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Risk-Based Inspection Analysis of Api 581 Pressure Safety Valve and Stripper Acid Gas Removal Unit at PT. XY

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ABSTRACT - The process involving the stripper equipment in the Amine Gas Recovery Unit (AGRU), which separates rich amine, is a crucial part of the natural gas purification system. The use of a pressure safety valve is essential to maintaining operational safety. Long-term mechanical damage can lead to equipment failures such as leaks, fires, and poisoning, negatively impacting production efficiency and personnel safety. Risk-Based Inspection (RBI) is a method for inspecting, preventing, and controlling incident risks through mathematical inspections related to Probability of Failure (POF) Analysis, Consequence of Failure (COF) Analysis, and Risk Evaluation, with the output being an inspection schedule. The study results include the probability of overpressure under fire scenarios (2,82504 x 10-08), overfilling (7,06261 x 10-07), failure to open (1,49 x 10-05), and leak (3,64 x 10-02), with the consequence category averaging E, indicating that the Matrik Risiko from these scenarios is high risk. The inspection schedule is set every four years because the remaining life is half the project duration, warranting inspections at a maximum interval of 10 years. This four-year interval is based on the regulations from the Ministry of Energy and Mineral Resources No. 38 of 2017. Operational conditions, such as frequent foaming in the AGRU influence it.

Keywords: RBI, POF, COF, risk analysis, inspection scheduling.

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INTRODUCTION

The process of stripper equipment in the Acid Gas Removal Unit (AGRU) separating rich amine (amine that has absorbed acid gases such as H_2S and CO_2) is a critical part of the natural gas purification system. Continuous processing of the stripper equipment can cause mechanical damage, such as corrosion (Saifulloh 2018). Pressure Relief Valve has the characteristics of fast opening or pop action and is proportional to the increase in pressure 13 opener. Based on the application, it can be used for liquids or fluids that can be compressed (Dyah et al. 2016). Stripper equipment will undoubtedly experience a decrease in performance, which affects the quality systematically, causing the impact of accidents. The examination and inspection process carried out in oil and gas installations is an essential and necessary thing in supporting the safety and reliability aspects of stripper equipment (Petroleum Institute 2006).

Failures in equipment might be the consequence of mechanical damage that has been present for an extended length of time., such as leaks, fires, and poisoning (Haugen et al. n.d.). There are four main reasons for the importance of maintenance: first, to ensure the safety of involved individuals; second, to enhance the effectiveness, efficiency, and reliability of work units; third, to prevent damage to work facilities; and fourth, to ensure continuity of operations through the availability of work facilities (Ir 1983).

Figure 1
Damage to one of the supporting structures of tank T-1B (Dyah et al., 2016)

Based on Figure 1, In 2020, the Makassar LPG Depot of PT Pertamina (Persero) MOR VII, which has tank T-1A and tank T-1B built in 1975, experienced an incident in the form of shifting the tank towards the southern foundation, shortly after the LPG loading process. This was caused by the 6 (six) supporting structures/pillars failing to accept the load. As a result, damage also occurred to the bracing structure and the inlet and outlet pipes which decreased towards the floor. This occurred because there was severe corrosion in the supporting structure of the T-1B LPG tank, which was mostly covered by a layer of refractory concrete so that the corrosion attack could not be seen from the outside and could not be inspected (Direktorat Jenderal Minyak dan Gas Bumi 2020). RBI (Risk Based Inspection) is a risk-based method for conducting an inspection; this method classifies operational equipment based on its level of risk because each tool has a different risk. The RBI method is implemented to ensure that high-risk equipment is handled with the utmost care, while lower-risk equipment is handled as required, reducing the frequency of excessive inspections (Qathafi & Sulistijono 2015). The implementation of the RBI method is based on two parameters, namely POF (Probability of failure) and COF (Consequence of failure). POF is influenced by several things, namely the type of equipment material being analyzed, corrosion rate, inspection effectiveness, and expert opinion, COF is influenced by the working fluid and its phase, toxic content, temperature, pressure, isolation, and mitigation systems (Soelaiman et al. 2004).

In accordance with prior research that employed the RBI (Risk-Based Inspection) methodology, the results obtained for the ETA-V-003 separator equipment have 24 parts that occupy the medium-risk category and four parts that occupy the medium high-risk category. Hence, the inspection schedule for parts with a medium risk level is 3 years, and for medium-high risk, detailed analysis and repair are carried out (Qathafi & Sulistijono 2015). With the above results, the RBI method effectively determines the risk of inspecting the separator equipment. With the above results, the RBI method effectively determines the risk of inspecting the separator equipment. Meanwhile, the RBI method results indicate that a more in-depth risk assessment of underground CO_2 storage is necessary to meet established safety standards. This study on three types of geological formations shows low to medium risk levels, suggesting that CO_2 can be safely stored in well-characterized locations (Lusyana & Atmanto 2022).

RBI is a risk control method for stripper equipment that conducts quantitative inspections related to POF analysis, COF analysis, and risk evaluation. The outputs achieved, namely inspection results such as damage mechanism identification, rate of deterioration, or so-called remaining life and equipment tolerance for determining future inspection plans (Institute n.d.). That is why the author took the final project title, namely "Risk Based Inspection Analysis of Api 58i Pressure Safety Valve & Stripper Acid Gas Removal Unit at Cpp PT XY".

