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DESIGN A *FEARLESS (FIRE SUPPRESSION AND SMART ALERT SYSTEM)* ON GAS LEAKS

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Abstract

In the natural gas management industry, gas leakage is a matter that must be considered. This is because if the leak is not handled immediately it will result in incidents and even work accidents that can lead to fatalities. To avoid gas leaks that can cause work accidents, a gas detector is used in the process to detect gas leaks from the start so that operators can find out if there is a gas leak. However, in the process, most of the gas detector equipment in the field experienced some damage which caused no gas leak to be detected and along with the development of gas detector detection system technology, its function could be upgraded to detect and extinguish fires caused by gas leaks. Taking these aspects into account, the purpose of this research is to design an automatic leak detection and fire extinguishing system called FEARLESS. The method used is a case study methodology and applied. From the data obtained in the field, it was found that there were 4 gas detector disturbances in 2019 and 5 times in 2020 which resulted in no detection of gas leaks when the detector was disturbed, as well as 34 gas leaks in 2019 and 42 times in 2020.

***Keywords**: Gas Leak*

1. Introduction

The oil and gas industry in Indonesia has currently been divided into 2 sectors, namely the petroleum management sector and the natural gas management sector (). The industry in charge of natural gas management has a work area that functions to analyze, calculate, regulate, close, increase and decrease gas flow called an *offtake station.* In gas distribution activities that are channeled through *offtake stations*, one of the most important things that must be considered and carried out risk control is related to gas leaks ( ). Under certain conditions, gas leaks can be caused by several factors, namely:

1. The pressure of the delivered gas exceeds the maximum specifications of the

equipment.

2. The presence of damaged equipment (*gas seal/repair kit*).

To find out the existence of gas leaks that occur at *the offtake station*, each gas facility is equipped with a gas leak handling system, including:

1. Gas Detector

   This gas detector is one of the main security equipment (*safety critical equipment*) that must be maintained related to the reliability of its function. The role of the gas detector is very important as the first sign or *alarm* in the event of a gas leak so that the operator or technician can immediately find out the accurate point of the location of the gas leak. However, at most *gas stations*, gas detector equipment does not function optimally, causing incidents or work accidents caused by gas leaks such as fires, explosions, and poisoning due to gas inhalation.

2. Leak Survey

   A leak survey is a gas leak checking activity using portable gas detectors and bubble liquids to ensure a leak in an area. This leak survey activity is carried out every 3 times in 1 week.

The following is the rate of work accidents in the oil and gas industry from 2015 to 2019 which has been classified at 4 levels: low, medium, severe, and fatal (Ditgen Migas, 2019).

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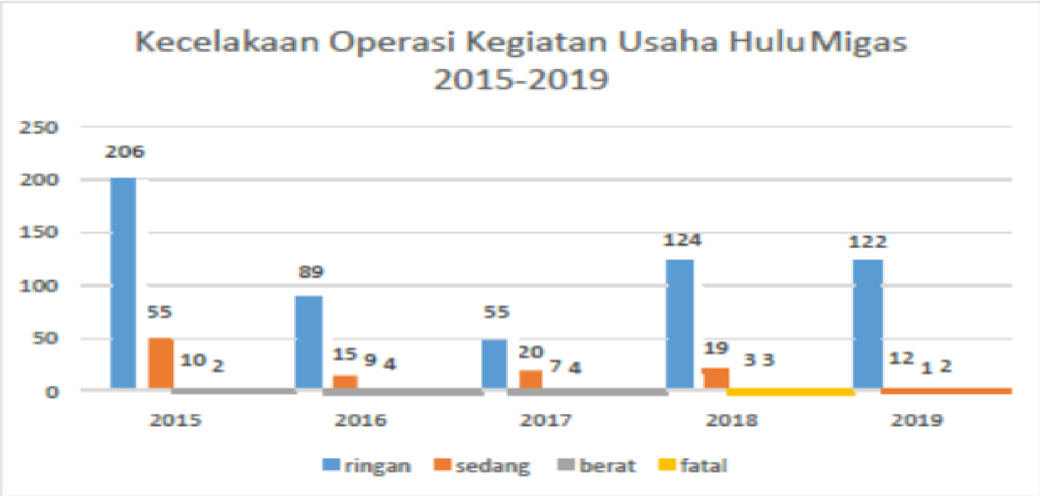

Figure 1. Work Accident Rate in the Oil and Gas Industry 2015 – 2019

Source: 2019 Performance Report of the Directorate of Oil and Gas KESDM

The non-optimal reliability of the gas detector function can result in *incidents* and even serious accidents and can cause huge losses to the company. Here is an example of an accident caused by an undetected gas leak.

In Indonesia, there are several cases of work accidents due to undetected gas leaks, including:

1. Batam

   Gas cylinders in one of the gas industries in Batam exploded and resulted in 1 person being killed and 3 people hospitalized.

2. Bekasi

   The LPG (*Liquefied Petroleum Gas*) filling plant was ripped off in the form of an explosion of an LPG filling station, where during LPG filling from the truck to the LPG cylinder there was a gas leak caused by a car shift, causing the hose to loosen and a gas leak. As a result of the accident, 4 people died from 70% burns and 7 people were treated (Asiyah Afiifah, 2020).

