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APPLYING THE LEAN 5S METHOD TO LABORATORIES AND PROTOTYPE WORKSHOPS

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The purpose of this study was to develop and apply a 5S method for laboratories and prototype workshops. The laboratories had no development plans or continuous improvement methods in use. The problems in the laboratories were the lack of systematic usage of tools and equipment as well as the lack of visualization and motivation. These problems led to disappearance of tools, waste of space and to common misunderstandings with the procedures in laboratories.

The work in the laboratories begun with the search for areas to improve; during the monitoring part of the process, the targets for sorting and straightening were found. The next step was to create plans for sorting the tools and straightening the work. Next, events for sorting and straightening were hold for the first time in the target laboratories. In the events, tools were sorted, labeled and located in a new way. Other improvements included floor markings and new cabinets and lockers for tools.

The results of these improvements and events were the following: significantly improved understanding of 5S among the staff, simplified distribution of tools and more visualized working environment. In other results of this implementation process, multiple findings were made regarding the implementation of the 5S for laboratories. The general implementation schedule for laboratories was developed with four questions that are essential for the implementation process in laboratories.

The key objective of this study was to start the process of implementation of a continuous improvement tool in laboratories. Another important objective was to make a path for future 5S implementations in laboratories. The two laboratories that appear in this study are on their way to the auditing level. The work will continue in these two laboratories, and new laboratories are already underway.

KEYWORDS:

5S, lean, continuous improvement, work flow, development, Kaizen, waste.

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LEAN 5S MENETELMÄN SOVELTAMINEN LABORATORIO – JA PROTOTYYPPI ALUEILLE

Tämän lopputyön tarkoitus oli kehittää ja ottaa käyttöön 5S järjestelmä laboratorioille ja prototyyppi alueille. Laboratorioilla ei ollut käytössään kehityssuunnitelmia tai jatkuvan parantamisen järjestelmää. Laboratorioiden ongelmia olivat työkalujen ja laitteiden epäjärjestelmällinen käyttö sekä visualisoinnin ja motivaation puute. Nämä ongelmat johtivat työkalujen katoamiseen, tilan hukkaamiseen ja yleisiin väärinymmärryksiin laboratorioiden käytännöissä.

Työ laboratorioissa alkoi parannuskohteiden etsinnällä. Laboratoriotyön seuraamisen ohella sorteerauksen ja systematisoinnin kohteet tulivat havaituiksi. Seuraava askel oli työkalujen sorteerauksen ja työn systematisoinnin suunnittelu. Sorteeraus- ja systematisointitapahtumat pidettiin ensikertaa kyseisissä laboratorioissa. Tapahtumissa työkalut sorteerattiin ja jäljelle jääneet merkittiin ja uudelleen sijoitettiin. Muita parannuksia laboratorioissa olivat lattioiden merkinnät sekä uudet työkalukaapit ja hyllyköt.

Tapahtumien vaikutuksina paranivat työntekijöiden ymmärrys 5S metodista, työkalujen jako ja käyttö sekä työtilojen visuaalinen ulosanti. Tapahtumien aikana tehtiin myös useita eri havaintoja koskien 5S metodin käyttöönottoa laboratorioissa. Laboratorioita varten muodostui yleinen käyttöönoton suunnitelma sekä neljä keskeistä kysymystä jotka määrittelevät käyttöönoton prosessia laboratorioissa.

Keskeinen syy tälle lopputyölle oli jatkuvan parantamisen työkalun käyttöönoton aloittaminen laboratorioissa. Toinen tärkeä tavoite oli luoda pohja tuleville 5S metodin käyttöönotoille laboratorioissa. Työ tulee jatkumaan tässä lopputyössä esiintyvissä laboratorioissa, 5S menetelmän käyttöönottoa suunnitellaan jo muissakin laboratorioissa.

ASIASANAT:

5S, lean, jatkuva parantaminen, työn virtaus, kehitys, Kaizen, hukka.

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LIST OF ABBREVIATIONS (OR) SYMBOLS

JIT	Just-in-Time, providing units just before they are needed.
TPS	Toyota Production System

1 INTRODUCTION

The implementation of 5S to the laboratories was divided into multiple parts. The first task was to scan the current situation within the laboratories. The next part was to introduce the plan to managers and employees. After the introduction, the events were hold for sorting and straightening the laboratories. Then the standards and auditing tool ware made to ensure continuous improvement and to sustain the changes that were made during the implementation process.

This study is divided into four parts. The first part provides relevant background information about the Toyota Production System which includes the philosophy of the 5S method. The second part is about applying the 5S method to laboratories in general: the important parts of the 5S method for laboratories are recognized. The third part is about the implementation of applied 5S method to two laboratories. In this part, the implementation process' that have been applied are presented and future actions suggested. The first section of third part is about the starting situation and the second part is about the implementation process and changes. Many of the situations are presented with pictures to create a clear understanding of the tasks.

In the last part, the results of the thesis are presented. The results of the 5S implementation are difficult to measure before the auditing level is reached. Thus, the results of the study include the instructions for the implementation of the 5S in laboratories and advice its future implementation in general.

This study was done for ABB which as a multinational corporation, employ 147000 people worldwide. ABB operates mainly in power and automation technology. In Finland, ABB Oy employs more than 5000 people. The turnover of ABB Oy was 2.3 billion Euros in 2013.