METHODOLOGY

Research Method

Based on Figure 2 above, the literature study in this research focuses on examining Applying the Risk-Based Inspection (RBI) methodology in conjunction with Application Programming Interface 581 in order to acquire an understanding of the computation of the POF and the COF in order to determine the level and value of risk. Issues related to the inspection object, namely the stripper, are also analyzed. During the data and information collection phase, relevant data are gathered to achieve optimal risk analysis results, involving both primary and secondary data. In the initial phase of RBI implementation, several adjustments are made before the calculation of probability and consequence is carried out. The Probability of Failure calculation aims to determine the likelihood of failure occurring in equipment protected by the PSV. Consequence calculations are performed based on consequence level 1, which is adjusted according to the area. Risk is then determined by multiplying The level of risk is established by contrasting the risk value that was acquired with the risk objective that was established beforehand, and the chance of failure is established by the consequences that would result from failure. The final stage involves developing an inspection plan based on according to the results of the RBI research, the amount of risk that the equipment poses. The following is a detailed sequence or scenario of the research:

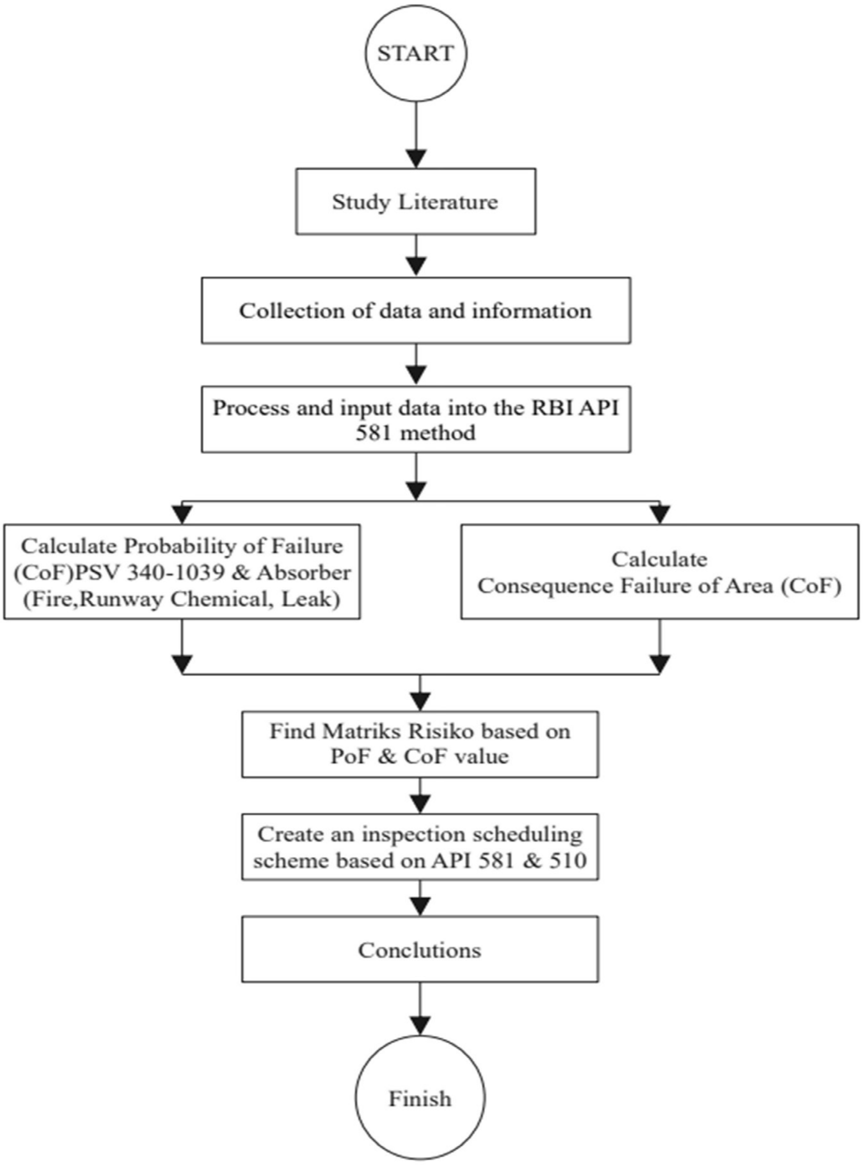

Figure 2
Flowchart of ageing study work method on AGRU (acid gas remove unit)

Study Literature

This literature study aims to gain an understanding of the risk-based inspection (RBI) methodology, which makes use of API 581, the computation of the probability of the PoF and the coefficient of determination (COF) is included in order to determine the extent of risk and its value. This study also includes understanding the problems with the object of inspection, namely the stripper.

Collection of Data and Information

At this stage, the main objective is to collect relevant data to obtain optimal risk analysis results. This research requires both primary and secondary data. Primary data includes inspection results on the equipment, process flow diagrams, piping and instrument diagrams, and specifications and designs of the Stripper and PSV. Meanwhile, secondary data consisted of historical data and interviews with engineers about the equipment.

