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Evaluation of the Implementation of an Active Fire Protection System in the Production Unit at a Plastic Pellet Manufacturing Company in Pasuruan, Indonesia

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Abstract

A plastic pellet manufacturing company in Pasuruan, Indonesia, is a company operating in the manufacturing sector and producing plastic pellets. Fire is one of the possible, unpredictably occurring risks during the manufacture of concrete. Unwanted fires can result in significant damage and human loss. Since it is impossible to foresee when or where a fire will strike, early prevention and response measures are required. Thus, as a preventive and mitigating action against the fire danger at a plastic pellet manufacturing In Pasuruan, Indonesia, the goal of this research is to assess the suitability of the active fire protection system. The research is observational and uses a descriptive method. The research findings show that plastic pellet manufacturing in Pasuruan, Indonesia, has an average suitability rate of 96% with regard to the implementation of the active fire protection system. The assessment of fire detector implementation, as per SNI 03-3985-2000, is classified as good (100%). The assessment of fire alarm implementation, as per SNI 03-3985-2000, is classified as good (100%). The assessment of sprinkler implementation, as per SNI 03-3989-2000, is classified as sufficient (80%). The assessment of fire extinguisher implementation, as per the Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980, is classified as good (100%). The assessment of hydrant implementation, as per SNI 03-1745-2000, is classified as good (100%). Conclusively, the suitability of the active protection system for plastic pellet manufacturing in Pasuruan, Indonesia, falls into the good category.

Keywords: Active Fire Protection System; Fire Detector; Fire Alarm; Sprinkler; Fire Extinguisher; Hydrant

1. Introduction

Industrial development is currently an important factor in Indonesia's national development, which has a positive impact on employment, increasing income, and equitable development. Industrial activities, even though they make a major contribution to the global economy, are not free from risks that can harm workers' welfare. Work-related accidents and illnesses are serious impacts that can arise from a work environment that is less safe and healthy. Accidents are often caused by human factors, physical conditions, and poor work environments.

The increasing risk of fire has been caused by increasing development in the industrial sector, which is characterized by the introduction of new processes, raw materials, and industrial products [1]. Fire is a disaster whose arrival cannot be known or predicted when and where it will occur, so early prevention and response activities are needed. Fire is an unwanted blaze that causes serious loss of property and life [2]. Based on data from the International Labour Organization (ILO) in 2012, fires in the industrial sector worldwide resulted in 426 people dying. Of the total deaths, 67.8% of the victims came from garment factories, 14.6% came from oil refineries, 8.7% came from fireworks factories, 5.9% came from shoe factories, 2.8% came from artificial rubber factories, and 0.2% came from firecracker factories [3]. Nationally, fires are very detrimental because they can disrupt national productivity and reduce people's welfare

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[4]. Therefore, all industries in Indonesia must implement efforts to prevent and control fire hazards in accordance with applicable standards so as not to endanger workers and harm many parties.

The company studied is a company operating in the manufacturing sector. This company produces plastic pellets. The production process at this company involves heat and processing, which can increase the risk of fire if not managed properly. In its production process, this company cannot be separated from the use of sophisticated installations or machines that require high electrical voltage and tools that have the potential to cause fire hazards. Apart from that, the raw materials and supporting materials used also have the potential to cause fires, such as wooden pallets and cardboard. Based on a preliminary study, there were 2 fire incidents in plastic pellet-producing companies in 2020–2024, caused by machines experiencing problems and also by human error. To face various fire risks while ensuring business continuity, the fire protection system implemented by the company must be made as optimal as possible so that it can overcome the danger of fire. Therefore, special attention is needed to analyze the fire protection system in plastic pellet-producing companies.

