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| RESEARCH ARTICLE

Risk Assessment of Aircraft Refueling Activities at the Indonesian Flight Academy Banyuwangi Using the Bowtie Method and Shell Model Human Factor

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| ABSTRACT
This study aims to assess the risks involved in aircraft refueling activities at the Indonesian Pilot Academy in Banyuwangi, using the Bowtie method and the SHELL Model Human Factor. The study adopts a qualitative descriptive approach to understand the emerging risks and human factors associated with the activity. Based on the research findings, fire risk emerges as the most dominant. These risks are then analyzed using the Bowtie method and the SHELL Model Human Factor to gain a comprehensive understanding of the causes and consequences of fire risk. Several identified causes of fire risk include non-compliance with procedures, absence of fuel flow measuring devices and fuel drum handling equipment, visual impairment due to sunlight, and inadequate temporary fuel storage conditions. Potential impacts include fire and significant damage to the aircraft. This research makes an important contribution to enhancing safety by providing relevant safety recommendations for aircraft refueling activities at the Indonesian Pilot Academy in Banyuwangi.

| KEYWORDS

Risk assessment, Aircraft refueling, Bowtie method, SHELL Model Human Factor, Fire, Safety**.**

| ARTICLE INFORMATION

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1. Introduction

The Banyuwangi Indonesian Pilot Academy is a pilot school that encompasses complex flight operational processes. One of the crucial flight processes is the activity of refueling aircraft. Refueling aircraft at the Indonesian Pilot Academy Banyuwangi still employs manual techniques; therefore, this activity carries the potential risk of accidents if not conducted properly. Accidents in the aircraft refueling process involve various factors such as human error, equipment failure, inadequate procedures, or poor environmental conditions. Research results indicate that 60% of aviation accidents in Indonesia are dominated by human factors (Eko Poerwanto & Uyuunul Mauidzoh, 2016). In an effort to minimize this risk, a precise and accurate risk assessment is needed. In risk analysis research, the Bowtie method has been proven effective in conducting risk assessments in various fields. The SHELL Model, Human Factor theory, will also be instrumental in identifying risks related to human factors.

Previous research has demonstrated the use of the Bowtie method in carrying out risk assessments in various fields, such as the mining industry (Zhang Cong et al., 2017), oil and gas (Subagyo & Kholil, 2020), and even in the health sector (Ronald & Bowie, 2020). However, not much research has discussed the use of the Bowtie method for carrying out risk assessments on aircraft refueling activities. Additionally, human factors play a crucial role in aircraft refueling activities, and thus the SHELL Model Human Factor theory can aid in identifying risks in aircraft refueling activities at the Indonesian Aviation Academy Banyuwangi. This final project research aims to determine the risks in the process of aircraft refueling activities at the Indonesian Pilot Academy Banyuwangi, developed using a Bowtie method approach and combined with the SHELL Model Human Factor theory to analyze human factors in depth. It is hoped that this research can help identify risks in aircraft refueling activities and provide recommendations for improving safety at the Indonesian Pilot Academy Banyuwangi.

2. Method

This research employs a descriptive qualitative approach. The variables in this research focus on human factors based on the SHELL Model theory, namely Software (Procedures and Regulations), Hardware (Equipment), Environment (Environment), Central Liveware (Central Human Factors), and Liveware (Human Factors). The population in this study comprises the entire community of the Indonesian Pilot Academy Banyuwangi involved in aircraft refueling activities. Meanwhile, the sampling technique uses a purposive sampling technique, selecting respondents with specific characteristics in line with the research objectives. Data collection techniques and research instruments used in this research include Observation, Interview, and Document Study. Data analysis is based on risk assessment techniques from ICAO DOC. 9859. The research was conducted at the Indonesian Aviation Academy Banyuwangi campus, specifically at the aircraft refueling location, during the period from March to September 2023.