3. Cikarang

   Companies engaged in the cosmetic sector experienced a gas leak in *the flexible tube* (gas hose) installed in the *deodorant perfume spray* line 2 installation. The gas

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leaking from *the flexible tube was* exposed to the *dryer* heating engine, causing an explosion. The crash left 28 workers dead and dozens of workers injured.

Not only in Indonesia, but accidents caused by undetected gas leaks also occur abroad including:

1. Romania

   There was a fire in the administrative building owned by the oil and gas company, the incident began when there was a gas leak around the pekrja lodging location. The gas then enters the building and there is an accumulation of gas in the limited space, resulting in the lower flammability of the gas being achieved. This is what caused the explosion in the building. The accident resulted in 2 workers suffering burns.

2. India

   The leak was sourced at the LG Polymers facility where the gas leaked and was not known or there was no alarm related to the sign of a gas leak. The operator of such enterprises at that time continued to carry out the operation of the equipment according to the schedule. A few moments later there was an explosion caused by the accumulation of gas that occurred in the room. This accident resulted in 11 deaths.

3. Gulf of Mexico (Deep Water Horizon)

   The chronology of the explosion accident on the Gulf of Mexico rig was caused by a gas leak that passed through the cement safety layer, where the gas leak was not detected by humans/operators. This resulted in oil and gas passing through the BOP and gushing through the rig then catching fire and exploding. The explosion activated an automated emergency system designed to cut the pipeline in the event of an emergency, but the system was unsuccessful in cutting the oil and gas flow pipeline. The crash resulted in 11 deaths, 17 other critical injuries, and environmental pollution due to talarge amount of oil and gas spilled in the Gulf of Mexico.

From several examples of work accident cases (explosions) caused by the insufficiency of the detector gas function, it causes various kinds of losses, including:

1. Disadvantages in terms of human resources

   These losses include the loss of professional personnel caused by the accident.

2. Material losses

   This loss is in the form of assets or buildings owned by companies that have suffered damage due to accidents.

3. Disadvantages in terms of the surrounding environment

   This loss is in the form of a negative impact caused by chemicals released at the time of a gas leak so this which is the surrounding environment polluted.

The effect of not working the detector gas accurately causes a lot of gas to be wasted without a gas leak being detected so this will be very dangerous for the environment, the potential for work accidents due to gas explosions, and financial losses due to gas leaks. The following is data on gas leaks in one of the oil and gas industries in the period from 2016 to 2020.

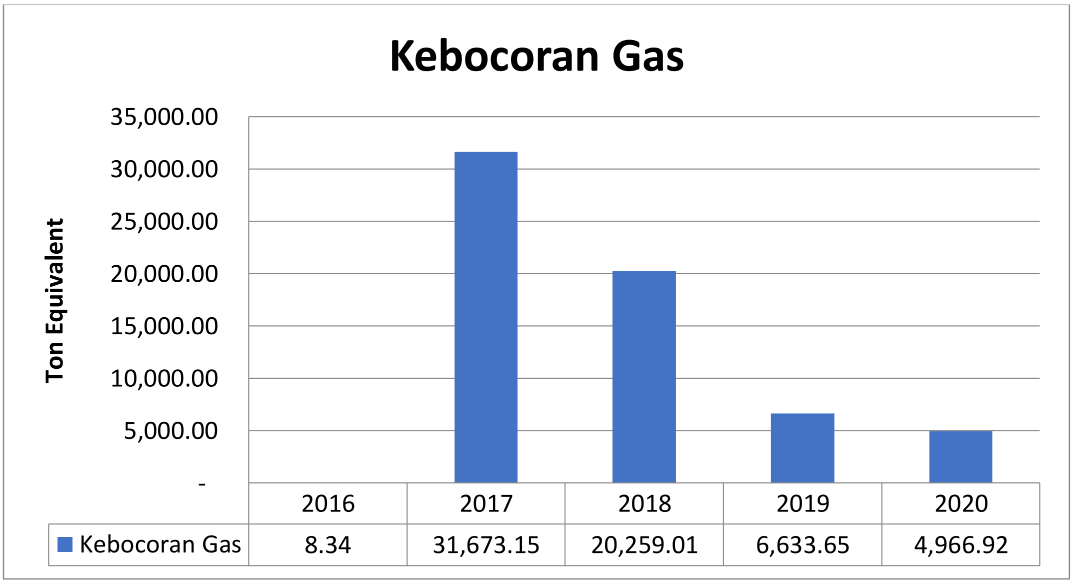

Figure 2. Gas Leaks 2015 – 2019

Source: PT PGN Year 2020

In 2019 there were 4 failures or disturbances that occurred in the detector gas system and 2020 there were 5 failures or disturbances. This results in no gas leakage being detected when the device is disturbed.

Seeing the importance of the gas detector function as an alarm or the main marker in the event of a gas leak, this study will discuss related to improving the reliability of the detector gas by using *FEARLESS (Fire Suppression And Smart Alert System).*

2. Theoretical Foundations

In conducting research, previous research sources are needed to compare the research that the author did with the results of research conducted by others. The research conducted by the author was themed on improving the reliability of detector gases by using FEARLESS (Fire Suppression and smart alert system). The following is a summary presentation quoted from several national and international journals that arebyh the research carried out.