2 THEORY OF 5S KAIZEN

2.1 Toyota

To understand the deeper meaning of the 5S method, the origins must be revealed. The method in question is only a small part of Kaizen, which stands for the continuous improvement in the Toyota Production System. For one to understand the true meaning of the Toyota Production System, one must understand how Toyota was born and why it is one of the most successful companies in human history. Depending on the source, Toyota is on the top 15 of the biggest companies worldwide. Forbes has listed Toyota Motor on the 12th position. However, in the Toyota Group, Toyota Motor Corporation is only a piece of a bigger system. The Toyota Group so called Keiretsu in Japan, means a group of companies where none of the members of the group holds higher power. These groups often include their own banking company, insurance company, some stores and business from different industries. The Toyota Group does not have an own bank yet, it is still considered to be a Keiretsu. In total, the Toyota Group is considerably bigger than Toyota Motor, however, it is not considered to be one big corporation because all of the core companies that compose the group work as individual companies. These companies own part of each other's shares to improve communication, increase predictability of the business and secure each other from hostile acquisition attempts. (The Economist 2009, Forbes Global 2000, 2014)

The Toyota Motor Corporation as we know it today was founded in 1937 by Kiichiro Toyoda, son of Sakichi Toyoda, a well-known Japanese inventor. The story behind Toyota starts with Kiichiros father, Sakichi Toyoda, who was the son of a relatively poor carpenter; Sakichi Toyoda has been referred as a "King of Inventors" and there is no question about the impact he has had on industrial production worldwide. (The Toyota Way, 2004; 15-17)

In the earlier years of Sakichi Toyoda, Sakichi was learning carpentry from his father. Once he had embraced the skills from his father, he started to develop

wooden spinning machines. His first looms he developed in 1894, the products he made were cheaper but better working than the existing ones at that time. Sakichi was a true visionary who was always looking for better solutions, he saw the burden of spinning and weaving the manual looms so he started to look for machine that would do the work for him. In his search, he ended up to a steam engine and eventually developed a highly advanced automatic loom that was powered by steam. While developing first automatic looms he created some working techniques which became essential in the Toyota Production System (TPS). For example genchi gembutsu was born when Sakichi applied the trial and error method to his looms developing. Genchi gembutsu is all about getting your hands dirty; it is about knowing what your company produces and how is it done. Jidoka, which means that a machine will stop itself when it faces problems, was created also during the development of looms. (The Toyota Way, 2004; 16)

The Toyoda Automatic Loom Works was founded in 1926 and is still part of the Toyota Group currently producing forklifts among other things. The looms however, were a great success and became well known worldwide. In 1929, Sakichi sent his son Kiichiro Toyoda to England to negotiate with Platt Brothers the sale of the rights to the patents. Platt Brother was a producer of high end spinning and weaving equipment; They eventually paid 100 000 English pounds for the patent rights, and with the capital, Kiichiro started to build Toyota Motor Corporation. (The Toyota Way, 2004; 17) It is also important to notice that Sakichi could have just handed the loom production to Kiichiro, but he explained to Kiichiro that everyone should complete some great projects during their lifetime. Sakichi had focused on looms, now was Kiichiros turn to focus on automobiles. It was a risky move at that time but Sakichi saw that automobiles might be the industry of tomorrow. (The Toyota Way, 2004; 18)

Kiichiro Toyoda studied in the Tokyo Imperial University and despite the theoretical education he received, he implemented his father's way of getting his hands dirty and doing things himself. On a trip to Ford's plant during his studies, he realized how shelves were filled in grocery stores just before they run out of

products. This was the ground for the Just-In-Time system which he later developed for automobile production. (The Toyota Way, 2004; 18)

The early years of Toyota Automotive Company were challenging for multiple reasons that were often not in the hands of the managers of the company. World War II had an impact on every aspect of life and Kiichiro was doubtless that the victory of Americans would shut down the company. However, Americans asked Toyota to produce trucks to rebuild Japan. The production of trucks gave Toyota more time but inflation collapsed also the sales of cars; Inflation in 1948 was driving Toyota into bankruptcy. Managers were asked to cut their salary voluntarily and employees experienced a 10% loss in their salary. Kiichiro was doing everything he could to avoid firing employees however, he eventually had no other options than to ask 1600 employees to retire voluntarily. (The Toyota Way, 2004; 19)

These cuts led to strikes and demonstrations and finally Kiichiro Toyoda stepped down as the president of the company. Kiichiro took the responsibility of failing to create an automotive company. However, Kiichiro was not to blame for the difficult situation of the company, war and inflation are incidents that one person cannot control. By resigning, Kiichiro followed the Toyoda family vision, philosophy by which the company's long term interests become a priority; two years after resigning, Kiichiro passed away.

After Kiichiro, another important family member that has had an impact in Toyota has been Eiji Toyoda, son of Heikichi Toyoda, Sakichi Toyoda's brother. Eiji Toyoda also went to the Tokyo Imperial University and soon after his studies Kiichiro asked Eiji to start a research lab for Toyota. As starting a research lab, Eiji was learning a valuable lesson on how to get things done. The lab was located in a garage where Eiji made some room and later hired 10 employees. At the same time Eiji Toyoda was exploring the suppliers of Toyota. (The Toyota Way, 2004; 19)

Later in his career, Eiji Toyoda became the president of the Toyota Motor Corporation and stayed as the chairman until 1994, until Shoichiro Toyoda

became the chairman. Eiji adopted the Toyoda's philosophy; getting things done is getting your hands dirty. During his career he also had a great impact on TPS by choosing the right employees. (The Toyota Way, 2004; 20)

