PNEUMATIC TEMPERATURE SENSOR FAILURE ANALYSIS P/N 767C0000-01 ON AN AIRBUS 330-300 AIRCRAFT AT PT GMF AEROASIA

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Abstrak — *This study aims to analyze the causes of sensor failure at PT GMF AeroAsia Tbk. The methodology used was observation, interviews, and document analysis. Modern aircraft rely heavily on reliable support systems, including pneumatic systems for regulating cabin temperature and safety. On an Airbus A330-300, a problem with the pneumatic temperature sensor was found, with corrosion on the sensor rod resulting in inaccurate temperature readings that could impact flight safety. This study aimed to analyze the causes of sensor failure at PT GMF AeroAsia Tbk. The methodology used was observation, interviews, and document analysis. Data were analyzed using Pareto charts and Fault Tree Analysis to identify the root cause. The results indicated that corrosion was the primary cause, exacerbated by environmental factors, weak inspection procedures, and a lack of technician understanding. In conclusion, the sensor failure was caused by a combination of technical, procedural, and human factors. This research helps develop better aircraft maintenance strategies to improve safety.*

Keywords: *Pneumatic Temperature Sensor, Aircraft Maintenance, Corrosion Failure, Fault Tree Analysis, Airbus A330-300.*

1. INTRODUCTION

The author understands that modern aircraft are a means of transportation with several highly complex supporting system configurations, encompassing various mechanical, electrical, and electronic sub systems that work in an integrated manner to ensure safe flight operations and long-term aircraft reliability. This complexity demands a planned and continuous maintenance program, considering that every component, both large and small, plays a significant role in overall perfor mance. One such strategic subsystem is the pneumatic system, which utilizes high-pressure air to regulate various critical aircraft functions, such as cabin temperature control, pressurization, and anti-icing (Vale rie Rappe, 2021). Within this system, the pneumatic temperature sensor plays a vital role because it monitors and controls the temperature of the pressurized air distributed to various parts of the aircraft, ensuring that temperature and pressure stability are maintained according to operational standards (Terry Simpson & Stefan Coreth, 2020). However, based on findings from field maintenance practices, it is known that these sensors often experience functional degradation over time. The most dominant form of failure is the appearance of corrosion on the sensor rod, which causes changes This study uses a descriptive qualitative approach, because the main objective of the study is to explore in depth the factors causing the failure of the pneumatic temperature sensor on the Airbus A330-300 (Strader et al., 2024). This approach *was chosen to gain a comprehensive understanding of the technical, procedural, environmental, and human aspects that affect sensor performance, so that the results of the study can provide a complete picture as well as recommendations for improvement (Sugiyono, 2020a).*

2. RESEARCH METHOD

2.1. Research Location and Subjects

The research was conducted at PT GMF AeroAsia Tbk, Cengkareng, one of the largest aircraft maintenance companies in Indonesia. The research subjects included the pneumatic temperature sensor P/N 767C0000-01 installed on an Airbus A330-300 aircraft, as well as personnel involved in the maintenance and component inspection process (Ciężak et al., 2023).

2.2. *Data Collection Sources and Techniques*

2.2.1. *Research data was obtained from two sources:*

- *Primary data, in the form of direct observations of the physical condition of the sensors, interviews with techni cians, engineers, and super visors who handle pneumatic system mainte nance (Sugiyono, 2020a).*
- *Secondary data, in the form of technical documents such as mainte nance manuals, job cards, task cards, logbooks, and shop reports related to the sensor maintenance history (Sugiyono, 2020a).*

2.2.2. *Data collection techniques include:*

- *Direct observation to detect corrosion conditions, physical damage, and the appropriateness of maintenance imple mentation.*
- *Semi-structured interviews to obtain detailed information from maintenance practitioners about procedures, expe riences, and obstacles encountered (Hamed Taherdoost, 2022).*
- *Documentation studies to track histo rical maintenance data and component failures (Sugiyono, 2020b).*

2.2.3. *Teknik Analisis Data Analisis data*

This is done through several stages:

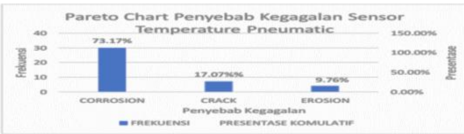
- *Data reduction by sorting data relevant to the factors causing sensor failure.*
- *Pareto analysis, to identify the most dominant factors causing failure (Dini Y.C & Iriani, 2024).*
- *Fault Tree Analysis (FTA), to systematically trace the root cause of damage by mapping cause-and-effect relationships (A Pambekti et al., 2022).*
- *Source triangulation, namely combi ning the results of observations, inter views, and documentation to increase the validity and reliability of findings (Lokanath Mishra, 2016).*

3. HASIL PENELITIAN DAN PEMBAHASAN

This research yielded important findings regarding the factors causing the failure of the pneumatic temperature sensor P/N 767C0000-01 on the Airbus A330-300. Direct observation revealed corrosion on the sensor shaft, causing discoloration, erosion of the protective layer, and the appearance of crust on the metal surface. This condition affects the sensor's ability to accurately read compressed air tempe rature. Interviews indicated that sensor failures often go undetected during routine inspections. This is because inspections focus more on the pneumatic system as a whole, rather than on specific sensor components. Several technicians also acknowledged the lack of job cards or task cards explicitly instructing visual inspec tions of this sensor. From the maintenance documentation perspective, it was found that sensor failure histories were rarely recorded in detail. Trouble reports typically only mention anomalies in the pneumatic system without specifying which sensor was the primary cause. This resulted in a *lack of a technical database to support predictive maintenance programs. Pareto diagram analysis indicated that corrosion was the most dominant cause, contributing 65% of total sensor failures. Environmental factors such as high humidity, poorly controlled storage, and incompletely dry hangar conditions signifi cantly contributed to the damage. Furthermore, procedural factors contri buted approximately 20%, related to the lack of specific sensor inspection instructions. Meanwhile, human factors contributed 15%, including techni cians' limited understanding and work habits that relied more on experience than technical documentation. Fault Tree Analysis (FTA) results reinforced the finding that corrosion was the primary root cause. Corrosion triggered errors in temperature readings, which then disrupted the pressurization and anti-icing systems. If not detected early, this condition could potentially trigger chain damage to other subsystems. The discussion of the research results indicated significant gaps in maintenance procedures. Pneumatic temperature sensors were considered minor components, despite their vital role in maintaining system stability. The absence of specific job cards prevented technicians from conducting visual inspections, often missing early signs of corrosion. These findings suggest that maintenance programs need to be improved by incor porating specific sensor inspection instruc tions into job cards and task cards. Additio nally, additional training for techni cians is crucial to raise awareness of critical compo nents that have been overlooked. This approach can minimize sensor failures and improve flight safety.*

No	Penyebab Kegagalan	Frekuensi	Presentase
1	*Corrosion*	30	73.17%
2	*Crack*	7	17.07%
3	*Erosion*	4	9.76%
	JUMLAH	41	100%

Faktor Penyebab Kegagalan Sensor Berdasarkan Analisis Pareto Sumber : Hasil Olahan Penulis



Pareto Chart Penyebab Kegagalan Temperature Sensor Pneumatic Sumber : Hasil Olahan Penulis

Overall, the research findings confirm that pneumatic temperature sensor failures are primarily caused by a combination of technical, procedural, and human factors. Improvement efforts should focus on developing more detailed maintenance procedures and providing ongoing techni cian training to improve sensor reliability and maintain aviation safety standards.

3.1. *Research Results*

3.1.1. *Identifying technical factors causing pneumatic temperature sensor failure*

This research fills a gap because there has been no previous in-depth study examining the technical failure of the pneumatic temperature sensor P/N 767C0000-01 on the Airbus A330-300. Maintenance practices tend to be general for pneumatic systems, resulting in less attention to the details of this sensor. Through direct observation and documentation, this study found that corrosion was the dominant technical factor affecting the sensor's temperature readings. The rationale for this objective is that sensors, although small, play a vital role in aircraft systems. If their failure is not technically understood, safety risks increase because the anti-icing, pressurization, and air conditioning systems could be compromised. By identifying corrosion as a primary factor, this study provides a scientific basis for developing a more targeted technical inspection strategy.