2. Material and methods

This research was conducted at the production unit of a plastic pellet-producing company in Pasuruan, Indonesia. An observational technique was combined with descriptive research as the research methodology. Data were obtained through direct field observations using a checklist based on standards outlined in SNI 03-3985-2000, SNI 03-3989-2000, SNI 03-1745-2000, and the Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980. The research focused on the evaluation of the active fire protection system, including the fire detectors, fire alarms, sprinklers, fire extinguishers, and hydrants. The instruments used in this research were observation sheets related to the active fire protection system, evaluating fire detectors and alarms according to SNI 03-3985-200 criteria, sprinklers according to SNI 03-3989-2000 criteria, fire extinguishers according to the Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980 criteria, and hydrants according to SNI 03-1745-2000 criteria. The assessment of the suitability of the active fire protection system implementation was classified into two categories: yes and no.

The research findings will be processed using data analysis techniques to guarantee that the interpretations that are produced are easily comprehensible. The active fire protection system assessment findings will be totaled based on the fulfilled scores, and this will determine the overall score. Data processing will be finished in the interim, and data analysis will begin. The percentage of each indication of the active fire protection system, such as fire extinguishers, fire hydrants, and fire alarms, will be determined as part of the data analysis process in this study. Here's how the fulfillment value for each active fire protection system indicator is calculated:

$$X=\frac{\text{Total Score}}{\text{Maximum Score}} \text{ x } 100\%$$

Explanation:

X= The percentage suitability results for the installation criteria of each type of active fire protection system, including fire detectors, fire alarms, sprinklers, fire extinguishers, and hydrants.

The percentage (X) that remains after determining the percentage of compatibility for each type of active fire protection system's installation criteria can be divided into four groups, including:

Table 1 The Suitability Results of the Fire Detector at Plastic Pellet-Producing Company in Pasuruan, Indonesia

Value	Category	Suitability	Description
>80&	Good	In accordance with regulatory provisions	All components of the fire protection system function perfectly
60-80%	Sufficient	Installed, but a small part of the installation is not appropriate	All components function, but there are several sub-components that function less than perfectly
<60%	Poor	Absolutely not in accordance with regulatory requirements	All components of the fire protection system are damaged or not functioning; their capacity is far below the established standards

Source: Harianja, Torua, and Hasibuan, 2020

3. Results and discussion

3.1. Evaluation of the Fire Detector Suitability in the Production Unit of Plastic Pellet Manufacturing in Pasuruan, Indonesia

Based on the results of interviews and observations, the fire detectors in the production unit at this plastic pellet-producing company in Pasuruan, Indonesia, are heat detectors and smoke detectors. The heat detectors used in the company are a combination of a rate of rise detector (ROR) and a fixed temperature detector, while the smoke detector used is a photovoltaic detector. The fire detector system in this company is automatically connected to the fire alarm system, so if the fire detector detects smoke, the fire alarm will sound. The company has a regular fire detector checking schedule. Apart from that, the activeness of the fire detector can also be seen from the security post panel; if it is damaged, then a "fault" will appear. The following are the results of observations and interviews regarding fire detectors in production units of a plastic pellet-producing company in Pasuruan, Indonesia, based on SNI 03-3985-2000.

Table 2 The Suitability Results of the Fire Detector at Plastic Pellet-Producing Company in Pasuruan, Indonesia

No.	Items Evaluated Based on SNI 03- 3985-2000	Suitability		Description
		Yes	No	
1	There is a fire detector system installed at certain points	✓		There is a smoke detector and heat detector system installed in the production unit
2	Installed fire detectors are accessible for maintenance and testing	✓		The fire detector can be reached using a triangular staircase
3	Fire detector protection against possible damage due to mechanical interference	✓		Protected because it is placed on the ceiling of a closed room
4	Sensor elements of the fire detector are clean and unpainted	✓		Sensors are on all over the production unit marked by flashing and unpainted infrared lights
5	Maximum fire detector distance is 9.1 meters	✓		The distance between the fire detectors is not more than 9.1 meters
6	Permanent inspection, testing, maintenance and storage of inspection results	✓		Inspection, testing, and maintenance every six months by the vendor and internal inspection
Level of Achievement		6/6 x 100% = 100%		

The percentage results indicate that the level of suitability with the implementation of fire detectors referring to SNI 03-3985-2000 at Plastic Pellet-Producing Company in Pasuruan, Indonesia, is 100%, categorizing it as having a good level of suitability with the implementation requirements. All six essential assessment criteria are fulfilled.