Table 1. Mapping research results

No	Writer	Year	Method	Research Results
1	(Yingting LUO et al.,)	2015	Dissolved Gas Analysis	Gas detection can be carried out using the principle of spectrum theory which uses infrared as a means used to calculate the amount of dissolved gas content.
2	(Tahani Aldhafeeri et al.,)	2020	Gas detection using optical, calorimetric, pyroelectric, metal oxide, and electrochemical sensors	Optical, calorimetric, pyroelectric, semi-conductor metal oxide and electrochemical sensors can function quickly and reliably. Related advantages and disadvantages can be selected according to the needs and conditions of the field.
3	(Pak Sibu Thomas et	2014	Gas detection	Gas detection using laser-based ionization

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	al.,)		using ionization detectors	detectors effectively detects the presence of methane concentrations.
4	(Wang Wen--qinga et al.,)	2012	Gas detection using spectroscopic methods	Detection of gas leaks using spectroscopic methods can effectively detect gases with low concentrations
5	(Jacob Geersen1 et al.,)	2010	Detecting methane gas leaks with gas detectors	The need to carry out the detection of methane gas occurring on the seabed
6	(Khan & Abbasi,)	2015	LPG gas leak detection smart tool was made with SMS notification	These systems and tools work as expected, and can detect LPG gas leaks and can send SMS notifications and activate alarms.
7	(K. Manichandana et al.,)	2018	The main objective of the work is to design a microcontroller based toxic gas detecting and alerting system.	IoT (Internet Of Things) technology to detect gas leaks with an additional smart alerting feature that uses text message delivery to relevant authorities can detect gas leaks that occur in the environment.
8	(Abhishek et al.,)	2017	Made to design and fabricate a safety device for detecting LPG and natural gas that avoids any accident from the leakage.	The prototypes made can detect effectively and efficiently detect low and high gas leak rates so that they can warn users if there is a gas leak.
9	(B. Amutha et al.,)	2020	Gas and smoke detection using Node MCU.	Gas leak detection information can be collected and monitored as one in a computer that is collected in a single database.
10	(Anjali M et al.,)	2018	Detected gas leak	The gas leak was successfully detected using

			with MQ6 sensor.	hardware using the MQ6 sensor.
11	(Tixier et al.,)	2017	HAZOP study	The presented CASE HAZOP study shows that although the bioethanol process is mature and does not contain hazardous chemicals or extreme operating conditions, it still finds the presence of unacceptable hazardous conditions such as fires and explosions.
12	(Xiang Li & Pei Liang Sun)	2016	Risk Analysis on Leakage Failure by the fuzzy bayesian network with a bow-tie model	Fault tree analysis, event tree analysis, and Bowtie models are excellent methods for leak risk analysis.
13	(N. Nithiya Rani,)	2014	Gas leakage monitoring and control using LabView	The system can detect the gas level in the air if it exceeds the specified set point, the LabView method is also used to monitor all leaks on a single display.
14	(Uthman Baroui,)	2019	Gas leak detection with LDS (Leak Detection System) and Data Fusion	The LDS (Leak Detection System) method can reduce the risk of gas leaks that can arise.
15	(P. Kalpana et al.,)	2020	Gas Leak Detection, Monitoring, and Safety System using IoT	This system functions properly so that if a gas leak is detected, the system will send a sensor signal to turn on the buzzer so that it can provide information that there is a gas leak.
16	(Sebasrian Iwaszenko et al.,)	2021	Detecting gas leaks using UAVs equipped with gas detectors	Leak detection using data UAVs runs well, and can even detect gas leaks in the ground.
17	(Graham M. Gibson et al.,)	2017	Detect gas leaks by using a camera	Detecting gas leaks can be more accurate by increasing the pixels of the detecting camera.

			lens	
18	(Siyue He et al.,)	2019	Accidents due to gas leaks	This is due to the uneven quality of workers, operations and construction have not been carried out as needed, and the management's lack of attention to the danger of gas leakage.
19	(Bara J. Emran et al.,)	2017	Detect gas leaks using UAVs	Leak detection using a UAV equipped with a laser detector can visualize the boredom of the pipeline.
20	(Margaret F. Hendrick et al.,)	2016	Leak detection using CH4 flux	Gas leaks can be detected and if left untreated can cause potential explosions in city pipelines

3. Methodology

The method used in this study is the case and applied research where the problem solving process is investigated by describing the current state of the research object. Based on the facts that emerge, research with this method focuses its attention on the discovery of facts (*fact-finding*) found in the field. The data processed comes from data on the amount of detector gas in the field based on P&ID, detector gas leak area coverage data, detector gas maintenance data, gas leak event log data, detector gas damage data, and dirty gas spare part replacement data.

The fulfillment of the gas, detector refers to PP No.5 of 2012 concerning the Implementation of the Occupational Safety and Health Management System clause 6.9 related to the emergency recovery plan.