3. Result

3.1 Profile of the Indonesian Aviation Academy Banyuwangi

The Banyuwangi Indonesian Aviation Academy is one of the official schools under the Ministry of Transportation of the Republic of Indonesia. Founded in 2013 as a pilot education institution with the name Banyuwangi Pilot Education and Training Center (LP3). Along with educational renewal and improving the quality of human resources in the field of transportation, this institution has experienced many changes and increased status from changing to the Banyuwangi Pilot Education and Training Center to becoming the Banyuwangi Indonesian Pilot Academy through the Regulation of the Minister of Transportation of the Republic of Indonesia Number PM 26 of 2019 concerning Organization and Work Procedures for the Indonesian Pilot Academy Banyuwangi on April 15, 2019. As an aviation education institution, the Banyuwangi Indonesian Pilot Academy has flight operational activities that are not free from risks, starting from the smallest risks to the largest and most serious, such as loss of life, loss/damage/destruction of assets to the fall of the organization's image if existing risks are not managed well. The activity of refueling an aircraft is one of the crucial flight processes. There are 37 training aircraft facilities owned by the Banyuwangi Indonesian Pilot Academy, including aircraft Cessna 172 Skyhawk SP, Piper PA-34 SENECA V, and SeaPlane Cessna 172 Skyhawk SP Modification. The process of refueling the aircraft is still carried out using manual techniques. To manage risk, this institution has a risk management policy as stated in the Director's Decree Number 532 of 2022 concerning Risk Management of the Indonesian Pilot Academy Banyuwangi. Apart from that, as a pilot school based on CASR 141, which regulates all flight operations, it has its own manual on risk management stated in the Safety Management System Manual For Indonesia Civil Pilot Academy (ICPA).

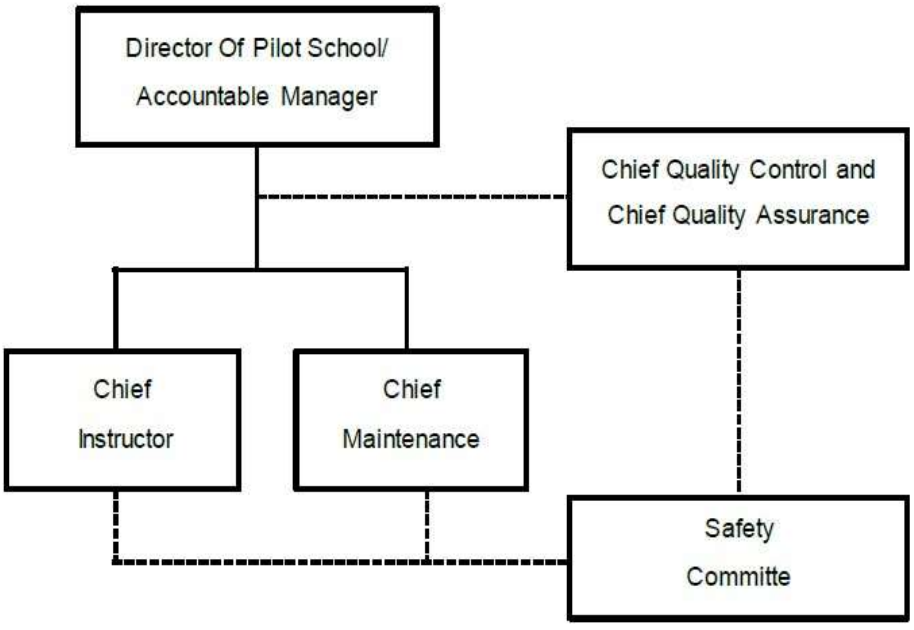

Figure 1. Pilot School Risk Management Organization Diagram
Source: Safety Management System Manual

3.2 Profile of Research Respondents

Data collection was carried out by researchers through observation, interviews, and document study. Interview respondents are parties who have relationships and responsibilities in aircraft refueling activities. The following is the profile of each respondent:

1. Mr. Dr. Efendi, S.E., M.Sc.: Head of Academic Administration, General Affairs, and Educational Facilities. He was chosen as the respondent as an authorized official in education and training activities.
2. Mr Sabam Danny Sulung, S.ST.: Aviation technician with experience in aircraft maintenance and management in aircraft refueling activities.
3. Mr. M. Arief Rakhman S: Flight Instructor or flight instructor. He was chosen as a respondent because he is the PIC (Pilot in Command) responsible for the aircraft's condition during flight.
4. Cadet Gading Tirta Gema Kusuma Hartanto: Pilot cadet majoring in DIII PST batch 2. He was chosen as a respondent because he is a student pilot responsible for the aircraft's condition during flight.
5. Mr. Paulus Sambada Biratnawa, A.Md.: Aviation technician and Quality Control CASR 145 Approved Maintenance Organizations. He was chosen as a respondent because he is responsible for controlling the risk of aircraft refueling.

