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Article

Analysis of the Causes of High Internal Temperature in the TMC Type-54EWNA Control Air Compressor on MV Pan Africa

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ABSTRACT

The control air compressor is one of the important auxiliary machines in the compressed air system on board a ship, which functions to supply air for both manual and automatic pneumatic control systems. One of the problems that frequently occurs in this equipment is an increase in internal temperature in the Control Air Compressor TMC 54-13 EWNA, which can reduce compressor performance and increase the risk of operational disturbances. This study aims to analyze the causes of high internal temperature and to determine appropriate corrective and preventive measures. The methods used in this study include direct observation, interviews, documentation, and Fishbone analysis. Direct observation of physical components, cross-referenced with alarm records and maintenance history, was used to support the root-cause conclusion. The incident evidence revealed a high internal temperature reaching 115°C, resulting in an automatic shutdown. The findings distinguish between the immediate technical cause, which was oil cooler blockage caused by rust and sludge deposits, and the underlying management causes, which included weak supervision and irregular implementation of the Planned Maintenance System (PMS). The recommended efforts to address these problems include optimizing the cooling system, strictly adhering to the PMS, and improving condition monitoring of compressor parameters. By implementing these measures, it is expected that the internal temperature can be controlled and the reliability of the ship's compressed air system can be maintained..

1. Introduction

Maritime transportation plays a pivotal role in international trade, necessitating the optimal operation of all vessel machinery to ensure safety and efficiency. Within the ship's machinery systems, compressed air systems are of critical technical importance for shipboard automation, and the failure of control air compressors poses significant operational risks. Specifically, the control air compressor supplies clean, dry air at approximately 7-10 bar for pneumatic automation and instrumentation control.

The specific equipment under study is the TMC 54-13 EWNA Control Air Compressor on board the MV Pan Africa. On July 16, 2024, during a voyage from Chile to Peru, the vessel's No. 1 Control Air Compressor experienced a "High Internal Temperature" alarm, reaching 115°C and triggering an automatic shutdown. This forced a switch to the standby unit, highlighting a vulnerability in the vessel's redundancy and underscoring the need for a systematic root-cause analysis.

Previous research has explored similar thermal failures. Handoyo et al. (2024) identified that overheating often stems from high ambient temperatures and fouling in fluid coolers. Similarly, Harahap et al. (2023) analyzed screw compressors and found that design errors in exhaust air ducts could trap heat, leading to alarms. In the context of marine lubrication, Bagaskara (2020) found that cooler blockage directly accelerates the degradation of lubricating oil, causing overheating. However, previous studies have not adequately addressed the combined role of cooler fouling, cooling water treatment, lubrication degradation, and PMS implementation in a real shipboard environment.

Based on these theoretical foundations, this study aims to conduct a practical Fishbone-based failure analysis that integrates direct observation, interviews, logbooks, and PMS records to systematically prevent recurrence. The objectives are to identify the factors causing high internal temperatures, analyze the impact of these failures, and determine effective maintenance strategies to restore optimal performance.

2. Literature Review

2.1 Compressor Theory

A compressor is a mechanical device that

increases the pressure of a gas by reducing its volume. Compressors are categorized into positive displacement types and dynamic types. The TMC 54-13 EWNA is an oil-injected rotary screw compressor, utilizing two meshing helical rotors to compress air, where internal heat management is strictly dependent on oil cooling mechanisms.

2.2 Screw Compressor Working Principle

In an oil-injected screw compressor, oil is injected into the compression chamber to seal internal clearances, lubricate the rotors, and absorb the heat of compression. The mixture of compressed air and oil is separated in an oil separator vessel, and the oil passes through an oil cooler before being reinjected. If cooler blockage occurs, heat removal becomes inadequate, causing oil temperatures to rise. Consequently, elevated temperatures reduce oil viscosity, diminishing rotor sealing and directly triggering high internal temperature alarms.