Date Safety Valve and Stripper

Table 1
PSV and stripper operating and material data

Process Conditions		
Name	**Value**	**Unit**
Operating Pressure	15.8	psig
Set Pressure	50	psig
Operating Temperature	338	°F
Relieving Temperature	274	°F
Total Back Pressure	9.19	psig
% Allowable Overpressure	10	%
Material PSV		
Body and Bonnet	SA 351 Gr. CF8M	
Bonnet	316L stainless st	
Seat and Rings	316L stainless st	
Resilient Seat Seal	316L stainless st	
Material *Stripper*		
hemispherical thickness (cap top)	13	mm
thickness vessel top	12	mm
thickness vessel model	12	mm
thickness vessel bot	15	mm
hemispherical thickness (cap bot)	16	mm

Fluid properties

Table 2
Fluid properties

Name	**Value**	**Unit**
vapor Density	993,029	Kg/m^3
NBP	217	°F
Auto Ignition Temperature	500	°F
Discharge Coefficient Liquid	0,61	-
Gravitasional Constant	1	-
H_2S	14800	PPM
CO_2	12950	PPM
Inventory Group Mass	11435.046	kg

RBI Initial Stage Work

At this stage, some adjustments are needed before calculating probability and consequences. These adjustments need to be made in the assessment using the RBI method in PRD, including: 1). Selection of PRD type; 2). Determining the hazard level of the operating fluid; 3). Determine the cause of overpressure; 4). Determine the protected equipment and 5). Determine the type of scenario.

Calculation of Open and Leak Failure Probabilities

The Probability of Failure (POF) calculation is performed to obtain the probability value of failure for equipment protected by a Pressure Safety Valve (PSV) based on one or more failure factors (American Petroleum Institute 2016). The probability of the The failure of the Pressure Relief Device (PRD) to open when it is required, as well as the likelihood that the protected equipment would be damaged experiencing leakage under high pressure. Fire, overfilling, runaway chemical reactions, etc can cause excess pressure. Each excess pressure scenario has a corresponding damage range DR_j. The following is the equation for the POF for the PRD:

$$P_{f,j}^{prd} = P_{fod,j} \; X \; DR_j \; X \; P_{f,j} \quad (1)$$

Where:

$P_{f,j}^{prd}$ = Is there a connection between the point of failure of a PRD and the jth overpressure demand scenario, failures per year.

$P_{fod,j}$ = Is the PRD POFOD associated with the j th overpressure demand case, failures/demand.

DR_j = Is the demand rate linked to the jth overpressure demand scenario, expressed in demands per year?.

$P_{f,j}$ = Is the POF (probability of failure) of the safeguarded equipment linked to the th j overpressure demand scenario, failures per annum?.

The determination of leakage is made using the following equation:

$$P_{l,j}^{prd} = pfod \; x \; Fop, j \quad (2)$$

Where:

$P_{l,j}^{prd}$ = Is the number of failures that occur annually used to measure the chance of leakage in the PRD.

$pfod$ = Where does the PRD POFOD, failures/demand fall?.

Fop, j = In the event of an overpressure demand at point j, the adjustment factor for overpressure.

Consequence Calculation Failure of Area

The consequences are calculated based on consequence level 1, the consequence area. The determination of the consequence area is as follows:

Consequences of Fire and Explosion

The consequence components of fire and explosion incidents:

$$CA_{cmd}^{flam} = \left(\frac{\sum gff_n \times CA_{cmd,n}^{flam}}{gff_{total}}\right) \quad (3)$$

Where:

CA_{cmd}^{flam} = In what degree does the final probability weighted component imply that the flammable consequence area, measured in square feet (m^2), is a flammable area?.

$\sum gff_n$ = Which of the following is an example of the general failure frequency: the failure rate per year for each of the n release hole sizes that were selected for the type of equipment that is being analyzed.

$CA_{cmd,n}^{flam}$ = Is the area of combustible consequences from blended equipment damage connected use the nth release hole size, which is m^2 (ft^2).

gff_{total} = Is all of the different release hole sizes added together to form the generic frequencies?.

The consequences of injuries resulting from fire and explosions.

$$CA_{inj}^{flam} = \left(\frac{\sum gff_n \times CA_{inj,n}^{flam}}{gff_{total}}\right) \quad (4)$$

Where:

CA_{inj}^{flam} = The ultimate probability-weighted area for personnel injury owing to flammable effects is measured in square meters (m^2) or square feet (ft^2), depending on the type of material being used.

$\sum gff_n$ = Is the annual failure rate for each of the n selected release hole sizes pertinent to the equipment under analysis an illustration of the general failure frequency.

$CA_{inj,n}^{flam}$ = Is the personnel injury consequence area combustible for instantaneous releases that are likely to auto-ignite, based on the release opening size in square meters (ft^2)??.

gff_{total} = Is the total of the unique release hole dimensions standard frequencies?.

Toxic consequences

$$CA_{inj}^{tox} = \left(\frac{\sum gff_n \times CA_{inj,n}^{flam}}{gff_{total}}\right) \quad (5)$$

Where:

CA_{inj}^{tox} = Could you please provide the final probability weighted personnel harm toxic consequence area, in square feet?.

$\sum gff_n$ = Is the generic failure frequency for each of the n release hole sizes selected for the type of equipment being evaluated, failures/year.

$CA_{inj,n}^{flam}$ = Is the personnel injury consequence area flammable for instantaneous releases that are likely to auto-ignite, as a result of the n release opening size, in square meters (ft^2)?.

gff_{total} = Is all of the different release hole sizes added together to form the generic frequencies.

The Release of Non-Flammable and Non-Toxic Substances.

The consequence of being non-flammable and non-toxic is calculated for non-combustible and non-toxic liquids in accordance with the equipment used. Therefore, this calculation is stated as zero (American Petroleum Institute 2016).