3.2. Evaluation of the Fire Alarm Suitability in the Production Unit of Plastic Pellet Manufacturing in Pasuruan, Indonesia

Based on the results of interviews and observations, the company has been equipped with a fire alarm system. The company has a manual and automatic fire alarm that is connected to the detector and sprinkler system. The following are the results of observations and interviews regarding fire alarms in production units of a plastic pellet-producing company in Pasuruan, Indonesia, based on SNI 03-3985-2000.

Table 3 The Suitability Results of the Fire Alarm at a Plastic Pellet-Producing Company in Pasuruan, Indonesia

No.	Items Evaluated Based on SNI 03-3985-2000	Suitability		Description
		Yes	No	
1	There is a fire alarm	✓		There is a fire alarm all over the production unit
2	Fire alarm are clearly visible, easily accessible, and can be heard throughout the area	✓		Fire alarms are easily accessible and can be heard throughout the area because they are evenly spread
3	The sound of the fire alarm is different from the other sound signals	✓		The fire alarm sounds are different from the sound/bells if the hooper machine needs to be filled, and the other sounds
4	The fire alarm automatically be directly connected to the sprinkler	✓		Fire alarms are automatically connected in fire detector, sprinkler, and hydrant systems
5	Set the fire alarm on the exit access track at a height of 1.4 meters from the floor	✓		The fire alarm is located at the exit access path of each unit and the height is not less than 1.4 meters
6	Fire alarm condition is good and wellined	✓		The alarm is in good condition, clean, and wellined
Level of Achievement		6/6 x 100% = 100%		

The percentage results indicate that the level of suitability with the implementation of fire alarms referring to SNI 03-3985-2000 at Plastic Pellet-Producing Company in Pasuruan, Indonesia, is 100%, categorizing it as having a good level of suitability with the implementation requirements. All six essential assessment criteria are fulfilled.

3.3. Evaluation of the Sprinkler Suitability in the Production Unit of Plastic Pellet Manufacturing in Pasuruan, Indonesia

Based on observations and interviews, the company has been equipped with a sprinkler system connected with fire detectors and alarms. Based on the direction of the emission, the sprinkler system in the production unit leads upwards. The following are the results of observations and interviews regarding sprinkler in production units of a plastic pellet-producing company in Pasuruan, Indonesia, based on SNI 03-3989-2000.

Table 4 The Suitability Results of the Sprinkler at a Plastic Pellet-Producing Company in Pasuruan, Indonesia

No.	Items Evaluated Based on SNI 03-3989-2000	Suitability		Description
		Yes	No	
1	There is a sprinkler system	✓		The sprinkler system automatically turns on when smoke is detected entering the detector or the heat detector is working
2	The sprinkler is not painted, ornamented or coated	✓		Sprinkler is not colored or not painted, not coated or ornamented
3	There are networks and supplies of clean water free of mud and sand	✓		There is a supply of clean water in the reservoir that is clean from mud or sand. Besides, it is also treated by drain every two months
4	Water supply system under management control	✓		The water supply system comes from the well water which is supervised by the management and will automatically recharge when it decreases.

5	The distance between the mounted sprinkler heads is not more than 4.6 meters	✓		The distance between the mounted sprinkler heads is not more than 4.6 meters
6	Installed sprinkler head in good condition and unobstructed	✓		The sprinkler head at the production unit is in good condition and there are no spider nests obstructing it
7	Automatically connected to a fire alarm	✓		The sprinkler became one system along with fire alarms and detectors
8	Availability of connections allowing firefighters to pump water into the sprinkler system	✓		There is a connection to the sprinkler's main pipe which is also in line with the hydrant pipe and connected with the alarm panel
9	24 spare sprinkler heads in stock		✓	The stock of spare sprinkler head is only 22
10	There are examination and testing procedures		✓	No screening procedures and sprinkler test have been performed on a routine bases, only a drain of the sprinklers and a visual inspection
Level of Achievement		8/10 x 100% = 80%		