2.3 Thermal Management and Failures

The "High Internal Temperature" alarm is a critical safety feature. Common causes include:

1. Cooler Fouling: Accumulation of scale or dirt acts as thermal insulation, severely reducing the heat transfer efficiency between the oil and the cooling water.
2. Oil Degradation: High temperatures accelerate oil oxidation, leading to sludge formation which further impedes cooling and lubrication.
3. Component Failure: Malfunctions in the thermal mixing valve or oil stop valve can disrupt oil flow.

"Furthermore, industry guidelines emphasize that the accumulation of sludge, scale, or varnish in the oil cooler acts as a severe thermal insulator, drastically reducing heat transfer efficiency and triggering extreme overheating in rotary screw compressors (Air Compressor Guide, n.d.; Sollant, n.d.)

2.4 Fishbone Analysis Method

To systematically analyze the failure, this study employs the Fishbone (Ishikawa) diagram. This method categorizes causes into Man, Machine, Method, Material, and Environment to identify the root cause of a specific effect.

The application of the Ishikawa or Fishbone diagram is widely recognized in modern marine engineering and smart maintenance operations

as a highly effective diagnostic tool, allowing engineers to systematically categorize complex technical failures into distinct dimensions such as Man, Machine, Method, and Material (IntechOpen, 2023).

3. Research Methodology

3.1 Research Design

This study utilizes a qualitative descriptive research design. In this engineering case study, the compressor overheating phenomenon cannot be separated from its operational context, including crew behavior and maintenance culture.

3.2 Time and Location of Research

The research was conducted over a continuous period of seven months, from 23 April 2024 to 24 November 2024, onboard the MV Pan Africa. The vessel is a Dual Fuel Diesel Electric (DFDE) LNG Carrier, and the study focuses on the Engine Room.

3.3 Data Sources

To minimize observer bias, data triangulation was performed by cross-checking direct observations with officer interview statements, alarm records, logbooks, PMS history, and the TMC manual.

1. **Primary Data:** The researcher performed daily monitoring, recording temperature parameters, visually inspecting coolers, and participating in component dismantling. Semi-structured interviews were conducted with two senior engineering officers (the Second Engineer and Third Engineer) focusing on maintenance history, PMS adherence, and troubleshooting methodologies, which were recorded via written summaries.
2. **Secondary Data:** Technical evidence was gathered from the TMC 54-13 EWNA Instruction Manual, Engine Logbooks, and PMS History records to establish baseline specifications and timelines.

3.4 Data Analysis Technique

The collected data was analyzed using a four-step Fishbone process:

1. **Problem Definition:** Defining the "Effect" as High Internal Temperature > 110°C.

2. **Brainstorming** **Categories:** Classifying potential causes into Man, Method, Machine, and Material.

3. **Causal Analysis:** Using the "5 Whys" technique to trace proximate causes (e.g., dirty cooler) directly back to underlying root causes (e.g., inadequate maintenance verification).

4. **Synthesis:** Integrating findings to propose targeted solutions.

4. Results and Discussion

4.1 General Description of Research Subject

The MV Pan Africa operates two identical Control Air Compressors. The technical specifications are outlined below:

Table 1. Technical Specification

Parameter	Specification
Manufacturer	Tamrotor Marine Compressors (TMC)
Model	TMC 54-13 EWNA
Type	Oil-injected rotary screw compressor
Capacity	390 Nm ³ /h @ 1.2 MPa (12 bar)
Cooling	Fresh Water (FW) cooled
Normal Temp Range	< 95°C
Alarm / Trip Setting	110°C / 115°C

4.2 Presentation of Findings

4.2.1 The Incident

On July 16, 2024, the No. 1 Control Air Compressor triggered an alarm peaking at 115°C. Because the manufacturer's specified normal operating temperature is < 95°C and the trip threshold is 115°C, an automatic safety shutdown occurred to prevent air end seizure.

4.2.2 Observational Data

Physical inspections following the shutdown revealed the following:

1. **Control Panel & Visual Inspection:** The fault log confirmed the temperature trip, with no external oil leakage or belt slippage.