Determining the consequences of final equipment damage and personnel injuries.

Component consequence area

$$CA_{cmd} = CA_{cmd}^{flam} \quad (6)$$

Where:

CA_{cmd} = Area of consequences of component failure, m^2 (ft^2).

CA_{cmd}^{flam} = To what extent does the final probability weighted component indicate that the flammable consequence area, m^2 (ft^2).

Personnel injury consequence area

$$CA_{inj} = CA_{inj}^{flam} \times CA_{inj}^{tox} \times CA_{inj}^{nfnt} \quad (7)$$

Where:

CA_{inj} = Area of the consequence of personnel injury, m^2 (ft^2).

CA_{inj}^{flan} = Area of consequence for personnel injury weighted by the final probability of flammability (m^2 or ft^2).

CA_{inj}^{nfnt} = The final weighted probability of the personnel injury consequence area for a release that is non-flammable and non-toxic, m^2 (ft^2).

CA_{inj}^{tox} = The weighted final probability of the toxic consequence area for injuries sustained by personnel.

Final consequence area

$$CA = max(CA_{cmd} \times CA_{inj}) \quad (8)$$

Where:

$CA = m$ = Is the ultimate consequence area, m^2 (ft^2)

CA = Area of consequences of component failure, m^2 (ft^2).

CA_{cmd} = Area of the consequence of personnel injury, m^2 (ft^2).

Risk Result Determination

Risk is determined based on the value of a comparison between the likelihood of failure and the possible outcomes of failure. The risk level is determined by comparing the risk value obtained with the risk target, which is observable in Table 7.18 API 581 determination of risk results: overfilling, fire, leakage, and failure to open.

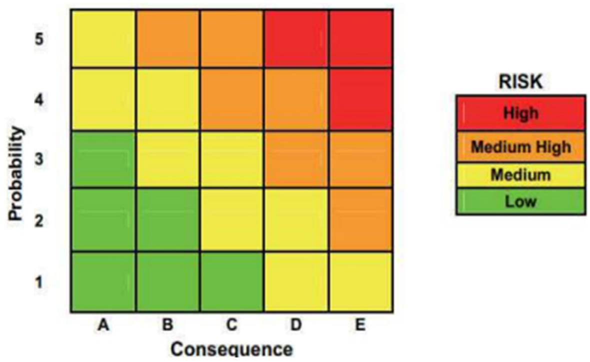

Figure 3
Risk matrix (American Petroleum Institute 2016).

Mapping the Probability and Consequence values based on the risk matrix, as seen in Figure 3above, for the purpose of graphically representing risk, is a successful strategy. There is a plot of probability on the horizontal axis and increases from its starting point. Users are responsible for defining and documenting the basis for determining the categories of Probability and Consequence, as well as the risk targets employed (American Petroleum Institute 2016).

Inspection Scheduling

Inspection planning is made according to the risk level of the equipment when the RBI analysis is performed.(Ir Dwi Priyanta & Dhimas Widhi 2016) The implementation of inspections does not directly reduce equipment risk, but it is expected to identify potential risks, schedule inspections of the stripper, and determine the inspection schedule based on the remaining lifespan, as given by the equation below.

$$R_L = \frac{t\ actual - t\ min}{CR} \quad (9)$$

Where:

R_L = Remaining life

$t\ actual$ = The actual thickness of the CML, in inches (mm), measured during the last examination.

$t\ min$ = The required thickness for CML or equivalent components in inches (mm)

CR = Corrosion rate.

Inspection is able to identify and quantify specific types of corrosion that may take place, including localized or general corrosion, cracking, and other sorts of damage. This type of corrosion can occur in a variety of places. Every category of damage has its own mechanism for detecting and measurement methods. Therefore, inspection planning is considered adequate if the inspection procedures and the extent of the locations that are being inspected are in accordance with the different kinds of damage that could take place. According to API 510 pressure vessel inspection, there are three types of inspections: internal, external, and on-stream inspections.

RESULT AND DISCUSSION

Results of Problem Analysis on Stripper Equipment Using HYSYS Method

It can be seen in Figure 3.1 above below the occurrence of weeping indications on trays one to five so as to cause the accumulation of liquid in the lower tray; this is what causes the H2S and CO_2 content that is followed down to be more. The correlation between the hysys results that can be seen in the figure above based on what happens in the field of demin water injected into the stripper based on actual conditions also affects the performance of the separation of H_2S and CO_2 in the stripper, where the demin water content can affect the mass and heat equilibrium between liquid vapors so that the composition of H_2S and CO_2 can be separated from rich amine when the reboiler temperature is increased (Hendriya Binawa Gana 2015). Chorealization between these problems if not controlling the operating conditions and internal cleaning of the column. This may cause overpressure on the stripper equipment.