4. Results and Discussion

4.1. Current State

In the results of data obtained from the operation and maintenance reports from 2019 to 2020, it is stated that based on the history of the detector gas equipment, it has suffered several damages including the following:

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Table 2. 2019 detector gas fault recapitulation

<table>
<tr><td colspan="5">2019 Detector Gas Fault Recapitulation</td></tr>
<tr><td>No</td><td>Moon</td><td>Number of Failures</td><td>Types of failure</td><td>PSM element</td></tr>
<tr><td>1</td><td>Jan</td><td>1</td><td>Fake Alarm</td><td>1. Safety Information Process2. Mechanical Integrity3. Investigation</td></tr>
<tr><td>2</td><td>Feb</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>3</td><td>Mar</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>4</td><td>April</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>5</td><td rowspan="2">May</td><td>1</td><td>Low Current</td><td>1. Operating Procedures2. Mechanical Integrity3. PSSR4. Investigation</td></tr>
<tr><td>6</td><td>1</td><td>Scale Fault</td><td>1. Operating Procedures2. Mechanical Integrity3. PSSR4. Investigation</td></tr>
<tr><td>7</td><td>June</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>8</td><td>July</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>9</td><td>August</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>10</td><td>September</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>11</td><td>October</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td>12</td><td>November</td><td>1</td><td>Dirty sensor</td><td>1. Operating Procedures2. Mechanical Integrity3. PSSR4. Investigation</td></tr>
<tr><td>13</td><td>December</td><td>0</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Total</td><td colspan="3">4</td></tr>
</table>

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Table 3. 2020 detector gas fault recapitulation

2020 Detector Gas Fault Recapitulation				
No	Moon	Number of Failures	Types of failure	PSM element
1	Jan	0	-	-
2	Feb	0	-	-
3	Mar	1	Corrupted programs	1. Safety Information Process2. Mechanical Integrity3. Investigation4. Moc
4	April	0	-	-
5	May	0	-	-
6	June	1	Error Scale	1. Operating Procedures2. Mechanical Integrity3. PSSR4. Investigation
7	July	1	Zero Fault	1. Operating Procedures2. Mechanical Integrity3. PSSR4. Investigation
8	August	0	-	-
9	September	0	-	-
10	October	0	-	-
11	November	1	Communication Error	1. Safety Information Process2. Mechanical Integrity3. Investigation4. Moc
12	December	1	Scale Fault	1. Operating Procedures2. Mechanical Integrity3. PSSR4. Investigation
Total		5		

Based on data from the recapitulation of detector gas disturbances from 2019 to 2020, it is stated that some damages or disturbances vary so this needs to be improved again related to the reliability of the detector gas.

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The following is an explanation related to interference or errors that occur in the detector gas.

1. Fake Alarm

   Fake alarm occurs due to the presence of methane gas or similar that is trapped in the gas sensor, where the trapped methane gas has a certain concentration and will only alarm temporary alarms.

2. Low Current

   Low current is a condition where the current entering the detector gas is less than 1 mA (in field conditions, this is indicated by the code E006). To fix this, the operator must be able to ensure a current input of 3.5 to 4.5 mA. In this condition, the operator can adjust the current splitter or replace the current splitter.

3. Scale Fault

   Scale fault is a condition where the gas sensor needs to be calibrated so that the lower limit and upper limit of the gas detector are precise.

4. Dirty Sensor

   A dirty sensor is an error that occurs in the detector gas caused by dust/dirt covering the sensor. This results in the gas sensor not being able to read the presence of gas leaks.

5. Program Corrupt

   A corrupt program is one of the disturbances that result in the system not running according to the initial settings the equipment is used.

6. Error Scale

   The scale error is a change in the set point value of a predefined scale. To repair this malfunction the operator simply performs recalibration on the detector gas and panel.

7. Zero Fault

   Zero faults is a condition where the inflow is far below 4 mA.

8. Communication Error

A Communication error is a disturbance that occurs when the equipment in the field cannot provide signal information on the panel, so there will be no tone of action whatsoever if there is an emergency in the field.

4.2. HIRADC

By using HIRADC were in the process, the identification of hazards that may occur in the gas detector system is carried out, assessing the risks that have the potential to occur if the danger occurs, and carrying out control so that the hazard can be reduced to the severity of the risk. At this stage, what is done is to use 5 hazard reduction hierarchies so that the impact or risk that occurs becomes smaller, the 5 hazard reduction hierarchies are as follows:

1. Elimination

   Elimination is carried out using eliminating the source of such danger.
2. Substitution

   Substitution is a way of lowering hazards by replacing equipment that is believed to replace the function of the tool with missing hazards as well.
3. Engineering Engineering

   This is done by carrying out an Engineering design so that the danger is minimized.
4. Administration (Procedure)

   This is applied using special rules that have been prepared to minimize the danger that occurs.
5. PPE (Personal Protective Equipment)

   PPE is the last and widely used way to minimize the danger by using safety equipment according to work.

To determine HIRADC or within the company often referred to as Risk Assessment Hazard Identification (IBPR), the company uses the 4 x 4 multiplication assessment

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method. The following is a reference for companies to conduct an assessment of the level of risk.

Step 1. Determining the degree of likelihood

Likelihood			
Value	**History**	**Intensity**	**Capabilities**
4	Has happened in a company within the same region/unit	Almost once a month it happens	Existing controls do not yet exist so danger/threats are almost certain to occur
3	It has happened in the company, but in different regions / units	Occurs between once every 1 – 3 months	Existing controls already exist but dangers/threats still occur
2	It has never happened in a company, but it has happened in similar industries or other industries	Occurs between once every 3 to 6 months	Existing controls are effective but weaknesses can still be found
1	Never happened in a company or similar industry or other industries	Occurs above once every 6 months.	Many layers of control exist so that the danger/threat is unprecedented

Table 4. Determination of the degree of probability

Total Values (History + intensity + Capability)	Category
11 - 12	Almost Certainly
8 - 10	Often
5 - 7	Maybe
3 - 4	Infrequently

