Integrating ICAO Standards and OHS Principles in Risk Mitigation for Foam Tender Operations at Airports

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Operation of Foam Tender Type I vehicles in firefighting duties at the airport has a high potential for danger that can threaten the safety of ARFF (Aircraft Rescue and Fire Fighting) personnel. The purpose of this study is to identify potential hazards and assess the level of work risk using the Hazard Identification and Risk Assessment (HIRA) method which refers to ICAO standards and Occupational Safety and Health (OHS) principles, in order to formulate an effective risk mitigation strategy. The method used is descriptive qualitative through observation, interviews, and documentation in the ARFF environment of Sultan Mahmud Badaruddin II Airport, Palembang. The results of the study found ten potential hazards, consisting of four high risks, five medium risks, and one low risk. The main risks include vehicle blind spots, driver panic attacks, dangerous manoeuvrers, and high pressure from emergencies. Control strategies are carried out by integrating ICAO Standards and the K3 risk control hierarchy such as engineering, administrative control, and use of PPE. This study provides an overview of a comprehensive risk mitigation model that is in accordance with occupational safety standards, and can be a reference in improving operational safety policies for ARFF vehicles in the airport environment. It is recommended that routine training related to K3 and the HIRA method be carried out for all personnel, as well as the implementation of risk control based on the elimination hierarchy to the use of PPE. These findings are expected to be the basis for improving the risk-based safety management system in the ARFF unit at the airport.

Keyword: ARFF, Foam Tender, HIRA, OHS, Safety Management Manual

1. INTRODUCTION

The Aviation Act No. 1 of 2009 states that aviation is an integrated system encompassing the use of airspace, airports, navigation, as well as safety and security aspects (Niwilingame, 2023). Aviation safety is a primary factor that must be fulfilled by every aviation industry in accordance with ICAO standards. Airports are also required to provide Aircraft Rescue and Fire Fighting (ARFF) services based on the category determined by the Directorate General of Civil Aviation (Agung et al., 2021). The ARFF unit plays a vital role in saving lives and property, as well as mitigating fires within a radius of 5 miles from the airport reference point.

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In addition to its main duties, the occupational safety of ARFF personnel must also be considered, as accidents may occur due to potential hazards or worker negligence (Nando & Yuamita, 2021). Previous studies have identified hazards within ARFF units, such as blind spots and the risk of being struck by hoses during training (Chaerunnisa et al., 2022). A fatal incident at Jorge Chávez International Airport in Peru, involving a collision between an aircraft and a fire truck caused by ATC–ARFF miscommunication, further emphasizes the importance of coordination and risk management.

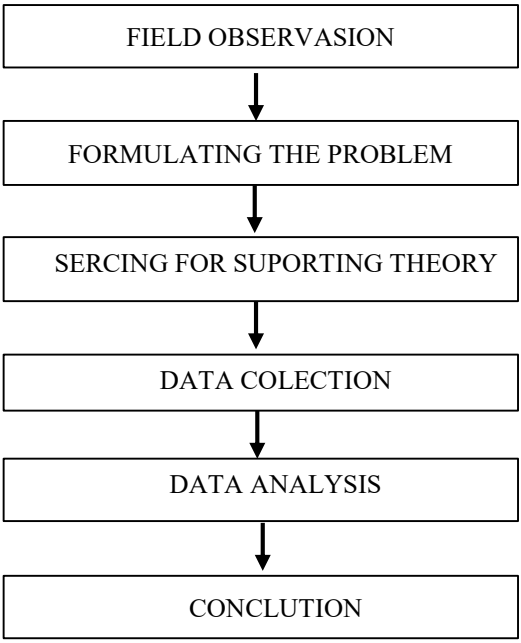
ICAO through the Safety Management Manual (ICAO Doc 9859 4th Edition – Safety Management Manual, 2018) mandates the implementation of a Safety Management System (SMS), particularly the Safety Risk Management component, which includes hazard identification, risk assessment, mitigation, and risk acceptance (Umar & Diah Anggraeni, 2001) .This approach is generally applied using the Hazard Identification and Risk Assessment (HIRA) method (Suryan et al., 2020). However, the application of HIRA in ARFF units remains partial and has not been fully integrated with Occupational Safety and Health (OSH) principles, especially in the operation of Foam Tender Type I vehicles (Nugraha et al., 2023).