3.3 Risk Analysis

Figure 2. Aircraft refueling activities using manual techniques

To determine the risks of aircraft refueling activities at the Indonesian Pilot Academy Banyuwangi, researchers conducted activity observations and interviews with respondents who had a direct relationship with these activities, both policy makers and implementers of these activities. The results of observations and interviews are then summarized using data reduction techniques so that research data can be presented and reviewed properly. The following is data from observations made by researchers in the field:

Table 1. Results of research data reduction

Data collection techniques	Results	Conclusion
Observation	The aircraft refueling process is carried out by technicians based on existing technical procedures and equipment handling refuel as well as safety equipment which are available. However, there are several dangerous conditions that can cause risk incidents/accidents during the refueling process.	There are several dangerous conditions that can cause risk incidents/accidents if risk control is not carried out.
Interview 1 (technician)	Validate the results of observations and document studies that have been carried out by researchers. There are several factors that cause danger, including error on technical refuel, the level of operator focus, available equipment, and environmental factors.	Factors that cause danger include: error on technical refuel, the level of operator focus, available equipment, and environmental factors.
Interview 2 (pilot)	The pilot in command (PIC) is responsible for the condition of the aircraft before fly Doing Preflight-check among them walk around to see the condition visually, and draining contamination check before flying is the pilot's responsibility	Dopre- check flight Before flying, the condition of the aircraft's fuel is the pilot's responsibility
Interview 3 (school manager)	Policies related to safety and security of refueling activities have been established in existing procedures. Meanwhile, evaluation and supervision is carried out by the SPI and SPM units. The plan for the future is that refueling activities will be carried out using fuel tanks, so no longer using manual techniques.	Policies related to procedures and supervision in managing aircraft refueling risks have been established.
Interview 4 (Quality Control)	Risk control for refueling activities is carried out every day to ensure that all activities are carried out based on established procedures However, in terms of equipment, we maximize the equipment currently available, and if there are findings, we immediately send an official note to management for immediate follow-up. Apart from that, with minimal personnel, communication and coordination are the keys to the success of refueling activities.	By maximizing existing equipment and personnel, the risk of refueling activities can be controlled properly.

Source: primary data

Underlies ICAO DOC. 9859 about Safety Management, key components of risk assessment(safety risk Assessment) includes hazard identification(hazard identification), analysis of the likelihood and severity of risks(Risk analysis probability and severity), risk assessment and tolerability(Risk assessment and tolerability), risk mitigation(Risk mitigation), and acceptance of risk(Risk acceptance). The following are the results of observations and interviews related to hazard identification carried out by researchers in the field:

Table 2. Data Hazard Identification

No	Danger	Potential Risks
1.	There is no instrument for measuring the flow of fuel entering the tank to determine the quantity of fuel.	Fuel spilled on the plane could pose a risk of fire.
2.	There is no drum fuel handling equipment in the storage shelter	The fuel drum is damaged, and fuel spills, risking loss and fire
3.	There is APAR Unserviceable	There are no mitigation tools if a large fire occurs.
4.	The operator was not careful in handling refueling	Fuel spill, fire, incident

5.	The refueling operator did not comply with existing procedures	Fire, incident/accident
6.	The pilot did not comply with procedures during the refueling process	An incident/accident, fire occurs
7.	The pilot did not carry out a quick drain fuel check	Fuel contaminated with water which can damage the engine
8.	Visual disturbance of sunlight during the refueling process	An error occurs, resulting in a fuel spill, fire, incident/accident
9.	If there is continuous rain, aircraft refueling is carried out in hangar C	Risk incident/accident, fire
10.	The temporary fuel storage area in Hangar C is not neat	Fire, incident / accident in the hangar
11.	Fuel temporary storage handling is not done properly	There was fuel spilled in hangar C; a fire broke out in the hangar
12.	Farmers burn straw next to the fuel shelter	Fire
13.	Communication and coordination of refueling operator officers	Spilled fuel, risk of incident/accident, fire
14.	Refueling operators do not have special competencies	Errors in handling, incidents/accidents, fire
15.	The level of fatigue affects the level of focus	Errors in handling, incidents/accidents

Source: primary data

The validity of the data collected by the researcher was tested using source triangulation techniques. Source triangulation is carried out by means of check-recheck, cross-check from observation data, interviews, and document studies by researchers during field observations.

