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Analysis Of Standby Horizon Gyro Indicator Failure on Cessna 172 Series Aircraft Using FMEA And FTA Methods At API Banyuwangi

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ABSTRACT

In aviation, navigation instruments play a vital role in ensuring flight safety, particularly during adverse weather and night operations. Among these, the Standby Horizon Gyro Indicator, also known as the Attitude Indicator, is critical for displaying aircraft pitch and roll relative to the horizon. Failures of this instrument can significantly compromise safety, making systematic analysis essential. This study investigates failures of the Standby Horizon Gyro Indicator on Cessna 172 Series aircraft using Failure Modes and Effect Analysis (FMEA) and Fault Tree Analysis (FTA). Data were obtained from field observations, pilot reports, and interviews with certified technicians at API Banyuwangi. The analysis identified five primary failure modes: Low Vacuum Indicator, Not Function, Toppled/Spin, Unbalanced Gyro, and Stuck. The Toppled/Spin condition was found to be the most critical, with a Risk Priority Number (RPN) of 126. FTA revealed root causes including vacuum pump aging, contaminated filters, inadequate knowledge, complacency, lack of supervisory cross-checks, and low safety awareness. Corrective actions involve replacing worn components, cleaning filters, and applying strict safety procedures, while preventive measures emphasize scheduled maintenance, double-check protocols, and periodic safety training. The findings highlight the importance of addressing both technical and human factors to enhance reliability, improve maintenance practices, and strengthen aviation safety culture.

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INTRODUCTION

In the world of aviation, navigation instruments play a vital role in guaranteeing the safety and effectiveness of aircraft operations, especially in adverse weather conditions or night flights. One of these critical instruments is Standby Horizon Gyro Indicator or Attitude Indicator and can be called Artificial Horizon, which indicates the position pitch and roll aircraft against artificial horizons. [1]

Figure 1 Standby Horizon Gyro Indicator Component[1]

Various instruments are used to indicate the angle of inclination (roll angle) aircraft. This is due to the limitations of the human vestibular system, which is incapable of accurately detecting aircraft movements, especially when in instrument flight without an external visual reference. Therefore, Standby Horizon Gyro Indicator serves to restore the correct spatial orientation to the pilot. [2]

Problem of the principle of appointment "roll" and "pitch" on Standby Horizon Gyro Indicator (Aircraft attitude indicators) has been an important topic in the aviation world since the beginning of the 20th century. As aviation technology develops, engineers and aviation psychologists are beginning to realize that the way aircraft attitude information is displayed to pilots, especially in flight conditions without external visual references, can affect spatial perception, decision-making, and overall flight safety. Therefore, the selection of the right indication system to indicate the orientation of the aircraft in the air is crucial and continues to be reviewed to this day [2]. There are two types of instruments Horizon Gyro Indicator on the Cessna 172 Series, which is digital (main instrument) dan analog (Standby). The function of the analog system is as standby/backup system. [3]

Based on pilot reports, API Banyuwangi's Cessna 172 Series aircraft, namely the Standby Horizon Gyro Indicator instrument, was found to have failed several times, one of which is the Standby Horizon Gyro Indicator toppled where the gyro position is reversed, as a result of which it can cause pilot disorientation, navigation errors, and even aircraft safety incidents in the event of an emergency situation or Primary Flight Display (PFD) and Multi-Function Display are Eror. Apart from the Pilot Report, when the author carried out aircraft maintenance duties on the Cessna 172 Series, the Standby Horizon Gyro Indicator failed to operate, the instrument is spin when the engine ground run. [Author's Data, 2025]

Based on the results of interviews with several technicians and observations in the field, there are several factors that cause the failure of the Standby Horizon Gyro Indicator, that are gyro failure, vacuum system leak, or dust/oil contamination. That is why it is necessary to conduct research to find the root cause of the problem to determine the optimal action to be taken in order to reduce or even eliminate the variety of causes of failure so as to increase the capability of the maintenance process at AMO API Banyuwangi.