Today Toyota is being led by Akio Toyoda, grandson of Kiichiro Toyoda, the founder of Toyota Motor Corporation. Akio Toyoda has faced many challenging moments during his career. In 2008, the global recession stroke on the manufacturing area and in 2011, Japan experienced a tsunami and in the aftermath, a nuclear disaster and a shortage of energy. Toyota has also had several recalls due to severe flaws in their cars. However, Toyota Motor Company has outsold all other car manufacturers in volume and consequently, become the biggest car manufacturer worldwide. In 2013, Toyota sold a total of 9,98 million cars and vans. The message of Akio Toyoda today, is concerned with sustainable growth. Akio has also said that Toyota must go back to its roots and seek long term benefits. To sell more cars, Akio sees that they must create ever-better cars and strike to continuously improve. (Toyota Motor Corporation annual report of 2013)

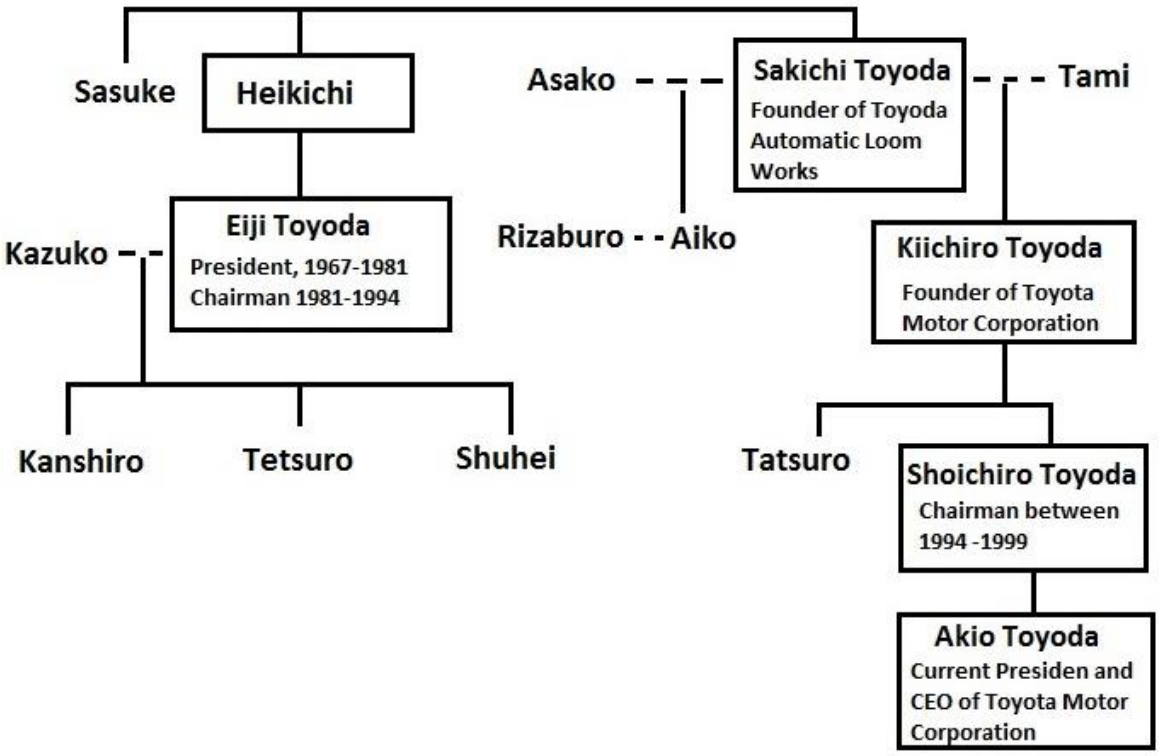


Figure 1. Toyoda family

(Monozukuri, Sakichi Toyoda; Modified)

2.1.1 Toyota Production System

The development of Toyota Production System has taken dozens of years and multiple people and it is far from finished. What was started by Sakichi Toyoda, is now being continued by the employees and suppliers today.

It is not a coincidence that countries that lost the Second World War, countries like Germany, Finland and Japan, were booming couple decades after war. Immediately after the war, the countries that had won were doing well. However, the countries that lost faced the big burden of reconstruction of a nation and reparation payments. There was little left in these countries but people worked to get everything out of what they had. During the 1970´s around the world, people started to realize that the products that came from Japan, were not poorly produced anymore. (5S Kaizen in 90 Minutes, 2008; 35-40)

During the Second World War in USA, two men dedicated to improve the material that was produced for the army. After the victory, there was no need for their detail oriented focus on production; these men were Dr. Joseph Juran and Dr. W. Edwards Deming. These two men had a great role in the boom of Japan. They received The Second Order of the Sacred Treasure from the Emperor of Japan for their tremendous influence on Japanese industry. (5S Kaizen in 90 Minutes, 2008; 35-40)

Another important person for the Toyota Production System has been Shigeo Shingo, who was not a high executive in Toyota but wrote books about manufacturing. These books revealed the Toyota Production System to the world and made Shigeo Shingo better known in western countries than in Japan.

The Toyota Production System is a complex system that has taken decades to develop. It is too wide to be deeply analyzed in this study, but the system lies on four principal thoughts, and they are the following: Just-in-Time, Jidoka, Heijunka and Kaizen. The implementation of one part or one method of the Toyota Production System does not require full understanding of the whole system. However, the philosophy is a common factor for all methods and should be

studied by everybody. The following section will cover the most central thoughts of the philosophy.