2. **Cooling System Inspection:** The inlet cooling water temperature was 32°C and the outlet was 33°C, demonstrating a negligible differential and significantly reduced heat transfer. Dismantling the cooler revealed severe fouling, with the tube bundle clogged by rust deposits and reddish sludge. [Figure 1: Placeholder for Image showing oil cooler fouling caused by rust/sludge deposits].
3. **Air End Inspection:** Boroscopic examination revealed minor scoring on the rotor surfaces, which was determined to be secondary damage resulting directly from the severe overheating.

4.2.3 Interview Data

1. Third Engineer: Reported that the PMS tasks had focused on external filter changes, while internal heat exchanger inspections had been deferred due to manpower constraints affecting PMS implementation.

2. Second Engineer: Stated that the alarm had been treated as a recurring issue managed by resetting the system, and identified the migration of rust from ship piping as the primary physical cause.

4.3 Discussion: Fishbone Analysis

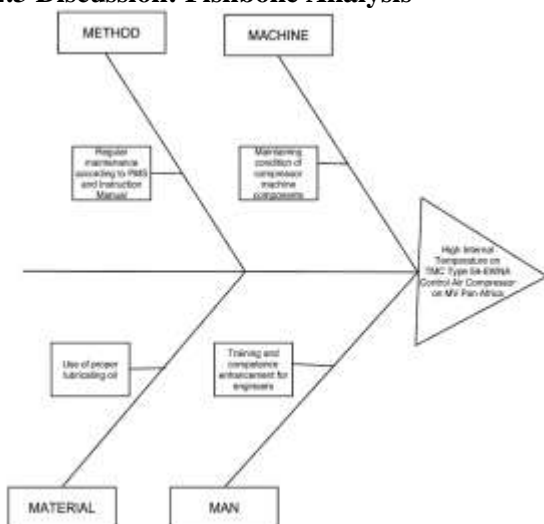


Figure 1. Fishbone Diagram

1. Machine (Mechanical Factors)

The primary mechanical failure was the Oil Cooler Blockage. As fouling thermal

resistance increases, the overall heat-transfer coefficient decreases; therefore, a higher oil temperature is required to remove the same heat load. The secondary failure (air end scoring) reduced compressor efficiency, creating a vicious thermal cycle.

2. Material (Component & Consumable Factors)

- a. **Cooling Water Quality:** The presence of rust indicates active corrosion due to untreated fresh water. The system lacked maintenance of the required pH range of 8.5-9.5 and adequate corrosion inhibitors as per the vessel's cooling water treatment manual.
- b. **Lubricating Oil:** Sustained operation above 100°C promoted thermal degradation, leading to blow-by of hot compressed air.

Proper cooling water treatment—including the regular application of corrosion inhibitors and strict pH management—is essential to prevent rust formation and degradation in shipboard steel piping systems (Marine Engineering Online, 2017).

3. Method (Procedural Factors)

PMS records indicated that the required cooler inspection and cleaning had been deferred, revealing a critical methodological gap where procedural paperwork was ticked without adequate physical execution.

The Planned Maintenance System (PMS) must not be treated as a mere administrative formality or 'tick-box' exercise; rather, it is a vital operational framework for scheduling maintenance, tracking machinery history, and ensuring strict compliance with the International Safety Management (ISM) Code (VoyageX AI, n.d.).

4. Man (Human Factors)

There was a distinct gap in maintenance management and verification, where senior engineers did not effectively verify the execution of the PMS. The crew's reactive maintenance culture allowed the root causes to compound until catastrophic breakdown.

4.4 Operational Impacts

The loss of redundancy in the control air system posed a severe operational risk, potentially leading to operational delays or loss

of pneumatic control for vital ship systems. Furthermore, high temperatures thinned the lubricating oil, making it harder for the separator to capture, risking oil carryover into delicate ship instrumentation.