Table 5. Total likelihood value

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Step 2. Determine

Kriteria	Potensi Dampak
(4) Fatal	*Fatality*
(3) Berat	*Lost Work Day Case*
(2) Moderat	*Resticted Work Day Case dan Medical Treatment Case*
(1) Ringan	*Nearmiss dan First Aid Case.*

Tabel Kriteria Potensi Keparahan

Kriteria		Potensi Kerugian
		Cidera/sakit penyakit
Sangat berbahaya	S4	Kecelakaan Kematian
Berbahaya	S3	Kecelakaan Sedang dan Kecelakaan Berat
Sedikit berbahaya	S2	Kecelakaan Ringan
Near Miss / First Aid	S1	Hampir Celaka dan Pertolongan Pertama
Kriteria Keparahan/ Konsekuensi (S)		
Kriteria S = Kriteria terbesar dari S1, S2, S3, S4		

Kriteria	POTENSI DAMPAK ASPEK			
	OPERASIONAL		KEUANGAN	HUKUM & SOSIAL
	JARINGAN	NON JARINGAN		
(4) Fatal	Terhentinya kegiatan operasional jaringan	Terganggu kegiatan operasional non jaringan 1 (satu) hari dan atau berdampak terganggunya operasional jaringan lebih dari 12 (dua belas) jam	Kerugian materil diatas	• Pelanggaran fatal yang mengakibatkan penyelidikan secara mendalam oleh regulator
			Rp. 200.000.000.000,-	• Pencabutan ijin usaha/ Penghentian operasi perusahaan
				• Publisitas negatif pada media international dan/atau pada headline media cetak/elektronik
(3) Berat	Terganggu kegiatan operasional jaringan 12 (dua belas) jam atau lebih	Terganggu kegiatan operasional non jaringan lebih dari 12 (dua belas) jam atau terganggunya operasional jaringan kurang dari 12 (dua belas) jam	Kerugian materil	• Pelanggaran serius yang mengakibatkan penyelidikan oleh regulator
			Rp. 50.000.000.000,- s/d	• Perijinan untuk beberapa kegiatan usaha perusahaan tidak dapat diperoleh
			Rp. 200.000.000.000,-	• Publisitas negatif pada media cetak/elektronik skala nasional
(2) Moderat	Terganggu kegiatan operasional jaringan kurang dari 12 (dua belas) jam	Terganggu kegiatan operasional non jaringan kurang dari 12 (dua belas) jam	Kerugian materil diatas	• Pelanggaran berat namun dapat diatasi dalam kondisi normal
			Rp. 10.000.000.000,- s/d	• Teguran / denda dari regulator
			Rp. 50.000.000.000,-	• Ligitasi oleh pihak ke-3
				• Publisitas negatif pada media cetak/elektronik skala regional
(1) Ringan	Kegiatan operasional jaringan terganggu selama 1 jam	Kegiatan operasional non jaringan terganggu selama 1 jam	Kerugian materil <	• Pelanggaran ringan yang memerulkan perhatian manajemen
			Rp. 10.000.000.000,-	• Keterlambatan pelaporan ke instansi terkait
				• Dampak minimal terhadap reputasi perusahaan

		KEPARAHAN /KONSEKUENSI			
		1 (Ringan)	2 (Moderat)	3 (Berat)	4 (Fatal)
KEMUNGKINAN	4 (hampir pasti)	Sedang	Tinggi	Ekstrim	Ekstrim
	3 (sering)	Rendah	Sedang	Tinggi	Ekstrim
	2 (mungkin)	Rendah	Sedang	Tinggi	Ekstrim
	1 (jarang)	Rendah	Rendah	Sedang	Tinggi

Table 7. Determining the level of risk

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Form Identifikasi Bahaya Penilaian Risiko

No	Failure	Potensi bahaya	Dampak	Pengendalian yang sudah ada	Tingkat Kemungkinan				Tingkat Keparahan	Tingkat Risiko	Rekomendasi Tindakan Perbaikan
					Histori	Intensitas	Kapabilitas	Level			
1.	Fake Alarm (alarm palsu)	Panik, dan dapat mengakibatkan cidera pada saat evakuasi / perbaikan	Cidera Ringan, Luka,Terjatuh, Terkilir	Memastikan dan menggunakan reset mode pada panel	3	1	2	mungkin	1	rendah	-
2.	Low Currrent	Gas detektor tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	4	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.
3.	Scale Fault	Tidak akurat dalam menentukan nilai kebocoran	Keterlambatan dalam proses penanganan kebocoran	Melakukan uji fungsi secara rutin	4	1	2	mungkin	1	rendah	-
4.	Dirty Sensor	Menimbulkan alarm palsu	Cidera Ringan, Luka,Terjatuh, Terkilir	Melakukan pemeliharaan rutin	3	1	1	mungkin	1	rendah	-
5.	Program Corupt	System tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	3	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.
6.	Eror Scale	Tidak akurat dalam menentukan nilai kebocoran	Keterlambatan dalam proses penanganan kebocoran	Melakukan uji fungsi secara rutin	4	1	2	mungkin	1	rendah	-
7.	Zero Fault	Gas detektor tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	4	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.
8.	Comunication Eror	Gas detektor tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	4	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.