METHODS

This study uses qualitative and quantitative descriptive approaches, with data obtained from direct observations, technician interviews, and aircraft maintenance documentation.

The methods used are Failure Modes and Effect Analysis in determining the Research Variables and determining the most risky variables with three parameters, namely Severity, Occurrence and Detection. [4] Then use Fault Tree Analysis to determine the root of the problem by means of interviews and Forum Grup Discussion (FGD) with several (3-4 people) technicians at API Banyuwangi [5]

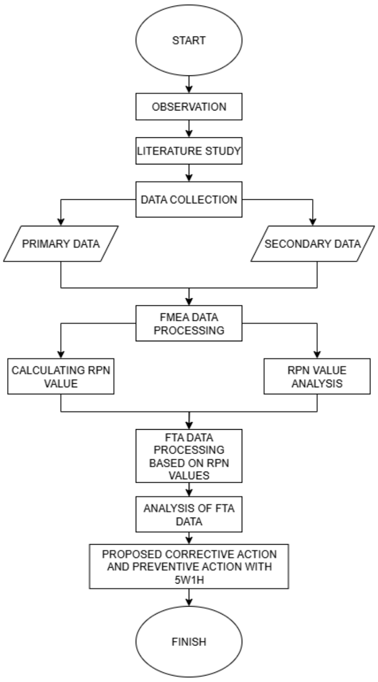

Figure 3 Research Flow Diagram

Observation

In Sugiyono' book [8], observation is a process carried out by observing and remembering. This technique is used when research is conducted related to human activities, environmental influences, procedural factors, and so on. To maintain the validity and credibility of the data, this study implemented a sequential data collection method based on triangulation techniques. [8] The process started with observation, which was carried out over the course of one month, from February to March 2025.

Literature Study

According to the book H.Prayitno [9], Literature study or preliminary study is the process of designing ideas and techniques that are relevant to the problem and objectives. This activity was carried out in March 2025.

Data Collection Techniques

Data collection techniques are required to obtain the necessary research data. There are 2 types of data used by the author, that are: Primary data sources and secondary data,

Primary Data is in the form of a collection of data that is directly from research through sources, namely with field observations, questionnaires and researcher interviews. The interview technique used is a structured interview, which is a predetermined question [6]. In Sugoyono's book [6] Observation is a process that is carried out by observing and remembering. This technique is carried out when research is carried out in relation to human activities, environmental influences, procedural factors and so on. According to [7] Data sources that provide data to data collectors are indirectly called secondary data sources. These things are such as literature studies, such as API Banyuwangi Engineering Information, journals, and other references to find answers and theoretical foundations for problems related to this topic.

Data Analysis and Hypothesis Testing Techniques

a. Failure Modes and Effect Analysis

In this step, the author distributes a questionnaire to 4-6 resource persons to assess Risk Priority Number (RPN) on the Failure Modes and Effect Analysis (FMEA) to calculate Severity, Occurence and Detection with the RPN formula, namely Severity x Occurrence x Detection. After the calculation is carried out, the results will be analyzed to determine the highest RPN value. The goal is to be further analyzed in finding the root cause of the cause with the highest RPN value using Fault Tree Analysis [4]

Table 1 Severity Effect Rank[4]

Effect	Severity Effect	Rank
Dangers without signs	It is very dangerous, it can have an impact on safety or government regulations. No damage warning before failure occurs.	10
Dangers with signs	The effect is dangerous, it can have an impact on safety or government regulations. There is a damage warning before the failure occurs.	9
Very high	Impacting the operation of the aircraft until it cannot be operated.	8
Tall	The aircraft is still operable but its performance is lower than before.	7
Keep	The aircraft can operate, but there are some minor glitches and there are malfunctioning components.	6
Low	Decline in aircraft performance and its follower components.	5
Very low	The aircraft can be used, but signs of damage are already felt, so it is necessary to repair the failure.	4
Small	The aircraft is still in good use, but there are few signs of damage to the system.	3
Very small	The aircraft is still in good use, but there are signs of damage to the system, but very little.	2
None	No effect was found.	1

Table 2 Occurence Effect Rank[4]

