Design of a Removal Tool for Air Dryer Filters on Scania P410 Using the 7UP++ Method

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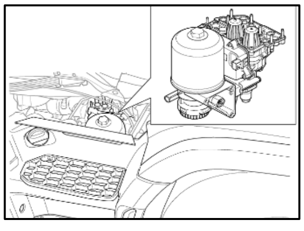
ABSTRACT

This study aims to design and evaluate the effectiveness of a specialized tool to facilitate the removal process of the air dryer filter on Scania P410 units, particularly in cases where the locking nut is detached. Common issues such as difficulty in filter removal, risk of thread damage, and potential harm to surrounding components are the main focus of this research. The custom-designed tool provides optimal grip without damaging adjacent parts, thereby improving maintenance efficiency and reducing the risk of component failure. Testing results show that the use of this tool can significantly reduce filter removal time from 30 minutes to just 5 minutes, representing an efficiency improvement of 83.3%. Therefore, the tool is proven to be effective in supporting maintenance processes, enhancing technician safety, and minimizing vehicle downtime. This study recommends the widespread adoption of the specialized tool and technician training to ensure safe and efficient air dryer filter maintenance.

Keywords: Special tools, 7UP method, Air dryer filter, Scania P410

1. Introduction

In the heavy equipment industry, maintaining machine efficiency and reliability is crucial for ensuring continuous operations. Vehicles such as the Scania P410 require dependable maintenance systems, particularly for vital components like the air dryer filter, shown in figure 1 according to the Multi Scania [1]. Which removes moisture from compressed air before it enters the braking system. Scheduled maintenance at 1000 Hours Meter (HM) intervals aims to prevent brake system failure, which could compromise the safety of both the vehicle and its operator. Therefore, developing effective maintenance strategies and supportive tools is an urgent necessity to sustain vehicle performance and extend operational lifespan.



Source: (Multi Scania, 2024)
Figure 1: Air dryer filter

Previous studies have explored the significance of air dryer systems in enhancing the durability of pneumatic components, particularly those involved in braking mechanisms. The implementation of air dryer systems in heavy-duty vehicles represents a notable engineering innovation aimed at mitigating the corrosive effects of moisture within compressed air systems [2]. The effectiveness of air dryers largely depends on their ability to maintain consistent air pressure and remove contaminants, both of which are essential for ensuring pneumatic system integrity [3]. When moisture is not effectively filtered, it can cause corrosion in metallic components, impair valve and actuator performance, and ultimately undermine the reliability of the braking system [4]. Prior research has also emphasized the role of air dryers in maintaining system stability and safety [5], and it is well established that component failures such as water buildup and clogged filter elements can significantly degrade brake performance, emphasizing the need for regular maintenance.

A problem frequency mapping was conducted on Scania P410 units operating in the mining area of PT. X, Tuhup site, Central Kalimantan, during the period from July 2024 to March 2025, shown in figure 2. The results indicate that the brake system represents the highest frequency of reported issues, with 75 recorded cases, followed by tire problems (58 cases), lamp group failures (47 cases), and suspension system issues (41 cases). Notably, air system-related problems, including those involving air dryer filters, were also significant, with 32 recorded instances. These findings highlight the critical importance of addressing recurring issues in the brake and air systems to improve operational reliability and reduce downtime in mining operations.

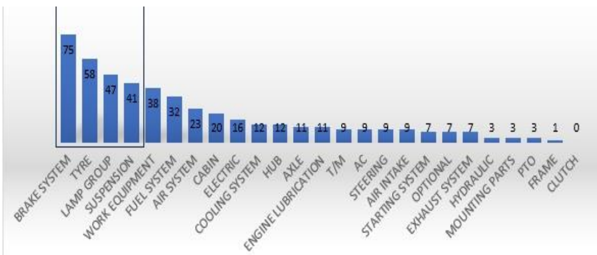


Figure 2: Problem frequency diagram

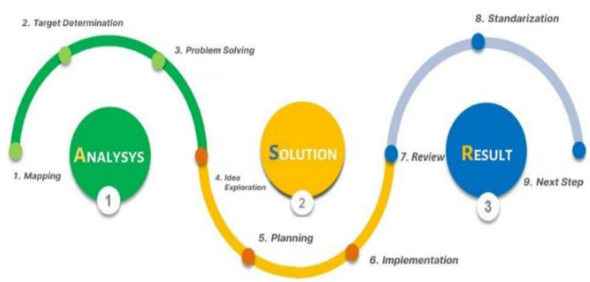
However, these studies have not specifically addressed practical technical failures encountered in the field, particularly mechanical issues such as broken or detached locking nuts on the air dryer filter, can be seen in figure 3. This issue is frequently reported by maintenance technicians and can lead to difficulties in filter removal using standard tools. Forced removal may result in damage to the filter mounting threads or surrounding air system components, increasing repair costs and downtime. Therefore, there is a clear need for a specially designed removal tool that can address this mechanical challenge safely and efficiently. This study aims to fill this research gap by developing a dedicated tool engineered to securely grip and remove the air dryer filter without causing collateral damage [6].

