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Fearless design on the gas leak (fire suppression and smart alert system)

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Abstract. 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. From this data, it is used as a reference in designing the FEARLESS (FIRE SUPRESSION AND SMART ALERT SYSTEM) to detect gas leaks. The application of the FEARLESS system can be drawn several conclusions, including applying the FEARLESS system can reduce the failure or damage that occurs so as to minimize the occurrence of undetected gas leaks. The FEARLESS system can be combined with two or more detectors to be implemented for various needs.

Keywords: gas leak, fearless, fire suppression, smart alert system, gas detector.

1. Introduction

Currently, the oil and gas industry in Indonesia is divided into two sectors, namely the sector of natural oil management and sector of natural gas management. Industries that have been assigned to manage natural gas have an area that functions to analyze, calculate, manage, close, up and down gas flow which is called offtake station. The gas delivery that is distributed by offtake stations, gas leak is the important things that must be noticed and carried out of risk control. The leak gas can be caused by some factors below:

1. Gas pressure distributed exceeds the maximum specifications of the equipment.
2. The broke equipment (seal gas/repair kit)

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To find out if there is a gas leak that occurs in the offtake station, in each gas facilitate must be completed with system of gas leak handling, such as:

1. Gas Detector

Gas detector is one of the main safeties (safety critical equipment) that should be kept because of its function. Gas detector role is more important as a sign if there is a gas leak so the operator knows the accurate point of gas leak location. But, in the gas station, gas detector equipment does not work maximally and it is the cause of job accidents that are caused by gas leak, such as fire, explosion, and poisoning from inhaling gas.

2. Leak Survey

Leak survey is an activity to check for gas leaks using detector gas portable and bubble liquid to ensure the leakage in those areas. The activity of leak survey is conducted three times in one week.

The work accident in the oil and gas industry in the years 2015 – 2019 that can be classified in four levels: low, medium, heavy, and serious can be seen on the figure 1 below (Ditgen Migas, 2019).

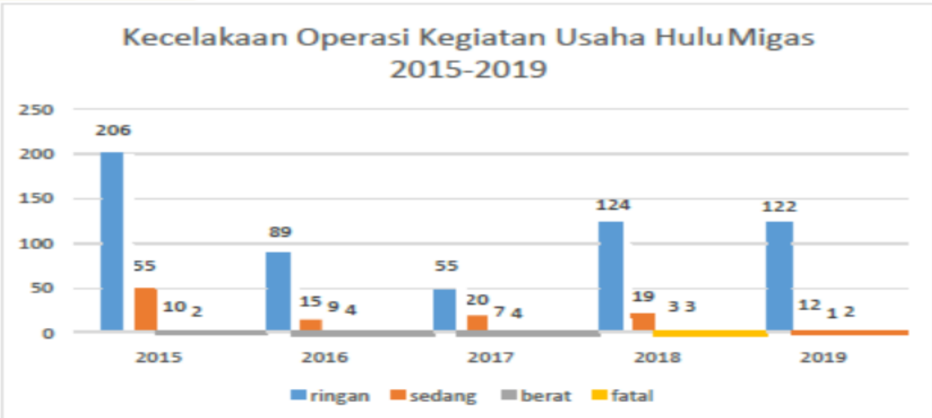


Fig. 1. Level of work accident in the oil and gas industry 2015-2019
Source: Performance report 2019 directorate of oil and gas ESDM.

The reliability of the function is not maximum and can cause a serious accident and big loss for the company. In Indonesia, there are some cases of work accident because of gas leak was not detected, they are:

1. Batam

Gas holder in the gas industry located in Batam exploded and one person died and three people were hospitalized.

2. Bekasi

LPG (Liquefied Petrolium Gas) filling factory exploded, it occurs when filling LPG from truck to LPG tube, there is a gas leak which is caused by car shift so it causes loose hose. Because of this accident, four people died because their body had burns 70% and 7 people were hospitalized.