Chances of failure	Failure percentage	Rank
Very High and Extreme: Failure Must Occur	1 of 2 events	10
Very High: hamper often occurs	1 of 3 events	9
High : repeated failures	1 of 8 occurrences	8
Relatively High	1 in 20 instances	7
Moderately high: occasional failures occur	1 in 80 occurrences	6
Keep	1 in 400 occurrences	5
Relatively Low	1 in 2,000 incidents	4
Low: failures that occur are relatively rare	1 in 15,000 incidents	3
Very low	1 in 150,000 events	2
It's almost impossible for failure to happen	1 in 1,500,000 events	1

Tabel 3 Detection Effect Rank [4]

Detection	Detection Opportunity Criteria	Rank
None	No system can detect the cause of the failure mode.	10
Very small	Almost no system is found available to detect the cause of the failure mode.	9
Small	There is an opportunity, but very few systems can detect failures.	8
Very low	Control exists, but it's not enough to detect failures.	7
Low	Control exists, but the ability to detect failures is low.	6
Moderate	There is control, but the ability is moderate/sufficient to detect failures	5
Relatively High	The control is high enough to detect failure mode.	4
High	High control mechanism against the possibility of failure.	3
Very high	The mechanism used has a very high chance of detecting failure mode	2
Definitely available	Mechanisms for detecting are available	1

b. Fault Tree Analysis

After obtaining the highest RPN value, the author then analyzes the data with interviews to find the root of the problem or the source of failure or damage to the components Standby Horizon Gyro Indicator Cessna 172 Series aircraft at API Banyuwangi using the Fault Tree Analysis (FTA). [8]

This method is used in the analysis of critical circumstances from the point of view of safety or reliability. The analysis in question is in the context of the environment and its operations to find the cause of the top event. This model is called a graphical model of various combinations of parallel and sequential disturbances that will result in a peak occurrence (top event) happen. Errors can be events related to the hardware components, human error (Human Error), software errors or other related events that may cause the top event to occur. [9]

c. 5W+1H

According to kristian adi in 2021 in the journal [10] 5W+1H analysis is a method used to examine the source of the problem of an event in detail with the what, where, when, why, who and how. Based on the journal [11] The explanation of 5W and 1H is as follows:

1. What , is a series of words that refer to an abstract person, thing, or concept that is influenced by action and that undergoes a change in circumstances.
2. Where , is a group of words that refer to the location marker in an event. The idea of location is not limited to physical location but also refers to abstract locations.
3. When (when), is a series of words that refer to the characteristics of time. In instances with the sense of time can be days, weeks, months, and years in a calendar or clockwork. It also refers to observations made before, after or during the occurrence of events such as damage, workmanship, etc.
4. Why , is the definition of the cause of an event
5. Who , is a reference to someone involved in the event.
6. How , is a series of words that refer to the way an action is performed

RESULT AND DISCUSSION

Based on engineering data at AMO API Banyuwangi, it was stated that several Standby Horizon Gyro Indicator failures on Cessna 172 Series aircraft were reported, namely Low Vacuum Indicator, Standby Horizon Gyro Indicator Not Function, Standby Horizon Gyro Indicator Toppled.The low vacuum indicator shows that the vacuum entering the pressure instrument is too low, or less than 4.5 inHg, there is a warning on MFD. Standby Horizon Gyro Indicator Not Function indicates that the standby instrument is not functioning or is not showing the direction. Standby Horizon Gyro Indicator Toppled indicates that the position of the artificial horizon line is inverted or toppled.