Figure 3: Detached locking nut during filter removal

The primary objective of this research is to evaluate the effectiveness of a specialized tool in simplifying the removal process of the air dryer filter from Scania P410 units when the locking nut is stripped or worn. Additionally, the study aims to formulate a technical solution to prevent potential thread damage and ensure safe disassembly. The design of this tool considers critical aspects such as functionality, safety, and ease of use for field technicians. Through this engineering design approach, the research is expected to contribute to the development of a more efficient, damage-free maintenance process and to support operational reliability in heavy vehicle maintenance practices [7].

2. Material and Methods

The Seven Up++ method, illustrated in figure 4. provides a systematic approach to guiding innovation activities. This framework enables a structured, traceable, and well-documented innovation process, facilitating both clarity and consistency throughout project development. Its structured nature helps generate effective solutions for present needs while also serving as a reference point for solving comparable problems in the future. The process is divided into three core phases: Analysis, Solution, and Result.



Source: (Guide Book UT, 2022)
Figure 4: 7Up++ Method

2.1. Overview of the Seven Up++ Method

Prior to commencing any repair or innovation initiative, a thorough preliminary assessment is essential to establish a structured foundation for the solution phase and to ensure that the targeted results are achieved efficiently [8].

- Analysis Phase: This initial phase involves systematic data gathering and problem mapping related to the component in question. In the context of this study, the focus is on the removal process of the air dryer filter. Key objectives are clearly defined, especially regarding the design of specialized tools that directly address the operational challenges encountered in the field.

- Solution Phase: This stage includes the development of ideas, detailed engineering planning, and the execution of those plans. Solutions are carefully crafted and tested to ensure they are technically sound and compatible with the functional demands of the maintenance process.

- Result Phase: The final stage centers on performance evaluation of the developed tools. This includes validating their effectiveness, documenting best practices, and integrating the tools into standard maintenance procedures to enhance consistency and efficiency in similar future applications [9].

2.2. Application of the Seven Up++ Method in Removing Air Dryer Filter

To enhance the efficiency and effectiveness of the air dryer filter removal process, the Seven Up++ method is applied with a focus on three critical variables: tool design suitability, manpower and time efficiency during maintenance.

- Tool Design Suitability
  This focus emphasizes the importance of designing a specialized tool that matches the shape, dimensions, and position of the air dryer filter on the Scania P410 unit. An appropriate design allows the tool to grip the filter securely, even when the locking nut is detached. Design compatibility also ensures that the tool can be used without interfering with adjacent components, thereby minimizing the need for additional modifications or special handling in the field.

- Manpower Optimization
  The Manpower Optimization variable evaluates the number of technicians required to perform the air dryer filter removal process, comparing conditions with and without the aid of the specialized tool. This analysis highlights the potential for reducing labor demands by enabling fewer personnel to complete the task efficiently and safely. The outcome contributes to increased work efficiency, better workforce allocation, and reduced operational labor costs [10].

- Time Efficiency During Maintenance
  Time efficiency is a critical metric in the maintenance of operational vehicles in industrial sectors such as mining. With the right tool, the time required to remove the air dryer filter is significantly reduced—from 30 minutes to just 5 minutes in this study. This increase in time efficiency enhances technician productivity and minimizes vehicle downtime, directly contributing to the company's operational performance.

By focusing on tool design suitability, manpower optimization, and time efficiency, the application of the Seven Up++ method offers a clear and practical way to improve maintenance processes for heavy equipment. This approach helps create safer, faster, and more effective solutions, supporting better performance and long-term operational reliability [11].

3. Results and Discussions

3.1. Analysis

The current method for removing the air dryer filter on the Scania P410 unit often involves inserting a tommy bar into available slots and extending it with a long pipe to generate sufficient torque, shown in figure 5. While this technique can be effective in certain conditions, it introduces several operational drawbacks. Primarily, the method requires additional manpower to stabilize the component and apply adequate force, which increases labor demands and overall maintenance time. Moreover, the reliance on makeshift extensions not only reduces ergonomic safety but also elevates the risk of tool slippage and unintended damage to surrounding components. These challenges highlight the necessity for a purpose-built removal tool designed to improve safety, reduce manual labor, and streamline the maintenance process.

Figure 5: Filter removal using a tommy bar method

Further analysis using a fishbone diagram identified four primary factors contributing to the prolonged cycle time in removing the air dryer filter nut: manpower, material, method, and measurement. The delays were primarily attributed to the lack of standardized work procedures, insufficient training of newly recruited mechanics, inadequate material durability, and the absence of accurate time measurement systems. These findings highlight the necessity of establishing clear standard operating procedures (SOPs), implementing structured training programs, improving material quality, and introducing effective work-time measurement tools to enhance service efficiency, shown in figure 6.

