



Improving Maintenance Culture to Achieve the Highest Operation
and Maintenance Standards Through Proactive Housekeeping
Program

Sponsored by
PT. Trakindo Utama Co., Ltd.

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Abstract

Contamination control is one of the most important aspects of heavy machine manufacturing. It helps in the process of product quality control, keeping the company clean and tidy, and making the machinery operate efficiently and effectively. The objective of this project is to help Trakindo, the biggest Caterpillar distributor in Indonesia to increase their star ranking in the Caterpillar Contamination Control Certificate by designing a new maintenance culture. Two main methods of field observation and interviewing were conducted to help gain information. However, to increase their star rankings, two main recommendations were suggested that could help to not only gain stars but also for maintenance and sustainability.

Executive Summary

Introduction and literature review

For Caterpillar distributors, the five star contamination control certificate is very important as it is a process which brings the best out of CAT's machines, while reducing the risk of failure and helping improve the environment.

Trakindo Utama BSD, our sponsor, sees this as an opportunity to develop a new maintenance culture through a housekeeping program to improve the warehouse practices and conditions that are needed to be inspected for the five star contamination control certificate.

As stated above, Trakindo would like the team to help increase their star ranking in the Caterpillar contamination control certificate by designing a new maintenance culture through a proactive housekeeping program. To clearly understand the project, the team researched for background information on the five star qualifications, types of contaminations, ways to improve training plans, case studies about training, Trakindo portfolio and Indonesian culture as part of the literature review chapter.

The team's objectives to achieve this goal are

- 1) To understand the implementation of Caterpillar's Star Contamination Control Certificate.
- 2) To identify systematic flaws at the Company's warehouse.
- 3) To determine the solution and prevention of the cause
- 4) Design a new maintenance culture to achieve our goals.

Methodology

To gain information about the Five Star Contamination Control Certificate and the training program, the team observed the warehouse and compared it to the qualifications and conducted an interview with the internal auditor who inspects the warehouse and the technicians who passed the training program. As a result, the information obtained was useful for analyzing the systematic flaws of the warehouse practices and conditions thus, the training program.

The background research indicated to us about different types of contaminants that could happen due to each practice and which conditions or activities were not acceptable according to the five star qualifications. From the interview, the internal auditor suggested that the training program should focus on increasing the discipline of the technicians because different people came from different backgrounds. By following this recommendation, the team was able to gain information about the training center, different practices that should be improved and aspects of the training program that should be improved.

After the team had obtained findings from the previously mentioned methodology, the team then conceptualized the information and came up with several recommendations on how to achieve the project goal.

Results

From the field observation of the warehouse, it could be seen that some of the criteria that are needed to be inspected for the Five Star Contamination Control Certificate have not met the qualifications due to the condition of the equipment and technician practices. The Company also indicated that one criteria that should be considered was the cost.

From interviewing the technicians, we learned that training is a must before becoming a technician at Trakindo. 90% of the technicians interviewed very much enjoyed and appreciated the training program and thought that it was important; however, 10% did not like the training program and did not think it was important. 40% were not satisfied with the training reward, which affected their motivation for getting trained. (More details are shown in the Results chapter).

Recommendations

From the team's findings and literature review, the team came up with two main recommendations that could help increase Trakindo's star rating in the Caterpillar Contamination Certificate.

1. Designing a new culture

- 1.1) The training program

- 1.2) Reward for outstanding performance

- 1.3) Management of non-compliance behavior

- 1.4) Creating a 5S poster for reminding the technicians on being aware of their practices.

2. Improving each criterion

From the field observation of the warehouse, it could be seen that the condition of some of the equipment and technician practices do not meet the five star qualifications. Each criterion was evaluated by considering cost, time and weight on score improvement, with cost and time being simultaneously considered so the priority of each criterion improvement was known. By the evaluation of the factors mentioned above, the team chose to focus on 15

criteria that could help increase the overall score for the five star certificate.
(More details in the Recommendation chapter).

Conclusion

From considering that contamination control plays an important role for Caterpillar distributors, Trakindo has shown how important it is for them to maintain the quality of each branch and Company's reputation by increasing the star ranking in the Caterpillar contamination control certificate. In order to achieve this goal, creative ideas are further needed to help create a new maintenance culture and ways to prevent issues from arising. Therefore, the team suggested two main recommendations to help Trakindo achieve the goal.

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Finding and Results <ul style="list-style-type: none"> • Statistic for star • Criteria that were classify as short time • Criteria that were classify as long time • Relationship between criteria and finding • Bubble Graph • Walk path is not safe • Lacking of oil barrel covers • Tile floor • Cracked trash bin • Rusted table in workshop • Gloves and cross-contamination • Fluid on the floor • Improper covering of machine • Using improper caps and plugs with hoses and machines • Methods of transporting, storing and disposing of waste fluids • Gaskets removed in disassembly area • Disorganized bulk hoses storage 	<ul style="list-style-type: none"> • Panipuk (Sandy) • Panipuk (Sandy) • Panipuk (Sandy) • Panipuk (Sandy) • Nattapon (Non) • Nattapon (Non) • Nattapon (Non) • Nattapon (Non) • Nattapat (Bung) • Nattapat (Bung) • Nattapat (Bung) • Nattapon (Non) • Achiraya (Minnie) • Achiraya (Minnie) • Nattapon (Non) • Panipuk (Sandy) 	Achiraya (Minnie)
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Chapter 1: Introduction

PT Trakindo Utama (Trakindo), our sponsor, is one of the biggest authorized distributors of Caterpillar® 's (CAT) heavy equipment, engines and fork-lifts in Indonesia. Precision parts and fluid systems that operate CAT's heavy equipment are highly-calibrated and need be utilized in a contaminant-free environment. Particulate contamination from things such as dust, dirt, metals, paint flakes, or sealing materials can disrupt the operation and decrease the workability of the machine. Currently, the Company wants to improve its contamination control standard and obtain CAT's 5-star contamination control certificate, the highest designated award given by Caterpillar for excellence in contamination control systems. By gaining CAT's 5-Star certificate, it shifts the Company towards a better operation in terms of contamination control and better operational discipline that will provide customers with greater confidence..

When working with heavy equipment, or heavy-duty machinery for construction, it is crucial to maintain optimum cleanliness. The concept has been taken into account by many big companies resulting in the creation of numerous machinery quality systems. As one of the widely known companies that manufactures and sells machinery, Caterpillar Inc. has created its own contamination control standard called the Five-Star Contamination Control Certification, which has since become a guideline for many companies. For the companies associated with Caterpillar, the Five-Star Contamination Control Certification is the operation norm expected to be strictly followed and is graded with a range of one to five stars. PT Trakindo Utama, an Indonesian based distributor of Caterpillar is mandated to this standard. Due to many circumstances, the Company currently owns a three-star certificate

and has set their priority to improve the company wide training program and their internal audit criteria to reach a new milestone. Our mission was to assist Trakindo in developing a proactive housekeeping program through an effective training plan and raise company wide awareness in contamination control.

Chapter 2: Literature review

The goal of this project is to increase Trakindo's star ranking from three to a higher rank as per the Caterpillar Contamination Control Certificate. The Caterpillar industry and distributors are required to follow this track. Each company can achieve CAT's contamination control certificate if they meet the qualification standards. There are 18 sections with 121 criteria in total to achieve the maximum of five stars. Currently, PT Trakindo Utama is at the three star level and aims to reach five stars in the future. The objective of this project was to help PT.Trakindo Utama improve their housekeeping program in order to reach a higher star ranking in Caterpillar's Contamination Control Certificate.

2.1 Background of PT. Trakindo Utama



Figure 1: PT. Trakindo Utama in Jakarta, Indonesia

Trakindo (Figure 1) is an authorized distributor in Indonesia for CAT, the largest global manufacturer of heavy duty equipment, diesel and natural gas engines, and heavy machinery. Trakindo was established in 1970 by Mr. AHK Hamami and became an authorized dealer for CAT in 1971. As an experienced distributor for over 40 years, Trakindo offers a complete selection of CAT engines.

The CAT contamination star control is a process which brings the best out of CAT's machines, while reducing the risk of failure and helps to improve the environment. A contamination control system controls anything that should not be in the machine's lubricants. The most common substances are particulate contaminants such as dirt, metals, paint flakes, rag fibers and sealing materials.

2.2 Five-Star Certified

To achieve the goal of this project, we should first understand the processes and qualifications of the 5-Star Caterpillar contamination control certificate.¹ According to the information gained from the Company, the contamination control report has to be submitted for an audit by Caterpillar twice a month. The following are some of the requirements of a good contamination control system.

- 1) Parts inventories maintained and protected in a clean environment
- 2) Oil system cleaning with special tools, high efficiency loop kidney filter
- 3) All bulk oils filtered prior to use
- 4) Specialized hydraulic hose cleaning processes
- 5) Dust control procedures in all shop areas

- 6) Portable particle counters to monitor the oil contaminant level
- 7) Clean Facilities + Clean Parts/Components + Clean Fluids + Clean Repair/Assembly Processes = Clean Machines/Engines



Figure 2: 5-Star CAT Contamination Control Certificate received by Trakindo in 2007

PT. Trakindo once achieved a 5-star certificate in 2007. The company's ultimate goal is to re-achieve the 5-star standard and maintain the status.

2.3 Types of Contamination

Contamination is the presence of unwanted materials during the manufacturing process. Cross-contamination will also occur if one of the processes is contaminated, which will then spread on to successive steps. Contamination can be separated into 2 groups; particulate contamination and chemical contamination.

2.3.1) Particulate Contamination

- i) Fibers: small particle contaminants contained in the lubricants in forms of microfiber from cleaning cloths. According to ISO 4407, it expresses the amount of contaminant as per one milliliter of the fluid.
- ii) Dirt: small particles that can permeate between the joints of the machines. There are the two main types of dirt contamination.
 - (1) Dirt that can be seen by the naked eye (Particle bigger than 40 micrometers)
 - (2) Dirt that cannot be seen by the naked eye (Particle smaller than 40 micrometers)
- iii) Metal: bigger and harder particles than dirt such as aluminium oxide.

2.3.2) Chemical Contamination



Figure 3: Heat detector

The heat detector is a machine used by CAT to detect the temperature of lubricants during storage.

i) Heat : When the temperature rises above 65°C, the oxidation rate is double and will result in halving the usable life of the lubricant.

ii) Water: If the lubricant is contaminated by water, it will affect the viscosity of the lubricant.

iii) Air: Chemical substances such as hydrogen sulfide and sulfur dioxide and also humidity could be found in the air.

2.4 Contamination Sources

Using improper equipment is not the only source that causes contamination. The environment around the warehouse such as open areas could also easily introduce contamination to the machines.

2.4.1) Built-In

- a. Due to the construction inside the workshop, there might be some contaminants that are able to affect the mechanical process of the machines.

2.4.2) Equipment

- a. Pitted Rods



Figure 4: Pitted rods

Pitted rods are frequent sources of contamination. When the rods of heavy machines become pitted or have holes, particles can get into the machines causing leakage and contamination.

a. Broken or Improper Breathers



Figure 5: Broken or improper breathers

Using broken or improper breathers can cause contamination. A breather is a type of air filter used in heavy machinery and lubricant barrels. Once they fail, dirt or dust cannot be properly filtered before the air is introduced inside the machine.

b. Worn Seals



Figure 6: Worn Seals

Worn seals can introduce contamination as they are missing or loosen from parts of the heavy machines. This affects the productivity of the machines and might lead to some leakage and contamination.

2.4.3) Maintenance and Service

As mentioned above, the warehouse environment could cause contamination.

