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Evaluation of Active Protection Systems for Fire Extinguisher at Locomotive Depot

Kholfana Bintan Maula Aditya Putri[1], Evelyne Martha Limanda[1], Muhammad Alif Indra Fahmi[1], Ana Islamiyah Syamila[1*], Yoka Bismayuda Prana[2]

[1]Public Health Department, Faculty of Public Health, University of Jember, Jember, Indonesia.
[2] PT Kereta Api Indonesia Daerah Operasional 9 Jember, Jember, Indonesia
*Corresponding Author: Email: ana.islamiyah@unej.ac.id

Abstract

Introduction: A fire is an accident that can occur in the railroad industry. Locomotive depots have various work processes and fuels that can cause medium-II fires. An active protection system using fire extinguishers is one of the preventive efforts that can be performed along with evaluation. However, fire extinguisher evaluations based on the regulatory standard have never been performed in the Locomotive Depot of Daop 9. This study aimed to evaluate the suitability of a Fire Extinguisher at PT KAI Daop 9 Jember Locomotive Depot with Permenakertrans No. 4 of 1980.

Methods: This study was an evaluation research. Data collection was conducted through semi-structured interviews to the Locomotive Depot Facility Supervisor, observations using a checklist sheet, and measurements. Data were analyzed using the univariate method and are presented using tables and narratives.

Results: The Locomotive Depot had several hazards from welding, locomotive electrical systems, fuel, and cigarette butts. A fire prevention program consists of providing a fire protection system, training, reporting, and forming an emergency response team. The locomotive depot had 13 powder fire extinguishers weighing 3.5-12 kg. The suitability of fire extinguisher installation and maintenance is sufficient category with 66.7% for installation and 74.3% for maintenance.

Conclusion: The Daop 9 Jember Locomotive Depot has several fire hazard risks and prevention programs. The suitability of the installation and maintenance of fire extinguishers was in a sufficient category. It is necessary to optimize fire prevention programmes through the cooperation of various parties to enforce applicable regulations.

Keywords: fire extinguisher, active protection system, hazard, locomotive depo, evaluation.

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Introduction

According to data from the Indonesian National Police, in 2022, there were 1,461 fire cases, which increased to 3,929 cases in 2023. The third most contributing province is East Java province, with a total of 158 fire cases.[1] There have been several cases of fires in the railway industry, one of which was the fire at the Halim Perdanakusuma fast train station in Jakarta on September 11, 2023. This fire occurred in the temporary protection section of the upper coating, so that the fire occurred on the roof of the station.[2] The

transportation industry is an industry engaged in the transfer of people, objects, and animals through various modes or vehicles as transportation. Trains are one of the transportation industries with locomotives and carriages. PT KAI has operational areas spread across the islands of Java and Sumatra, where the island of Java is divided by Operational Areas (Daop). Daop is divided into nine regions, with Daop 9 centered in July, which is located on Dahlia Street No. 2. Pagah, Jemberlor, Patrang, Jember Regency, East Java. Daop 9 is equipped with supporting facilities such as the Locomotive Depot as a place to prepare and maintain locomotives.[3]

The locomotive Depot as a place to maintain and repair trains has a function, one of which is refueling train locomotives. The presence of fuel can trigger the risk of fire.[4] Train repair activities cannot be separated from the welding process, the presence of heat sources from high temperatures and electricity can cause the risk of fire.[5] Preventive efforts to prevent fires can be done through active fire protection systems, which are fire protection equipped with fire detectors, water-based fire extinguishing systems, and chemical-based fire extinguishing systems such as fire extinguishers.[6] Fire extinguishers are lightweight tools that can be easily used by one person when extinguishing fires at the beginning of a fire. Each fire extinguisher has installation and maintenance requirements according to the Minister of Manpower and Transmigration Regulation Number 4 of 1980, where fire extinguishers must be checked at least twice a year.[7] Fire extinguisher inspection is carried out as an OHS program to monitor firefighting equipment. The function of the fire extinguisher inspection is to ensure the completeness and feasibility of the fire extinguisher function, so that when there are findings of defects, they can be repaired immediately.[8]

Fire emergency response efforts at Daop 9, especially at Jember Station in the Locomotive Depot section, have been carried out, including the installation of fire extinguishers. Fire extinguisher checks were carried out by employees at the Locomotive Depot, and occupational health inspections were carried out by employees from the health unit every quarter. Fire extinguisher inspections at the Jember Station Locomotive Depot have never been evaluated based on applicable regulatory standards. Based on this background, it is necessary to evaluate the suitability of fire extinguishers at the Jember Station Locomotive Depot using applicable regulations. The company is expected to improve the provision of fire extinguishers as an active protection system for fire emergency response.