Figure 4 Unbalanced Gyro

Based on the results of observations and interviews with one of the technicians with a Cessna 172 Series rating at API Banyuwangi, the various failures that occurred in this instrument included Standby Horizon Gyro Indicator Spin, Unbalanced Gyro and Standby Horizon Gyro Indicator Stuck. Standby Horizon Gyro Indicator Spin mean the artificial horizon line rotates continuously. Unbalanced Gyro means the artificial horizon line is shaking when the aircraft is operated. Standby Horizon Gyro Indicator Stuck indicates that the line of artificial horizon hasn't move, and the gyro stick doesn't move when aircraft is operated. Based on engineering data, field observations, and interviews with one of the technicians with Cessna 172 Series rating qualifications at API Banyuwangi, it was concluded that the variations in the causes of Standby Horizon Gyro Indicator failures are Low Vacuum Indicator, Standby Horizon Gyro Indicator Not Function, Standby Horizon Gyro Indicator Toppled/Spin, Unbalanced Gyro and Standby Horizon Gyro Indicator Stuck.

Failure Modes and Effect Analysis

Before combining the three FMEA parameters, the first step that needs to be carried out is to assess each parameter in relation to the type of damage/error that occurred. But first, we need to form a team to determine the buoyancy of each parameter (Severity (S), Occurrence (O), Detection (D)) which includes experts in certain fields, then multidisciplinary and cross-functional who have capabilities in the field being analyzed [4]. The optimal size for a team formation is usually 4 to 6 people, but the minimum number is determined by: The number of failure modes from the FMEA analysis. [12] In connection with this, the author distributed questionnaires to 4 technicians with Cessna 172 Series rating qualifications at AMO API Banyuwangi. Based on the results of the FMEA questionnaire that had been assessed by the speakers, the main cause of failure of the Standby Horizon Gyro Indicator was the failure of the Standby Horizon Gyro Indicator Toppled/Spin.

Table 4. Risk Priority Number Questionnaire Results

No	Respond	Forms of Damage	Severity (S)	Occurrence (O)	Detection (D)
1		Low Vacuum Indicator	6	5	3
2		Standby Horizon Gyro Indicator Not Function	6	5	3
3	1	Standby Horizon Gyro Indicator Topled/Spin	7	5	3
4		Unbalanced Gyro	8	4	3
5		Standby Horizon Gyro Indicator Stuck	7	5	2
6		Low Vacuum Indicator	6	5	3
7		Standby Horizon Gyro Indicator Not Function	6	5	3
8	2	Standby Horizon Gyro Indicator Topled/Spin	8	5	2
9		Unbalanced Gyro	7	4	3
10		Standby Horizon Gyro Indicator Stuck	6	5	2
11		Low Vacuum Indicator	6	5	3
12		Standby Horizon Gyro Indicator Not Function	7	5	4
13	3	Standby Horizon Gyro Indicator Toppled/Spin	8	5	3
14		Unbalanced Gyro	7	4	3
15		Standby Horizon Gyro Indicator Stuck	7	5	3
16		Low Vacuum Indicator	6	4	3
17		Standby Horizon Gyro Indicator Not Function	6	5	3
18	4	Standby Horizon Gyro Indicator Toppled/Spin	8	5	4
19		Unbalanced Gyro	5	5	3
20		Standby Horizon Gyro Indicator Stuck	6	5	3

Based on **Table 4**, a questionnaire was obtained from the respondents of the Cessna 172 Series rating technician at API Banyuwangi. Next, the author will add up the average value of each parameter assessed by the respondent, then calculate it using the following equation [13]:

$$\text{Average} = \frac{\text{Total value of each parameter for each form of damage}}{\text{Number of respondents}}$$

The average value of each indicator is shown in the equation below:

a. Average Severity on Low Vacuum Indicator damage:

$$\text{Average} = \frac{6+6+6+6}{4} = 6$$

b. Average Occurrence on Low Vacuum Indicator breakdown:

$$= 4.75 \text{Rata} - \text{rata} = \frac{5+5+5+4}{4}$$

c. Average Detection on Low Vacuum Indicator damage:

$$\text{Average} = \frac{3+3+3+3}{4} = 3$$

d. Average Severity on Standby Horizon Gyro Indicator Not Function damage:

$$\text{Average} = \frac{6+6+7+6}{4} = 6.25$$

e. Average Occurrence on Standby Horizon Gyro Indicator Not Function damage:

$$\text{Average} = \frac{5+5+5+5}{4} = 5$$

f. Average Detection on Standby Horizon Gyro Indicator Not Function fault:

$$\text{Average} = \frac{3+3+4+3}{4} = 3.25$$

g. Average Severity on Standby Horizon Gyro Indicator Toppled/Spin damage:

$$\text{Average} = \frac{7+8+8+8}{4} = 7.75$$

h. Average Occurrence on Standby Horizon Gyro Indicator Toppled/Spin damage:

$$\text{Average} = \frac{5+5+5+5}{4} = 5$$

i. Average Detection on Standby Horizon Gyro Indicator Toppled/Spin damage:

$$\text{Average} = \frac{3+3+3+4}{4} = 3.25$$

j. Average Severity on Unbalanced Gyro damage:

$$\text{Average} = \frac{8+7+7+5}{4} = 6.75$$

k. Average Occurrence on Unbalanced Gyro damage:

$$\text{Average} = \frac{4+4+4+5}{4} = 4.25$$

l. Average Detection on Unbalanced Gyro damage:

$$\text{Average} = \frac{3+3+3+3}{4} = 3$$

m. Average Severity on Standby Horizon Gyro Indicator Stuck's damage:

$$\text{Average} = \frac{7+6+7+6}{4} = 6.5$$

n. Average Occurrence on Standby Horizon Gyro Indicator Stuck's damage:

$$\text{Average} = \frac{5+5+5+5}{4} = 5$$

o. Average Detection on Standby Horizon Gyro Indicator Stuck's damage:

$$\text{Average} = \frac{2+2+3+3}{4} = 2.5$$

Based on the results of the calculation above, the average value of each parameter obtained from the results of the questionnaire is displayed in the form of a Table as follows:

Table 5 Risk Priority Number calculation results

No	Component	Forms of Damage	Severity (S)	Occurrence (O)	Detection (D)	RPN (S x O x D)
1	Standby Instrument Artifical Horizontal	Low Vacuum Indicator	6	4,75	3	85,5
2		Standby Horizon Gyro Indicator Not Function	6,25	5	3,25	101,5
3		Standby Horizon Gyro Indicator Toppled/Spin	7,75	5	3,25	126
4		Unbalanced Gyro	6,75	4,25	3	86
5		Standby Horizon Gyro Indicator Stuck	6,5	5	2,5	81.25

Table 5 shows the average value of each damage indicator based on severity, occurrence and detection parameters. In the Table, it can be seen that the priority scale value shows a failure in the form of a Standby Horizon Gyro Indicator Toppled/Spin, which has an RPN value of 126. This value is obtained by multiplying the severity score of 7.75, which represents an extreme effect (as shown in Table 1), by the occurrence score of 5, indicating a moderate failure rate of approximately 1 in 400 events (as shown in Table 2), and the detection score of 3.25, which suggests that there is a relatively high level of control in place to detect the failure (as shown in Table 3). The most significant value is the severity value, which has an extreme effect, which can affect aircraft operation to the point of inoperability. Although, Standby Horizon Gyro Indicator Not Function being in second place, but the severity of this incident is still at the significant stage. That mean, the aircraft can operate, however there are some minor glitches and there are malfunctioning components.

The lowest number or minority problems are Standby Horizon Gyro Indicator Stuck with an RPN value of 81. From the data obtained above, the author will focus on the most dominant or priority problem, that is the Standby Horizon Gyro Indicator Toppled/Spin problem as the top event for fault tree analysis method. The average values suggest that there is no significant variation among the failure types across each indicator, as all types have the potential to cause instrument damage. However, to enable deeper analysis in subsequent research using Fault Tree Analysis (FTA), the highest rated failure standby horizon gyro indicator toppled/spin was selected as the focus of this study. A fault tree is an event analysis that aims to find a root cause by focusing on one top event.[15].

Fault Tree Analysis (FTA)

This method is employed to analyze critical conditions from both safety and reliability perspectives. The analysis focus on the human factors and operational context to identify the causes of the top event. It’s a graphical model representing various combinations of parallel and sequential failures that could lead to the occurrence of the top event. These failures may involve hardware components, human factors, software faults, or other related events that contribute to the top event[11].