2.1.2 The Philosophy

The most common and severe mistake people make with the TPS is to think it as a physical tool that will change everything. The most important part of the system is the shop floor employee. Thus, when changes are made in a company, if the management personnel do not spend enough time on the shop floor, the changes will remain superficial. Consequently, some improvements will be seen but the real change will not be achieved without the full commitment of the management personnel.

The reason for which it is important to understand the background of the Toyota Production System is to understand the very important part of the system, the philosophy. As described earlier, the Toyoda family was never afraid to get their hands dirty and show the way. They always took responsibility for their actions, sometimes even from others´ actions. After all, whatever the employees do, the manager is always the responsible one.

It was not to increase the family fortune, when Sakichi Toyoda told Kiichiro Toyoda to start producing cars, but to create something great that would also benefit the society. The vast sense of justice and righteousness that lied and lies in the mind of all managers in Toyota is the backbone of the Toyota Production System and the most important part of every method that exists within the system.

To successfully implement the Toyota Production System, managers have to first understand the fact that they are the responsible ones. It is also important to create an atmosphere of mutual respect between the shop floor employees and the managers. In continuous improvement, it is essential to learn from each other and to be honest to each other. The wider the gap between white collar and blue collar employees is, the more difficult it will be to implement any of the systems TPS provides. After all, TPS is about doing the right thing. Whether it was about a single employee or a multinational customer, everybody should be always

involved and taken into consideration. By doing together the organizations will reach the highest possible results. TPS is not about the methods, but it is about the objective that lies far in the future. Long-term goals can be hard to maintain but will provide more benefits in long run. (Tätä on Lean, 2013; 89-93, 148-149. Toyota Global, Guiding Principles at Toyota)

2.2 5S Kaizen

Kaizen is often translated in to English as an “improvement”; in Japanese however, Kaizen is composed by two separate words, Kai and Zen. Kai can be translated as “to change continuously” and Zen as “to get better”; together these words have a meaning of “continuous improvement”. The 5S Kaizen stands for an improvement method that combines multiple methods to create a solid base for continuous improvement. (5S Kaizen in 90 Minutes, 2008; 27)

The 5S Kaizen is often misunderstood as being only a simple housekeeping method for minor changes, but the strength of the 5S lies under details and continuous work. Once all the steps are being applied precisely and the groundwork has been done with great focus on detail, the last step and the most important step that will be left to be taken, is continuing the work.

In practice, the 5S consists of five steps that all start with “s”. Starting from the beginning, the steps are Sort, Straighten or set in order, Shine, Standardize and Sustain. Each step has several focus points that can take time, from a few hours up to couple months, depending on the implementation place.

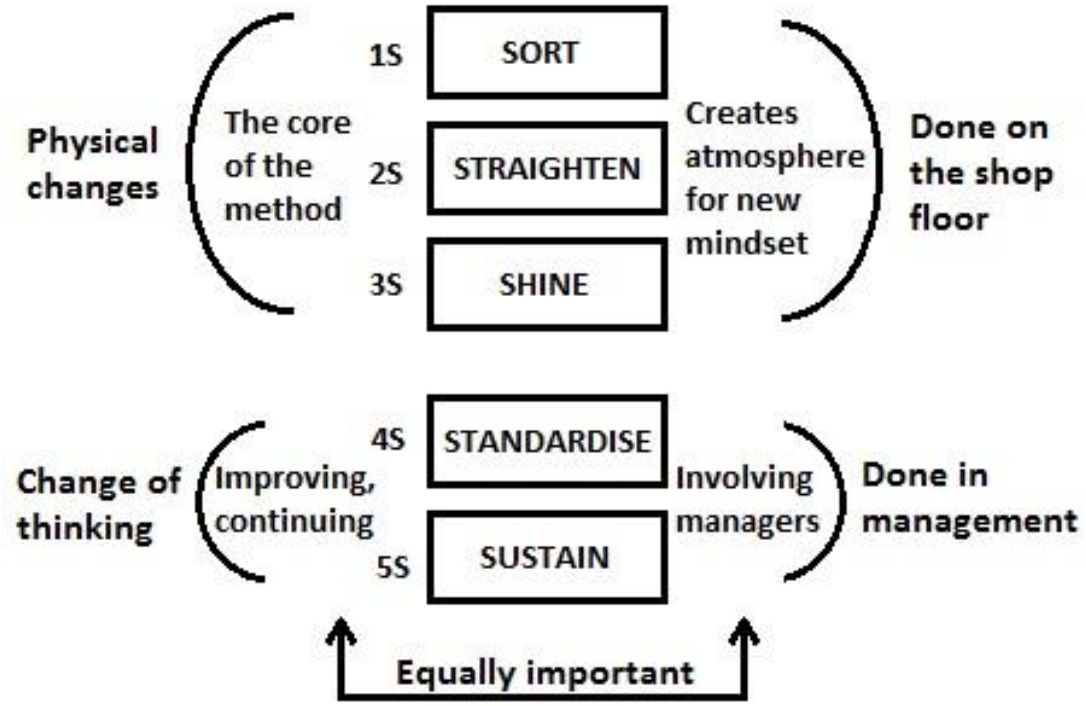


Figure 2. Five steps of 5S

(5S Kaizen in 90 Minutes, 2008; 106; Modified)