Methods

This study uses an evaluative approach to evaluate the suitability of the implementation of the Fire Extinguisher active protection system at the Locomotive Depot of PT. KAI Daop July 9 with applicable regulations. Data were collected through semi-structured interviews, observations, measurements, and documentation studies using a questionnaire developed by the researchers based on Regulation of the Minister of Manpower Number 4 of 1980. Interviews were conducted with informants who were involved in and understood the implementation of Fire Extinguisher management at PT. KAI Daop 9 Jember. The Occupational Health Executor in the Health Unit was the key informant in this study. The main informant, workers who are directly involved in the social interactions being studied, was the Locomotive Depot Facility Supervisor who is responsible for the Fire Extinguisher procurement fire prevention program. Observations were made on the indicators of selection, installation, and maintenance of fire extinguishers using an observation checklist sheet to obtain an overview of the suitability of Fire Extinguisher implementation with applicable regulations. After data collection, the average of each indicator component was calculated. Measurements were made to determine the length of the Fire Audit Assessment Level.9 Measurements floor made to determine the completeness of the Fire Extinguisher installation from the base floor and the completeness of the fire

extinguisher installation sign using a meter. The data were analyzed using univariate analysis by analyzing single data for each research object. The data are then presented in narrative and tabular forms.

Results

Potential Fire Hazard at Locomotive Depot of Daop 9 Jember

The locomotive Depot was a minor locomotive maintenance location. The locomotive maintenance process involves checking the feasibility of the components to repair or replace damaged components. During the process, several fire hazards were found at the Daop 9 Jember Locomotive Depot work site. One fire hazard is found in the welding process, where the welding process creates sparks and utilizes electricity that has the potential to cause a fire. In addition, the locomotive inspection and maintenance process utilizes an electrical system that is at risk of short circuiting to cause sparks.[10] The process of refueling locomotives is also a source of fire hazard risk because fuel is one of the triggers for fire according to the fire triangle theory. In addition, the Daop 9 Locomotive Depot is equipped with a smoking area in the form of two gazebos, which can be a potential source of fire hazard risk through flames on cigarette butts.

Fire Prevention Program at Daop 9 Jember

Several fire prevention programs are implemented at the Locomotive Depot of Daop 9 Jember as a strategy to eliminate and prevent potential fires in order to minimize losses.[6] One of the efforts made is through fire protection systems including evacuation routes accompanied by emergency exit signs, water supply pumps, fire extinguishers, and hydrants. The 2-story building on Daop 9 Jember is also equipped with a lightning distributor installation. In addition, other programs are conducted in the form of fire emergency response training and the use of first aid, which includes education, field practice, and disaster simulation videos. The process of reporting potential hazard findings at PT KAI Daop 9 is facilitated by the Safety Railway Investigation (SRI) online platform. The findings will then be followed by the Safety Inspector to be reported to the center and returned to the relevant unit for repair. The display of potential hazards that have not been addressed will have an open status and will change the status to close if it has been addressed and validated. The implementation of Daop 9's fire prevention program is the responsibility of Daop 9 Jember's emergency response team, which is formed in each work unit and is led by the Head of Daop/Executive Vice President. Unfortunately, there are still some units that have not formed emergency response teams, and the entire team does not have special competencies and certifications regarding emergency response.

The Selection of Fire Extinguisher at Daop 9 Jember

Table 1 shows the details of the selection of fire extinguishers at the Locomotive Depot of Daop 9 Jember. The fire extinguishers at the Locomotive Depot were spread across several different work locations, totaling 13 units with powder types. This shows that the selection of a powder fire extinguisher is in accordance with the type of fire based on the fire potential in the form of ABC-class fires. The weight of each fire extinguisher varies from 3.5 - 12 Kg.