Figure 5 Standby Horizon Gyro Indicator Toppled

Based on results Focus Group Discussion or interviews with three qualified persons Cessna 172 Series Rating at API Banyuwangi, the author got the answer that the failure was in the form of Standby Horizon Gyro Indicator Toppled/Spin occurs due to 3 main causative factors, there are hardware, human factor and maintenance procedure.

Based on the interviews, one of the hardware-related causes of the Standby Horizon Gyro Indicator toppled or spin is the failure of vacuum pressure to reach the unit. This occurs due to wear on the vacuum pump brush or hardening of the seal, because the component aging.

Additionally, the gyro filter is often not cleaned, leading to further contamination. This typically happens because the unit has not yet reached its scheduled maintenance interval, which, according to the Cessna 172 Series Maintenance Manual is replace every 600 flight hours [14].

Regarding human factors, vacuum hose leaks are often caused by personnel failing to properly secure the clamps due to a lack of knowledge of the required mounting force. Furthermore, vacuum hoses may become bent during installation because personnel do not pay attention to hose positioning. This results in improper airflow and is often triggered by inadequate supervision and a sense of complacency among maintenance personnel. These findings were conveyed by a field technician certified on the Cessna 172 Series at API Banyuwangi. This problem can close the air sucked by the vacuum to the gyro instrument. And if that happens, the vacuum will fail to operate, and that can be result in fatalities or even accidents, because the pilot didn’t know the position of the aircraft when an emergency occurs and must use standby instruments.

Moreover, interviews with technicians revealed that Standby Horizon Gyro Indicator failures, such as toppled or spin, can also result from poor maintenance procedures. For instance, components may be dropped during installation or subjected to vibration, leading to internal damage. Such issues typically arise due to a lack of awareness to safety procedures and insufficient awareness during the maintenance process. Based on the explanation above, the diagram arrangement of the fault tree analysis shown in **Figure 6** is as follows.