Based on preliminary observations conducted at the ARFF unit of Sultan Mahmud Badaruddin II International Airport, various potential hazards were identified during the preparation, operation, and post-operation stages of Foam Tender activities, ranging from slipping risks, blind spots, hose water pressure, to wheel chocks being dislodged. This indicates a gap between regulations and field practices. Therefore, this study aims to develop an integrative HIRA model based on ICAO and OSH principles for the operation of Foam Tender Type I vehicles, providing a comprehensive approach to hazard identification, risk assessment, and mitigation strategies in the airport environment (Amalia, 2019).

2. METHODOLOGY

Research This study employs a descriptive qualitative design aimed at illustrating potential hazards and occupational safety risks in the operation of Foam Tender vehicles at Sultan Mahmud Badaruddin II International Airport, Palembang.

The research subjects include Airport Rescue and Fire Fighting (ARFF) personnel who are competent in operating Foam Tender vehicles, as well as employees of the Safety and Risk Department who are knowledgeable about the Hazard Identification and Risk Assessment (HIRA) method and aviation safety management. The object of the research is the activities of ARFF personnel in operating Foam Tender vehicles, ranging from boarding the vehicle, driving, using firefighting equipment, to parking the vehicle. The following are the stages of qualitative research conducted by the researcher.



The stages of this research began with field observations of ARFF personnel activities in operating the Foam Tender Type I vehicle at Sultan Mahmud Badaruddin II International Airport, as well as observations at the Safety and Risk Department to examine the conformity of existing conditions with the Directorate General of Civil Aviation Regulation No. KP 622 of 2015, which provides Technical Guidelines for Civil Aviation Safety Regulations Part 139-08 concerning the acceptance and implementation of the Safety Management System (SMS) at airports. The results of these observations served as the basis for problem formulation, namely the identification of potential occupational safety risks, which were then analyzed using the HIRA method. Subsequently, the researcher conducted a literature review by examining relevant studies and theories. Data collection was carried out through direct observation, interviews with related informants, documentation, and review of supporting documents. The data obtained were then analyzed based on the ICAO Doc 9859 Safety Management Manual, Fourth Edition 2017 and the HIRA form to identify hazards, assess risk levels (likelihood and severity), and develop mitigation recommendations in accordance with ICAO standards and occupational safety and health (OSH) principles. Finally, the last step of the research was to determine the results and draw conclusions from the collected data.

3. DISCUSSION

Based on the hazards identified from the observation results, a risk assessment process was subsequently carried out to evaluate the risks and dangers of these hazards. The risk assessment was conducted by multiplying the severity and probability of each

identified hazard, and the results were presented in the form of a risk matrix table. This process provided the categorization of each hazard. The following table presents the results of the risk assessment conducted together with the Safety and Risk Department unit of Sultan Mahmud Badaruddin II International Airport, Palembang.

Table 1. Risk Assesment

Based on the results of the Risk Assessment table, which evaluates the risks faced by personnel in the ARFF unit at Airport, a total of 10 hazards were identified in the

No	Task/Activity	*Hazard*	Risk	*Risk Matrix*		P X S
				P	S	
1	Driving the vehicle	Vehicle blind spot	Run over resulting in death	5	A	5A
2	Driving the vehicle	Panic attack	Loss of control, palpitations leading to shortness of breath and vehicle rollover	4	C	4C
3	Vehicle maneuvering	Vehicle rollover during maneuver	Fall resulting in serious bodily injury	5	A	5A
4	Deploying hose (Handline)	High-pressure hose	Entanglement, struck by nozzle causing head injury	5	A	5A
5	Using rescue tools (RAM Tools, Combi Tools, Chainsaw)	Load/pressure from rescue tools	Impact on body parts causing injury	4	D	4D
6	Entering the Foam Tender	Slip on footstep	Fall causing minor bodily injury	3	C	3C
7	Approaching the vehicle	Slippery floor and water puddles	Slip and fall injury	3	C	3C
8	Handling ladder and suction hose (4.5 inch)	Falling ladder and suction hose	Struck and injured personnel body parts	3	C	3C
9	Operating manual turret	Pinched/struck by manual turret	Impact with turret causing bodily injury	3	C	3C

operation of the Foam Tender Type I vehicle, consisting of 4 hazards with high risk, 5 hazards with moderate risk, and 1 hazard with low risk. In the high-risk category, the