There are two main sources in this point:

a. Environment:

Open system: Dust and dirt are small particles with diameters of 2.5 to 10 um. Mostly known as Particulate Matter, PM2.5 and PM10 for which the number after PM tells us the size of each particle in micrometers.

Replacement part: If any parts of heavy machines are replaced, contamination, dirt and dust, may get inside any of the machine parts.

b. Discipline:

Work Practices: Caused by employees who lack training or lack work discipline of correctly practicing and maintaining cleanliness.

2.5 Basic goals of contamination control

The basic goal of contamination control is to maintain cleanliness. To reach the goal, there are several suggested actions that Caterpillar recommends their associates to do which can be broken down into the following:

2.5.1) Actions Contributing to Success

- a) Always clean materials, tools or equipment before bringing into contaminant-free areas.

- b) Always wear appropriate gear or PPE (Personal Protective Equipment) according to the factory's dress code before entering the site or production line.
- c) Always keep an eye on the potential violations to basic contamination control such as:
 - i) Improper working methods
 - ii) Not enough information provided during practices

2.5.2) Access and Administration Control

- a). Restrict controlled areas by distinctive labelling such as signs or ropes.
- b). Label all tags with radiological information.
- c). Design the operation line so that it distinctly separates the contaminated and non-contaminated areas.

2.5.3) Preventive Methods

- a). When conducting pre-job briefs
 - i. Discuss measures that will help reduce or prevent spreading of contamination.
 - ii. Plan to clean and sanitize all areas before, during and after work.
- b). Site visitors should follow the correct dress code when entering the working area to prevent contamination

2.6 Protective and Considerations

Contamination control is an important part of a proactive maintenance strategy. Knowing the types of contamination is crucial for this project. If the employees can distinguish the types of contamination, it will be easier to identify suitable options to eliminate the contaminants and to improve housekeeping in the facility. For example, the employees will be able to distinguish the differences among types and forms of contamination of dust, surface, airborne vapors or gases.

2.7 Warehouse Observation and Investigation

Conducting an observation and investigation of the warehouse can help gather information for analysis and evaluation. It is one of the most important parts for public participation before choosing suitable methods. These are the factors that should be considered during the observation.

2.7.1) Establish the contaminated area at each location.

2.7.2) Use floor coverings or decontamination.

2.7.3) Restrict access.

2.7.4) Quarantine and collect all contaminated materials.

2.8 Ways to improve the training plan

There are several ways to improve the training plan. We can conduct a literature review on factory case studies on training programs to provide ideas on what can be done at Trakindo. First, prepare survey questions for employees to understand the organizational

performance, what are their expectations, and their perception towards the importance of training. Moreover, make sure that the training program and the operation goals go in the same direction. Expectation theory is used to satisfy employees' needs. We can also design the action and estimate the time for achieving each goal. Engagement is also important for keeping employees motivated.

2.9 Theories to support the plan

These are Five theories that were chosen to help support our understanding and recommendations.

2.9.1 Theory 1: Strategy To Improve

To develop the system, understanding the structure of the organization is essential. From this theory, we will be able to develop clear result-oriented objectives stated in measurable terms and also identify activities required to accomplish the objectives. Also, allocate specific responsibilities to the appropriate personnel. Next, the time used could possibly be estimated to achieve the appropriate sequencing.

i. Implementation of strategic plans

To develop a systematic filtration process that facilitates process and the commitment of the Control Manager, the Company must consider:

- 1) Organizational structure
- 2) People
- 3) Culture

- 4) Control systems

- ii. Strategic control

- 1) A formal control system should be developed which will help the strategic plan to proceed. Setting up and testing channels for information about the progress, problems, and suitability of strategic assumptions to the environment
- 2) Ultimate goals: Detect and fix downstream issues to improve strategies and goals.
- 3) Corrective actions based on assessments and recommendations
- 4) Negative feedback should prompt the immediate action to be resolved before the problem occurs.

- iii. Possible corrective actions include:

- 1) Updating strategic assumptions: Evaluating and estimating the outcome of the actions planned.
- 2) Reformulating strategic plans: Identify the weaknesses and keep the plan updated.
- 3) Rewriting policies: Edit the policies to be more strict and more easy to abide by.
- 4) Modifying budget allocation: In order to find solutions to improve the problems, the budget must be considered to make the most out of the profit.

- iv. Root Cause Analysis

We employed Root Cause Analysis (RCA) to identify problematic areas and most suitable solving options. There are two types of RCA:

1) RCA Reactive for analyzing unexpected outcomes and to identify the most efficient and effective solutions;

2) RCA Proactive for analyzing the probability and potential of the occurrence of unexpected outcomes so that precautions can be raised to prevent it from rising to the level of protection or FMEA (failure mode and effect analysis). Root Cause Analysis consists of 4 major areas: the first point is the turning point which is needed to understand how this outcome happened by looking back in the past. After identifying the turning point, the next thing that should be done is a cognitive walkthrough, which is the step where we are going to identify and inspect the stakeholders that are related to this problem. Always ask “Why?” when it comes to an unexpected outcome. This is the best way to improve and understand more about the problems. The last step is a comprehensive scan, which is the hardest method. This way, we will focus on every single point that has the potential to cause the unexpected outcome to occur.

2.9.2 Theory 2: Internal Audit

An internal audit is not the rule of a factory but can be conducted to review the operational activities of the organization. This type of auditing is determined by the entity's management. Conversely, an external audit is obligatory for every separate legal entity, which means the third party is included in the organization to perform a process of checking and giving their opinion to state the situation and ways of improvement. As a basis for control, both external and internal audits should be considered. In our case, we chose to focus on the internal audit because the contamination control system is conducted within the Company. An Internal audit is easier to control than an external audit and it consists of an

executive reality check of employees and the company system. It also takes less time if compared to an external audit.

i) Executive Reality Checks

- 1) Top managers always follow up on the lower level employees to ensure that the employees are aware of this protocol.

ii) Internal Audits

- 1) Independent appraisals of organizational operations and systems are conducted to assess the effectiveness and efficiency.

2.9.3 Theory 3: Total Quality Management (TQM)

Improving total quality management is also an important factor of continuous improvement for maintaining the company's five stars. Creating an organizational culture commits to this continuous process of detecting and reducing or eliminating errors in manufacturing, streamlining supply chain management, improving the customer experience, and ensuring that employees are up to speed with training. The TQM aims to make all parties involved in the production process accountable for the overall quality of the final product or service with teamwork skills. TQM mainly deals with the product quality, service processes and customer satisfaction.

2.9.3.1) Four Principles of Total Quality Management

- 1) Do it right the first time: Designing and building quality into the product.
- 2) Be customer-centered: Satisfying the customer's needs and identifying the stakeholders with priority.

- 3) Make continuous improvement a way of life: Kaisen, A Japanese word meaning continuous improvement (quality is an endless journey) which involves the search for actual or potential trouble spots.

The avenues for continuous improvement:

- a) Improved and more consistent product and service quality
 - b) Faster cycle times
 - c) Greater flexibility
 - d) Lower costs and less waste
- 4) Build teamwork and empowerment
- a) Empowerment: Adequate training, access to information and tools, involvement in key decisions and fair rewards for results.
 - b) Teamwork: Suggestion systems, QC circles and self-managed teams and Teamwork and cross-functional teams.

2.9.4 Theory 4: Expectancy Theory (Vroom)

Vroom theory is a model that assumes motivational strength as a function of perceived probabilities of success. A person's motivational strength can lead others due to rewards for effort-performance.

Motivational strength: The level of effort that should be put from bottom to top respectively. Because the motivational force consists of three perceptions, if one of these criteria below is zero then the whole equation will equal to zero as well.

2.9.4.1) Perceived effort-performance probability

This is also known as expectancy. It is based on the effort and performance relationship. If a person believes that putting the effort into a job has the potential to achieve set goals, that person will accept the work and get the job done. But if a person believes that his or her potential is not enough then that person is going to quickly give up. Therefore, expectancy depends on important factors which are potential, self-confidence, and target. If the person already has the potential with the addition of self-confidence, then the target is achievable. To sum up, expectancy is the ability to increase the potential for people. Training and coaching methods are also included to increase and support the confidence of that person.

2.9.4.2) Perceived value of rewards

This is the relationship between the goal and the outcome of that goal. The results may be obtained here as a reward, money, self pride, honor, reputation or position. It depends on the factors that affect instrumentality, which is the assurance that the desired result is also achieved. This also involves the confidence in leaders that is fair and reliable which can be increased if the organization has a clear evaluation system and clear policy announcement.

2.9.4.3) Perceived performance-reward probability

This is also known as valence. Valence is the value of consequences that are received by people who are the target for persuading. This is the case whereby the value might be -1, 0, 1 depending on what the targets want. If the value of valence equals +1, it means that the targets have motivation to do the work. If the valence equals 0, it means the targets do not feel committed to the consequences of the action. This means their motivation is equal to zero. Finally, if the targets never want the result and they try to avoid the result, the valences

are equal to -1. This means the motivation is negative. In other words, this means the targets are trying to do the opposite thing to not face the result.

2.9.4.5) Case study to support expectancy theory

a) Case study of Tesco UK

Tesco UK believes that for an organization that has an extensive operating network and a large number of employees, a critical and intelligent evaluation is essential. According to the interviewees, Tesco follows a simple and transparent performance evaluation, and all employees who are evaluated will recognize the evaluation criteria. In addition, to ensure transparency, employees will be aware of employers, executives, who will assess them. This step is taken to ensure that no employees feel prejudiced in their work processes. Further predictions about the performance appraisal process at Tesco respondents emphasized that the organization conducts quarterly performance assessments for lower level employees and receives bonuses and financial rewards. However, lower level employees are given the opportunity to take the exam for promotion, based on the evaluation of efficiency. Similarly, performance evaluations for senior management are held every year, and employees are given the option to choose from the financial and non-financial compensation categories.

b) Case study of Motonet

Motonet is one of the Broman Group Oy which is a consolidated company that sells auto parts, equipment, tools, boating and fishing equipment. This company uses the expectancy theory to satisfy the needs of all employees.

At first they used the profit sharing to employees by 0.0025% of the total sales multiplied by the total working hours. However, this caused conflict among the workers who

work hard who received the same sharing as those workers who were lazy. After Motonet identified this conflict, they countered this issue by increasing the Christmas bonus so it was more linked to individual performance.



Figure 7: The change of sales and personnel over 5 years of Motonet

2.9.5 Theory 5: Order the priorities

Priority is to rank the goals, objectives, and activities in order of significance and timing of each decision. Before making any decisions, it needs to respect the priority ranking that will be related to how to allocate resources.

2.9.5.1) The A-B-C priority system

A are the actions that are “Must be done” which means it will rank in the first priority when coming to making decisions, unless it has some consequences in both positive and negative aspects which can critically impact the company.

B are the actions that are “Should be done” which means the actions are necessary to be done in order to achieve the objectives.

C are the actions that are “Nice to do” which means it will rank in the last priority in the decision meaning they are not necessary but may give more advantages to the plan. This will have little effect on the company if they carry out the actions or not.

Chapter 3: Methodology

This chapter describes the data collection design and methodology of our research to assist PT Trakindo Utama to achieve the 5 stars certificate of the Caterpillar contamination control. Once the causes and issues were identified, we designed a program to help PT Trakindo Utama improve their maintenance culture to achieve a higher quality rating. We identified the best practices by collecting records of past outcome scores and compared those to the maximum possible score of each category using statistical parameters to identify the most suitable options. The team analyzed internal factors by observing the warehouse and focusing on sections of stagnant scores for the past four months. Ranking of criteria that can be improved were set according to their statistical scores according to these objectives:

1. To **understand** the implementation of Caterpillar's Star Contamination Control Certificate.

We conceptualized the causes of the problems that were harvested for supporting evidence. To prepare ourselves before visiting the warehouse, we obtained some information on the requirements of the contamination control inspection, information on component repair and assembly, hose assembly storage, parts handling storage. Other aspects of contamination control criteria were researched to help us identify options for improving the current star ranking of the warehouse which could be detailed in the literature review.