3. Cikarang

The cosmetic company has a gas leak in the flexible tube installed in the deodorant parfum spray line 2 installation. The leaks of gas from the flexible tube exposed by the dryer cause it to explode. This accident caused 28 people to die and many people were hurt.

Not only in Indonesia, accidents caused by gas leaks not detected occur in the board, they are:

1. Rumania

There is a fire in the oil and gas company. This accident occurs when there is a gas leak in the location of the worker's accommodation. Gas enters the building and then occurs in the limitation room so it causes lower flammability from the gas. This causes an explosion in those buildings, so two workers have burns.

2. India

The leakage from the LG Polymers facilitates the gas leak and there is no alarm about the gas leakage. The company operator has done equipment operation as scheduled and then an explosion has occurred caused by gas accumulation. This accident cause 11 people to die.

3. Mexico bay (Deep Water Horizon)

The explosion in the rig of Mexico bay was caused by a gas leak passing the cement safety and the gas leak was not detected by the operator. This is because the oil and gas passing BOP and gush through the rig and then on fire and explode. The explosion activated an automatic emergency system designed to cut the pipeline in the event of an emergency, but the system failed to cut the oil and gas pipelines. This accident caused 11 people to die, 17 people to have critical injuries, and environmental pollution due to the large amount of oil and gas spilled in the Gulf of Mexico.

Based on the cases of explode which caused by the unreliability of the gas detector function causes various of losses, including:

1. Losses in terms of human resources

This loss includes the loss of professional personnel resulting from the accident.

2. Material loss

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

3. Losses 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 makes the surrounding environment polluted.

The effect of not working the gas detector accurately causes a lot of gas to be wasted without detecting a gas leak so that this will be very dangerous for the environment, 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 from 2016 to 2020.

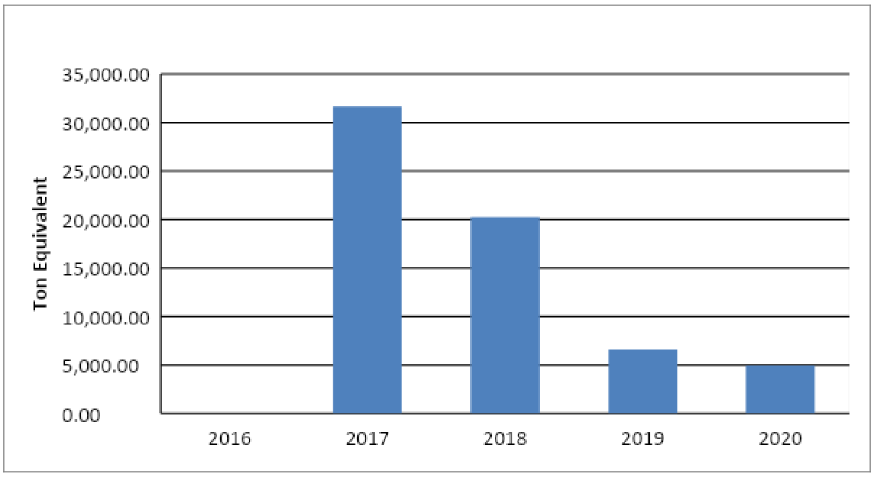


Fig. 2. Gas leak 2015-2019
Source: Performance report of PT. PGN in 2020.

In the year 2019, there are four (4) failures that occur in the detector gas system and in 2020 there are five (5) failures. This is because detector gas is not detected when the equipment has failure or disturbance.

Based on the explanation above, detector gas is more important as an alarm when a gas leak occurs. In this research will analyze the increase of detector gas reliability using FEARLESS ((Fire Suppression and Smart Alert System).

In conducting research, sources of previous research are needed to compare the research that the author did with the results of research conducted by others. The research conducted by the author has the theme of increasing the reliability of the gas detector by using FEARLESS (Fire Suppression and smart alert system). The following is a summary presentation quoted from several national and international journals in accordance with the research conducted.

Table 1. Research result.

No	Researcher	Year		Method	Research result
1	[1]	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.