10	Parking the vehicle	Rebounding stop wheel	Striking personnel causing injury	2	D	2D

potential impacts include severe injury, permanent disability, or even death. In the moderate-risk category, the impacts may cause minor injuries to personnel that could lead to restricted working hours. Meanwhile, in the low-risk category, the impacts are limited to minor injuries that do not require mitigation. The results of this risk assessment serve as the basis for formulating risk mitigation or risk control recommendations to address workplace hazards, with the aim of minimizing or reducing the risk level of identified potential hazards.

After conducting a risk assessment, the next step is to provide risk control recommendations to minimize the risk of the hazard. This mitigation step aims to lower the risk level by providing risk control recommendations based on ICAO Doc 9859 Safety Management Manual and risk mitigation based on the K3 risk control hierarchy.

Table 2. Risk Control Recommendation and Re- Assessment

Based on the table above, the operation of Foam Tender Type I at Airport presents significant potential hazards to the safety of ARFF personnel. A total of 10 hazards

No	Hazard	Risk	ICAO Risk Control Recomendation	Occupational Health and Safety Risk Control Hierarchy	Risk Matrix		P X S
					P	S	
1.	Vehicle blind spot	Run over resulting in death	1. Training: Personnel training on the importance of increasing OHS awareness. 2. Regulation: SOP for safe and secure driving 3. Technology: 360° cameras and sensors	1. Engineering Control Addition of 360° camera sensor 2. Administrative Control SOP for safe zones and safety behavior training 3. Personal Protective Equipment (PPE) Using Complete PPE	2	A	2A
2.	Panic attack	Loss of control, palpitations leading to shortness of breath and vehicle rollover	1. Training: Driving safety culture education 2. Regulation: SOP for safe and secure driving, personnel medical check-up	1. Engineering Control Fatigue and stress monitoring system technology 2. Administrative Control SOP for safety driving, personnel medical check-ups,	2	A	2A

			3. Technology: Creation of a personnel stress monitoring program or application	socialization of dangers and risks in vehicles 3. Personal Protective Equipment (PPE) Using Complete PPE			
3.	Vehicle rollover during maneuver	Fall resulting in serious bodily injury	1. Training: Personnel training on the importance of increasing K3 awareness. 2. Regulation: SOP for safe and secure driving 3. Technology: Maintenance of brake and tire systems and non-functioning spare parts, fire truck simulator	1. Engineering Control fire truck simulator and automatic brake sensor repair 2. Administrative Control safety culture training, routine medical check-up , SOP maneuvering 3. Personal Protective Equipment (PPE) Using Complete PPE	2	A	2A
4.	High-pressure hose	Entanglement, struck by nozzle causing head injury	1. Training: Understanding work instructions for using hoses and providing work safety awareness materials 2. Regulation: safety procedures for operating fire hoses on vehicles, use of PPE 3. Technology: Replacing damaged hoses and nozzles and repairing the pump system on vehicles	1. Engineering Control Replacing damaged hoses and nozzles 2. Administrative Control SOP for hose use, safety culture training 3. Personal Protective Equipment (PPE) Using Complete PPE	2	A	2A

were identified, consisting of 4 classifieds as high risk, 5 as moderate risk, and 1 as low risk. The main risks include vehicle blind spots, driver panic attacks, dangerous