The Installation of Fire Extinguisher at The Locomotive Depot of Daop 9 Jember

Table 2 shows the results of observations and interviews regarding the suitability of the installation of fire extinguishers at the Locomotive Depot of Daop 9 Jember with Regulation of the Minister of Manpower Number 4 of 1980. The results of observations and interviews show that the percentage of APAR installation suitability is classified as sufficient with a value of 66.3%.[9]

The Maintenance of Fire Extinguisher at The Locomotive Depot of Daop 9 Jember

Table 3 shows the results of observations and interviews regarding the suitability of APAR maintenance at the Locomotive Depot of Daop 9 Jember with Permenakertrans No. 4 of 1980. The results of observations and interviews show that the maintenance suitability value is

classified as sufficient with a percentage of 74.3%.[9]

Table 1. Selection of Fire Extinguishers

No	Location	Type	Amount	Weight
1.	Study room	*Powder*	1	3.5 kg
2.	Losd Headroom (maintenance)	*Powder*	1	4.5 kg
3.	Welding Location	*Powder*	2	5 kg
4.	B3 Waste Site	*Powder*	1	5 kg
5.	Maintenance Location	*Powder*	3	3.5 kg
6.	Crew Support Carriage	*Powder*	1	3.5 kg
7.	Tool Help Carriage	*Powder*	2	3.5 kg
8.	Source of Fuel Filling	*Powder*	1	12 kg
9.	Monitoring Room	*Powder*	1	3.5 kg
Total			13	

Tabel 2. Installation of Fire Extinguishers

No	Indicators in Regulation of the Minister of Manpower Number 4 Tahun 1980	Compliance with Regulations				Information
		In accordance		It is not in accordance with		
		N	%	N	%	
1.	Fire extinguishers are placed in a position that is easy to see	12	92.3%	1	7.7%	Fire extinguishers are placed in positions that are easy to see. such as in front of the room next to the door. but there are Fire extinguishers whose front is covered by shelves and items.
2.	Fire extinguishers are equipped with installation markings	10	77%	3	23%	There are Fire extinguishers that are not equipped with installation marks
3.	The height of the Fire extinguishers installation marking is 125 cm from the ground floor	3	23%	10	77%	Most mounting marks are installed more than 125 cm from the bottom of the floor
4.	The location of Fire extinguishers from one another no more than 15 m	13	100%	0	0	The installation of each Fire extinguishers from each other is not more than 15 m
5.	Fire extinguishers use red color	13	100%	0	0	All Fire extinguishers are red
6.	Fire extinguishers are not in a condition with holes or defects	11	84.6%	2	15.4%	There were no defects or holes that found on Fire

No	Indicators in Regulation of the Minister of Manpower Number 4 Tahun 1980	Compliance with Regulations				Information
		In accordance		It is not in accordance with		
		N	%	N	%	
						extinguishers, but there were 2 Fire extinguishers that were found in a rusty condition
7.	Fire extinguishers are installed hanging on the wall with a stand or placed in a cupboard	12	92.3%	1	7.7%	Fire extinguishers are installed on walls with sturdy stand for a total of 7, while the other 5 Fire extinguishers are placed in cupboards, and the other one is placed directly on the floor of the helper carriage.
8.	Fire extinguishers are placed at their peak position 1.2 m from the floor surface, except for CO_2 and *powder* can be installed lower (base distance from floor not less than 15 cm)	12	92.3%	1	7.7%	Fire extinguishers that are not placed in a hanging position or placed on the floor do not have a minimum distance from the floor
9.	Fire extinguishers are not installed in rooms with a temperature of 49^{o}C to -44^{o}C	13	100%	0	0	The work environment or location where the fire extinguisher is installed does not exceed range 49^{o}C to -44^{o}C
10.	The installation mark image is an equilateral triangle measuring 35 cm	0	0	13	100%	All installation mark images have a triangle size that is smaller than 35 cm (it is only 19 cm in size)
11.	The letters are 3 cm high and white	0	0	13	100%	All the letters are white but the size is smaller than 3 cm or around 2 cm
12.	The height of the arrow is 7.5 cm and it is white	0	0	13	100%	All arrows are white but the size is shorter than 7.5 cm or around 5 cm
13.	The basic color of the installation mark is red	13	100%	0	0	All basic colors for fire extinguisher