No	Researcher	Year		Method	Research result
2	[2]	2020		Gas detection using optical, calorimetric, pyroelectric, metal oxide, and electrochemical sensors	Optical, calorimetric, pyroelectric, semi-conducting metal oxide and electrochemical sensors can function quickly and reliably. The advantages and disadvantages can be selected based on the needs and field conditions.
3	[3]	2014		gas detection using ionization detector	Gas detection using laser-based ionization detectors effectively detects the presence of methane concentrations.
4	[4]	2013		gas detection using spectroscopy method	Detection of gas leaks using the spectroscopic method can effectively detect gasses with low concentrations.
5	[5]	2016		Methane gas leak detection with gas detector	The need to detect methane gas that occurs on the seabed
6	[6]	2001		LPG gas leak detection smart tool was made with SMS notification	These systems and tools work as expected and can detect LPG gas leaks, send SMS notifications, and activate alarms.
7	[7]	2019		The main objective of the work is designing micro controller based toxic gas detecting and alerting system.	IoT (Internet Of Things) technology to detect gas leaks with the additional feature of smart alerting that uses text messages to relevant authorities can detect gas leaks in the environment.
8	[8]	2017		Made to design and fabricate a safety device for detecting LPG and natural gas that avoid any accident from the leakage.	The prototype can effectively and efficiently detect low and high levels of gas leakage so that it can warn users if there is a gas leak.
9	(B. Amutha et al.,)	2020		Gas and smoke detection using	Gas leak detection information can be collected

No	Researcher	Year		Method	Research result
				Node MCU	and monitored in one computer organized in a single database.
10	[9]	2018		Detected gas leak with MQ6 sensor.	The gas leak was detected using hardware using the MQ6 sensor.
11	(Tixier et al.,)	2017		HAZOP study	The HAZOP case study shows that even though the bioethanol process is mature and does not contain hazardous chemicals or extreme operating conditions, unacceptable hazardous conditions such as fire and explosion are still found.
12	[10]	2017		Risk Analysis on Leakage Failure by fuzzy bayesian network with a bowtie model	Analysis of fault, event analysis, and the Bowtie model are excellent methods for leak risk analysis.
13	[11]	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 also monitors all leaks in one view.
14	[12]	2019		Gas leak detection with LDS (Leak Detection System) and Data Fusion	LDS (Leak Detection System) method can reduce gas leak risk.
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	[13]	2021		Gas leak detection using UAV completed with gas detector	Leak detection using UAV data goes well and can detect underground gas leaks.
17	[14]	2017		Gas leak detection	Gas leak detection can be

No	Researcher	Year		Method	Research result
				using camera lens	accurate if camera pixel detection is increased.
18	[15]	2019		Accident of gas leak	It is due to the uneven quality of workers, the operation and construction have not been carried out as needed, and the management's lack of attention to the dangers of gas leaks.
19	[16]	2017		Gas leak detection using UAV	Leak detection using a UAV with a laser detector can visualize pipeline leaks.
20	[17]	2016		Leak detection using CH4 flux	Gas leaks can be detected and if left untreated can cause potential explosions in urban pipelines.

Materials and Methods

The method used in this research is case study 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, this research method focuses its attention on facts found in the field. The processed data comes from data on the number of gas detectors in the field based on P&ID, data on the coverage area of gas detectors, maintenance data on gas detectors, data on gas leak event logs, data on gas detector damage and data on replacement of gas detector spare parts.

For fulfillment of detector gas based on PP No 5 of 2012 regarding the implementation of safety management system and work health in clause 6.9 about the emergency recovery plan.