We met a machinery expert in Thailand and learned about the basic operation and maintenance of heavy duty machinery. Warehouse observation allowed us to observe routines of staff and their responsibilities which helped us identify key criteria that could be

improved. Due to limited time, we only focused on sections that could be improved in a timely manner, with minimal routine disruption, and at an effective cost.

2. To **identify** flaws at the Company's warehouse.

Our team observed the warehouse focusing on the employee routines and different criteria conditions that received low scores during the routine internal audit and compared them to the five star qualifications. Our team interviewed employees, the internal auditors at the warehouse, to learn about the training program and inspection criteria. We randomly sampled 6.25% warehouse employees (10 out of 160) for interviews and 2 internal auditors.

3. To **determine** solution options and design preventive actions.

The information gathered from observing the warehouse and interviews were analyzed. Case studies were selected for examples of good solutions and how they were achieved. From conceptualization, the team had evaluated the conditions of equipment and practices that should be improved, by relating to some information in the literature review and the suggestion of the internal auditor.

4. To **design** a new maintenance culture for improving the standard of quality

After we received the information from interviewing, we converted the information into a statistical form for gathering and preparing the solution for our sponsor. Then, we made a short presentation from the plan which we thought could most suitably solve the Company's issue. We also found some case studies for supporting our ideas in the slides.

Chapter 4: Data Collection and Analysis

Data collection and analysis were conducted by 1) observation at Trakindo's warehouse on work routine, employees practices, and working conditions according to the standard, 2) by random interview of branch employees and internal auditors about the training program in place. The employee interview was conducted on 10 people which consisted of 8 technicians, 1 tool calibrator, and 1 storage area staff. We also interviewed two certified internal branch auditors. The set of interview questions are in appendix A, and the responses are in appendix B.

The contamination control process at the factory is divided into 2 sections; the workshop and the warehouse. For this project, we focused on how to improve the warehouse technician performance score.

Ten employees were randomly interviewed to ascertain their perspectives about the training center. Eight were technicians, one was a tool calibrator, and the last one was a storage area employee. 40% (n=4) were unsatisfied with the training program reward. 90% (n=9) liked the training program and believed that the training program is important and felt the Company should carry on with the program. However, 10% (n=1) disliked and saw the training program as unnecessary. Interview questions are listed in appendix A.



Figure 8 and 9: Interviewing employees at Trakindo Warehouse

We interviewed the internal auditors and found these common responses:

- Both auditors believed that the auditing scores could be improved.
- Achieving the 5 Stars rating will not improve Trakindo the experience received by the customers very much. However, it will have high impact on the Company reputation and ability to compete in the industry
- Discipline is very crucial when it comes to employee performance as it normalizes different personal experience to a unified standard.
- Training is very effective to implement change in behavior and should be implemented on safety and waste management.
- All technicians should receive a training program in contamination control and job related skills before starting his/her job.
- One of the auditors indicated that the tidiness and record keeping in the oil barrels section could be improved.

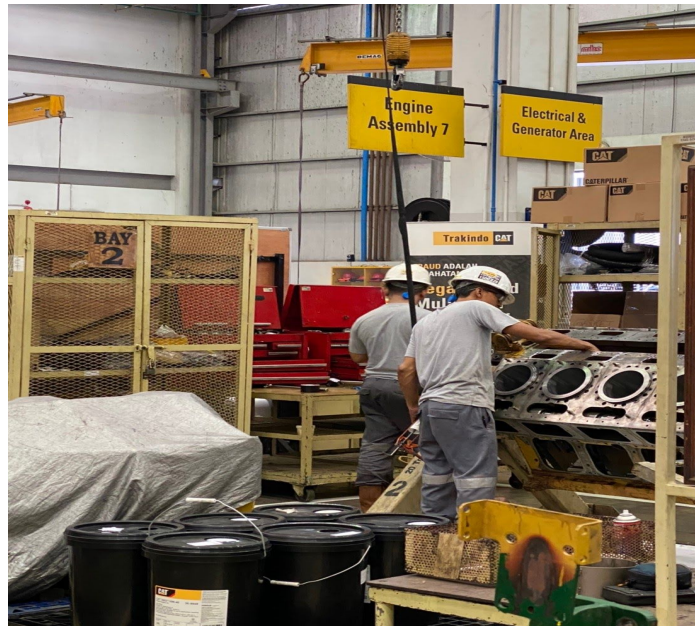


Figure 10: Trakindo Utama BSD Warehouse

At Trakindo warehouse where machines are fixed, repaired, cleaned, and stored.

4.1. Statistics of the Caterpillar contamination control stars

The qualifications of the five star contamination control certificates were provided during the warehouse observation. The internal auditor showed us different areas of routine operations and equipment storage which were of interest. The scores of each criteria were categorized into 3 levels: good, acceptable, and not recommended.

- ‘Good’ , for the maximum score possible in the section
- ‘Acceptable’ for action items that received only half of the maximum possible score
- ‘Not recommended’ when the operation was poor and received zero points

Trakindo further classified each criteria based on cost as expensive, intermediate, and inexpensive. Based on these descriptions, we classified improvement plans into short-term and long-term. Short-term are the criteria that could be improved immediately and long-term are ones that may take more time to improve due to cost.

Trakindo also set weight differences to signify the importance of each criteria. At the end, we identified 18 problematic areas based on the audit scores of the last 4 months.

Section 1 - Training		Oct	Nov	Dec	Jan	
1.1	Contamination control training program in place	5	5	5	5	10
Section 2 - Equipment Wash Facility						
2.3	Hot Water and soap / degreaser used with pressure	5	5	5	5	10
Section 3 - Shop Attribute						
3.2	Workshop doors installed and functional.	0	0	0	0	6
3.3	Floor condition.	3	3	3	3	6
3.4	Walkways / safety / storage areas marked and kept free of obstacles (inside and outside).	3	3	3	3	6
3.9	Part washing stands filtered to meet cleanliness targets.	0	0	0	0	10
Section 4 - Shop Practices						
4.2	Use of proper hose / tube end protection.	5	5	10	10	10
4.7	Approved methods of transporting, storing and disposing of waste fluids.	3	3	3	3	6
4.8	Assembly aids container (lubricant or grease) cleanliness managed.	4	4	4	4	8
4.11	Timeliness of cleaning up lubricant, fuel and coolant spills.	8	8	4	8	8
4.13	Purposed waste containers clean and organized.	2	4	2	2	4
Section 5 - Disassembly Area In Specialization Shop / CRC						
5.3	Gaskets removed in disassembly area.	5	10	5	5	10
Section 7 - Hydraulic Cylinder Rebuild Shop / Area						
7.4	Ports in assembled cylinders protected with appropriate caps / plugs.	5	5	5	5	10
Section 6 - Fuel Injection Component Test Room / Area						
6.6	Floors are in good condition.	2	2	2	2	4
Section 8 - Powertrain / Hydraulic Test Room / Area						
8.3	Hoses, fittings and covers capped, covered or properly protected.	3	3	3	3	6
Section 9 - Engine Dynamometer Room						
9.3	Proper breather on lubricant and fuel storage tanks.	8	4	8	4	8
Section 12 - Hydraulic Hose Building / Rebuilding						
12.1	Bulk hose storage.	5	5	5	5	10
Section 14 - Bulk And Portable Fluid Storage						
14.6	Lubricant barrel storage.	3	3	3	3	6

Good
Acceptable
NR

Table 1: Eighteen criteria set from audit data during October 2019 to January 2020.

Once the 18 criteria were identified as areas to be improved, we further ranked them by three factors which were cost, time, and weight. We identified 15 criteria that can be easily fixed which we called them as short-term criteria.

Fifteen short-term criteria	
Criteria No.	Criteria Name
1.1	Contamination control training program in place
2.3	Hot water and soap / degreaser used with pressure
3.4	Walkways / safety / storage areas marked and kept free of obstacles (inside and outside).
3.9	Parts washing stands filtered to meet cleanliness targets.
4.2	Use of proper hose / tube end protection.
4.7	Methods of transporting, storing and disposing of waste fluids.
4.8	Assembly aids container (lubricant or grease) cleanliness managed.
4.11	Timeliness of cleaning up lubricant, fuel and coolant spills.
4.13	Purpose waste containers clean and organized.
5.3	Gaskets were removed in the disassembly area.
7.4	Ports in assembled cylinders protected with appropriate caps / plugs.
8.3	Hoses, fittings and covers capped, covered or properly protected.
9.3	Proper breather on lubricant and fuel storage tanks.
12.1	Bulk hose storage.
14.6	Lubricant barrel storage.

Table 2: Selected short-term criteria

We further weighted these 15 short-term criteria listed in Table 3 , each criteria was weighted with 3 parameters explained in section 4.1 and identified 4 areas that could be improved right away at a very reasonable cost.

Three Long-term criteria	
Criteria No.	Criteria Name
3.2	Workshop doors installed and functional.
3.3	Floor condition.
6.6	Floors are in good condition.

Table 3: Selected long-term criteria

The Long-term criteria listed in Table 4 were weighted with 3 parameters explained in section 4.1 and were classified into long term criteria due to the possibility of obstruction of workflow and costs.

4.3. Relationship between criteria and findings

To categorize criteria:

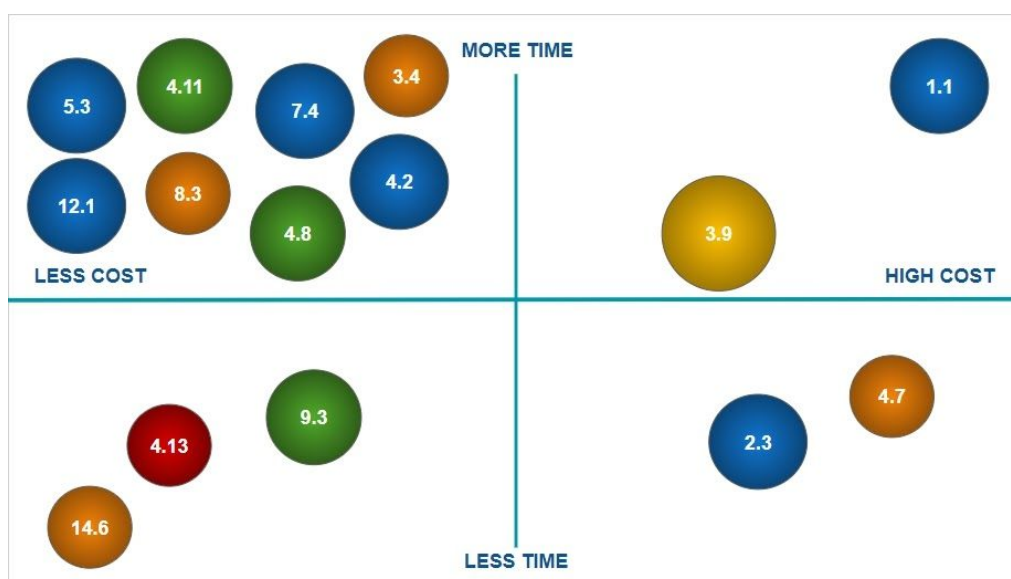


Table 4: Bubble graph projection of different criteria weighted by time and cost. The size and color for each bubble indicates the weight score of each criterion.