No	Indicators in Regulation of the Minister of Manpower Number 4 Tahun 1980	Compliance with Regulations				Information
		In accordance		It is not in accordance with		
		N	%	N	%	
						installation signs are red
Average Percentage		66.3%		33.7%		

Tabel 3. Maintenance of Fire Extinguishers

No	Indicators in Regulation of the Minister of Manpower Number 4 Tahun 1980	Compliance with Regulations				Information
		In Accordance		It is Not in Accordance		
		N	%	N	%	
1.	Fire extinguisher is checked twice a year	13	100%	0	0	All fire extinguishers are checked under the responsibility of the facility supervisor once a week
2.	There are clearly legible fire extinguisher usage instructions	3	23%	10	77%	There are several fire extinguishers that are equipped with instructions for using the APAR in the form of stickers
3.	There is an inspection record label	13	100%	0	0	All fire extinguishers are equipped with inspection record labels protected with plastic material
Average Percentage		74.3%		25.7%		

Discussion

Potential Fire Hazard at Locomotive Depot of Daop 9 Jember

Potential fire hazards at the Locomotive Depot arise from the welding process, which generates sparks due to friction and pressure. Electric welding machines can trigger fires if sparks come into contact with flammable materials, such as fuel present in locomotives or fuel storage areas.[10] The maintenance and servicing processes that are prone to fire hazards involve electrical work. One example is the locomotive electrical system, which converts rotational power from diesel into electrical power. Damaged electrical systems can lead to short circuits and produce sparks.[10] This aligns with research by Buyung,[11] which indicated that electrical short circuits were a significant fire factor at the Tangerang Class I Penitentiary.

The locomotive depot also serves as a refueling station for locomotives. The presence of fuel oil poses a fire hazard, as the combination of fuel and oxygen from the air when exposed to sparks from operational processes can trigger a fire, in accordance with the fire triangle theory.[12] This is supported by research conducted by Mubarok,[13] which found that fires at airports could occur due to fuel oil coming into contact with heat sources such as sparks.

The smoking area provided by the Daop 9 Jember Locomotive Depot, shaped like a gazebo, can also be a potential fire hazard. This area serves as a source of ignition for matches and smoldering cigarette butts. According to data from the Jakarta Fire and Rescue Department, discarded cigarette butts are one of the leading causes of fires. Cigarettes can become an open flame source that may lead to fires.[14]

Fire Prevention Program at Daop 9 Jember

PT. KAI Daop July 9 established and implemented a fire prevention program. The fire protection system at Daop 9 Jember can be categorized according to Permenpu No. 26 of 2008. This fire protection system includes rescue facilities such as exit routes equipped with exit direction signs. The provision of water supply pumps, fire extinguishers, and hydrants is classified as an active protection system, which consists of a complete system, including fire detection systems, water-based extinguishing systems, and chemical-based extinguishing systems. Additionally, there is lightning protection installed on the two-story building to prevent fires.[6]

Another fire prevention program involves training related to fire responses conducted by the Fire Department to encourage awareness and attitudes towards fire prevention. This aligns with the findings of community services conducted by Casban,[15] which indicated that the training provided includes presentations to enhance knowledge and practical methods for extinguishing fires. PT. KAI Daop 9 Jember also provides an online platform for reporting potential fire hazards, which aids in risk identification and determination of follow-up actions. After assessing the fire potential, the company can evaluate safety procedures. If the prevention program is deemed ineffective, the company will implement continuous improvements.[16]