Results and Discussions

Nowadays Condition

Based on the operation and maintenance report in 2019 to 2020 state that the history of detector gas equipment has many troubles as below:

Table 2. Recapitulation of detector gas disturbance in 2019

Recapitulation of detector gas disturbance in 2019				
No	Month	Total of Failure	Types of Failure	PSM element
1	January	1	Fake Alarm	1. Process of Safety Information 2. Mechanical Integrity 3. Investigation

Recapitulation of detector gas disturbance in 2019				
No	Month	Total of Failure	Types of Failure	PSM element
2	February	0	-	-
3	March	0	-	-
4	April	0	-	-
5	May	1	Low Current	1. Operating Procedure 2. Mechanical Integrity 3. PSSR 4. Investigation
6		1	Scale Fault	1. Operating Procedure 2. Mechanical Integrity 3. PSSR 4. Investigation
7	June	0	-	-
8	July	0	-	-
9	August	0	-	-
10	September	0	-	-
11	October	0	-	-
12	November	1	Dirty sensor	1. Operating Procedure 2. Mechanical Integrity 3. PSSR 4. Investigation
13	December	0	-	-
Total		4		

Table 3. Recapitulation of detector gas disturbance in 2020

Recapitulation of detector gas disturbance in 2020				
No	Month	Total of Failure	Types of failure	PSM element
1	January	0	-	-
2	February	0	-	-
3	March	1	Programs Corrupt	1. Process of Safety Information 2. Mechanical Integrity 3. Investigation 4. MOC
4	April	0	-	-
5	May	0	-	-
6	June	1	Error Scale	1. Operating Procedure 2. Mechanical Integrity 3. PSSR 4. Investigation
7	July	1	Zero Fault	1. Operating Prosedure 2. Mechanical Integrity 3. PSSR 4. Investigation
8	August	0	-	-

Recapitulation of detector gas disturbance in 2020				
No	Month	Total of Failure	Types of failure	PSM element
9	September	0	-	-
10	October	0	-	-
11	November	1	Communication Error	1. Process of Safety Information 2. Mechanical Integrity 3. Investigation 4. MOC
12	December	1	Scale Fault	1. Operating Procedure 2. Mechanical Integrity 3. PSSR 4. Investigation
Total		5		

Based on the data of recapitulation of detector gas disturbance in 2019 to 2020, there are various disturbances, so this is needed to upgrade again regarding detector gas reliability.

The explanation of the disturbance that occurs on the detector gas is below:

1. Fake Alarm

A fake alarm occurs because methane gas is trapped in the gas sensor, where the trapped methane gas has a specific concentration and will only trigger a temporary alarm.

2. Low Current

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

3. Scale Fault

Scale fault is a condition where gas sensors must be calibrated until the lower and upper limits of precision detector gas.

4. Dirty sensor

A dirty sensor is an error that occurs in the detector gas caused by dirty or dust that covers up the sensors. This is because a gas sensor cannot read the gas leak.

5. Corrupt program

Corrupt program is one of the disturbances that cause the system to not work based on the first setting of equipment used.

6. Error scale

Error scale is the change of set point value from the scale that has been determined. The operator could re-calibrate the gas detector and panel to fix this failure.

7. Zero Fault

Zero Fault is a condition where the inflow is far under four mA.

8. Communication error

A communication error is a disturbance when the equipment cannot provide an information signal to the panel, so there is no action if there is an emergency in the area.

HIRADC

By using HIRADC where in the process identification of hazards may occur in the gas detector system, assessment of potential risks if these hazards occur, and control so that can reduce these hazards the level of risk severity. At this stage, what is done is to use five hazard reduction hierarchies so that the impact or risk that occurs becomes smaller, five hazard reduction hierarchies are as follows:

1. Elimination

   Elimination is done by eliminating the source of the hazard.
2. Substitution

Substitution is a way to reduce hazards by replacing equipment that is believed to be able to replace the function of the tool with a loss risk.

3. Engineering manipulation

   This step was conducted using engineering design to minimize the danger.
4. Administration (Procedure)

   This step can be implemented using special regulations arranged to minimize the hazard.
5. Personal Protective Equipment

This step is used by many people according to work to protect them from danger and also to minimize the hazard.