The percentage results indicate that the level of suitability with the implementation of sprinkler referring to SNI 03-3989-2000 at Plastic Pellet-Producing Company in Pasuruan, Indonesia, is 80%, categorizing it as having a sufficient level of suitability with the implementation requirements. Out of the ten essential assessments, there ae two requirements that are not fulfilled. The point that has not been achieved well is that 24 spare sprinkler heads are not available an there are no routine screening and testing procedures.

3.4. Evaluation of the Fire Extinguisher Suitability in the Production Unit of Plastic Pellet Manufacturing in Pasuruan, Indonesia

Based on the results of observations and interviews, the production unit of this company has fire extinguishers. The available fire extinguishers are made up of several types, namely, fire extinguishers containing dry chemical powder, AF11, HCFC, Cf21, and CO2. The selection and placement of types of fire extinguishers have been adapted to the categories and existing fire risks according to the Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980 in Indonesia.

According to the results of the observations and inspections of the fire extinguisher at the production unit of the plastic pellet manufacturer, the whole fire extinguisher unit is in good condition. This is due to the routine maintenance and inspection of the firing extinguisher on a regular basis, which is once a week. The inspections are much better than the 6-month/1-year standard, according to Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980. The following are the results of observations and interviews regarding fire extinguishers in production units of a plastic pellet-producing company in Pasuruan, Indonesia, based on Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980.

The percentage results indicate that the level of suitability with the implementation of fire extinguishers referring to Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980 at Plastic Pellet-Producing Company in Pasuruan, Indonesia, is 100%, categorizing it as having a good level of suitability with the implementation requirements. All nine essential assessment criteria are fulfilled.

Table 5 The Suitability Results of the Fire Extinguisher at a Plastic Pellet-Producing Company in Pasuruan, Indonesia

No.	Items Evaluated Based on Ministry of Labour and Transmigration Regulation No: Per. 04/MEN/1980	Suitability		Description
		Yes	No	
1	There is a fire extinguisher	✓		The fire extinguisher is available throughout the production unit
2	The fire extinguisher location has been in line with existing fire classifications	✓		The fire extinguisher type of dry chemical powder is placed in the production unit because it involves living electrical equipment and producing plastic pellet products
3	The fire extinguisher is placed in a place that is easy to see, accessible, and unobstructed by anything	✓		All fire extinguishers are easy to see and accessible, and no fire extinguisher is blocked by any object, tool, or material
4	The fire extinguisher installation mark is well and correctly installed	✓		The entire fire extinguisher in the production unit has been marked with the fire extinguisher installation mark
5	The fire extinguisher is placed hanging or placed in an unlocked closet	✓		The fire extinguishers are placed hanging and placed in an unlocked closet
6	The top part of the fire extinguisher is placed 120 centimeters from the bottom of the floor	✓		The placement height of the entire fire extinguisher in the production unit is 120 centimeters from the base floor
7	The distance between one fire extinguisher and the other is a maximum of 15 meters	✓		The distance between one fire extinguisher and the other does not exceed 15 meters
8	Each fire extinguisher is inspected twice a year for a period of six months and twelve months	✓		The fire extinguisher is checked once a week
9	Each fire extinguisher has a card or label placed indicating the month and year of maintenance	✓		Each fire extinguisher in the production unit already has a card or label containing maintenance time updates
Level of Achievement		9/9 x 100% = 100%		

3.5. Evaluation of the Hydrant Suitability in the Production Unit of Plastic Pellet Manufacturing in Pasuruan, Indonesia

Based on observations and interviews, the company has 34 hydrants spread evenly around the factory area. Of the 34 hydrants, 10 are outdoor hydrants and 24 are indoor hydrants that are evenly spread throughout the factory area. The hydrogen boxes in the building contain a hose, pulley, and nozzle. The types of nozzles used in this company are jet nozzles and spray nozzles. For indoor hydrants, use a hose reel.