4. Discussion of Research Results

4.1 Risk Assessment

Once the hazard is known, the next step is risk assessment. Based on ICAO DOC. 9859 risk assessment measures probability and severity risks adjusted to organizational policies. Risk probability is the likelihood that a safety consequence or outcome will occur. Meanwhile, risk severity is defined as the level of harm that may be expected to occur as a consequence or result of the identified hazard. Next is the ranking safety risk index created by combining the score results probability and severity to obtain a risk assessment matrix. The following is the risk assessment policy for measuring probability and severity based on Decree No. 532 of 2022 and the Safety Management System Manual.

Table 3. Probability table based on Decree No. 532 of 2022

Level Possibility	**Possibility Criteria**		
	Percentage in 1 year	**Number of frequencies in 1 year**	**Incident Low Tolerance**
Almost not Occurred (1)	0% < x ≤ 5%	Less than 2 times a year	1 incident in last 5 years
Rarely Occurs (2)	5% < x ≤ 10%	3 to 5 times a year	1 incident in last 4 years

Sometimes Happens (3)	10% < x ≤ 20%	6 to 9 times a year	1 incident in last 3 years
Frequently Occurs (4)	20% < x ≤ 50%	10 to 12 times a year	1 incident in last 2 years
Almost Sure Happened (5)	50% < x ≤ 100%	More than 12 times a year	1 incident in last 1 year

Source: Decree No 532 of 2022

Risk management at the Indonesian Pilot Academy Banyuwangi stipulates that all risks related to Flight Operations, Aviation Facilities and Finance use probable criteria low tolerance events.33
Source: Decree No 532 of 2022

Table 4. Probability and Severity Table based on Safety Management System Manual

Severity of Consequences			**Probability of Occurrence**		
Aviation Definition	Meaning	Value	Qualitative Definition	Meaning	Value
Catastrophic	• Aircraft/equipment destroyed • Multiple deaths	A	Frequent	Likely to occur many times (has occurred frequently)	5
Hazardous	• A large reduction in safety margins, physical distress, or a workload such that operational personnel cannot be relied upon to perform their tasks accurately or completely • Serious injury • Major equipment damage	B	Occasional	Likely to occur sometimes (has occurred infrequently)	4
Major	• A significant reduction in safety margins, a reduction in the ability of operational personnel to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency • Serious incident • Injury to persons	C	Remote	Unlikely to occur, but possible (has occurred rarely)	3
Minor	• Nuisance • Operating limitations • Use of emergency procedures • Minor incident	D	Improbable	Very unlikely to occur (not known to have occurred)	2
Negligible	• Few consequence	AND	Extremely improbable	Almost inconceivable that the event will occur	1

Source: Safety Management System Manual

Once the value is known probability and severity, the level safety risk index created by combining the score results in probability and severity. Each combination of probability and severity is presented in a safety risk assessment matrix. A safety risk assessment

matrix is used to determine the tolerability of safety risks. The following is the risk assessment matrix policy based on Decree No. 532 of 2022 and the Safety Management System Manual.

5. Conclusion

This study aimed to assess the risks involved in aircraft refueling activities at the Indonesian Pilot Academy in Banyuwangi, using the Bowtie method and the SHELL Model Human Factor. The study used a qualitative descriptive approach to understand the emerging risks and human factors associated with the activity. Based on the results of the risk assessment carried out by researchers, it can be concluded that the risk of fire is the most dominant risk in aircraft refueling activities at the Indonesian Pilot Academy Banyuwangi. This research makes an important contribution to enhancing safety by providing relevant safety recommendations for aircraft refueling activities at the Indonesian Pilot Academy in Banyuwangi.

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