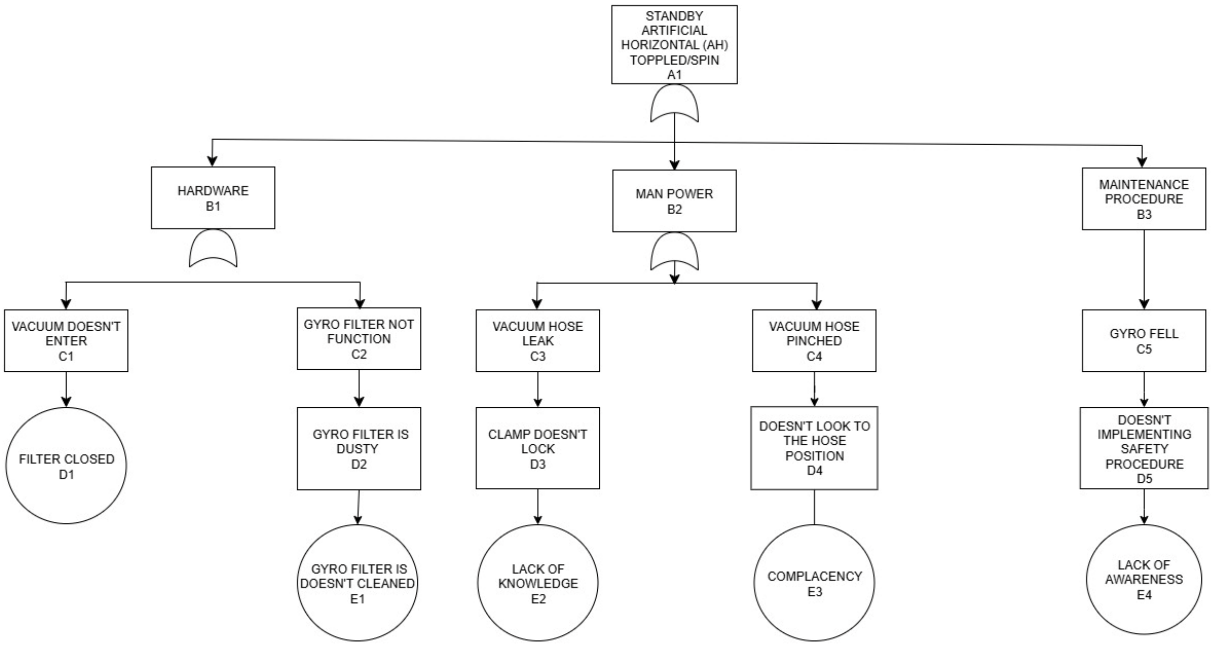

Figure 6 Fault Tree Analysis Diagram

Table 6 Fault Tree Analysis Diagram Description

No	Problem	Information
A1	Standby Horizon Gyro Indicator Topled/Spin	Standby Standby Indicator Horizon Gyro Indicator inverted or rotating
B1	Hardware	There is an influence of the hardware object or hardware on the instrument
B2	Human Factor	There is influence from humans
B3	Maintenance Procedure	There is an influence of the aircraft maintenance process
C1	Vacuum Doesn't Enter	Air does not enter the vacuum instrument Standby Horizon Gyro Indicator
C2	Gyro Filter Not Function	Gyro filter does not work during aircraft operation
C3	Vacuum Hose Leak	Vacuum pipes or ducts have leaks
C4	Vacuum Hose Pinched	Bent or pinched vacuum pipe or duct
C5	Gyro Fell	Standby Horizon Gyro Indicator or Gyro components dropped during installation
D1	Filter Closed	Vacuum filter tertutup
D2	Gyro Filter Is Dusty	Dirty or dusty filter gyro
D3	Clamp Doesn't Lock	Clamp does not lock the hose tightly
D4	Doesn't Look To The Hose Position	Personnel do not pay attention to the position of the hose during installation
E1	Filter Is Doesn't Cleaned	Gyro filter is not cleaned during maintenance
E2	Lack Of Knowledge	Lack of knowledge from personnel

E3	Complacency	Satisfaction with one's own work, so that personnel do not convey to supervisors for cross-check
E4	Lack Of Awareness	Lack of vigilance from personnel

Regarding to **Table 6**, the most dangerous failures that caused Standby Horizon Gyro Indicator are damage caused by human factors, with percentage of 60% or 3/5 incident. Such as, Personnel do not pay attention to the position of the hose during installation and Satisfaction with one's own work, so that personnel do not convey to supervisors for cross-check. In general, aircraft maintenance errors are caused by human factors, with a percentage of 80% [16]. In several journals or research, it is also stated that the cause of aircraft crashes is mostly caused by human factors. As in study Poerwanto, et al, it was explained that the most dominant cause of aviation accidents is estimated to be human factors, with a percentage reaching 60% [17]. Based on the aircraft accidents that have occurred, it can be concluded that, according to the FAA (Federal Aviation Administration), there are three contributing factors: weather at 13.2%, the aircraft used at 27.1%, and human error at 66%. Aviation studies and statistics indicate that human error is the largest contributing factor in aircraft accidents [19]. That's why, it's necessary to refreshing training about safety management systems and several suggestions for improvement which will be explained in the 5W+1H sub-chapters, as follows:

5W + 1H (What, Why, Who, When, Where and How)

Table 7; 5W+1H Description

Indicatior	No	What	Why	How	Who	When	Where
Hardware	C1	Vacuum Doesn't Enter	Dirt in the vacuum filter is not cleaned during 50 Hours or 100 Hours maintenance	**Corrective Action:** Checking each vacuum filter on the Cessna 172 Series aircraft at API Banyuwangi, if there is dirt that accumulates, it will be cleaned or replaced.	Personnel	Every 7 days	Hangar charlie API Banyu wangi
				Preventive Action: Perform maintenance on the vacuum filter during maintenance 50 hours or 100 hours	Engineer	Each mainte nance 50 hours or 100 hours	Hangar charlie API Banyu wangi
	C2	Gyro Filter Not Function	A lot of dirty air enters the vacuum filter, so the filter works extra,	**Corrective Action:** Checking each gyro filter on the Cessna 172 Series aircraft at API Banyuwangi, if there is dirt	Personnel	Every 7 days	Hangar charlie API Banyu wangi