To determine HIRADC in the company can be called Hazard Identification Risk Assessment. The company uses an assessment method of multiplication 4x4. Company reference conducting risk level assessment can be seen below:

Step 1. Determine of Probability Level

Table 4. Determine of Probability Level

Probability			
Value	History	Intensity	Capability
4	Happened in a company in the same unit	Occurs nearly 1 month	There are no existing controls so that the hazard occurs
3	Happened in a company, but in the different are	Occurs between 1-3 months	There are existing controls but the hazard occurs.
2	Never happened in a company, but happens in the same industry or other industry.	Occurs between 3-6 months	Existing controls are effective but the weaknesses still can be found.
1	Never happened in a company or in the same industry or other industry.	Occurs once every 6 months.	Many of the existing controls so that the hazard never occurs.

Table 5. The total of Probability Assessment

Total of Assessment (History + intensity + capability)	Category
11 - 12	Almost happen
8 - 10	Often
5 - 7	Possibly
3 - 4	Rarely

Step 2. Determine

Criteria	Impact Potential
(4) Fatal	Fatality
(3) Heavy	Lost Work Day Case
(2) Moderate	Restricted Work Day Case and Medical Treatment Case
(4) Light	Near miss and First Aid Case

Table of Potential Serious Criteria

Criteria		Loss Potential
		Injury/Disease
Very Dangerous	S4	Death accident
Dangerous	S3	Moderate accident and Heavy accident
A little dangerous	S2	Light accident
Near Miss / First Aid	S1	Near miss and First Aid Case
Serious criteria/Consequences (S)		
Criteria S = The biggest criteria of S1, S2, S3, S4		

Table 6. Determine of Serious level

Criteria	Aspect of Impact Potential			
	Operator		Finance	Law and Social
	Network	Non-Network		
(4) Fatal	Cessation of network operation.	Disrupted non-network operation activities 1 days or impact of disrupted network operation more than 12 hours.	Material loss up to Rp. 200.000.000.000,	• Fatal violations that affect in depth investigation by the regulator. • Revocation of business license. • Negative publicity in the international media or headline of print/electronic media.
(3) Heavy	Disrupted network operations 12 hours or more.	Disrupted non-network operation activities more than 12 hours or disrupted network operation less than 12 hours.	Material loss Rp. 50.000.000.000 - Rp. 200.000.000.000	• Serious violations that affect in depth investigation by the regulator. • Licenses for some business activities were not obtained. • Negative publicity on the print/electronic media on the national scale.
(2) Moderate	Disrupted network operational activities for less than 12 hours.	Disrupted non-network operation less than 12 hours	Material loss up to Rp 10.000.000.000 - Rp. 50.000.000.000,-	• Heavy violations but can be solved in the normal condition. • Warning/amercement from regulator. • Litigation by third parties • Negative publicity on the print/electronic media on the national scale.
(1) L ight	Network operational activities have been interrupted for 1 hour.	Non-network operational activities have been interrupted for 1 hour.	Material loss < Rp. 10.000.000.000	• Light violations that need management attention • Delay in reporting to relevant agencies • Minimal impact on company reputation

Table 7. Determine the risk level

		Consequences Severity			
		1 (Light)	2 (Moderate)	3 (Heavy)	4 (Fatal)
Probability	4 (Almost happen)	Medium	High	Extreme	Extreme
	3 (often)	Low	Medium	High	Extreme
	2 (Possibly)	Low	Medium	High	Extreme
	1 (Rarely)	Low	Low	Medium	High

FEARLESS PLANNING

The data that must prepare to design FEARLESS (Fire suppression and smart alert System) are as follows:

1. Data on environmental conditions that will protect

a. Open Area

In open area environmental conditions this affects the number of gas detectors required and the type of fire extinguishing media to be used. This is due to the wind factor which causes gas leaks to be difficult to detect so it requires a lower detector gas height which results in an increase in the number of detector gasses and the wind factor also affects the type of fire extinguishing media used (foam, liquid chemical, or gas).

Fig. 3. Open area

b. Closed Area

In a closed area, it will be easier for the detector to detect a gas leak due to the light nature of the gas and the absence of wind factors that cause the gas to decompose in all directions so that if a leak occurs, gas will point upwards. This case will result in a more flexible placement of detector heights, thereby expanding the detector coverage area.