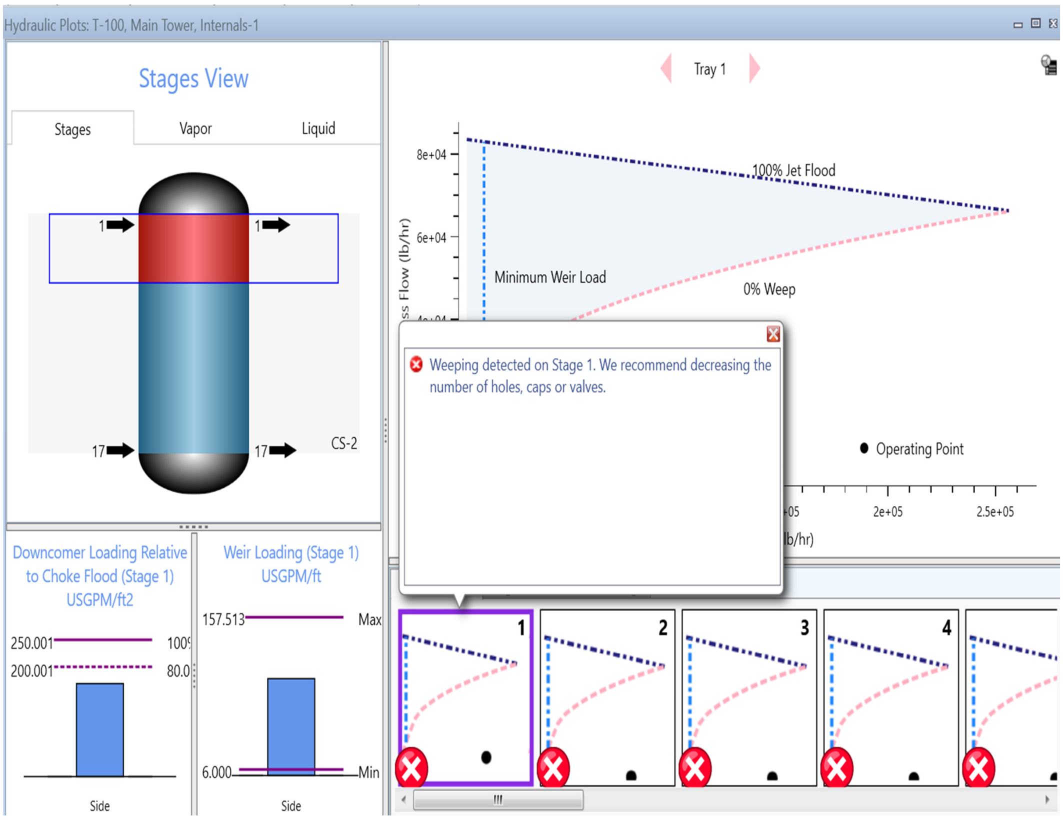

Figure 4
Internal column stripper based on HYSYS simulation

Following the method used to obtain inspection results to prevent the occurrence of risk probability to the AGRU unit, the following POF and COF PSV results will correlate to form an inspection schedule for stripper equipment.

Probability of Failure Open and Leak

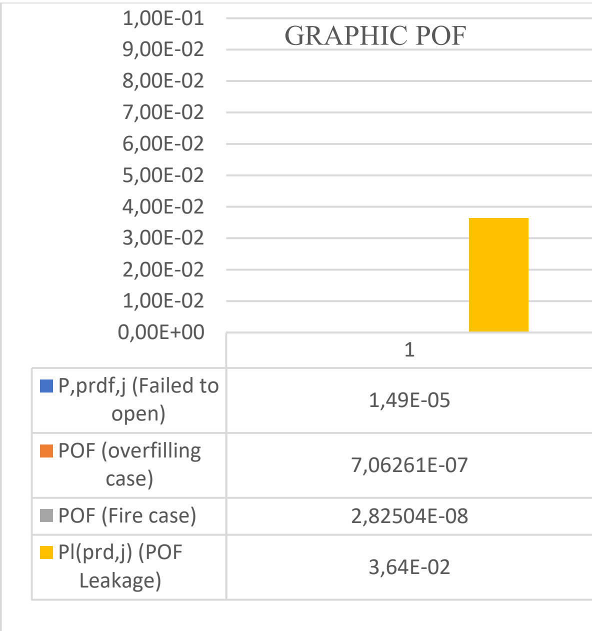

Figure 5
Graphic POF

Based on Figure 3.2. Determine the point of equipment failure that is protected from overpressure, Pf,j using DR (demand rate), which, as a consequence, failed to open, which is 1.0 based on API 581, MAWP of PSV equipment. From the results of Pf,j used to calculate the results of the likelihood of failing to open the PSV were determined by applying equation 1 to determine the probability of failing to open the PSV. the results of the probability of failing to open the PSV which is 1.49 x 10^{-05} failure/year. From the results of failing to open the PSV by looking at the risk matrix table, it can be said that the probability of failing to open the PSV is minimal because it is category 1.

Based on the table above, the results of POF overfilling and fire are obtained based on how to determine the probability of overfilling and fire. The results in the table above explain the probability that occurs in the overfilling and fire scenarios for the case of failure to open if there is overpressure on the equipment protected by the PSV (350-PSV-1057), which occurs against the risk of overfilling probability is minimal because the value of 7.06261 x 10^{-07} failures/year and the probability of fire is 2.82504 x 10^{-08} based on table 7.18b API 581, which is in category one.

The table above explains the probability of failure due to overpressure, which causes leakage of equipment; the probability of leak is obtained from the multiplication of the leakage probability by the ratio of the operational pressure to the pressure that was decided upon. Based on the results, the probability of leakage is greater than the probability of overfilling and fire because it has a result value of 3.64 x 10^{-02}. Based on the data table 7.4 results, API 581 is a basis for choosing the level of probability that causes leakage to the equipment so that the leakage results are obtained (moderate).

Consequence PSV Failure Area.