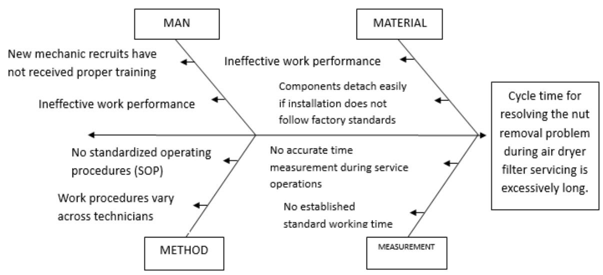


Figure 6: Fishbone Diagram

3.2. Solution Development

Following the analysis, several solutions were formulated to tackle the identified root causes, as outlined in Table 1.

Table 1: Idea Exploration for Root Causes and Solutions

Category	Root Cause	Alternative Solution	Benefit
Man	New mechanics/interns lack sufficient training	Implement sharing/mentoring program with senior mechanics	New recruits can quickly adapt without formal training
Method	Inconsistent work procedures	Develop Standard Operating Procedures (SOPs) for streamlined workflow	Reduced processing time
Material	Low material durability	Design and utilize special tools to prevent failure	Faster execution and improved reliability
Measurement	Absence of standard working time	Establish standard working time based on average performance	Provides a reference for work efficiency

In designing a special tool for removing the air dryer filter, both field observations and dimensional analysis were conducted to ensure compatibility with actual service conditions. The tool design features four pins with a diameter of 10 mm and a height of 100 mm, mounted on a 12 mm thick base plate. The assembly is fastened using four M14 bolts and reinforced with an M36 nut at the center. A 2.5 mm radius fillet is added at the corners to enhance structural durability. These specifications guided the development of the tool, as illustrated in figure 7.

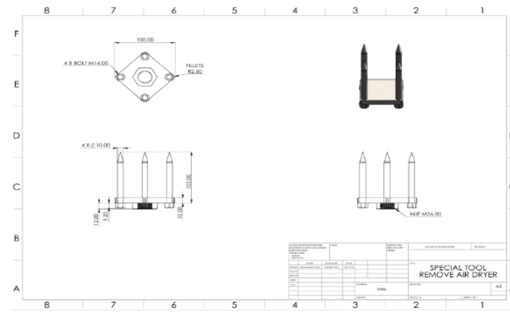


Figure 7: Design of Special Tool Remove Air Dryer Filter

3.3. Tool Development

The manufacturing process of the special tool employed a milling machine to achieve high precision and production efficiency, as illustrated in figure 8.

Figure 8: Development of Special Tool

3.4. Testing and Results

The developed tool was tested through a direct application process in the field. The test began by removing the side cover of the air dryer unit to access the filter component. The tool was then installed by aligning and securing it to the filter. Once properly positioned, the tool was activated by applying impact force using a hammer to break the filter's lock. As a result, the filter was successfully detached from the assembly, as illustrated in figure 9.

Figure 9: Testing of Special Tool

The comparative results before and after using the special tool are summarized in Table 2.

Table 2: Comparative Results

ASPECT	BEFORE	AFTER
QUALITY	Risk of damaging other components	A special tool is used as a preventive measure to reduce the risk of component damage
COST	If component damage occurs, it leads to high replacement costs	Minimizes expenses due to component damage
DELIVERY	Service cycle time for removing the air dryer takes 30 minutes	Service cycle time for removing the air dryer is reduced to 5 minutes
MORALE	The product image for the customer is just ordinary	The product image for the customer improves

The implementation of the special tool significantly enhanced the quality, cost-efficiency, and speed of the air dryer removal process. The use of this tool reduced the risk of component damage, minimized replacement costs, and shortened the service cycle time from 30 minutes to only 5 minutes. Moreover, it contributed to an improved product image from the customer's perspective, highlighting its potential for wider adoption in similar maintenance operations across the industry.

4. Conclusion

The development and implementation of a specialized removal tool for the air dryer filter on Scania P410 units have substantially improved maintenance procedures by addressing common field challenges such as detached locking nuts. This tool reduced the filter removal time from 30 minutes to just 5 minutes, enhancing time efficiency by 83.3%.

In addition, the tool minimizes the risk of component damage, reduces maintenance costs, and improves operational safety by enabling technicians to perform the task with greater precision and reduced physical strain.

Furthermore, the improved maintenance quality has positively impacted the perceived product image from the customer's perspective. These outcomes demonstrate the tool's potential for widespread application in similar heavy equipment maintenance scenarios.

Future studies should explore long-term durability, operator training protocols, and the potential integration of smart or automated features to further enhance the effectiveness and reliability of the tool.

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We hope that the findings of this research will serve as a meaningful contribution to the advancement of scientific knowledge and the development of more efficient maintenance practices in the heavy equipment industry.
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