Party Damage Simulation

Based on Figure 6, the total PoF value of the third party damage is 4.92, with a certainty level of 85%.

3.1.6 Equipment Design

Based on the assessment, the equipment design score is 5.00. These results are based on the design is well documented, and the design of the equipment meets the international applicable codes & standards. The following figure is the simulation result of Crystal Ball for the Equipment Design.

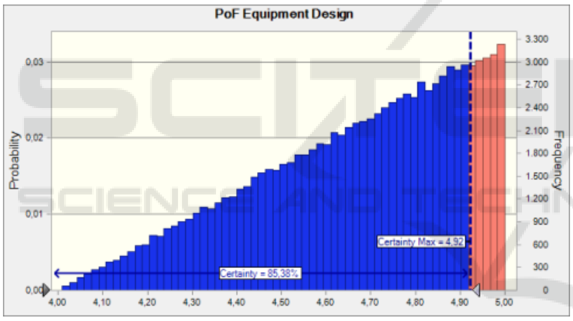

Figure 7 Equipment Design Simulation

Based on Figure 7, the total value of the equipment design is 4.92 with a certainty level of 85%.

3.1.7 Construction Factor

Based on the assessment, the equipment design score is 4.00. These results are based on the equipment constructed following (as-built drawing) and mainly supervised (75%). The following figure is the simulation result of Crystal Ball for the Construction Factor.

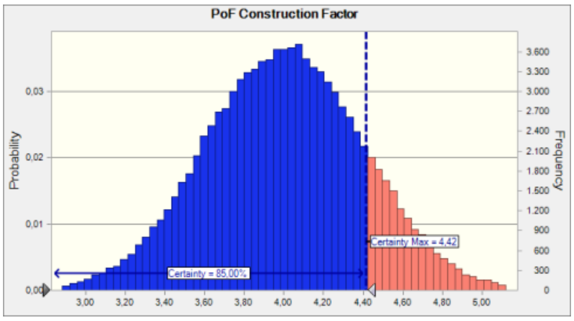

Figure 8 Construction Factor Simulation

Based on Figure 8, the total value of the equipment design is 4.42 of 85%

3.1.8 Probability of Failure Total Score

The following figure is the simulation result of Crystal Ball for total Probability of Failure (PoF)

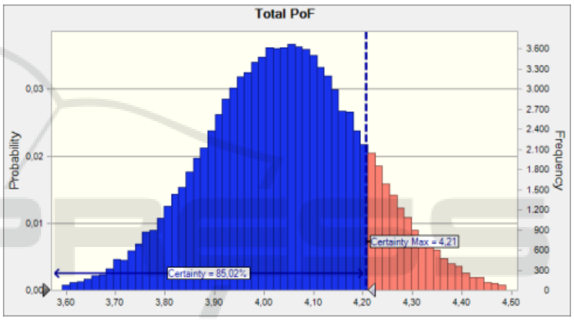

Figure 9 Total PoF

Based on Figure 9, the total PoF value of installation is 4.21, with a certainty level of 85%. Referring to the risk matrix, the probability level is at level 1

3.2 Consequence of Failure Calculation

3.2.1 Safety Consequence

Based on the assessment, the safety factor score is 1.00 of 5.00. These results are based on no leakage history in the installation.

3.2.2 Environmental Consequence

Based on the assessment, the environmental score is 3.50 of 5.00. These results are based on the installation fluid service score is crude oil & sweet natural score 5.00 of 5.00 which are flammable material, but there is no ignition source the score 2 of 5.00, and the density of population is ASME location class 2 the score 2 of 5.00

3.2.3 Assets Loss Consequence

Based on the assessment, the assets loss score is 1 of 5.00. These results are based on the 1 (one) day production delay, which cost <US$ 1 million in repair, but there is no record of shutdown history.

3.2.4 Company Reputation Consequence

Based on the assessment, the company reputation consequence score is 4 of 5.00. These results are based on the national media coverage in the event of an installation failure.

Table 4. CoF Calculation Result

No	Consequence	Percentage	Score	Final Score
1	Safety Factor	30%	1	0.3
2	Environmental Factor	25%	3.5	0.88
3	Assets Loss	35%	1	0.35
4	Company Reputation	10%	4	0.4
TOTAL CoF				1.93

3.2.5 Final Risk

Based on Total PoF x Total CoF, the result of ORF Installation shown in the figure below.

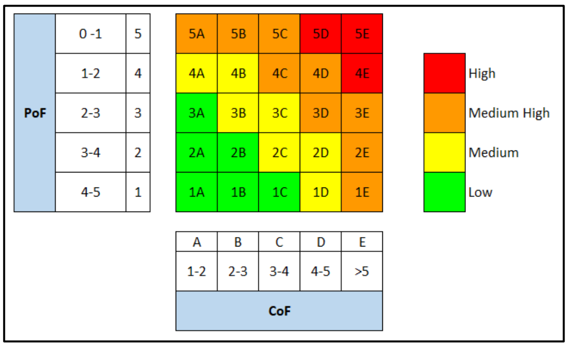

Figure 10. Final Risk

4 CONCLUSIONS

Based on the risk analysis assessment results, the probability level is 1 (one), and consequence A so refer to the risk matrix that the risk level of the Onshore Receiving Facility Installation is in the "Low" zoning, which indicates an insignificant and acceptable risk profileg.

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