Table 8. Form of identification of risk assessment hazard

No	Failure	Hazard Potential	Impact	Existing control	Possibility level				Severity	Risk level	Recommendation of corrective action
					History	Intensity	Capability	Level			
1	Fake Alarm	Panic, may result in injury during evacuation/improvement	Light injury (hurt, fall, sprain)	Ensure and using a reset mode in the panel	3	1	2	Possible	1	low	-
2	Low Current	Detector gas cannot detect gas leak.	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	4	1	2	Possible	4	Extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically
3	Stale Fault	Inaccurate in determining the leakage value	Delays in the process of handling the leaks	Carry out routine of function test	4	1	2	Possible	1	low	-
4	Dirty Sensor	Cause a fake alarm	Light injury (hurt, fall, sprain)	Carry out routine maintenance	3	1	1	Possible	1	low	-
5	Program	System cannot detect	- Gas	Carry out	3	1	2	Possible	4	extreme	- Designing a

	Corrupt	gas leak	losses are getting bigger - There is fire/explosion	routine checks in the detector gas panel.							system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically
6	Error Scale	Inaccurate in determining the leakage value	Delays in the process of handling the leaks	Carry out routine of function test	4	1	2	Possible	1	low	-
7	Zero Fault	Detector gas cannot detect gas leak	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	4	1	2	Possible	4	extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically
8	Communication error	Detector gas cannot detect gas leak	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	4	1	2	Possible	4	extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically


Fig. 4. Closed area

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

a. Gas Detector

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

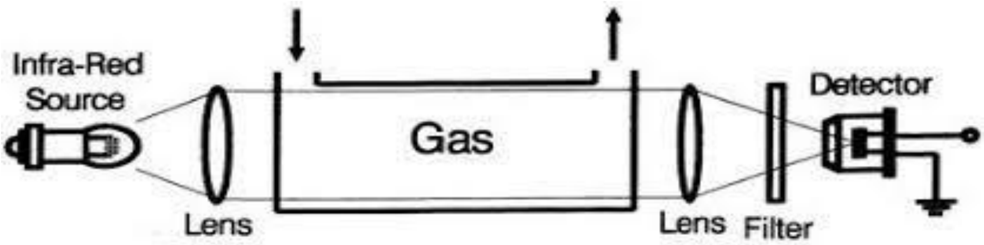


Fig. 5. The procedure of the infrared gas detector.

b. Fire Detector

Based on the previous studies' results and updated products, it is stated that the most effective detector is a detector that uses infrared, where this type of detector can distinguish between an actual flame and a light that is almost similar to a flame such as reflection of welding light, camera flash and light that caused by lightning.

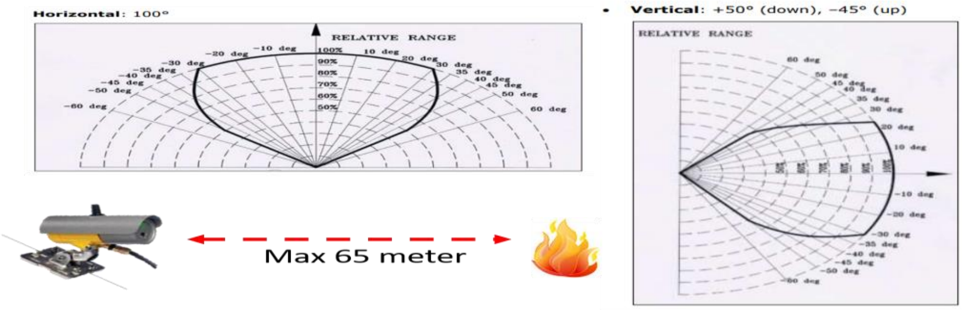
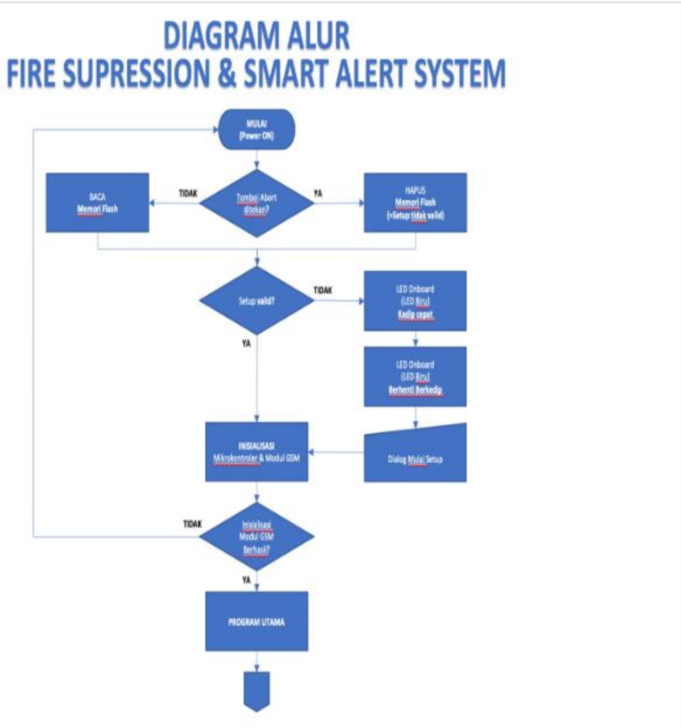