For the yellow color, the size is the biggest, as the full score of the criteria is 10. For the blue bubbles, the full score weight is 5. For the green bubbles, the full score weight is 4. For the orange and red bubbles, the weight is a full score of 3 and 2 respectively.

To identify ease and cost effectiveness for our sponsor to improve their contamination control process, we used this bubble graph to plot out potential areas worth considering.

4.3.1 Low cost, Less time

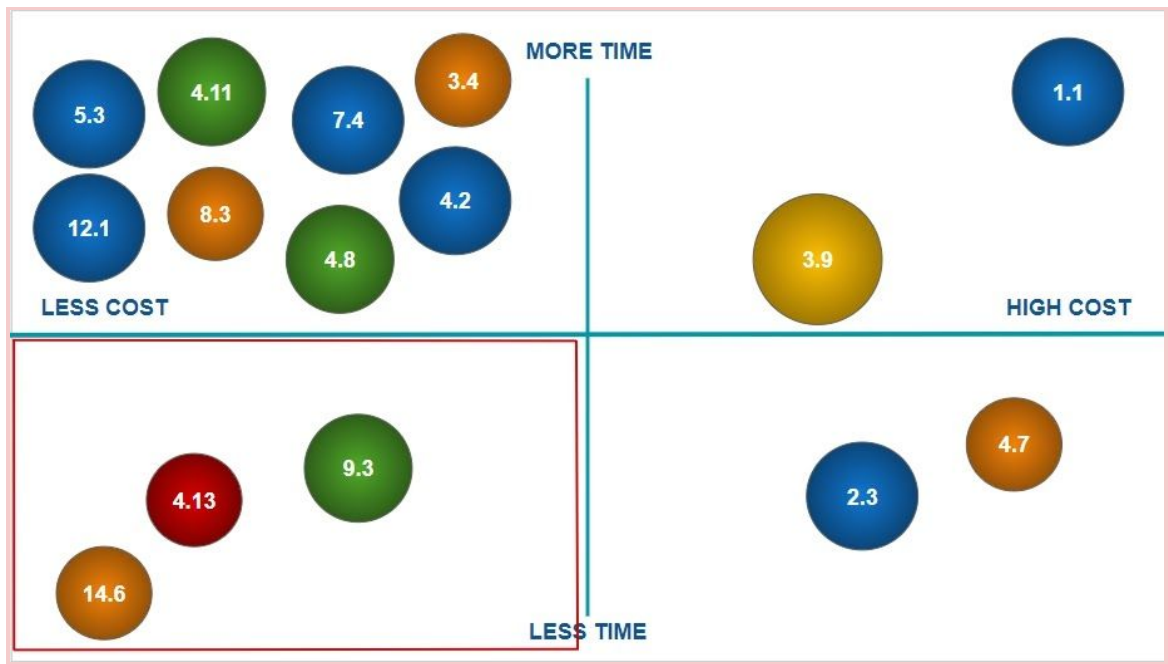


Table 5: Bubble graph projection of criterias that uses low cost and takes less time to improve

There are 3 criteria (4.13, 9.3 and 14.6) that fall in the low cost and less time quadrant. Criteria in this section can easily be solved such as a new replacement can be purchased to make an immediate improvement. We recommend Trakindo to set these 3 criteria as first priority and proceed with the improvement immediately.

Criterion 4.13: Propose waste containers be cleaned and organized



Figure 11: Poor condition of garbage bins

The contamination control criteria specifies the shape, color and condition of a garbage bin. To obtain a higher audit score, new garbage bins should be purchased and maintained.



Figure 12: The garbage bin has been corroded by solvent

Criterion 9.3: Proper breather on lubricant and fuel storage tanks



Figure 13: Breather on lubricant and fuel storage

The very small cylinder on top of the tank is called the breather. It helps filter the air that passes through the lubricant barrel. Once they fail, dirt or dust cannot be properly filtered before the air is introduced causing contamination of the stored lubricant. Caterpillar standard recommends air breathers to be changed every six months. The air breather in this figure has already been in operation for over a year and therefore has failed the inspection..

Criterion 14.6: Lubricant barrel storage



Figure 14: Examples of barrels with a proper and improper cover.

The oil barrel bung holes must be closed with plugs and with a top-cover to prevent contamination by water. As it rains, water is trapped on top of the barrels, and eventually the bungs are submerged. As a drum heats (through sunlight and ambient temperature) and cools, it actually “breathes.” That is, air is exchanged from the headspace on top of the oil into the atmosphere. When water is sitting on top of the bungs during the “inhaling” process, it is pulled into the oil by suction. This can occur in drums that have never been opened. Once the water is in the oil, it begins to settle to the bottom of the drum and raises the fluid level in the drum. As this process continues, more and more water is accumulated at the bottom of the barrel, deforming the barrel and pushing oil out of the bungs. At the time of our inspection, the protective cover was out of stock and therefore, the score was only at an “acceptable” level.

4.3.2 Low cost, more time

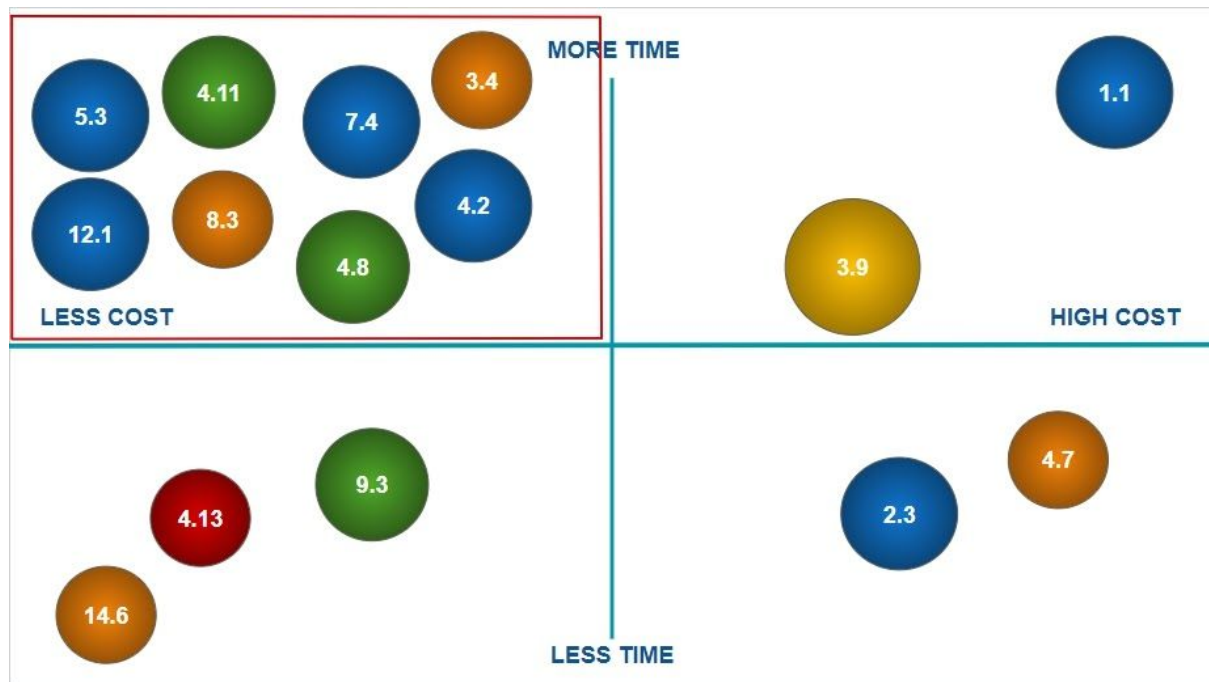


Table 6: Bubble graph projection of criteria that uses low cost and takes more time to improve

The criteria which fall within this quadrant are inexpensive to correct but take longer. There are eight criteria that fit this category: 3.4, 4.2, 4.8, 4.11, 5.3, 7.4, 8.3 and 12.1 These criteria can be improved at an inexpensive cost. However, underlying problems are lack of good maintenance culture of employees due to lack of on the job training.

Criterion 3.4: Walkways/ safety/storage area marked and kept free of obstacles

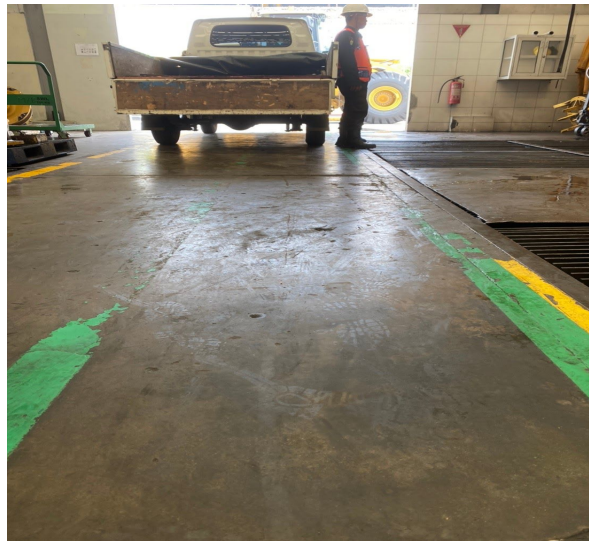


Figure 15: Walk path in the machine bay

Safety and good housekeeping practice is important for industrial warehouses where heavy equipment operates alongside the workers. Designated areas for heavy equipment must be provided in an easy to spot location to avoid hazards. The figure shows that the green marking of the safe walk path in the warehouse has scraped off and is also blocked by a truck. The machine bay at this factory is too crowded and the workers had no choice but to park the truck on the walk path risking a hazardous incident. This behavior put the score of criteria 3.4 at an “acceptable” level.

For the next 4 criteria (4.2, 4.8, 7.4 and 8.3) caps and plugs of tubing, hoses and containers are missing or are in bad condition, or are the wrong size or shape causing contamination to occur.

(Criterion 4.2: Use of proper hose / tube end protection, Criterion 4.8: Assembly aids container (lubricant or grease) cleanliness managed, Criterion 7.4: Ports in assembled cylinders protected with appropriate caps / plugs, Criterion 8.3: Hoses, fittings and covers capped, covered or properly protected)



Figure 16: This is the figure of aid containers containing lubricant and grease.

During our observation, there were tubes, hoses, and machinery parts that did not have proper coverage at openings and holes risking dust contamination. According to the information provided by internal auditors, hoses and machine openings must be covered with perfectly fitting plugs and covers to prevent dust and contaminants from getting inside the machines. According to the Caterpillar's Contamination Control policy, oil and grease containers should be covered with rubber plugs upon storage. As it could be seen in the picture, the opening holes were bare with no plug or cover.