2.3 1S: Sort, Seiri

Sort, in Japanese Seiri, stands for cleaning all the waste and non-value adding items out of the workplace. The topmost idea of sort is to remove all the waste so that the real problems can be seen. By sorting the tools and arranging the rest of the workplace, the personnel is able to focus on significant problems and to improve their work and their internal processes. (5S Kaizen in 90 Minutes, 2008; 59-60)

2.3.1 Waste, Mura

Mura is a Japanese word that means the type of waste that comes with irregular workflow, which can cause a loss of time or decrease in efficiency when using the human resources on its fullest. A single task can set back an entire process when other workstations are waiting on a task to get done. An everyday situation with Mura is the coaching of a new employee. It is a public opinion that every new

employee should be offered a decent practice period or training for their jobs. However this is often overlooked in companies as a less important task. (5S Kaizen in 90 Minutes, 2008; 61)

2.3.2 Waste, Muri

Muri means overly stressful or strenuous work which will eventually lead to loss of equipment or human resources. Overly stressful work will wear machinery faster than expected creating financial loss due to the greater investments compared to the time the machinery serves. (5S Kaizen in 90 Minutes, 2008; 62) Overly stressful work has similar consequences on people. A person can take more work occasionally, but cannot continue for longer periods. Stress is a good motivator but will have a negative effect on a person when it continues for too long. For a company, it is more profitable to employ enough people than risk losing skilled personnel for the sake of overly stressful work.

2.3.3 Waste, Muda

Muda includes several types of wastes, one of the most famous assortment is Taiichi Ohno's seven wastes. These wastes are the essential part of the Toyota Production System and the modern foundation of Lean production. (5S Kaizen in 90 Minutes, 2008, 63)

2.3.3.1 Waste of over production

The over production stresses the employees and retire machines prematurely and unnecessarily. However, when a plant or a production line over produces material or products, the over production itself is not the most problematic part of the practice. The greatest waste is seen in the outcome of the over production.

In a plant where there is production lines that produce certain products to the next line and ultimately the finished product to the customer, inside or outside the company. The production rate of the plant must be levelled to the need of the customer. Whether the customer is the next production line or a consumer, over production will always lead to oversized warehouses and additional systems that

are required in between productive functions. (5S Kaizen in 90 Minutes; 2008, 63-71)

2.3.3.2 Waste of inventory

In the Toyota production system, inventory is commonly considered to be waste. It is a necessary evil that must be reduced as close to nothing without affecting the customer delivery accuracy.

In old fashioned pushing type of production plants, the inventory waste is common problem. It increases overhead costs and requires systems to manage a practice that will not even increase the customer value of produced products. The company might own multiple tools and machines, for example forklifts, only because they have too large warehouses. A lot of recourses are also tied up to these warehouses and not creating profit.

One simple way to see the non-profitable practices is to perform a value stream mapping. Executing the value stream mapping will help the managers to see the production from a customer's point of view and understand the non-profitable practices. (5S Kaizen in 90 Minutes, 2008; 63-71)

2.3.3.3 Waste due to rejects and repairs

In traditional thinking, rejects are part of the production as well as the workshops that are employed for repairing those products that are rejected. Rejects are waste for obvious reasons since the product in which material and labor work has been invested, will not create any profit. In worst situation, the investments will not be recovered and the product is thrown away.

The reason why Ohno has included repairs to waste, is the additional costs and time the repair will take. Even if the repaired product gets sold, the net profit can turn into net loss when additional time and money has been invested to repair the product. (5S Kaizen in 90 Minutes; 2008, 67)

2.3.3.4 Waste of excessive motions

In production line, excessive motions are those actions that are being made without adding any value to the product, or adding value takes unnecessary recourses. For example if on a production line, certain kind of screwdriver is needed every once in a while, the motions for seeking the tool are excessive. Once considering if the action or motion is excessive, it is important to recognize which tools or equipment are needed in the value adding procedure. Some tools are either so expensive or so large that they can not be fitted next to the working area. However, it should be considered that the time consumed in the excessive motion is also worth money. (5S Kaizen in 90 Minutes; 2008, 63-71)

2.3.3.5 Waste of over processing

In the waste of over processing, the essential issue is the failure in filling the customer needs. In the Toyota Production System, the producer is required to fill the need of the customer as promised. Anything more or less than agreed is waste. Over polishing can even be a failure to the customer if it prevents the customer to use the product where it is supposed to be used. (5S Kaizen in 90 Minutes, 2008; 63-71)

2.3.3.6 Waste of waiting

Waste of waiting is more obvious waste since waiting in a company is often on employees working hours which generates financial losses to the company. Just-In-Time system can help the company to do what is needed when needed, like the name suggests, just in time. Waiting is always unnecessary and can often be managed by changing the production rate or investing into new machines. However, solution to waiting should not be over production. In some cases, waiting can be the best solution to start with. (5S Kaizen in 90 Minutes, 2008; 63-71)

2.3.3.7 Waste of transportation

Since the earlier mentioned waste of excessive movement was about waste that employees face in their work. Waste of transportation is about work on higher level. Over production leads also to excessive transportation when the products must be stored in a warehouse and then collected again for the next process. For a shop floor employee waste of transportation is not as clear as excessive movements. (5S Kaizen in 90 Minutes, 2008; 65)

Waste of transportation leads back to waste of inventory which is mostly caused by over production and bad planning of production. Poorly managed production leads into this waste and causes the company to invest into equipment that would not be needed if the production would run on an optimal rate.