Fig. 6. The Procedure of the infrared fire detector.

3. System program data

The programming system in FEARLESS is designed not to be fixed on only one type of detector, but this system is designed to be compatible with various types of detector combinations, both gas detectors, fire detectors, and smoke detectors, as well as other detectors. This programming system complements the existing system, where the current system can only provide alarms, but FEARLESS can improve system reliability by providing additional functions related to blackouts and real-time delivery of emergency conditions related to fires caused by gas leaks. The following is a programming language system that has been designed and implemented.



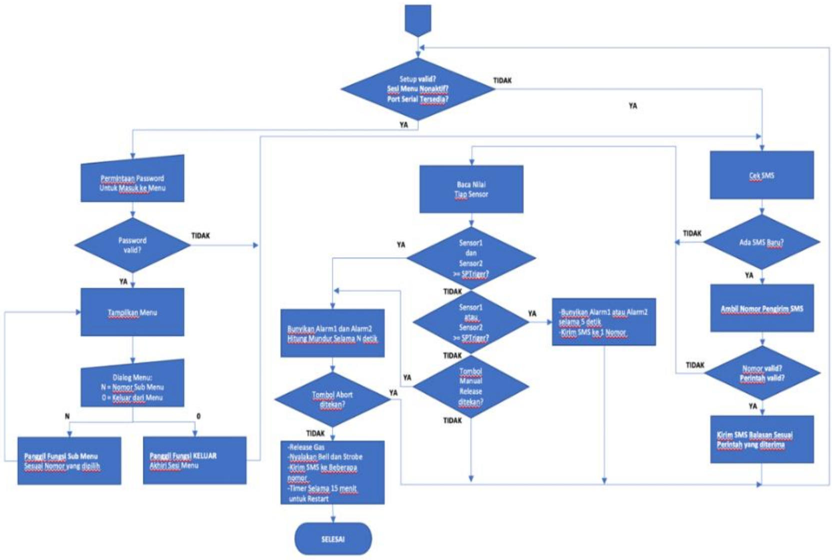


Fig. 7. FEARLESS program.

The result of FEARLESS application

Based on the data obtained from reports of disturbances and repairs to the gas detector system, it is stated that several minor and major damages represent the system's reliability. The following is a data comparison table before and after applying the FEARLESS method.