Table 8. Risk assessment hazard identification form (IBPR)

4.3. FEARLESS Planning

The data that must be prepared to design FEARLESS (Fire Suppression And smart aLErt SyStem) are as follows:

1. Data on the condition of the surrounding environment to be protected

   In this factor of environmental conditions, the things that must be considered are as follows:

   1. Open Area Environment

      The environmental conditions of this open area affects the number of gas detectors required and the type of fire extinguishing media to be used. This is due to the wind factor that causes gas leaks to be difficult to detect so that it requires a lower detector gas height which increases the number of detector gases and wind factors also affect the type of fire extinguishing media used (foam, liquid chemical, or gas).

Figure 3. Open area design

2. Enclosed Area Environment

In conditions of a closed area, it will make it easier for the detector to be able to detect gas leaks because of the nature of light gases and the absence of wind factors that cause the gas to decompose in all directions so that if there is a leak, the gas will naturally point upwards. This will result in more flexible placement of the detector height, thus expanding the scope of the detector area.

Figure 4. Open area design

2. Detector specification data used

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In the planning of the FEARLESS system, it is designed using a combination of at least 2 detectors. It is used as 2 different functions, namely to activate alaram and activate the system release on the outage. In this case the combination of detectors used is a fire detector and a gas detector.

1. Detector Gas

   Based on the results of previous research and updated products, it is said that the most effective and efficient detector is a detector that uses infra red, where this type of detector is more responsive and can detect gas leaks with low concentrations.

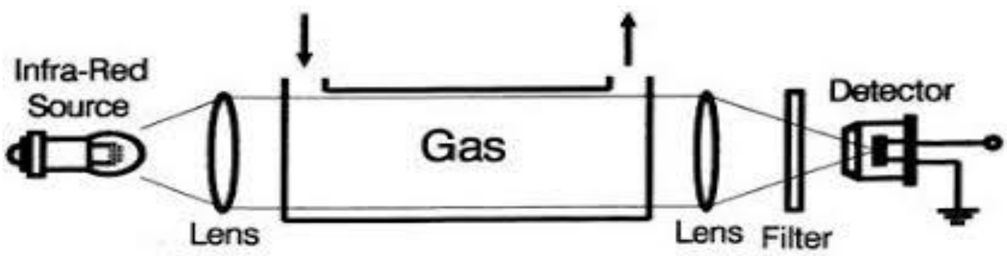

Figure 5. How infra red gas detectors work

2. Fire Detector

   Based on the results of previous research and updated products, it is said that the most effective and efficient detector is a detector that uses infra red, where this type of detector can distinguish which is the real flame with light that is almost similar to the flame such as the reflection of welding light, camera flash and light caused by lightning.

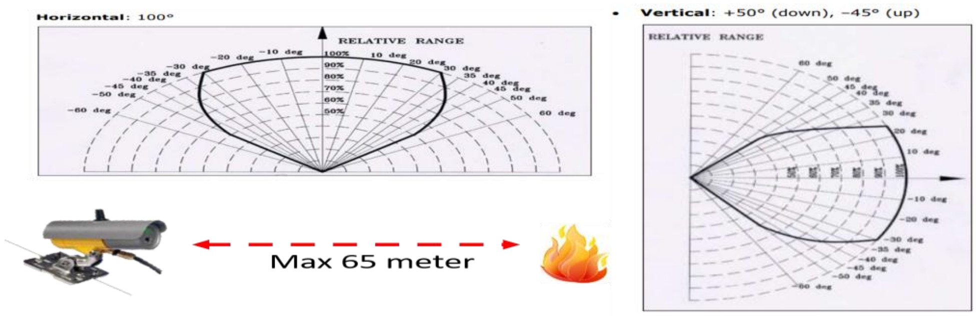

Figure 6. How infra red flame detectors work

3. Data system program

   The programming system on FEARLESS is designed not to be fixated on only one type of detector, but this system is designed to be compatible with several types of detector

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combinations, both gas detectors, fire detectors, and smoke detectors, as well as other detectors. This programming system complements the system that has been running, where the system that has been running can only provide alarms, but FEARLESS can improve the reliability system by providing additional functions related to extinguishing and real time delivery of emergency conditions related to fires caused by gas leaks. Here is a programming language system that has been designed and has been implemented.