2.4 2S: Straighten, Seito

Straightening, Seito in Japanese, is about making the workplace more visual. This can be done by removing obstacles on our sight or creating more simple ways on passing the information. One powerful procedure is to enable the right way of working. This can be done by taking a picture of tools on how they should be and putting it next to the tools cabinet.

Some of the actions in straighten might not have obvious benefits. However, it is far more important to create a mindset that will give the opportunity for the employees to improve their working area and truly understand that they have an impact in the system. Once the working area is being cleared out from obstacles and straighten, the employees can see the fundamental problems that might exist in their work. One relatively easy way to start is to draw lines on the floor, this will clarify the areas on the shop floor and start the change in people's minds: Everything at the workplace has its own place.

By making work more visual, the company will save in labor hours by cutting down in searching tools, training new employees and creating ineffective and useless systems. After everything is clearly marked and all of the tools have their own spots, it becomes less attractive to just leave those tools or equipment lying

around. The human mind works so, that it is easier for it to leave a bag of objects to a landfill than to a well-organized garage.

2.4.1 Straighten in practice

The philosophy and the new mindset is in the center of straighten as well. The new mindset is however something that can not be forced, it can only be promoted. There are several changes that can be done in almost every environment. First thing to do is to label all tools and equipment and this way recognize the ones that were left after sort. If the tools are on a wall, shadows can be drawn to make it clearer, where each tool is supposed to be located. Once the tools have been sorted and the places have been fixed, next step is to take pictures and post them on top of the cabinets, this will make auditing easier and shorten the time that is used in finding the right tools. (5S Kaizen in 90 Minutes, 2008; 83)

One often used method to create clearer working area and to enable the right kind of mindset is to paint the floors. This is relatively cheap and quick to do and will clarify the environment and make space to where it is needed. It is recommended to start with tape, when the areas have settled they can be painted. Like mentioned earlier, painting or taping the floor will create the mindset for keeping places organized and clean, but it is also an important tool for safety. The evacuation time will be reduced by marking the free zones on the floor and this way ensure a safe exit. (5S Kaizen in 90 Minutes, 2008; 85)

2.5 3S: Shine, Seiso

Cleaning is often understood as a necessary task to keep places in a decent condition. Still, cleaning goes deeper than just sweeping floors. Regular cleaning will purify the air and reduce the amount of sick leave days. Cleaner air will also make the machines work longer. Enhancing the philosophical understanding of the shine among the employees is important. It is necessary to make the employees understand that the benefits of cleaning will also eventually reach

them as well. Cleaner working environment will also increase the motivation of the employees. (5S Kaizen in 90 Minutes, 2008: 96)

The third step of the 5S can be started already when the first two are still under process. Hiroyuki Hirano has recommended to divide the responsibility of cleaning to three areas: storage, equipment and estates. The more people is involved, the greater possibilities there will be to succeed in continuous cleanliness. This is why every employee should be made responsible of their immediate working environment. (5S Kaizen in 90 Minutes, 2008: 100)

2.6 4S: Standardize, Seiketsu

Fourth step of the 5S method includes multiple standards created by managers. The standards can be about cleaning, tools, equipment or anything that is essential in the area of implementation. The standards hold the central place in auditing, the audit lists are based on standards and are updated when the standards are updated due to the continuous improvement.

In the book of “5S Kaizen in 90 Minutes”, Andrew Scotchmer gives a list of the benefits of standardization. This list gives the general picture of what standardization is:

- the standards are supposed to describe the easiest way to do the best job
- the standards offer the best way to preserve know-how and expertise
- the standards provides a way to measure performance
- the standards shows relationships between cause and effect
- the standards provides a basis for maintenance and improvement
- the standards provides objectives and indicate training – goals
- the standards provides a basis for training
- the standards creates a basis for audit or diagnosis
- the standards provides a means for preventing the reoccurrence of errors and for minimizing variability

(5S Kaizen in 90 Minutes, 2008; 112)

2.7 5S: Sustain, Shitsuke

The last step of the 5S method is sustain. As the name suggests, it is about keeping the 5S on the surface and in the minds every employee. Sustaining the 5S method at the workplace is in the responsibility of the managers. To sustain, managers are required to enable easy communication, effortless implementation of new ideas, continuous education and continuous improvement. This step as well as the fourth step are about involving the managers on everyday work. Managers must know what and who are they leading. Since one of the most valuable part of the 5S is a motivated employee, it is on the managers responsibility to create the right kind of atmospere, enable the work on the shop floor and motivate the employees. The people on the shop floor might not know about the fifth step, but they need to see the impact of it.

The actions to sustain the 5S method vary. Several steps that are suggested by Andrew Scotchmer in his 5S Kaizen book, can be adopted in almost every location. Andrew Scotchmer proposes to develop a communication system where information moves easier from the shop floor to management, he also recommends to implement a staff suggestion system where ideas can reach to a better forum and get higher probability for actual implementation. Two other things that he ranks high in the fifth step, are getting to know your staff and in general, motivating them. Knowing your staff creates a feeling of care, care leads to trust and respect which will all by itself, motivate people to do a better job. (5S Kaizen in 90 Minutes, 2008; 134)

3 APPLYING THE METHOD IN A LABORATORY

3.1 Applying the 5S method

The 5S method can be used in almost any environment, from an office to a production line and even in your own garage. In applying the method it is important to realize which parts are important in the environment in question. Some of the characteristics of the 5S method can be irrelevant for the actual place of implementation. In laboratories, there is no over processing in a same way there is in production. Since laboratories mainly produce just results, waste of over production is not a significant problem either,