The condition of the yard hydrant is in accordance with applicable standards, including that the hydrant pump functions well, the hydrant cover is not difficult to open with a lever, and the connector or coupling is not rusty and fits easily with the end of the hose mouth. Furthermore, the hydrants are supported by a fire pump system.

- Pressure vessel with stable pressure at 8 bar (normal)
- Two main pump units (diesel pumps)
- One spur pump unit to stabilize water pressure (jockey pump)

Hydrant checks are carried out routinely once a week. Meanwhile, hydrant operational tests are carried out every month. The following are the results of observations and interviews regarding hydrants in production units of a plastic pellet-producing company in Pasuruan, Indonesia, based on SNI 03-1745-2000.

Table 6 The Suitability Results of the Hydrant at a Plastic Pellet-Producing Company in Pasuruan, Indonesia

No.	Items Evaluated Based on SNI 03-1745-2000	Suitability		Description
		Yes	No	
1	There are sufficient hydrants to handle fires throughout the factory area	✓		There are 34 hydrants evenly distributed around the factory, and there are 4 indoor hydrants in the production unit
2	The hydrant box must be easy to open, see, and reach and not be obstructed by any objects	✓		The hydrant box is easy to open, easy to see, and unobstructed
3	All hydrant equipment and hydrant boxes are painted red, while the hydrant writing is white	✓		All hydrant equipment is painted red, and the writing is white
4	There are instructions for use posted in an easily visible place	✓		Instructions for use are installed in a place that is easily visible, namely, attached to the front of the hydrant box
5	There is hydrant equipment: a hose nozzle, coupling, and opening tap, which are installed and always ready to use	✓		Complete equipment and nothing damaged
6	There is a yard hydrant	✓		There are 10 yard hydrants
7	Yard hydrants have a minimum pressure of 3.5 bar	✓		Yard hydrant at 8 bar pressure
8	Yard hydrants are located along fire engine access routes	✓		All outdoor hydrants can be accessed by fire engines because they are located on the main road within the company. There is even a special area for fire engines to get a water supply if they run out of water
9	All hydrant equipment is in good condition and always ready to use	✓		All the equipment is good and ready to use
10	Operational and completeness tests of hydrant components are carried out once a year	✓		Checking and maintenance are carried out once a week, but operational tests (simulations of hydrant use) are carried out every two months)
Level of Achievement		10/10 x 100% = 100%		

The percentage results indicate that the level of suitability with the implementation of hydrant referring to SNI 03-1745-2000 at Plastic Pellet-Producing Company in Pasuruan, Indonesia, is 100%, categorizing it as having a good level of suitability with the implementation requirements. All ten essential assessment criteria are fulfilled.

4. Conclusion

This potential fire hazard in production units in a plastic pellet-producing company in Pasuruan, Indonesia, can come from the production process, the use of sophisticated installations or machines that require high electrical voltage, and tools, raw materials, and production supporting materials that have the potential to cause fire hazards.

- Analysis of fire protection systems in production units of a plastic pellet-producing company in Pasuruan, Indonesia:

- The level of achievement of fire detector conformity with SNI 03-3985-2000 in production units is 100%, which means good.
- The level of achievement of fire alarm conformity with SNI 03-3985-2000 in production units is 100%, which means good.
- The level of achievement of sprinkler conformity with SNI 03-3989-2000 in production units is 80%, which means sufficient.
- The level of achievement of fire extinguisher conformity with Ministry of Labour and Transmigration Regulation No. Per. 04/MEN/1980 in production units is 100%, which means good.
- The level of achievement of fire detector conformity with SNI 03-1745-2000 in production units is 100%, which means good.
- The overall evaluation results for the implementation of active fire protection systems at a plastic pellet-producing company in Pasuruan, Indonesia, are 96%, which is in a good category.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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