Indicatior	No	What	Why	How	Who	When	Where
			so that the filter is dirty before the maintenance time	that accumulates, it will be cleaned or replaced			
				Preventive Action: Perform maintenance on the gyro filter during maintenance 50 hours or 100 hours	Engineer	Each mainte nance 50 hours or 100 hours	Hangar charlie API Banyu wangi
Human Factor	C3	Vacuum Hose Leak	The clamp hose does not lock perfectly due to lack of supervision from the supervisor	**Corrective Action:** Emphasizing the mechanic or supervisor who is in charge of always doing double checks to complete a job.	Manager	During the briefing before work	Hangar charlie API Banyu wangi
				Preventive Action: Refreshing personnel regarding safety procedures.	Aircraft Technician	Every 2 years	Hangar charlie API Banyu wangi
	C4	Vacuum Hose Pinched	When tide is less attentive to the position of the hose because of complacency, so personnel do not convey it to the supervisor forcrosscheck.	**Corrective Action:** When installing a vacuum hose, the supervisor or technician must do a double check to ensure the work of the mechanic	Aircraft Technician / supervisor	During the mainte nance process	Hangar charlie API Banyu wangi
				Preventive Action: Emphasis on technicians or supervisors who are in charge of supervising and double checking the mechanics who work.	Manager	During the briefing before work	Hangar charlie API Banyu wangi
Maintenance Procedure	C5	Gyro Fell	When replacing, personnel do not apply safety procedures during installation, so	**Corrective Action:** By implementing safety procedures when carrying out maintenance on components that are susceptible to damage such as instrument indicators and instrument engines, as	Manager	During the briefing before work	Hangar charlie API Banyu wangi

Indicatior	No	What	Why	How	Who	When	Where
			when lifted, components fall to the floor, resulting in damaged components.	well as supervision by supervisors in the work.			
				Preventive Action: Refreshing personnel regarding safety procedures and safety awareness.	Manager	Every 2 years	Hangar charlie API Banyu wangi

CONCLUSIONS

This study comprehensively analyzed the potential failures of the Standby Horizon Gyro Indicator on Cessna 172 Series aircraft operated at API Banyuwangi by applying Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA). Five distinct failure variations were identified, namely Low Vacuum Indicator, Indicator Not Function, Indicator Toppled/Spin, Unbalanced Gyro, and Indicator Stuck. Based on the Risk Priority Number (RPN) evaluation, the most critical failure was determined to be the Toppled/Spin condition (RPN = 126), while the least critical was the Stuck condition (RPN = 81). Further investigation using FTA revealed that the root causes of the most critical failure primarily originated from technical and human factors, including vacuum pump aging, uncleaned gyro filters during maintenance, limited personnel knowledge, complacency in performing tasks, insufficient supervisory cross-checks, and low safety awareness.to mitigate these risks, corrective measures were proposed, such as replacing vacuum pumps with worn brushes or hardened seals, cleaning contaminated gyro filters, and enforcing stricter safety procedures during maintenance. Additionally, preventive actions were emphasized, including scheduled vacuum pump and gyro filter inspections every 50–100 flight hours, mandatory double-checking procedures, and periodic safety training refreshers for maintenance personnel every two years**.** the findings highlight the importance of a structured and systematic approach to failure analysis in aviation maintenance. By prioritizing high-risk failures, addressing both technical and human factors, and implementing robust corrective and preventive actions, this study provides valuable insights that can strengthen maintenance planning, enhance operational reliability, and improve safety culture within flight training environments.

SUGGESTIONS

1. Conduct quantitative probability analysis in the FTA to determine the statistical contribution of each root cause to the top event.
2. Expand the study to include multiple aircraft types or institutions for broader validation.
3. Integrate vibration analysis or real-time monitoring to detect early signs of gyroscope malfunction.

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