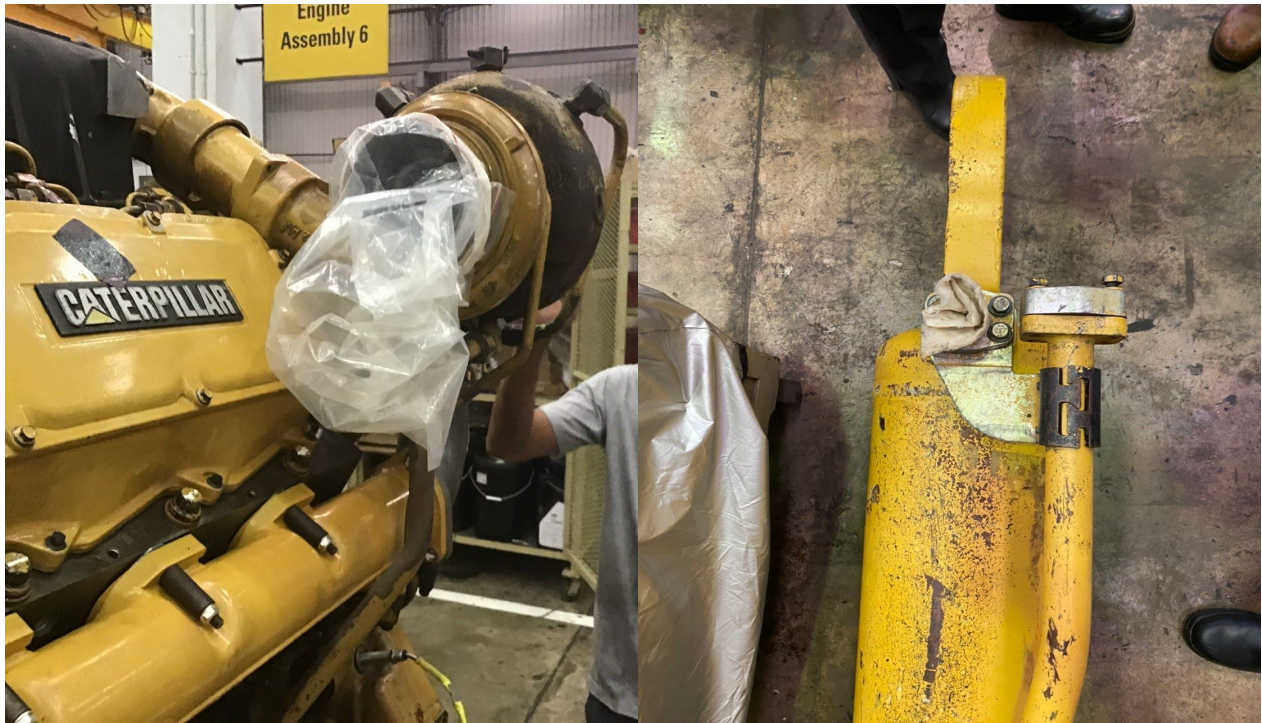


Figure 17 and 18: Improperly covered machines

The machines in these figures were waiting to be serviced at PT Trakindo Utama. Both machines were not covered properly according to Caterpillar guidelines and risked further damage during storage.

Criterion 4.11: Timeliness of cleaning up lubricant, fuel and coolant spills)

Wet floors were observed throughout the machine bay during our observation. Wet floors reduce the safety level of the warehouse. Wet floors were observed at non-washing points too.

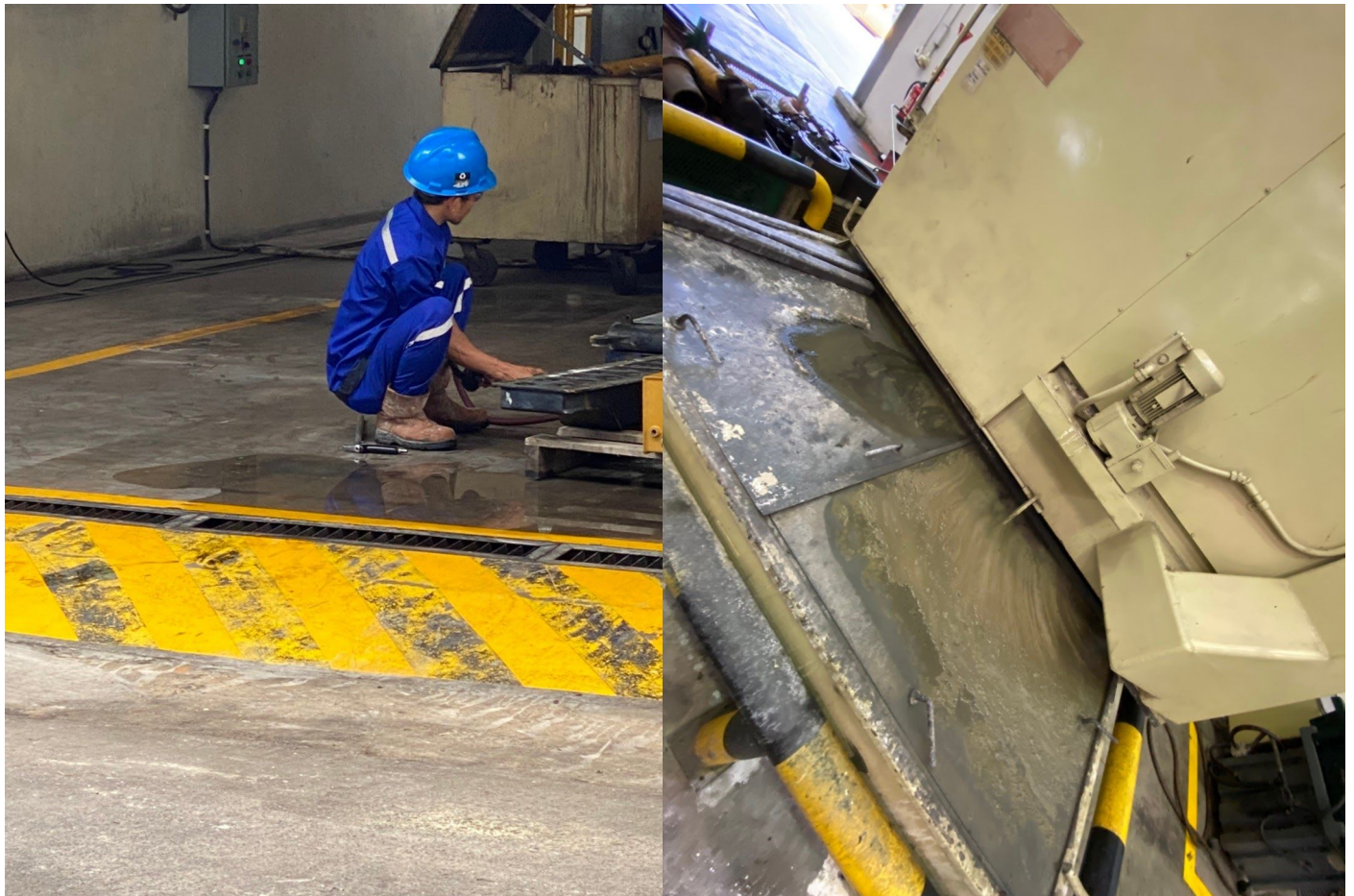


Figure 19 (Left): Employee worked on wet floor without any attempt to clean it up

Figure 20 (Right): Fluid leaking from the machine.

Criterion 12.1: Bulk hose storage

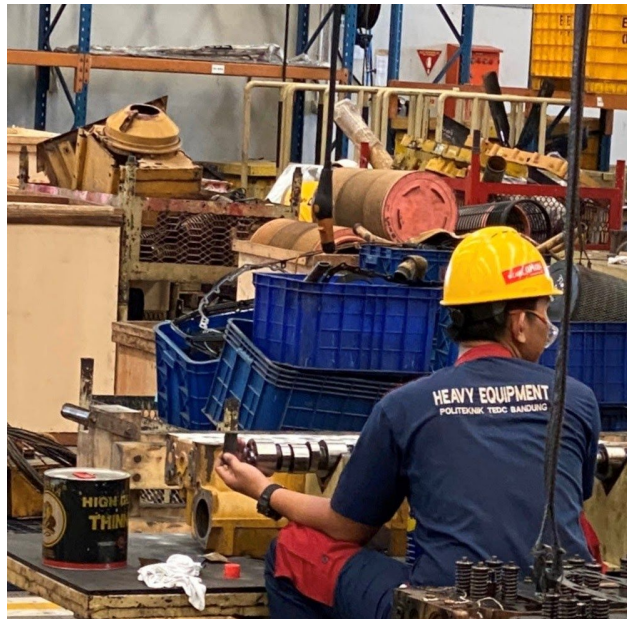


Figure 21: Bulk hose storage

Caterpillar recommends that the hose storage unit be well organized and ready for use. The equipment, tooling and storage shelves should be cleaned on a regular basis. However, it was found that the bulk hose storage area was not organized and had some buildup contaminants in corners and around the shelves, which made this criteria receive a score at the “not recommended” level.

Criterion 5.3: Gaskets were removed in the disassembly area

Disassembling of machinery parts should be performed in a dry designated area; lubricants are permitted for the removal of gaskets. Figure 26 shows the spraying process to visualize hairline fractures of the machinery before the corresponding gaskets are removed before repair. The employees performed this process in an undesignated area due to the crowded condition of the factory.



Figure 22: Machine was painted in the white-red color to detect hairline fractures

4.3.3 High cost, less time

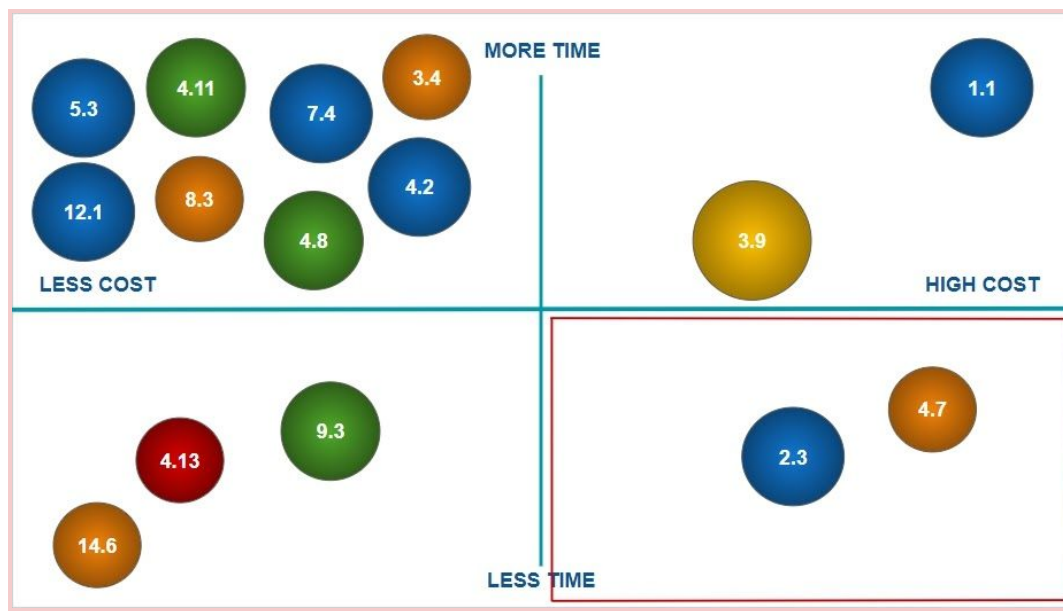


Table 7: Bubble graph projection of criteria that uses high cost and takes less time to improve

The criteria falling in this quadrant (2.3 and 4.7.) can be fixed quickly but require a high budget.

Criterion 2.3: Hot water and soap / degreaser used with pressure

The figure on the left showed a washing station of heavy machinery such as: articulated trucks, telehandlers, track loaders, etc. The cleaning process takes 4-6 hours. Figure on the right is a close up shot of a semi-auto spraying pump. It is manually controlled which means the workers must stop the pump and soap the machine by hand before hosing the entire machine clean afterward. The whole cleaning process takes a long time.



Figure 23 (left): Current manual washing station



Figure 24 (right) : Semi automatic heavy duty washing machine

Criterion 4.7: Methods of transporting, storing and disposing of waste fluids.