Table 9. Comparison of before and after FEARLESS application

<table>
<tr><td colspan="5">Recapitulation of Distraction before and after FEARLESS Application</td></tr>
<tr><td>Months</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="4">Planning 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>
<tr><td>April</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>May</td><td>2 (1 minor, 1 major)</td><td>0</td><td>Testing and Monitoring</td><td>0</td></tr>
<tr><td>June</td><td>0</td><td>1 (minor)</td><td>0</td><td rowspan="2">Manpower Certification</td></tr>
<tr><td>July</td><td>0</td><td>1 (major)</td><td>0</td></tr>
<tr><td>August</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>September</td><td>0</td><td>0</td><td>1 (minor)</td><td></td></tr>
<tr><td>October</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>November</td><td>1 (minor)</td><td>1 (major)</td><td>0</td><td></td></tr>
<tr><td>December</td><td>0</td><td>1 (minor)</td><td>0</td><td></td></tr>
</table>

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

1. A failure notification occurs when the system sends system status information to the user.

The FEARLESS system still uses credit, so notifications are sent to paid users. At that time, the balance from the number used by the FEARLESS system runs out so the FEARLESS system 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 results in damage to the aristers in the FEARLESS system.

The FEARLESS system can reduce the risk value contained in the Hazard Identification and Risk Assessment Form, where it can minimize the risk of damage or failure of the FEARLESS system. The following explains the reduction of hazards and risks that have been implemented.

The assessment before FEARLESS application

Form of identification of risk assessment hazard

No	Failure	Hazard Potential	Impact	Existing control	Possibility level				Severity	Risk level	Recommendation of corrective action
					History	Intensity	Capability	Level			
1	Fake Alarm	Panic, may result in injury during evacuation/improvement	Light injury (hurt, fall, sprain)	Ensure and using a reset mode in the panel	3	1	2	Possible	1	low	-
2	Low Current	Detector gas cannot detect gas leak.	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	4	1	2	Possible	4	Extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically
3	Stale Fault	Inaccurate in determining the leakage value	Delays in the process of handling the leaks	Carry out routine of function test	4	1	2	Possible	1	low	-
4	Dirty Sensor	Cause a fake alarm	Light injury (hurt, fall, sprain)	Carry out routine maintenance	3	1	1	Possible	1	low	-
5	Program Corrupt	System cannot detect gas leak	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	3	1	2	Possible	4	extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically
6	Error Scale	Inaccurate in determining the leakage value	Delays in the process of handling the leaks	Carry out routine of function test	4	1	2	Possible	1	low	-
7	Zero Fault	Detector gas cannot detect gas leak	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	4	1	2	Possible	4	extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically
8	Communication error	Detector gas cannot detect gas leak	- Gas losses are getting bigger - There is fire/explosion	Carry out routine checks in the detector gas panel.	4	1	2	Possible	4	extreme	- Designing a system that has real-time detection capabilities - Designing a system that can be used to extinguish fires automatically

		Consequences Severity			
		1 (Light)	2 (Moderate)	3 (Heavy)	4 (Fatal)
Probability	4 (Almost happen)	Medium	High	Extreme	Extreme
	3 (often)	Low	Medium	High	Extreme
	2 (Possibly)	Low	Medium	High	Extreme
	1 (Rarely)	Low	Low	Medium	High

The assessment after FEARLESS application

No	Failure	Potensi Bahaya	Tingkat Risiko				Hirarki Pengendalian					Penerapan Program	Due Date	PIC	Risiko Dengan Kontrol Tambahan						Keterangan
			R	S	T	E	EL	SUB	REK	ADM	APD				Keparahan	Kemungkinan	Tingkat Risiko R	S	T	E	
1.	Low Current	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 Error	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

		Consequences Severity			
		1 (Light)	2 (Moderate)	3 (Heavy)	4 (Fatal)
Probability	4 (Almost happen)	Medium	High	Extreme	Extreme
	3 (often)	Low	Medium	High	Extreme
	2 (Possibly)	Low	Medium	High	Extreme
	1 (Rarely)	Low	Low	Medium	High

Conclusions

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

1. Applying the FEARLESS system can reduce the failure or damage that occurs so as to minimize the occurrence of undetected gas leaks.

2. The FEARLESS system can be combined with two or more detectors to be implemented for various needs.
3. Applying the FEARLESS can minimize the occurrence of unknown or undetected malfunctions.

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