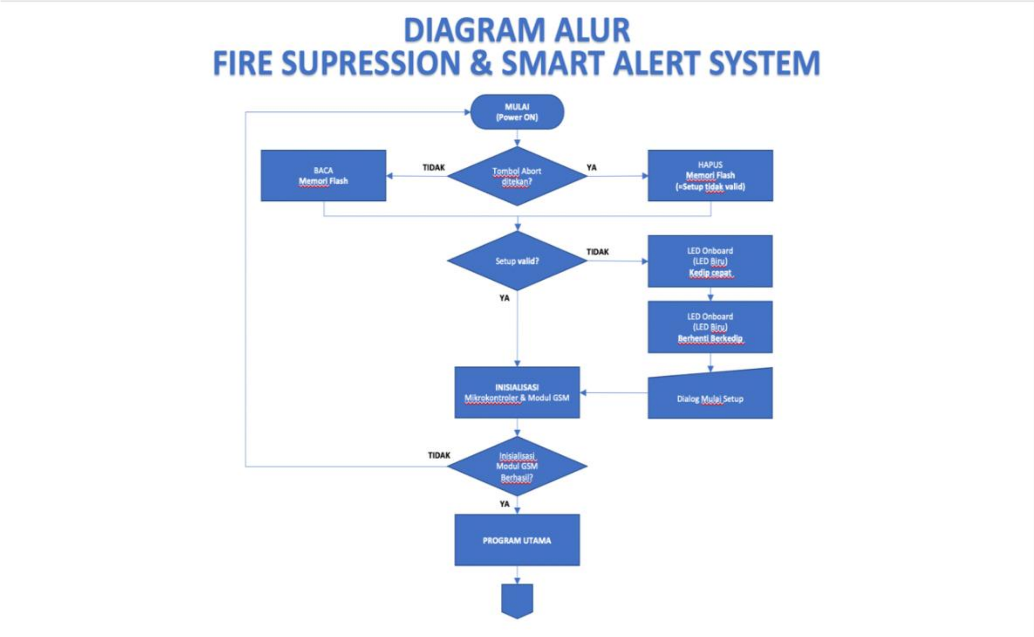

Figure 7. FEARLESS programming language

4.4. Results of FEARLESS Implementation

Based on the data that has been obtained from the report of interference and repair of the detector gas system, it states that there are several minor damages and major damages which presents the reliability of a system. The following is a comparison table of data before and after the implementation of the FEARLESS system.

<table>
<tr><td colspan="5">Recapitulation of Disorders Before and After the Application of FEARLESS</td></tr>
<tr><td>Moon</td><td>2019</td><td>2020</td><td>2021</td><td>2022</td></tr>
<tr><td>January</td><td>1 (minor)</td><td>0</td><td rowspan="3">Planning, Design, and Assembly</td><td>0</td></tr>
<tr><td>February</td><td>0</td><td>0</td><td>1 (minor)</td></tr>
<tr><td>March</td><td>0</td><td>1 (major)</td><td>0</td></tr>
</table>

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April	0	0		0
May	2 (1 minor, 1 mayor)	0	Trials and Monitoring	0
June	0	1 (minor)	0	Disnaker Certification
July	0	1 (major)	0	
August	0	0	0	
September	0	0	1 (minor)	
October	0	0	0	
November	1 (minor)	1 (major)	0	
December	0	1 (minor)	0	

Table 2. Comparison before and after the implementation of FEARLESS

The data table above shows that there are 2 minor disturbances in the FEARLESS system, where the disturbances are as follows:

1. The occurrence of a notification file when the system sends system status information to the user.

   This is because the FEARLESS system still uses credit, so the notification sent to the user is paid, and at that time the credit from the number used by the FEARLESS system runs out so that FEARLESS cannot send notifications.
2. The occurrence of a ground fault in the system.

   This is because when it rains the FEARLESS system is struck by lightning which causes the ariester on the FEARLESS system to be damaged.

With the implementation of the FEARLESS system, it can reduce the risk value contained in the Hazard Identification and Risk Assessment Form, where the risk of damage or failure of the FEARLESS system can be minimized. The following is an explanation of the harm and risk reduction that has been implemented.

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Assessment before the implementation of FEARLESS

Form Identifikasi Bahaya Penilaian Risiko

No	Failure	Potensi bahaya	Dampak	Pengendalian yang sudah ada	Tingkat Kemungkinan				Tingkat Keparahan	Tingkat Risiko	Rekomendasi Tindakan Perbaikan
					Histori	Intensitas	Kapabilitas	Level			
1.	Fake Alarm (alarm palsu)	Panik, dan dapat mengakibatkan cidera pada saat evakuasi / perbaikan	Cidera Ringan, Luka,Terjatuh, Terkilir	Memastikan dan menggunakan reset mode pada panel	3	1	2	mungkin	1	rendah	-
2.	Low Currrent	Gas detektor tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	4	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.
3.	Scale Fault	Tidak akurat dalam menentukan nilai kebocoran	Keterlambatan dalam proses penanganan kebocoran	Melakukan uji fungsi secara rutin	4	1	2	mungkin	1	rendah	-
4.	Dirty Sensor	Menimbulkan alarm palsu	Cidera Ringan, Luka,Terjatuh, Terkilir	Melakukan pemeliharaan rutin	3	1	1	mungkin	1	rendah	-
5.	Program Corupt	System tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	3	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.
6.	Eror Scale	Tidak akurat dalam menentukan nilai kebocoran	Keterlambatan dalam proses penanganan kebocoran	Melakukan uji fungsi secara rutin	4	1	2	mungkin	1	rendah	-
7.	Zero Fault	Gas detektor tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	4	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.
8.	Comunication Eror	Gas detektor tidak dapat mendeteksi adanya kebocoran gas	- Losses gas semakin besar. - Terjadi Kebakaran / ledakan.	Melakukan pengecekan rutin pada panel gas detektor	4	1	2	mungkin	4	ekstrim	- Merancang sistem yang memiliki kemampuan deteksi secara real time. - Merancang sistem yang dapat digunakan untuk memadamkan api secara otomatis.