3.1.2.*Evaluating Weaknesses in Pneumatic Temperature Sensor Maintenance Procedures*

This study also addresses gaps in main tenance documentation. Previously, job *cards and task cards did not include specific instructions for visual and functional inspections of the sensors. This made it difficult to detect damage early. This study demonstrates that these procedural weaknesses significantly contri bute to sensor failures. The rationale for this objective is that maintenance proce dures serve as work standards that deter mine whether inspections can be perfor med consistently. Without clear procedu res, technicians rely solely on experience, increasing the potential for human error. By identifying these weaknesses, this study provides the basis for revising technical documentation to include pneumatic tempe rature sensors as critical components that require regular inspection.*

3.1.3. *Analyzing human factors affecting sensor performance and maintenance processes*

This study fills a gap in understanding the contribution of human factors. While failu res have often been attributed to technical factors, interviews reveal that technicians' limited understanding of sensor functions and work habits that do not always refer to technical documentation contribute to increased failure rates. This study provides a new perspective, emphasizing that human factors are as important as technical and procedural factors. The rationale for this objective is that aircraft reliability is determined not only by the condition of components but also by the competence of the technicians who maintain them. Additional training, technical material up dates, and increased awareness of critical sensors are essential. By emphasizing the role of humans, this study broadens the scope of solutions beyond technical improvements to include strengthening the capacity of maintenance personnel. Ove rall, this study successfully addresses gaps in the literature and industry practice. The first gap, related to technical factors, was addressed with the finding that corrosion was the dominant cause. The second gap, related to procedural weaknesses, was addressed with evidence that the absence of dedicated job cards/task cards was a major obstacle to early detection. The third gap, related to human factors, was mapped through interviews, which emphasized the importance of improving technicians' understanding. Thus, this study makes a comprehensive contribution by demons trating that pneumatic temperature sensor failures are triggered by a combination of technical, procedural, and human factors. The resulting improvement recommenda tions emphasize not only replacing dama ged components but also restructuring maintenance procedures and streng thening technician competency. This argu ment aligns with the research objective of producing a more specific, risk-based main tenance strategy oriented toward improving flight safety.

4. *CONCLUSIONS AND RECOMMENDATIONS*

4.1. Conclusions

- *The results of this study indicate that the failure of the pneumatic temperature sensor P/N 767C0000-01 on the Airbus A330-300 was predominantly caused by corrosion, triggered by environ mental factors, weak maintenance procedures, and limited technician understanding. These findings confirm that sensors, despite their small size, play a critical role in maintaining the stability of the aircraft's pneumatic system. The absence of dedicated job cards or task cards often results in potential sensor damage going undetec ted during routine inspections.*

- *The human factor has been shown to increase the risk, due to work habits that rely more on experience than on verifying technical documents. This means that efforts to improve aviation safety are not sufficient with just technical component improvements but also require strengthening procedural* *aspects and human resource compe tencies. A further impact is the need to implement a risk-based maintenance strategy through the addition of specific sensor inspection instructions, periodic visual and functional checks, and ongoing technician training. With these steps, aircraft system reliability can be increased, downtime can be reduced, and aviation safety standards can be better assured in the future.*

4.2. *Recommendations*

- *Addition of Special Job Cards/Task Cards: Create work instructions that specifically regulate visual and func tional inspections of pneumatic tempe rature sensors.*
- *Periodic Visual Inspections: Schedule routine visual inspections to detect early signs of corrosion.*
- *Measured Functional Testing: Conduct periodic sensor functional tests using calibration tools.*
- *Environmental and Storage Control: Improve storage standards by control ling humidity and ensuring adequate ventilation.*
- *Additional Technical Training: Provide training for technicians to enhance their understanding of critical sensor func tions.*
- *Strengthening the Documentation System: Record detailed sensor inspec tion results in logbooks or shop reports.*
- *Implementing a Risk-Based Approach: Integrate Pareto analysis and FTA into preventive maintenance programs.*

4.3. *Implications*

Theoretically, this study expands the literature on small but critical component failures in aircraft systems and emphasizes the importance of risk-based analysis in maintenance. Practically, this study provi des a reference for the aircraft maintenance industry, particularly PT GMF AeroAsia Tbk, in improving sensor inspection procedures and increasing maintenance effectiveness. Furthermore, these findings are also relevant for regulators seeking to strengthen pneumatic component mainte nance standards to optimize aviation safety oversight.

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