Description	Important in production line 5S	Important in laboratory 5S
SORT		
Waste, Mura: irregular work flow	x	xx
Waste, Muri: overly stressing work	x	x
Waste, Muda: waste of over production	xx	
Waste, Muda: waste of inventory	x	x
Waste, Muda: waste of rejects and repairs	x	
Waste, Muda: waste of excessive motions	x	x
Waste, Muda: waste of over processing	x	
Waste, Muda: waste of waiting	xx	xx
Waste, Muda: waste of transportation	x	x
Method: One is best	x	
Method: Red tagging	x	x
STRAIGHTEN		
Visual management	x	x
Labeling	xx	x
Floor markings	x	x
Pictures	x	xx
SHINE		
Daily cleaning time		x
Weekly cleaning time	x	x
Involving everybody	xx	x
Regular maintenance for equipment	x	xx
STANDARDIZE		
Standard for cleaning	xx	x

Standard for tools	x	x
Standard for 5S/6S	xx	x
Rewarding system	xx	x
Regular auditing	xx	xx
SUSTAIN		
Weekly meeting	x	x
Keeping 5S in minds	xx	x
Managers participation	xx	x
Staff suggestion system	x	xx
Accreditations for areas that score high in audits	x	x
Valuation system: x = important xx = essential		

Table 1. Table of 5S characteristics

The table above shows the differences in the 5S characteristics between a production line and a laboratory. Most of the wastes do not exist as substantially in a laboratory as they exist in production.

3.2 Important methods and practices for laboratories

3.2.1 Mura waste

The Mura type of waste means the waste that creates irregular work flow. It often causes delays and difficulties on forecasting timetables. It becomes waste when other parts of the process are delayed because of a delay that occurs somewhere else in the process. At first glance this does not seem to be a big issue for laboratories, because it is very difficult to estimate the time usage in testing and development activities. The problem of Mura is actually a significant problem but it is often not perceived as such. The problem in laboratories is the instruments and equipment because in tests and development, the employees need instruments to measure the results; such instruments are often expensive and can not be purchased for every team. If one team needs an essential instrument or machine for longer than expected, it will most likely lead to delays on others tests.

3.2.1.1 Solution for Mura

Solving the problem of Mura can be challenging, but it can be improved with few tasks. Usually the tools for improving Mura can be found from straightening. In a laboratory, it is important to create a clear system for the usage of the instruments and machines. Other important parts are proper training and visual management. These three will decrease the time used for searching and using instruments and machines. Thus even if a team uses a specific machine for longer than expected, the waste time will be minimized with the tasks explained above.

3.2.2 Red tagging

Red tagging is normally done in the first step of the 5S. The tools that are not necessarily needed are tagged with a red piece of paper or marked on another way. Once the tagged tools are needed, the user is asked to mark the date to a list which is used to follow the usage of the tool. If the tool is needed it will be kept and stored, if not, it will be thrown away. However, this will not work in a laboratory since some of the tools are needed more seldom than every six months. Red tagging is supposed to take a minimum of 3 months but is often less than half a year. Thus in a laboratory this would lead to throwing away important tools.

3.2.2.1 The solution for red tagging

Since in laboratories some of the tools can be used less than once a year, there is a need to create a method with a similar idea to Red tagging, but with a longer-term view. This solution could be a red basket or a box where the tool is being put and then the usage of the tool is being followed for a year. Then, once a year the box will be emptied and the list explored. The tools that are not used can be then be thrown away. For example, in the D-laboratory there are some tools that can be used only every four years when some of the electric motor set-ups are changed. The rare usage is not a problem but the uncertainty of the importance of a tool is a problem.

3.2.3 Visual management

Visual management is about making the workplace clearer. It includes for example: labeling, floor markings and pictures. The difference between production line and laboratories in this study is that on a production line the labels are more essential since on the line there can be many tool cabinets. It is important to know from which tool cabinet the tool is from, because mixing the tools will lead to waste of time and excessive movements. In laboratories on the contrary, the pictures are more important because there is often greater variation of tools than there is on a production line. However, these are smaller details, in practice, visual management is important in every 5S implementation. However, in one of the laboratories of this study, there are more floating employees. The variation of employees raises the importance of visual management. Once the workplace has more visual guides and hints, it is easier for new and inexperienced employees to work by the rules. Consequently, less tools are being left around when these employees know where they are supposed to leave the tools.

3.2.4 Cleaning

To ensure that the tests are run without failures, it is important in laboratories to keep the machines in good condition. It is also important to keep things clean in a production line but in laboratories the feature that makes cleaning essential is irregularity. Because the machines and instruments are not always used on a regular basis, it is very important to have clear cleaning and maintenance schedules.

3.2.5 Standardizing

It is not easy to agree on the standardizing details in laboratories because the practices are more complex than what they are on production lines. This leads to the fact that standardizing as it is used on production lines, is not as important in laboratories. Making the laboratory standards more detailed will cause a problem when the testing methods or materials change. This will only lead to waste of time

when the standards have to be written again. However, auditing in laboratories is as important as in other implementations because auditing is the backbone of the 5S method and the motor for continuous improvement.

3.2.6 Staff suggestion system

In laboratories the staff suggestion system plays an important role between management and the employees. It is also an important system on production lines, but on average, the employees have a greater impact on their environment in laboratories. Meaning that the employees in the laboratories are often specialists who know what they need for their work. A staff suggestion system can be as simple as weekly meetings. It is also important that the employee who has a suggestion for improvement, feels free and confident to bring it into the knowledge of management.