Cof analysis is carried out to estimate the consequences that may occur due to stripper overpressure that makes the PSV fail to open and leak. The following are the results of the consequence area of the equipment protected by the PSV.

Table 3
CoF result (consequence of failure)

COF Fc Value			
COF	**Value**	**Unit**	**Category**
CA (AIL) cmd, n	3793.736	m^2	E
CA (AIL) inj, n	16051.466	m^2	E
CA (AINL) cmd, n	1895.943	m^2	D
CA (AINL) inj, n	3471.626	m^2	E
COF Value AIT			
CA (flam)cmd,n	1895.943347	m^2	D
CA (flam)inj,n	3471.625993	m^2	D
COF Components and Personnel			
CA (flam)cmd,n	37.175	m^2	B
CA (flam)inj,n	68.071	m^2	B
COF Toxic			
CA (tox)inj	174811.1984	m^2	E
COF Final			
CA	68.071	m^2	B

Table 3 above is the result of the last or final consequence area of all consequences, namely flammability and toxicity. Where the specified time to produce a release of 1.7 seconds results in a

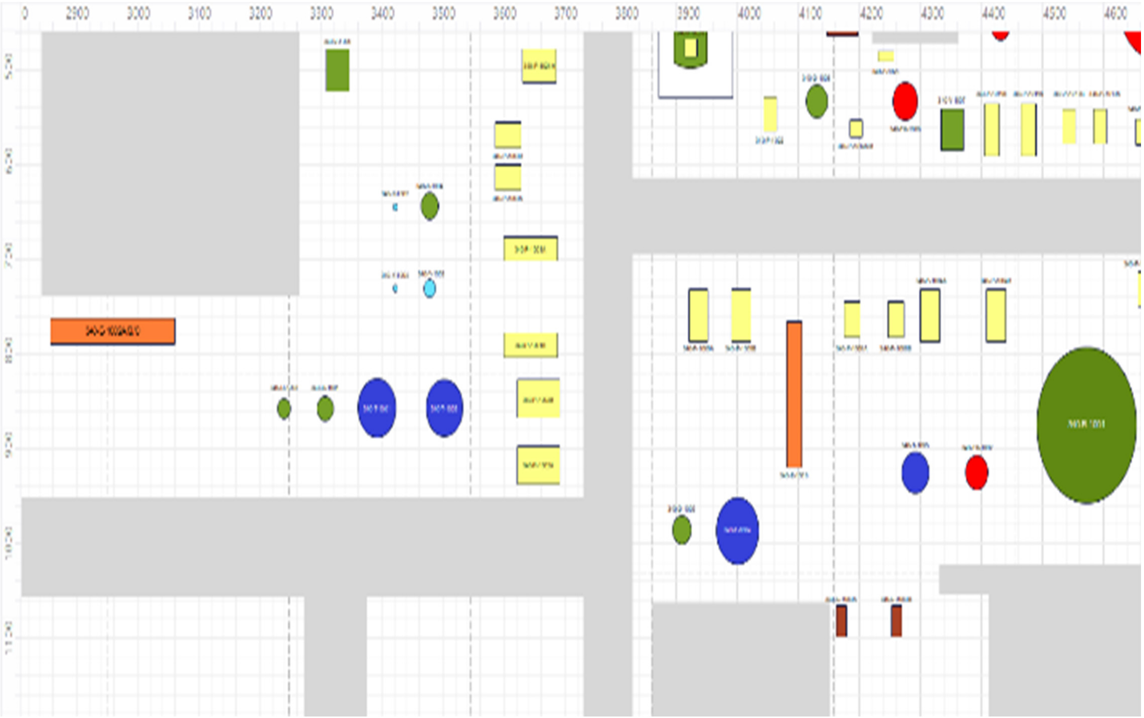

Figure 6
Stripper tool position layout

consequence of 68.071 m2 of the probability area. The results of the probability and consequence can be seen from the risk matrix; the risk result is low and high because it takes the average consequence that occurs, which is category E.

Based on Figure 6 in the picture above, failing to open the PRD can cause a consequence that influences other equipment, which can be seen in Figure 6 below. There is equipment beside the absorber, which is the central tower in the AGRU unit, so the consequence that occurs can cause a dangerous risk at PT XY. The stripper and absorber equipment are marked with red and blue lines. Will cause a consequence at the first 1.7 seconds marked by the first probability, namely leakage with a value of 3.64×10^{-02}, overfilling with a value of 7.06261×10^{-07}, fire with a value of 2.82504×10^{-08}. Therefore, the consequence of a fire is very small because there is a mitigation system from PT XY, namely a closed system, a control system, an outage system, and a fire prevention system.

Tabel Matriks Resiko

Based on Figure 7 Determination of the risk matrix fails to open based on table 4.18 API 581. probability or probability of overpressure that fails to open PSV, which can cause fire, overfilling, and leakage scenarios. The results obtained from the probability of failing to open based on API 581 are 1.49×10^{-05} with category 1, and the consequence of failing to open is category E. The result obtained from the average results of the consequences can be seen in the table above (the results of all COFs calculated). From the results of this matrix, it can be concluded that under a small probability, the occurrence of failing to open the overpressure case is extensive. However, the consequences of this failure to open are enormous.