4.5 Corrective and Preventive Actions

4.5.1 Corrective Actions (Immediate Repair)

- 1. Cooler Replacement:** A spare oil cooler was installed because the fouled unit required off-ship chemical descaling.
- 2. Piping Modification:** The engineering team fabricated new bypass connections for heavily corroded sections and installed isolation valves.
- 3. Oil System Flush:** The system was flushed, filters were replaced, and fresh synthetic oil was added.

4.5.2 Preventive Actions (Long-Term Strategy)

- 1. Optimization of PMS:** A concrete PMS schedule should mandate cooler inspection at specific intervals (e.g., every 2,000 running hours), strictly verified by a senior officer.
- 2. Enhanced Monitoring:** A structured trend-monitoring log must be implemented to track the following parameters daily: internal temperature, oil temperature, cooling water inlet/outlet temperatures, discharge pressure, and running hours.
- 3. Chemical Dosing Regime:** Strict enforcement of cooling water pH and inhibitor testing must be maintained.

Job No.	Job Title	Interval	Unit	Planned	Done	Due Date
1	Compressor Control Oil Filter Change/Check	2000 H	20 Day	0	0	18-03-2025
2	Compressor Control Oil Filter Change/Check	2000 H	20 Day	0	0	18-03-2025
3	Compressor Control Oil Filter Change/Check	2000 H	20 Day	0	0	18-03-2025
4	Compressor Control Oil Filter Change/Check	2000 H	20 Day	0	0	18-03-2025
5	Compressor Control Oil Filter Change/Check	2000 H	20 Day	0	0	18-03-2025
6	Compressor Control Oil Filter Change/Check	2000 H	20 Day	0	0	18-03-2025

Figure 2. Planned Maintenance System

5. Conclusion

The high internal temperature failure and subsequent 115°C shutdown of the TMC 54-13 EWNA Control Air Compressor on the MV Pan

Africa was caused by oil cooler blockage from rust and sludge deposits, degraded oil, irregular cooling water treatment, and weak PMS implementation. The mechanical components failed primarily because fluids were degraded due to maintenance management gaps. Implementing the recommended piping modifications and enforcing proactive maintenance restores thermal stability, safeguarding the vessel's pneumatic systems and ensuring compliance with international safety management standards (such as the ISM Code). Future research should investigate the application of automated condition monitoring systems, such as temperature trending algorithms, vibration monitoring, and routine oil analysis, to predict heat exchanger fouling before it triggers critical alarms.

This study demonstrates that the reliability of marine auxiliary machinery is contingent upon the holistic management of the "Man-Machine-Method-Material" ecosystem. The mechanical components (Machine) failed because the fluids (Material) were degraded, which occurred because the procedures (Method) were not followed by the crew (Man).

By implementing the recommended piping modifications, enforcing strict chemical dosing, and transitioning to a proactive maintenance culture, the thermal stability of the compressor has been restored. These measures ensure that the compressor operates within its designed thermodynamic envelope, safeguarding the vessel's critical pneumatic systems and ensuring compliance with international safety management standards. Future research could investigate the application of automated condition monitoring systems (vibration and thermal trending) to predict such heat exchanger fouling before it reaches critical alarm levels.

References

- Ali Mahmudi, Ir. M. Eng. (2017). *Buku Bahan Ajar Pompa dan Kompresor*. Bandung: Politeknik Negeri Bandung.
- Bagaskara, R. (2020). *Analisis percepatan penurunan kualitas minyak pelumas pada control air compressor akibat tersumbatnya cooler diatas kapal mv. pan americas*. Politeknik Ilmu Pelayaran.
- Giampaolo, T. (2023). *Compressor Handbook: Principles and Practice: Second Edition*.
- Handoyo, E. A., Marianto, F., & Tandio, J. H. (2024). Study and analysis of an industrial