Figure 25: Poor conditioned trolley for transport of lubricants and fluids

Safe working conditions are very important for any factory. All equipment must be in good condition to reduce hazards and mistakes. We noticed the workers used very old and unstable trolleys to transport fluid in the factory. This can cause spills or contamination of fluid samples during transportation on the trolley. Poor condition of this trolley reduces the audit score to “acceptable”.

4.3.4 High cost, more time

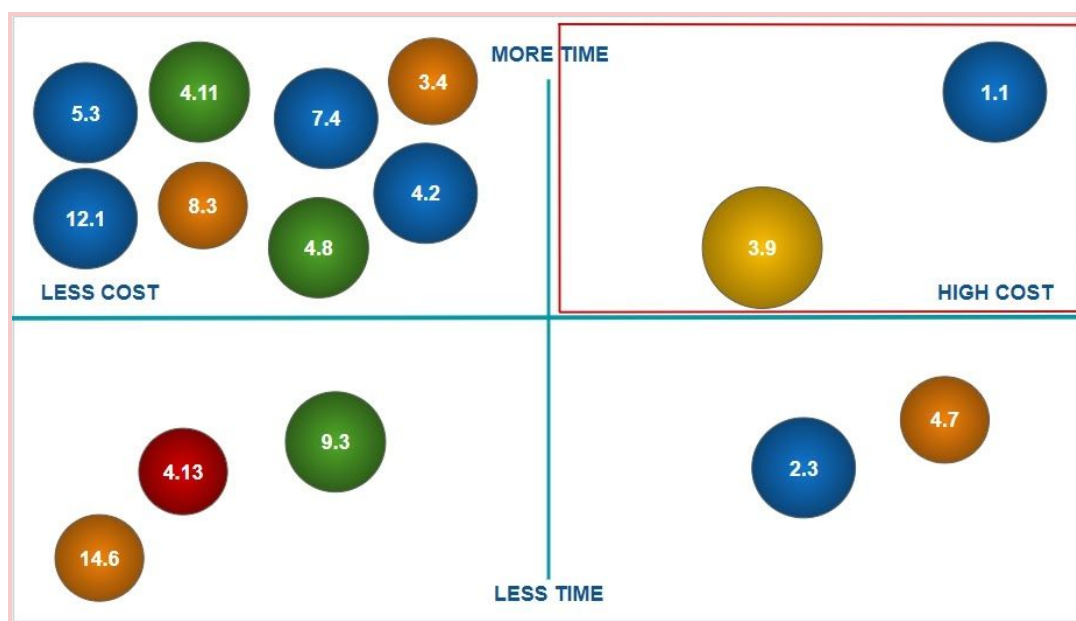


Table 8: Bubble graph projection of criteria that uses high cost and takes more time to improve

The criteria in this quadrant takes a longer time to solve at a high cost. There are two criteria in this quadrant which are criteria 1.1 and 3.9.

Criterion 1.1: Contamination control training program in place



Figure 26:Trakindo training program

For each technician to become an employee at a Caterpillar distributor, they have to pass a training program. At Trakindo, there is a training center to which the warehouse technicians must go to learn about the contamination control program and carry out workshops before they can apply for their actual position. However, there was one employee from the warehouse that we interviewed who said that she had never gone to the training center but had only been briefly trained on contamination control here at the branch. She also indicated that the lessons and workshops were very few and only took 1-2 days.

Criterion 3.9: Parts washing stands filtered to meet cleanliness targets

We observed an old rusty cleaning table in the workshop. The table is made out of steel with the color scraped off which can cause cross-contamination. From interviewing the auditor, we found out that employees tended to be careless and did not follow appropriate practice to first wash the dirty equipment in the first tub. The employees often skipped the pre-wash and proceeded directly to the real wash causing contamination in machinery parts. This behavior caused the audit score to be at a “not recommended” level.



Figure 27: The poor condition of the washing bench with scraped paint and rusty.

Chapter 5: Recommendations

This chapter discussed the statistical analysis of the results and recommendations to help solve the issues. This included our recommendations for each finding to create a new maintenance culture in the Company with involvement of all employees to help our sponsor achieve their goal.

Designing a new culture

1. The training program

Trakindo should set training programs at regular intervals throughout the year, e.g. every 4-6 months. This will keep the employees up to date with all criteria and provide retraining on their practices. Video instructions should be employed to increase learners engagement and maximize knowledge retention on all contamination control topics. Employees should understand the concepts of the audit process to make them keen on good housekeeping and maintenance culture.

2. Reward for an outstanding performance

The factory should consider putting a strategic awarding system that addresses: compensation, benefits, recognition, and appreciation. Performance is the easiest to address since it is directly linked to the set goal. The factory can recognize outstanding employees by special awards such as a special bonus or an annual company trip that incorporates training for new career development options.

a. Expectancy Theory

The best suitable theory for creating the new policy is the expectancy theory which focuses on the needs of the employees. The employees will be asked to provide their opinions of the reward they are entitled to. The supervisor should verbally provide positive appraisal of the subordinates with options of career development opportunities. The program promotes a highly positive working atmosphere for employees to control their career growth.

3. Management of non-compliance behavior

Ineffective performance management can dramatically reduce the level of performance in a workplace. The factory must provide an adequate performance management system with opportunities to address problems and generate effective solutions. Employees that perform well can lose motivation if they have to carry the burden of poor performing colleagues. Most employees who are not performing well would also like to improve. The factory needs clear procedures, organizational support, and willingness to manage the underperformance issues. Factory managers should be trained to quickly identify and address issues of noncompliance. The factory team should be encouraged to have a culture of ongoing feedback and discussion about performance issues in an open and supportive environment.

4. Creating a 5S poster is a continuous improvement activity. It is also known as the 5S's of Kaizen. This poster will summarize and define all of the 5Ss.

- a. The first one is Seiri (Sort); all employees are able to separate the necessary and unnecessary items in the working place. "Unnecessary"

refers to unused, unrelated items in operation; employees need to be able to identify and eliminate them immediately. If all employees are able to follow this step there will be more cabinet space and improve the working environment.

- b. The Second S is Seiton (Set in order); employees are able to arrange items in the workplace with regulations for ease and convenience of picking the item such as identifying a safe walking way with clear lines and identifying temporary storage areas and items should be tagged and placed in their correct category. The advantage of this step is reducing the time to find the item and also reduce accidents.
- c. The third S is Seiso (Shine); employees are able to clean the working place and get rid of dust on the floors, various tools, shelves, and etc. The Pro of this S is creating a good working environment, extending the life of equipment.
- d. The fourth S is Seiketsu (Standardize); This is the way to set the standard and ensure that the first 3 Ss are maintained and improved continuously.
- e. Last but not least, the fifth S is Shitsuke (Sustain): This means that employees need to comply with the regulations of the department and keep on track so it becomes habitual.

Recommendation for criterion 3.9: Unsafe walk path

As our team went to observe the warehouse, the green tapes which marked the walk path were badly scraped and peeling off. Our recommendation is to replace PET laminate with aluminium tape. From the team observation, we found out that currently the material that company used is PET laminate with PVC which has a lower heat resistance and is more easily scraped off. Thus, from our research we would like to recommend PET laminate with aluminium which has the ability to resist a higher temperature and is harder to scrape off which would prolong the lifetime. Considering the weather and environment of Jakarta, we recommend that using PET laminate with aluminium for the walk way is suitable for the warehouse.

Recommendation for criterion 14.6: Lack of covers on the oil barrels

Some of the barrels were covered with corrugated plastic which are made of PP, polypropylene. PP is widely known as a porous plastic which stretches at room temperature and high temperatures resulting in pores and enlarged sizes (Figure 10). Some of the barrels were covered with PVC, Poly-vinyl-Chloride, which is also known as elastomers porous materials. Moreover, rubber contains a higher percentage of porosity than polypropylene. However, the porous size of both will not enlarge until the temperature increases.

Our recommendation would be to buy new corrugated plastic if the barrels are stored outside in the open areas. According to the durability of each material, polypropylene has a higher ability to deal with higher temperatures than PVC, Poly-Vinyl-Chloride. The second option is to order more 1U-6156 covers which are the tight-fitting covers. 1U-6156 is made

of PVC. It can help prevent dirt, water, airborne particles and other contaminants from entering oil barrels. It is also wise to store the barrels inside the warehouse (CAT Hydraulic System, 2014).

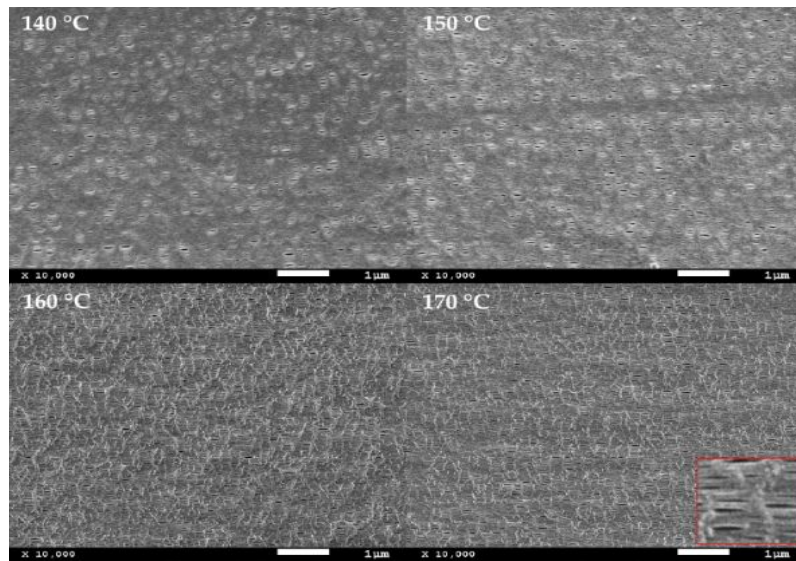


Figure 28 : Polypropylene pores have been enlarged by the increase in the temperature.

Sample	Annealing (°C)	F_c	X_m (%)	Pore Density (Pores/ μm^2)	Pores Area (%)	Average Pore Size (μm)	Porosity (%)	Gurley Permeability ($\mu\text{m}/(\text{Pa}\cdot\text{s})$)
H-5R	140	0.60	52.0	1.5	0.9	0.062	0.41	0.003
	150	0.66	57.3	10.4	3.3	0.059	0.46	0.003
	160	0.73	59.9	13.7	5.1	0.065	0.45	0.003
	170	0.73	53.7	13.8	4.5	0.058	0.49	0.004
H-10R	140	0.67	53.9	6.9	2.4	0.062	0.45	0.004
	150	0.68	58.2	11.2	3.1	0.066	0.55	0.008
	160	0.74	59.5	14.2	5.8	0.070	0.85	0.048
	170	0.76	56.1	13.9	5.1	0.069	0.75	0.039
H-20R	140	0.72	46.3	7.7	2.6	0.063	0.45	0.003
	150	0.75	55.6	6.0	2.2	0.066	0.55	0.006
	160	0.76	59.6	7.8	3.2	0.069	0.59	0.019
	170	0.77	51.3	7.6	2.7	0.063	0.56	0.013

Table 9 : This shows the percent of pore areas due to the increasing temperature of polypropylene

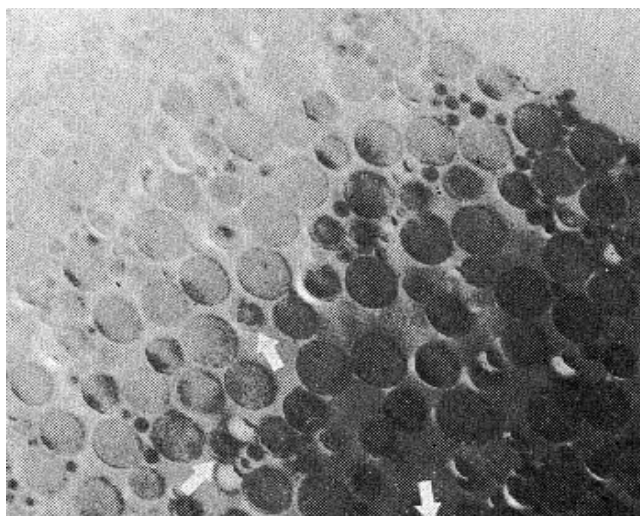


Figure 29: These are the pores on the PVC surface when zoomed on.