		KEPARAHAN /KONSEKUENSI			
		1 (Ringan)	2 (Moderat)	3 (Berat)	4 (Fatal)
KEMUNGKINAN	4 (hampir pasti)	Sedang	Tinggi	Ekstrim	Ekstrim
	3 (sering)	Rendah	Sedang	Tinggi	Ekstrim
	2 (mungkin)	Rendah	Sedang	Tinggi	Ekstrim
	1 (jarang)	Rendah	Rendah	Sedang	Tinggi

Assessment after the implementation of FEARLESS

No	Failure	Potensi Bahaya	Tingkat Risiko				Hirarki Pengendalian					Penetapan Program	Due Date	PIC	Risiko Dengan Kontrol Tambahan						Keterangan
															Keparahan	Kemungkinan	Tingkat Risiko				
			R	S	T	E	EL	SUB	REK	ADM	APD						R	S	T	E	
1.	Low Currrent	Gas detektor tidak dapat mendeteksi adanya kebocoran gas				v			v			Pembuatan system pendeteksian dan pemadaman otomatis	Desember 2021	Operasi & HSSE	2	1	v				Resiko Diterima
2.	Program Corupt	System tidak dapat mendeteksi adanya kebocoran gas				v			v			Pembuatan system pendeteksian kerusakan sejak awal dan real time	Desember 2021	Operasi & HSSE	2	1	v				Resiko Diterima
3.	Zero Fault	Gas detektor tidak dapat mendeteksi adanya kebocoran gas				v			v			Pembuatan system pendeteksian kerusakan sejak awal dan real time	Desember 2021	Operasi & HSSE	2	1	v				Resiko Diterima
4.	Comunication Eror	Gas detektor tidak dapat mendeteksi adanya kebocoran gas				v			v			Pembuatan system pendeteksian kerusakan sejak awal dan real time	Desember 2021	Operasi & HSSE	2	1	v				Resiko Diterima

		KEPARAHAN /KONSEKUENSI			
		1 (Ringan)	2 (Moderat)	3 (Berat)	4 (Fatal)
KEMUNGKINAN	4 (hampir pasti)	Sedang	Tinggi	Ekstrim	Ekstrim
	3 (sering)	Rendah	Sedang	Tinggi	Ekstrim
	2 (mungkin)	Rendah	Sedang	Tinggi	Ekstrim
	1 (jarang)	Rendah	Rendah	Sedang	Tinggi

5. Conclusions

Based on the results in the previous chapter, the application of the FEARLESS system can be drawn several conclusions including:

1. The application of the FEARLESS system can reduce failures or damage that occur so as to minimize the occurrence of undetected gas leaks.
2. The FEARLESS system can be combined with 2 or more detectors so that it can be implemented in various needs.
3. The application of FEARLESS can minimize the occurrence of unknown or undetected malfunctions.

References

1) Al-Badi dan I. AlMubarak, "Permintaan energi yang terus meningkat di negara-negara GCC," Arab J. Basic Appl. Sci. , jilid. 26, tidak. 1, hlm. 488–496, Januari 2019.
2) Sugiyono, Metode Penelitian dan Pengembangan (Research and Development/R&D) . 2016.
3) M. Risnandar, "Studi Penerapan Panel Surya Di Badan Geologi Bandung," Universitas Pendidikan Indonesia, 2014.
4) S. Wuryanti, Neraca Massa dan Energi . Bandung: Politeknik Negeri Bandung, 2016.
5) W. Murti, "Desain Ulang TPS 4 Limbah B3 PT Petrokimia Gresik," Universitas Airlangga, 2007.
6) Retno L.P. Marsud, "Laporan Kinerja" Direktorat Jenderal Minyak Dan Gas Bumi Kementrian Energi Dan Sumber Daya Mineral, 2021.
7) Ridha Ababil, "Annual Report" PT. Perusahaan Gas Negara, 2020.
8) Alfin Ali., dkk, "Laporan Kinerja" Direktorat Jenderal Minyak Dan Gas Bumi Kementrian Energi Dan Sumber Daya Mineral, 2019.
9) Asiyah Afifah, Korban Meninggal Ledakan Gas di PT. Semar Gemilang, 2020.
10) Yingting LUO1, a* , Xudong OUYANG2 , Hao WU1, F. L. and H. T. S. (n.d.). Methane Detection at Low Concentration Based on 2f Harmonic Signal, 2015.
11) Aldhafeeri, T., Tran, M.-K., Vrolyk, R., Pope, M., & Fowler, M. A Review of Methane Gas Detection Sensors: Recent Developments and Future Perspectives. Inventions, 5(3), 28, 2020.
12) Thomas, S., & Shahnaj Haider, N. Instruments for Methane Gas Detection. International Journal of Engineering Research and Applications, 4(5), 137–143, 2014.
13) Wang, W., Zhang, L., & Zhang, W. Analysis of Optical Fiber Methane Gas Detection System. Procedia Engineering, 52, 401–407, 2012.
14) Geersen, J., Scholz, F., Linke, P., Schmidt, M., Lange, D., Behrmann, J. H., Völker, D., & Hensen, C. Fault zone controlled seafloor methane seepage in the rupture area of the

2010 Maule earthquake, Central Chile. Geochemistry, Geophysics, Geosystems, 17(11), 4802–4813, 2012.

15) Khan, F. I., & Abbasi, S. A. An assessment of the likelihood of occurrence, and the damage potential of domino effect (chain of accidents) in a typical cluster of industries. Journal of Loss Prevention in the Process Industries, 14(4), 283–306. 2015

16) Ganesh, R. S., Mahaboob, M., AN, J., C, L., S, P., & Kumar, K. K. Smart System for Hazardous Gases Detection and Alert System using Internet of Things. 2021 5th International Conference on Electronics, Communication and Aerospace Technology (ICECA), 511–515, 2021.