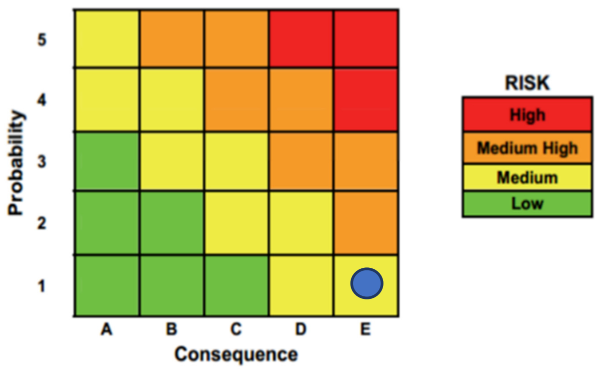

Figure 7
Risk matrix failure to open

Based on Figure 8 above, the results of the probability of fire and consequence obtained by the risk matrix are category E on the consequence and category 1 (2.82504 x 10-08) on the probability of the results obtained on the risk matrix based on table 7.18 of API 581, from the results of the risk matrix it can be said that the probability of the occurrence of fire due to failure to open and overpressure is minimal. However, the occurrence but consequence of fire is extensive because it has category E.

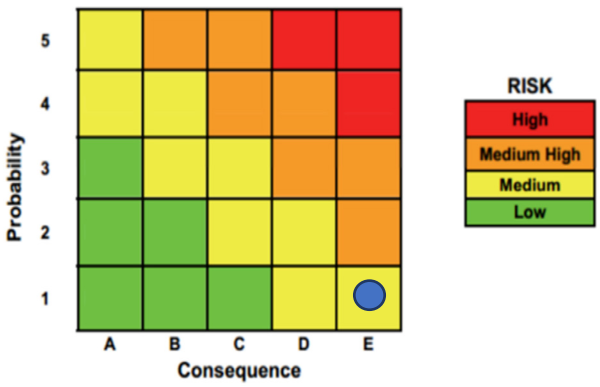

Figure 8
Risk matrix fire

Based on figure 3.6 above, the results in the overfilling risk matrix with a probability value of 7.06261 x 10-07, category one and consequence category E, so it is obtained that the probability that occurs in the overfilling scenario is minimal. However, the consequence caused by overfilling is enormous, so the risk of overfilling is said to be medium or moderate. The first event of a leak due to failure to open the PRD will result in the fluid coming out due to the large amount of liquid in the stripper.

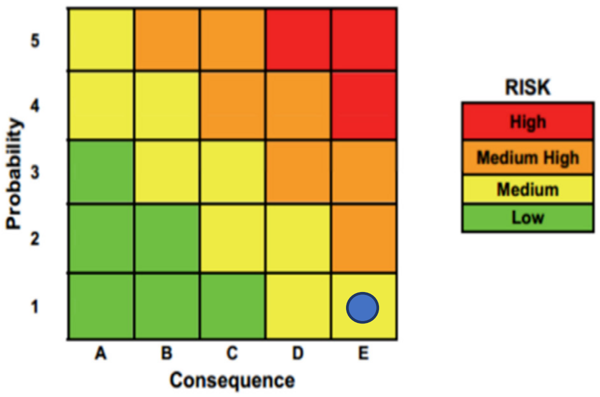

Figure 9
Risk matrix overfilling

From the results in Figure 3.7 of the leakage risk matrix, the probability category four and consequence category E results are obtained with a leakage probability value of 3.64 x 10^{-02} so that the probability of leakage is substantial compared to the probability of overfilling and fire due to failure to open, which is caused by overpressure.

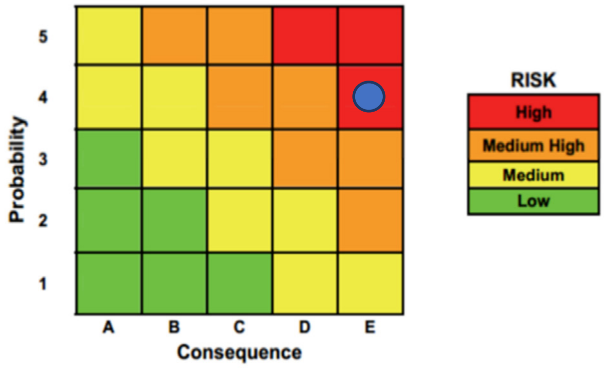

Figure 10
Leakage risk matrix

Inspection Schedule

Inspection is a method of checking the technical condition of equipment to ensure efficient and safe operation. The inspection schedule for depletion damage is determined based on the remaining service life of the equipment.

Table 4
Result of remaining life calculation

Name	t actual (mm)	t min (mm)	RL (year)
hemispherical thickness (cap top)	13	13	10.1553
thickness vessel top	12	12	9.3741
thickness vessel model	12	12	9.3741
thickness vessel bot	15	15	11.7177
hemispherical thickness (cap bot)	16	16	12.4989

From Table 4 above, the results of the remaining life of the shell stripper component from the hemispherical top to the bottom with the minimum thickness are equated with the actual because the related company has never checked the thickness in the last seven years from the installation time 2017. The remaining time of use of each component in the stripper has an average result - the average is still half the project life of 20 years. So, with reference to API 510, internal and on-stream inspections are used as a reference interval for the inspection schedule, which is a maximum of 10 years, which can be seen in the table below the inspection schedule.