- compressor facing overheat problem. *AIP Conference Proceedings*, 2951(1). <https://doi.org/10.1063/5.0181402>
- Harahap, Z. I. R. P., Almahdi, & Assagaf, I. (2023). Analisa Penyebab Alarm High Temperature Pada Air Screw Compressor KAESER DSD 202. 227-236. <http://prosiding.pnj.ac.id>
- Majka, M. (2024). *Fishbone Diagram*. October, 1-10.
- Putra, T. (2022). *Analisis Penyebab Working Air Compressor Tidak Dapat Bekerja Optimal Di Kapal Mt. Bull Sulawesi*.
- Sugiyono, Prof. Dr. H.M.Si. (2023). *Metode Penelitian Kualitatif*. Bandung: Alfabeta.
- Valand, D., Bhabhor, K. K., Jani, D. B., & Gandhi, T. (2023). Parametric Analysis of a Screw Compressor: A Critical Review. *International Journal of Advanced Research in Science, Communication and Technology*, January, 59-71. <https://doi.org/10.48175/ijarsct-7836>
- Wu, H., Liu, J., Shen, Y., Liang, M., & Zhang, B. (2021). Research on performance of variable-lead rotor twin screw compressor. *Energies*, 14(21). <https://doi.org/10.3390/en14216970>
- Air Compressor Guide. (n.d.). Contaminated or Clogged Cooler: Rotary Screw Compressors Troubleshooting. Air Compressor Guide. <https://www.air-compressor-guide.com/troubleshooting/rotary-screw-compressors/overheating-screw-compressor/clogged-cooler>
- Bagaskara, R. (2020). Analisis percepatan penurunan kualitas minyak pelumas pada control air compressor akibat tersumbatnya cooler diatas kapal mv. pan americas [Undergraduate thesis, Politeknik Ilmu Pelayaran Semarang]. Repository PIP.
- Giampaolo, T. (2023). *Compressor Handbook: Principles and Practice* (2nd ed.). River Publishers.
- Handoyo, E. A., Marianto, F., & Tandio, J. H. (2024). Study and analysis of an industrial compressor facing overheat problem. *AIP Conference Proceedings*, 2951(1). <https://doi.org/10.1063/5.0181402>
- Harahap, Z. I. R. P., Almahdi, & Assagaf, I. (2023). Analisa Penyebab Alarm High Temperature Pada Air Screw Compressor KAESER DSD 202. Prosiding Politeknik Negeri Jakarta, 227-236. <http://prosiding.pnj.ac.id>
- IntechOpen. (2023). Perspective Chapter: Smart Maintenance in Modern Ship Engineering, Design and Operations. IntechOpen. <https://www.intechopen.com/chapters/78118>
- Mahmudi, A. (2017). *Buku Bahan Ajar Pompa dan Kompresor*. Politeknik Negeri Bandung.
- Majka, M. (2024). *Fishbone Diagram*. ResearchGate, 1-10. https://www.researchgate.net/publication/385065860_Fishbone_Diagram
- Marine Engineering Online. (2017). Cooling Water Treatment for Diesel Engines on Ships. Academia. <https://www.academia.edu/34450125/>
- Putra, T. (2022). *Analisis Penyebab Working Air Compressor Tidak Dapat Bekerja Optimal Di Kapal Mt. Bull Sulawesi* [Undergraduate thesis, Politeknik Ilmu Pelayaran Makassar]. Repository PIP Makassar.
- Sollant. (n.d.). The temperature of the screw air compressor is too high, explain in detail. <https://www.welldrillingrigs.com/screw-air-compressor-temperature-is-too-high/>
- Sugiyono. (2023). *Metode Penelitian Kualitatif*. Alfabeta.
- Valand, D., Bhabhor, K. K., Jani, D. B., & Gandhi, T. (2023). Parametric Analysis of a Screw Compressor: A Critical Review. *International Journal of Advanced Research in Science, Communication and Technology*, 59-71. <https://doi.org/10.48175/ijarsct-7836>
- VoyageX AI. (n.d.). What Is a Planned Maintenance System (PMS)? Complete Guide for Shipping Companies. <https://voyagex.ai/what-is-planned-maintenance-system/>
- Wu, H., Liu, J., Shen, Y., Liang, M., & Zhang, B. (2021). Research on performance of variable-lead rotor twin screw compressor. *Energies*, 14(21). <https://doi.org/10.3390/en14216970>