The Selection of Fire Extinguisher at Daop 9 Jember

Based on a study of fire hazard potential from operational processes at the Locomotive Depot, it was found that the sources of fire are divided into three categories: Class A for solid materials such as tools in the depot, Class B for flammable liquids such as fuel oil, and Class C for sources originating from electrical short circuits. Class ABC fires can be extinguished using a powder-type Fire Extinguisher according to the written regulations. Powder-type fire extinguishers have been implemented for all fire extinguishers available at the Locomotive Depot, supported by the fact that the type of powder used is suitable for Class ABC. As indicated by the cylinder.[7] The suitability of extinguishing agents should consider the environmental conditions of the locomotive depot to prevent ineffective responses that could exacerbate fire risks. For example, the use of water-based extinguishers in electrical fires can make the situation more dangerous, whereas powder extinguishers do not pose this risk. The selection of powder extinguishers is suitable for ABC class fires, the match between the function of the extinguisher and the fire source can ensure that fire incidents can be managed properly.[17]

The Installation of Fire Extinguisher at The Locomotive Depot of Daop 9 Jember

The placement of fire extinguishers must comply with Permenaker No. 4 of 1980, which states that they should be located in easily visible and accessible areas. At the Locomotive Depot, Fire Extinguishers are installed near room doors, close to machines in the welding and maintenance areas, and near the exit doors of auxiliary cars. However, there are instances of improper placement, such as Fire Extinguishers in closed rooms, which are obstructed by cabinets and other materials, making them difficult to see. Proper placement is crucial to ensure ease and effectiveness of Fire Extinguisher use during small fires.[18]

Permenaker No. 4 of 1980 stipulated that Fire Extinguisher installation signs should be 125 cm above the floor. At the Locomotive Depot, not all Fire Extinguishers are equipped with installation signs, particularly in auxiliary crew and equipment cars and the fuel filling area. For Fire Extinguishers that do have signs, most do not meet the height requirement, measuring between 130-135 cm. The purpose of the installation signs is to facilitate the search for Fire Extinguishers,

especially in low-light conditions or when fire extinguishers are not directly visible.[19] a height of 125 cm is the average eye level for adults, ensuring that the signs are easily readable. The signs must be placed unobstructed by other objects and be visible from a distance. The completeness and proper placement of Fire Extinguisher signs are essential to ensure accessibility and effectiveness during fire emergencies.[20]

Permenaker No. 4 of 1980 specified the size and design of Fire Extinguisher installation signs, which should be triangular with sides measuring 35 cm and a red background. The sign must display the text "ALAT PEMADAM API" in white, 3 cm high, and a white arrow pointing downwards, 7.5 cm high. Research by Rosul et al. (2023) also carried out an evaluation of the suitability of fire extinguishers, it was found that most of the 70% of fire extinguishers did not find markers while the other 30% of fire extinguishers did not comply with regulations.[6] At the Locomotive Depot, while the background color and text are compliant, the size of the triangle, letter height, and arrow height do not meet the regulations. The use of red and white aims to facilitate the search for Fire Extinguishers because of their striking contrast.[19] a letter height of 3 cm was designed to be readable from a distance of 80 feet, allowing users to easily identify Fire Extinguishers during a fire. According to Permenaker No. 4 of 1980, the distance between Fire Extinguisher placements should not exceed 15 m, and this has been implemented at the Locomotive Depot. Close placement aims to facilitate access when necessary to expedite the extinguishing process. Fire Extinguishers should be mounted on sturdy walls or placed in unlocked cabinets. At the Locomotive Depot, Fire Extinguisher placement complies with regulations, with strong hooks for hanging and special cabinets for storage. Storing Fire Extinguishers in cabinets also protects them from extreme temperatures, moisture, and heat that could damage the cylinders.[21]

The placement of Fire Extinguisher at the Locomotive Depot complies with Permenaker No. 4 of 1980, where the top of the Fire Extinguisher is 1.2 m from the floor, except for CO2 and powder types, which can be installed lower, provided the bottom remains at least 15 cm above the floor. All Fire Extinguishers at the Locomotive Depot were of the powder type, and although installed lower than 1.2 m, they maintained a distance of 15 cm from the floor. This placement facilitates access for adults and prevents moisture that could cause the powder medium to clump.[22]