Table 5
Inspection schedule calculation results

Name	RL	Schedule	Unit
hemispherical thickness (cap top)	10.15536	4	year
thickness vessel top	9.374179	4	year
thickness vessel midel	9.374179	4	year
thickness vessel bot	11.71772	4	year
hemispherical thickness (cap bot)	12.49891	4	year

Inspection scheduling is carried out based on the reference to the Minister of Energy and Mineral Resources regulation number 38 of 2017 concerning the condition of the primary stripper process, which has experienced a decrease in performance, which can be seen in Figure 4 (Internal stripper column based on HYSYS simulation) as a result of hysys simulation for depicting the internal condition of the stripper column, Determination of the scheduling value is also based on the risks experienced by the stripper presented in Figure 8 to 10 of the risk matrix which has a high risk based on the highest risk in the scenario due to overpressure, namely the risk of leakage, and based on the remaining life that is already half of the project life, the inspection time is 4 years.

Inspection Method

One of the goals of an inspection is to identify the potential dangers that may be present. in a scheme of events against process conditions so that it indicates damage or potential danger to a piece of equipment. Based on the risk results, namely high risk, with the probability of a vast scenario of leakage of 3.64×10^{-02} with category three, the occurrence of leaks has a higher interval. Also, each component in the stripper has a remaining life that is still half the life of the project, so the author assumes the inspection method based on API 581 under the internal inspection method of testing with ultrasonic waves, which is a procedure that does not cause damage that uses ultrasonic waves to detect internal defects, wall thickness, and corrosion. The selection of ultrasonic testing is also based on field conditions that process acid gas at a high concentration of 14800 ppm (1.48%mol). External methods are based on visual insulation testing, supporting structures, vibration, pressure, and leakage. External inspection allows early detection of internal damage. If the detection system shows signs of damage, follow-up measures such as internal inspections can be taken.

Based on previous research using the an approach known as Risk-Based Inspection (RBI) based the Stripper DA-101 equipment, it was found that the lining plate component has a medium-high risk level, while the tube, swirl, distributor plate, and sieve tray components are at a medium risk level. According to RBI standards, the Stripper DA-101 equipment requires internal inspections every 2 years and external inspections every 1 month. The Lining Plate, Tube, and Swirl components must be repaired immediately (Hendriya Binawa Gana, 2015). The results from the author's research indicate that the probability of overpressure is as follows: fire scenario (2.82504×10^{-8}), overfilling (7.06261×10^{-7}), failure to open (1.49×10^{-5}), leak (3.64×10^{-2}). The consequence results averaged to category E, leading to a Risk Matrix indicating a high risk (1) for the leak scenario and a medium risk (3) for the other scenarios. Based on Risk-Based Inspection (RBI) scheduling, inspections should be conducted every 4 years, half of the project's remaining life (RL) of 20 years. The results of the previous research correlate with the author's study, confirming the alignment of the RBI method in determining risks and scheduling inspections for equipment.

CONCLUSION

From the results and discussion above, the following conclusions are obtained:

The results of the probability of overpressure in the fire scenario (2.82504×10^{-08}), overfilling (7.06261×10^{-07}), failure open (1.49×10^{-05}), leak (3.64×10^{-02}), and for the consequence, results obtained the average category E so that the risk matrix obtained from the scenarios that occur is high risk. So, the probability of problems occurring in stripper equipment protected by PSV is greater.

The inspection schedule is set every 4 years because based on the results obtained the remaining life is half of the project time; the maximum inspection is 10 years, so an interval of 4 years is taken based on the basis of the Minister of Energy and Mineral Resources Regulation No. 38 of 2017, the selection of 4 years of inspection is also based on the influence of operating conditions due to the frequent occurrence of foaming on AGRU.

The application of the 4-year inspection schedule on stripper equipment is influenced by the risks experienced by stripper equipment if there is a failure to open the PSV with the highest consequence, namely leakage, resulting in consequences for components and personnel so that a high risk is obtained which correlates to the remaining life of the stripper equipment which is already half of the project life so that a 4-year schedule is set following the regulations.

It is using incomplete data results in determining inspection schedules and risk matrices that are less than the actual.

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No index entries were found. These should be concise. Ethics require that colleagues be consulted before being acknowledged for their assistance in the study. The heading for this section is the primary head described for the materials and methods section. Subdivisions are not used in this section.

GLOSSARY OF TERMS

Symbol	Definition	Unit
POF	Probability of failure	
COF	Consequence of failure	
CR	Corrosion rate	mm/year
R_L	Remaining life	year
NBP	Normal Boiling Point	-
$P^{prd}_{l,j}$	the PRD probability of leakage	failures/year
$P^{prd}_{f,j}$	the POF of a PRD associated	failures/year
DR_j	the demand rate associated	demands/year
$P_{f,j}$	the POF (loss of containment) of the protected equipment	failures/year
$pfod$	the PRD POFOD	failures/demand
$CA^{flam}_{cmd,n}$	The blended component damages the flammable consequence area	m^2
gff_{total}	the sum of the individual release hole size generic frequencies	failures/year
CA^{flam}_{inj}	the final probability weighted personnel injury flammable	m^2
$CA^{flam}_{inj,n}$	the final probability weighted personnel injury flammable	m^2
CA^{tox}_{inj}	the final probability weighted personnel injury toxic	m^2
CA^{flam}_{cmd}		m^2
CA	the final component damage consequence area	m^2
CA_{cmd}	is the final probability weighted component damage flammable consequence area	m^2
CA_{inj}	the final personnel injury consequence area	m^2

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