5.	Load/pressure from rescue tools	Impact on body parts causing injury	1. Training: Providing safety material in using tools and techniques for using tools 2. Regulation: SOP for use of tools in vehicles and use of PPE 3. Technology: Ergonomic design, providing protection for tools, and application of tool maintenance checklists	1. Engineering Control Ergonomic design, tool protection, digital tool maintenance application 2. Administrative Control SOP for tool use, safety culture training 3. Personal Protective Equipment (PPE) Using Complete PPE	2	C	2C
6.	Slip on footstep	Fall causing minor bodily injury	1. Training: Providing safety culture materials in the workplace. 2. Regulation: Procedures for getting on and off a vehicle, use of PPE 3. Technology: Using anti-slip footstep material and repair of bolts on the footstep	1. Engineering Control footstep material and bolt repair on the footstep 2. Administrative Control Safety culture training, SOP for getting on and off vehicles 3. Personal Protective Equipment (PPE) Using Complete PPE	2	D	2D
7.	Slippery floor and water puddles	Slip and fall injury	1. Training: Providing Safety Culture material in the workplace 2. Regulation: Use of complete PPE 3. Technology: Epoxy floor, installing sign "Slippery floor"	1. Engineering Control Epoxy Floor, floor drying Control 2. Administrative Control Safety culture training 3. Personal Protective Equipment (PPE) Using Complete PPE	2	D	2D

8.	Falling ladder and suction hose	Struck and injured personnel body parts	1. Training: Providing safety materials for using tools 2. Regulation: Procedures for lowering and raising stairs and use of PPE 3. Technology: Installing safety signs	1. Engineering Control Automatic safety systems, safety signs 2. Administrative Control SOP moving equipment 3. Personal Protective Equipment (PPE) Using Complete PPE	2	E	2E
9.	Pinched/struck by manual turret	Impact with turret causing bodily injury	1. Training: Vehicle familiarization 2. Regulation: SOP for safe and secure manual operation of the turret and use of PPE 3. Technology: Maintenance programmable logic controller turret	1. Engineering Control Automatic safety systems, safety signs 2. Administrative Control Programmable Logic Controller maintenance, 3. Personal Protective Equipment (PPE) Using Complete PPE	2	E	2E
10.	Vehicle blind spot	Run over resulting in death	1. Training: Personnel training on the importance of increasing OHS awareness. 2. Regulation: SOP for safe and secure driving 3. Technology: 360° cameras and sensors	1. Engineering Control Addition of 360° camera sensor 2. Administrative Control SOP for safe zones and safety behavior training 3. Personal Protective Equipment (PPE) Using Complete PPE	2	A	2A

maneuvers, and high-pressure fire hoses, all of which have the potential to cause serious injuries or fatalities.

Mitigation efforts were carried out through a combination of administrative controls (SOP training, medical check-ups, and reinforcement of safety culture) and engineering controls (installation of 360° cameras, fire truck simulators, equipment

maintenance, epoxy flooring, and stress monitoring systems). The implementation of these measures has proven effective in reducing risks from the high-risk category to moderate or low levels. As a result of the recommended risk control strategies, the initial 4 high-risk hazards were successfully reduced to the moderate-risk level, while 5 moderate-risk hazards were reduced to four low-risk hazards, leaving only 1 hazard that remained at the moderate-risk level**.**

One of the key strengths of this study is the integration of Occupational Safety and Health (OSH**)** principles into the risk mitigation process using the HIRA method in accordance with ICAO standards. This integration allows risk assessments to not only consider potential impacts on operational safety but also holistically cover the protection of ARFF personnel in terms of ergonomics, psychosocial aspects, and occupational health. Such an approach is rarely found in previous studies, which generally focused only on technical and operational risks at airports. By referring to the OSH risk control hierarchy—from hazard elimination to the use of PPE—this study provides a more comprehensive, realistic, and applicable mitigation model in high-risk work environments such as ARFF units.

Thus, the findings of this study not only demonstrate the existence of significant potential hazards in the operation of Foam Tender Type I vehicles but also provide a comprehensive overview of the weaknesses in the current safety system implementation. The proposed mitigation recommendations can serve as practical guidance in developing OSH training and awareness programs, SOP evaluations, and the enhancement of safety-supporting technologies for ARFF personnel in the airport environment.

4. CONCLUSION

This study identified 10 potential hazards in the operation of Foam Tender Type I at the ARFF unit of Airport, consisting of physical, ergonomic, and psychological risks. The findings revealed that existing risk controls have not fully complied with the OSH risk control hierarchy, particularly in safety training, SOP implementation, and the application of adequate engineering or technological interventions. The key conclusion is that an integrated approach combining ICAO-based HIRA with OSH strategies is essential to establish an effective and preventive safety system. Regular risk identification and assessment must be linked directly to the development of SOPs, routine training, and the use of supporting technologies such as stress sensors and monitoring dashboards.

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