The color of Fire Extinguisher cylinders is regulated by Regulation of the Minister of Manpower Number 4 of 1980, which specifies that they should be red, a standard that has been applied to all Fire Extinguishers at the Locomotive Depot. Research by Aramiko.[23] indicates that red was chosen because it is conspicuous and commonly used in warning signs. The regulation also prohibits the installation of Fire Extinguishers that are perforated or damaged owing to rust; however, the Locomotive Depot still has Fire Extinguishers in a defective condition. Corrosion-related defects can reduce the quality of the Fire Extinguisher cylinder.[6] APAR conditions that are rusted indicate that maintenance and checking are not optimal, this affects the optimization of APAR functions when used to extinguish fires. APAR that is maintained and in good condition will make it easier when used in an emergency at any time.[24]

Permenaker No. 4 of 1980 prohibits the installation of fire extinguishers in work environments with temperatures exceeding 49°C to -44°C. At the Locomotive Depot, Fire Extinguisher installation was conducted in accordance with these regulations, without drastic temperature changes that could affect their effectiveness. Placing Fire Extinguishers outside the specified temperature range can lead to low or high pressures, as well as the risk of powder fire extinguishers freezing at low temperatures, which reduces extinguishing effectiveness. High temperatures also increase the risk of explosions. These findings align with the research by Azizah,[22] which shows that Fire Extinguishers are installed at the recommended temperatures.

The Maintenance of Fire Extinguisher at The Locomotive Depot of Daop 9 Jember

Maintenance of Fire Extinguisher in accordance with Permenaker No. 4 of 1980 must be conducted at least twice a year. At the Locomotive Depot, inspections are carried out weekly, which include checking the physical condition and turning over powder-type Fire Extinguishers. The goal is to ensure that the Fire Extinguisher remains in good condition and to promptly address any defects found.[25] The responsibility for inspecting Fire Extinguishers at the Locomotive Depot lies with the Facility Supervisor, assisted by designated workers. The results of the inspections are recorded on a checklist hung on the Fire Extinguisher cylinder, in accordance with Permenaker No. 4 of 1980. This sheet includes the date, condition of the Fire Extinguisher, and inspector's signature. If issues such as abnormal pressure or damage are found, the warehouse team is notified for follow-up. The warehouse team then took action based on these findings.

In addition to self-inspections, Fire Extinguishers are inspected by the Health Unit every three months across all areas of PT. KAI Daop 9 Jember, including the Locomotive Depot and Direct Crossing Lines (JPL). The inspection covers seven indicators recorded on the Fire Extinguisher Inspection Control Card. The results of the inspections were reported through the Occupational Health Supervision Google Form and reviewed by the Health Manager. If any discrepancies were identified, the findings were communicated to the Human Resources and General Unit for follow-up by the relevant unit. The maintenance process also ensures the availability of usage instructions for fire extinguishers, in accordance with Permenaker No. 4 of 1980. However, not all fire extinguishers at locomotive depots are equipped with these instructions. Fire Extinguishers with instructions are placed above the installation sign in the form of stickers, written in both Indonesian and English, and accompanied by illustrations to facilitate understanding. These instructions are essential to ensure the correct use of Fire Extinguishers and to prevent damage due to improper usage.[26]

Conclusion

PT KAI Daop 9 Jember Locomotive Depot has a risk of fire hazards from the welding work process that can cause sparks, electrical system hazards that can cause short circuits, danger of refueling as a fire trigger, and danger of smoking areas. The fire prevention program at the Daop 9 Jember Locomotive Depot is carried out through an active fire protection system, one of which is the provision of fire extinguishers. The selection of fire extinguishers in the form of ABC powder installation and maintenance of fire extinguishers has a percentage of conformity of 66.3% and 74.3%, respectively, which is a sufficient category. It is necessary to optimize the fire prevention program and cooperation from all parties in compliance with applicable regulations to avoid losses in both materials and life. Our research can be used as a reference for corrective actions and for improving the provision of fire extinguishers as an active fire emergency protection system. However, our study has limitations, namely, the scope of the research unit. It is limited to the locomotive depot, as one of the units in Daop 9. Further research can expand the unit where the research is carried out so that Daop 9 can be described as a whole.

Ethics approval

Not applicable.

Availability of data and materials

Not applicable.

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Author Contribution

The researcher plays a role in data collection, analysis, and presentation until it becomes a research article.

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