Recommendation for criterion 5.3: Cracked garbage bin

In the Company, the garbage bins are made out of HDPE, High Density Polyethylene. It comes with a higher tensile strength and density ratio than other plastic substances. The ratio of the HDPE is around 930-970 kg/m³. HDPE has a melting point of around 210-270 degrees Celsius (Table 5). However, it is likely that HDPE is very sensitive to some solvents such as Hydrocarbon with aromatic rings, Halogenated, and Ketones.

MATERIAL	MELT TEMPERATURE RANGE (°C)	MOULD TEMPERATURE RANGE (°C)
ABS	190-270	40-80
ABS/PC ALLOY	245-265	40-80
ACETAL	180-210	50-120
ACRYLIC	220-250	50-80
CAB	170-240	40-50
HDPE	210-270	20-60

Table 10: This table shows the ability of absorbing the temperature of HDPE and ABS which are known as the best plastic for producing garbage bins.

Normally, garbage bins are made of HDPE, High Density Polyethylene, which has high tensile strength and density ration. The ratio of the HDPE is around 930-970 kg/m³. It has a melting point of 210-270 celsius(table 5) and is resistant to many solvents. It is also opaque, which is perfect for storing items that are sensitive to light. However, HDPE is very sensitive to some solvents such as Hydrocarbon with aromatic, halogenated and also ketones. This material is the most suitable for making garbage bins in the current plastic market.

Our recommendation to fix this issue would be ordering garbage bins for storage in case the old ones become scraped. It would be better to have some in the stock which should always be checked.

Recommendation for criterion 4.2: Rusted Table In the Workshop

There was a rusted table in the washing part area. Upon closer inspection, we learned it was made of steel which is the material that is susceptible to runs. According to our research, there are two materials that are suitable for this kind of work :

The first one is stainless steel of which there are many types but we would recommend only type 304 and type 316. Stainless steel has a tensile strength of 505 MPa and the density of 8 g cm⁻³ which is stronger than aluminium. Type 304 is the most common type of stainless steel which consists of 18% chromium and 8% nickel. Chromium is what makes stainless steel corrosion resistant, in the phase of chromium oxide. If the surface has been scraped, then stainless steel would rust. What makes type 316 different is it contains molybdenum to help resist corrosion to chlorides such as ice and salt. However, the price is higher, if compared to type 304.

The second one is Aluminium of which we will look only at type 5052 and type 6061. Aluminium has tensile strength of 276 MPa and density of 2.81 g cm⁻³. Therefore, it is lighter than stainless steel. However, the advantage is that aluminium does not rust. Both of them are composed of magnesium and silicon which is the main component but the difference between 5052 and 6061 is that 6061 contains a higher level of silicon. Rust is caused by iron oxide and as Aluminium does not contain iron in its composition, it does not rust. However, aluminium does oxidize (Figure 30).



Figure 30 : An aluminium part that has oxidized

Our recommendation would be either buy a stainless steel table which costs more than aluminium but has a higher ability to carry more weight. However, stainless steel can rust if its surface has been scraped off. Aluminium is also a good choice because it costs less and cannot rust. However, it cannot carry as much weight as stainless steel. Moreover, to make employees improve their practices in this case, knowledge about the process of washing or instructions should be provided in the training center and indicate that they should be more aware and act carefully to avoid negative consequences. Having some infographics or instructions for the washing process at the station could be helpful.

Recommendation for criterion 4.13: Fluid on the floor

We recommend that once there is a spill or any fluid on the floor, it should be cleaned immediately. Fluid spills have two main effects. The first main effect is that it can cause contamination to the machines and equipment. The second main effect is that it can cause danger, as wet floors are slippery. This recommendation could be supported by providing knowledge in the training center that spills should be cleaned up immediately and raise awareness.

Recommendation for criterion 3.4: Only an automatic machine is acceptable

From the warehouse observation, it has been said that the hot water and soap machine they own there is a manual one. In order to increase the score of this criteria, the hot water and soap machine should be a semi-automatic or automatic one. By using an automatic machine, it will improve the efficiency of the work because it will be finished quicker. We recommend the branch to purchase a new automatic machine because it will be a long-term benefit, improve the efficiency and increase their score. Also, there is an annual budget for purchasing this. The price for a new automatic machine is around IDR150.000.000 or \$11.000, which we think will not be over the budget.



Figure 31: Heavy automatic washing machine

Recommendation for criteria 4.7, 4.11, 8.3, 9.3: Using improper cover caps and plugs with the hoses and machines

Dust prevention system is one of the most important processes in contamination control. From this finding, our team found out that using improper cover caps can lead to dust problems through the holes in the machines which will lead to contamination. We were advised that the shortage of caps and plugs is because they are out of stock, so they chose to use any kind of cap they find to cover the openings or do not use caps at all.

Our recommendation is to order the caps from the CAT to keep in reserve and employees should regularly check that the stock is adequate and inform the head of the department immediately when they run out of stock. This could also be supported by receiving knowledge and awareness from the training center. The overview of the criteria

should be provided in the training center, which we believe could increase the level of discipline in employees.

We also recommend creating an infographic of which cap belongs to which tools with separate colors. From our research, there are 7 types of oil safe fluid systems which are pump, cat, stretch hose extension, utility lid, stretch spouts libs, stumpy hose extension and stumpy stoup lids. Each type has a different physical appearance, color and function.

Recommendation for criterion 4.7: Methods of transporting, storing and disposing of waste fluids

From this finding, the proper methods of transporting, storing and disposing of waste fluids should be by a vacuum pump system or vacuum vessel. It should be connected directly to the machine or component reservoir and connected directly to a drain cart.



Figure 32: Vacuum pump system or vacuum vessel

However, our team found out that the branch still transports waste fluid using old wheel-drained carts which is acceptable but they are old with rust and several dents in the

surface of the metal. This leads to spilling of fluids during transportation but is unavoidable even though fluids transferred to the reservoir should not be spilled. Therefore, our recommendation is to use the vacuum pump system if the company has it or purchase it, if there is not one.

We also recommend spray-on wax and oil coating which can help prevent rust. In this case using oil based sprays is an easier and less expensive way to prevent rust. Oil based spray displaces moisture and can be applied to a wet surface. Combined with thick gel oil under the carts, potholes, wheels and rocker panels it will provide the best protection. Rust-proof oil also protects electrical components, brakes and fuel pipes from corrosion.

Moreover, the branches can use the proper type of self-healing coating according to the properties of the cart's components by finding the most appropriate material to deal with rust that appears on the metal surface.



Figure 33 and 34 : Example of spray-on wax and oil for preventing rust

Recommendation for criterion 8.3: Gaskets removed in disassembly area

Improperly removing gaskets can reduce the lifetime of the machine significantly. This leads to an increase in cost for the Company and several problems in the future such as loss of funds and accidents that could happen in the work site due to malformation of the machines. Therefore, our team's recommendation is to raise employees' awareness and give more knowledge to the employees. Moreover discipline, environment, and culture of the work place is also important to raise the quality of the employees' work.

From our research, this problem can be fixed by designing a new culture by using a theory such as expectation theory and creating the reward system for outstanding employees to achieve. This will make employees have more motivation to perform correctly not only in the workshop but also in the entire company.

Recommendation for criterion 12.1: Unorganized bulk hose storage

The recommendation for this finding is to send employees to the training center. As we analyzed the categories from chapter 4 data collection and analysis we found out that this finding was related directly to contamination control and training. Thus, the best way to ensure that the equipment was well organized was to start from the people.

Conclusion

The Interactive and Science Social Project gave the JKT2 team an opportunity to collaborate with PT Trakindo Utama, in order to create ideas to improve maintenance culture through housekeeping programs for the machines. According to the methodology, the team has observed the production line and interviewed related people to gather important factors and determine the requirement for gaining 5 stars on the contamination control to decide a suitable plan for taking care of the machines and to improve the maintenance culture of the Company.

This plan will be adapted to the current working techniques of the Company. However, this project will involve time, funds, and a combination of the effort and intention of many people that are involved with the project. Lastly, our group JKT2 team, wishes that over the course of the project, the team would be able to introduce the concept of a plan to help improve the star rankings of the Company in the maintenance culture.

Appendix A

Questions for interviewing the employees:

1. Introduce ourselves / Also employees
 - a. Name
 - b. Age
 - c. Education / (Major)
 - d. How long have you been working here
 - e. Have you ever been in a training program before
 - i. If yes then how did you feel about it (Scale 1-5) 1- Greatly Dislike, 5- Supremely like
 1. Why ?
 - ii. What is your main role when it comes to training?
 1. Diff. in position
 - iii. How often do you get trained while being an employee
 1. Monthly or Annually ?
 2. How long does it take ?
 - iv. Any qualifications for training that make progress
 1. How much score is needed to pass the training program
 - v. Any Reward / Incentives
 1. Salary ? Bonus?
 2. Promotion
 - vi. Do you think that the training program is able to be improved?
 1. Any suggestions ?
 - f. Once an audit comes, which problems are frequently faced/ detected?
 - i. Before the audit
 - g. Do all employees need training?
 - h. Do you really know the goal of training?
 - i. If the answer is No
 - i) So, what was required for you to become an employee?
 - ii) Isn't it a main qualification?
2. What will make you excited to join the training?

Questions for Internal Auditor in Trakindo BSD

1. Do you know about the five star qualifications?
 - a. If not we will explain about the stars. What is the meaning of stars, how to achieve it, why is it important?
2. Which parts of the qualifications does Trakindo still lack? *
 - a. Show them the criteria and ask specifically in the part which we focus on (Training)
3. Why are the places that need improvement still unimproved? *
 - a. If you really know what the problem is, why isn't that part fixed ? What is the obstacle?
4. Before the auditing how are employees prepared or trained?
 - a. How long does it takes to get ready
5. Why internal audit is necessary
 - a. Does it really improve the score when it comes to the next audit ?
6. Have companies ever been audited by external companies?
 - a. What is the criteria
 - i. ISO
 - ii. Customer Standard
7. What resources will the training require?
8. *What will the training cost? Does it have a major effect on the company's cost?*
9. What is the real goal for the training program
10. *Are you satisfied with the auditing results?*
11. Does the Caterpillar Auditor come follow up with the results?
 - a. If yes how often
 - b. How do they follow up the results
12. What will be the impact on your customers ?
 - a. If the training program is satisfied
 - i. What is the measurement
 - ii. Any feedback?

Finding No.	Criteria.Name
1	3.9. Part washing stands filtered to meet cleanliness targets.
2	14.6. Lubricant barrel storage.
3	5.3. Gaskets were removed in the disassembly area.
4	4.2. Use of proper hose / tube end protection.
5	2.2. Hot Water and soap / degreaser used with pressure
6	4.13. Purposed waste containers clean and organized.
7	3.4. Walkways / safety / storage areas marked and kept free of obstacles
8	1.1. Contamination control training program in place
9	4.7. Approved methods of transporting, storing and disposing of waste fluids.
9	4.11. Timeliness of cleaning up lubricant, fuel and coolant spills.
9	8.3. Hoses, fittings and covers capped, covered or properly protected.
9	9.3. Proper breather on lubricant and fuel storage tanks.
10	4.8. Assembly aids container (lubricant or grease) cleanliness managed.
11	8.3. Hoses, fittings and covers capped, covered or properly protected.
12	12.1. Bulk hose storage.

Appendix B

Employee interview answers

Interviewee 1: Has been working in Trakindo for 14 years as a technician and graduated as a maintenance major. He has been to the training program before and said that it is a basis of the Caterpillar company. Lessons taught in the training program consist of contamination control, learning about components and how to analyze problems. From 1-5, he rated a full score of 5 and stated that he very much enjoys the training program. The main role of the training program is practicing and learning theories. An employee receives training once a year for 1 week period. To pass the training program, each employee needs to pass the post test. No rewards are required. If an employee disobeys the rules, they will receive a warning letter. This interviewee thinks that the training center is good enough and does not need any improvements. The storage area is the place where they face many problems when being audited. In this interviewee's opinion, every employee needs training but it depends on their supervisor and thinks that the goal of training is to pass the post test. Thinking about improving himself is what excites him about taking part in the training.

Interviewee 2: Has been working in Trakindo for 18 years and is a supervisor of the technicians. He graduated in industrial engineering. He has been to the training program before and rates the training program at 5 which is the full score. The main roles while training are development, how to manage a business, making sure the activities are ready, checking the quality, action and engines. An employee gets trained once a year, for a 1 week period. As he had said, no score is needed to pass the training program. For this interviewee, he does not want any rewards because he gets self satisfaction. For the punishment, if a person disobeys the rules, they should get more warnings and meet with the manager. In his opinion, everyone needs training and the goal of training is for employees to know how to manage themselves. Not going to work, meeting friends from other branches and sharing thoughts is what excites him about going to the training center.

Interviewee 3: Has been working in Trakindo for 7 years as a technician in the machine bay and worked at HINO company before. He graduated from Polytechnic PNG, which is a college program of Trakindo in Jakarta. He has never attended the training program before because he attended the Polytechnic PNG instead. In the Polytechnic, the main things learned in the program were basic mechanics, fundamental engineering, how to analyze problems and contamination control. This program takes 3 years. Some rewards that he gained before are holidays or holiday time. If a person disobeys the rules, they will get a warning letter. He thinks that the goal of training is to improve each person's skills and career path. Gaining more knowledge and skills, participating in workshops, learning about new

products or values and making more friends is what excites him about joining the training center.

Interviewee 4: Has been working in Trakindo for 9 years as a part time technician. He calls himself part time because he also works at home. He graduated in industrial engineering. He has taken part in the training program yearly and very much enjoys the training program because of the facilities and modules. The main activities carried out in the training program are practical work in the workshop and the lab. An employee has to attend the training program once a year, for a period of 1 or 2 weeks. He thinks the training center is the best already and thinks that the goal of training is to study to improve skills. He also thinks that all employees need training. The good meals and getting proper rest from work is what makes him excited to join the training center. If it is possible, he would like to go for training more than go to work.

Interviewee 5: Has been working in Trakindo for 8 years as a technician and graduated in electrical engineering. He has been in the training program before and very much enjoys the training center. The main activities in the training program are studying and practical work in the workshops. He said that each employee has to attend the training program two times per year and each time it takes 2 weeks. He has suggested that the timing of the training program should be extended because there are many things to learn in the training program and he thinks that there is not enough time. He thinks that all employees should attend the training program and thinks that the goal of the training program is for improving each person's skills. Getting time to rest from working is what excites him about going to the training program.

Interviewee 6: Has been working in Trakindo for 24 years in the tool calibration position and graduated in electrical techniques. He attended a training program which is different from the normal training center because of his position of tool calibration. He likes the training program because he thinks that the lessons learned can be applied to his job of supporting the mechanics and he was also taught about First Aid. The main role in the training program is practical work is provided in the workshops. Each employee is trained once a year for 2 weeks depending on the program. In order to pass the program, the employee needs to score 90% in the exam. He said that if an employee disobeys the rules, the punishment is a warning letter. He thinks that the goal of training is for him to learn about additional calibration tools, by getting to know about more tools once he passes each level of training. Getting to improve his skills, learning more about tools and improving himself is what excites him about the training program.

Interviewee 7: Has been working as a technician at Trakindo for 12 years. He has attended the training program before and very much enjoys it because basic information is

taught and can be used to support his work. He graduated in mechanical engineering. The main role carried out in the training program is to keep the work environment clean and everything clean. The training program provides a formal training for the first day of training. The training is 1 week long and takes 8 hours per day. In order to pass the program, they have to pass a multiple choice exam. Rewards gained from the training program is a certificate and the advantage from being more notable at work. He said that he does not want an individual reward but wants a team reward instead because he works as a team and everyone should be recognized. He suggested that the training program should provide animation videos when teaching because usually there are only pictures and writing. He thinks that every employee should be trained and the goal of training is to improve their performances and be more efficient at work. The environment at the training center makes him want to go training.

Interviewee 8: Has been working as a technician at Trakindo for 12 years. He has attended a brief training program at this branch before. The difference between training at this branch and training at the center is that there are more workshops at the center and there are more things taught there. He very much enjoys the training because he thinks that it is important for his work of inspecting the machines. In the training, the main role is implementation in the workshop. For training at the branch, it is required once a year and takes 1-2 days. In order to pass the training, a multiple choice exam is given. For training at this branch, he suggested that the training time is too short and should be extended. He thinks that the goal of training is to prevent contamination to engines. Gaining more knowledge, knowing how to deal with problems and knowing how to do everything correctly is what excites him about the training.

Interviewee 9: Has been working at Trakindo as a technician for 13 years. He graduated from a machinery program at senior high school that cooperates with Trakindo (STM Singosari). He has attended the training program before, especially the contamination control one. He said that the program was boring because there was no challenge for him as he was not interested in cleaning but interested in machines instead. He said that from school, only the basics of machines and materials were taught, but in contamination control training, it is more in depth and subtle. He thinks that every employee should receive training and thinks the goal of training is to keep everything clean which will make working easier. The food and snacks are what excite him about the training.

Interviewee 10: Has been working as a storage area employee for about 8 or 10 years; she cannot remember exactly. She has graduated in electronic engineering and has never attended the training program. She said that the training program is not necessary as it could be learned from a book. She thinks that the goal of getting trained is to know how to maintain the efficiency of machines. She does not want any rewards other than customer's satisfaction and no complaints.

Internal auditor interview answers

1. Madinah Ramat

The five star qualifications are the standards for contamination control. It is needed to increase the image of the Caterpillar industry to customers and competitors. There is no direct influence on the customers if the number of stars decreases or increases and it does not have a major effect on the Company's value. It is rather like a long term plan for the Company. The minimum stars to achieve is 3 and the highest is 5.

Internal audit is necessary because it is a standard regulation from Caterpillar. It is conducted twice per month, as the first audit and second audit. The Company's internal auditor will submit the star ranking to Caterpillar. Mostly, the auditor does not inform the employees in advance that they will conduct the audit.

There is an external audit from Caterpillar every year by choosing at random from the 60 branches. For this auditing, they give 2 weeks advance notice about which day they will conduct the audit.

Both Contamination Control training and auditor training is free.

At the training center, the whole program duration for an employee is 1 year and the training provided includes Service Development, Service Management, Material RSD and Contamination Control. Caterpillars always send an update. At the training center, presentation slides are used to teach each of the topics.

Madinah is not satisfied with the audit results yet and he believes that his team could progress up to 5 stars. He said that housekeeping is the main reason for not gaining 5 stars.

These aspects could be improved for gaining 5 stars:

- 1) Inconsistency
- 2) Housekeeping
- 3) Employees don't want to keep the workplace clean
- 4) Responsibility of all employees

The improvement can be carried out quickly or slowly depending on the workload of the technicians.

Madinah explained that training is a method for behavior change and is a discipline matrix of waste management.

For the punishment, if someone does something wrong or disobeys the rules, the inspector will share his findings at the safety talk activity that all employees attend.

Rewards are given only after passing the training. The employees with the top 3 scores in the post test will receive a souvenir from the company.

Madinah suggested that for the training program, using just pictures and words are not enough. There should be a video for the contamination control training and televisions provided for workshops. He also said that the training center is mandatory for technicians only but not for staff in the laboratory. In order to become an employee, they would have to pass the program of technician skills and contamination control.

Contamination Control implementation is divided into 2 sections of the Company; the workshop and the warehouse. This time, we focused on the technicians in the warehouse. The benefit of contamination control is it extends the life of the machines which is beneficial to customers. He also added that contamination control training should include the service men helpers, not only the workers.

Oil barrels are one of the sections that should be improved. It is a problem because of consistency from no order and lack of compliance.

If everything is correct, the score will be “Good”. If only 1 aspect is determined, the score will automatically be “Acceptable”.

For punishment policies, the human capital is the one responsible for this. Recently, if an employee disobeys the laws, they will get a formal warning. The safety committee will vote if that person shall get a warning letter or not once discussed at the meeting.

2. Tri Mulyanto

The five star qualifications is a measurement to show what is needed to be improved as a mission. The finest score to achieve which is 5 stars is to get more than 95% and to get all the threshold questions answered “Yes”. The main problem due to contamination control is “discipline”, which makes the company fail in the housekeeping section. The contamination control audit is conducted twice a month; the first audit is 1-10 and the final audit is 11-20. The importance is not about gaining the stars but of the implementation.

Tri said that if the Company gains 5 stars, it will impact the profit of the Company in the long term because of the Company’s image and competition with other companies.

Contamination Control is one of the added values. It gives more value to the Company thereby encouraging the Company to put more effort into it.

Mostly, customers do not visit the warehouse before buying the products. They know of Trakindo from word of mouth from others.

What is mainly lacking from the CC qualification is training, bulk and portable fluid storage (section 14), shop practices, fluid cleanliness, consistency, awareness and lastly, housekeeping which is hard to maintain.

For the solution, they still use reminders or just a report for discipline. While conducting the audit, the reference of each section to be checked can be opened so each question is easy for implementation to the auditor.

The main obstacle is inconsistency which is hard to instill in a person.

Tri said that BSD is easier to improve because it is nearest to the main head office, which is more manageable.

The most important aspect Tri talked of is about discipline. He said that each person has different backgrounds and some of them are self contractors, or even just high school students.

Internal Audit is important because it monitors and measures implementation in the program. Besides contamination control, the company has an SHE department audit etc. Also, we have to ensure that the program is running well.

Comparing the first audit results to the final results not much difference was noticed.

Inconsistency is caused by not all people having the same perceptions.

The Caterpillar Audit or the external auditor always informs the Company before coming.

Contamination Control is one of the critical points in the surface program of customer service.

If the contamination control is not well done, it will cause problems to the SHE Department.

The work of employees has positive impacts on the company's revenue.

The maximum number of times each employee goes to the training center is 3 times per year.

Tri said that the real goal for training is that the participants must apply what they have learned to the operation. (Knowledge from training is applicable).

Tri is not satisfied with the auditing results yet because he believes that there are still places of improvement and also inconsistency which cannot be solved.

For the violation punishment, the person who disobeys the laws will receive a standard warning and their action will be shared at the safety meeting. There are 3 warning steps followed by detention.

Competition of contamination control depends on the internal branch. This gives acknowledgement for branches that perform well.

Tri said that the team had thought of holding a photo competition via contamination control whereby each person could take pictures of inappropriate actions or performance of others and send it to the head. This will help gain awareness among the employees.

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