4 IMPLEMENTING 5S TO D-LABORATORY AND M-LABORATORY

4.1 D-laboratory

In the D-laboratory the major issue was the absence of any system that would define the current state of tools and space and maintain the order. The issue caused tools to disappear and time losses when the employees were looking for them. The lack of a mutual system for tools causes employees to work the way they see is the best way as individuals; the way how two different employees think, might differ far from each other. Safety risks are also common in this type of spaces and some sharp-edged pieces were found in the working area.

4.1.1 The starting point of the D-laboratory

4.1.1.1 Wastes of D-laboratory

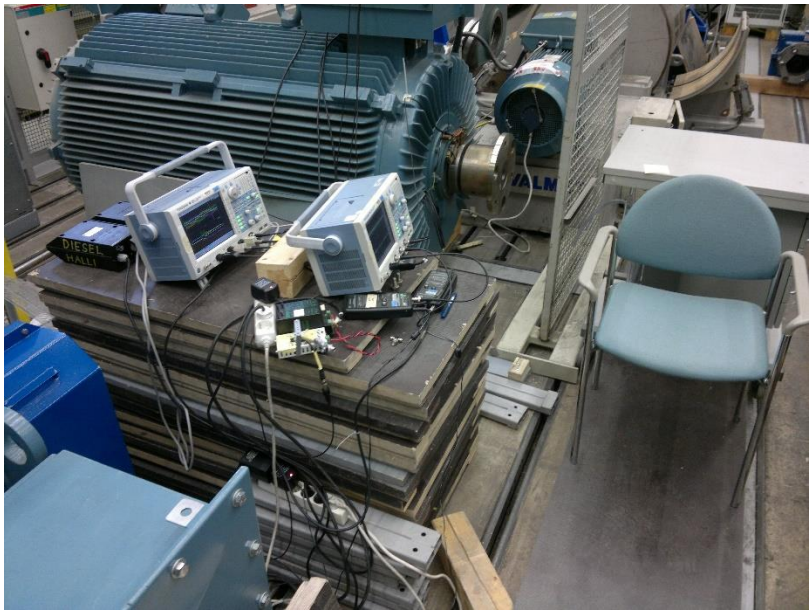
In the D-laboratory there was physical waste as well as non-physical waste. Time was wasted on searching for tools and putting things in order. The Mura type of waste in the D-laboratory has created delays on testing due mainly to other tests taking longer than expected. Thus, with Mura in the D-laboratory, schedules are significantly more challenging to develop leading to a worse predictability of testing time.

The multiple large cables stored on the aisle and in the middle of the motors were creating Muda and Mura types of waste. Muda because the cables take over a lot of space and Mura because it creates an irregular workflow since the exact cable is more difficult to find.

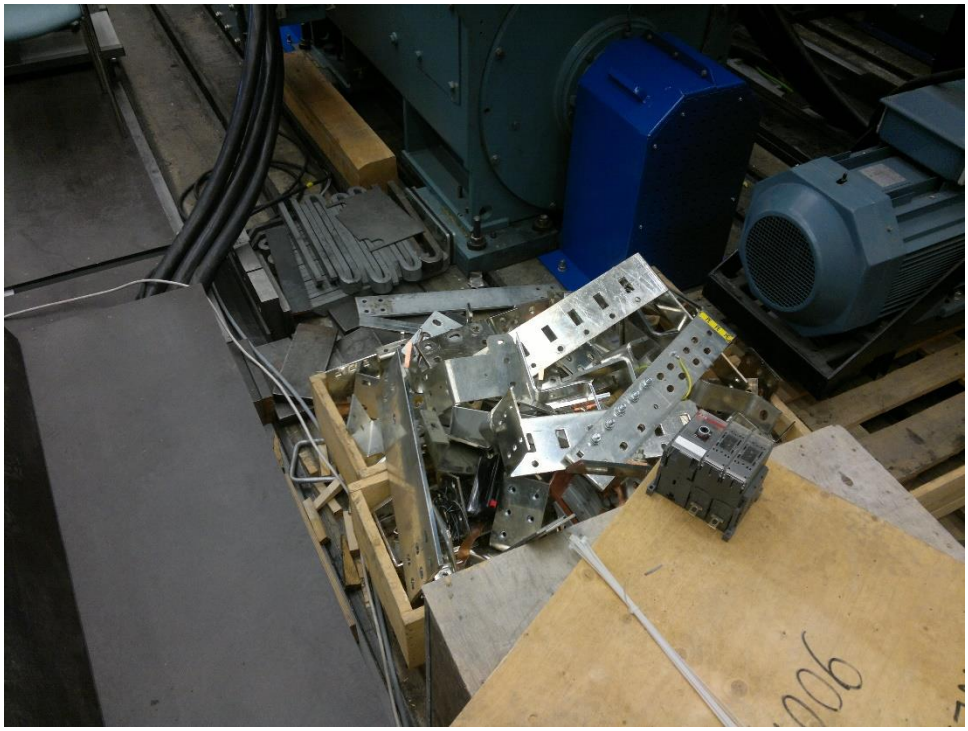
Picture 1. Large cables in the D-laboratory, ground plan number: 1

Picture 2. Cables in the middle of motors, ground plan number: 4

There was also another place that was creating safety risks and some irregular working flow in middle of motors; there were measuring equipment and sharp-edged objects without cover. These problems were agreed to be solved on longer-term development with set-up changes.



Picture 3. An inefficient and dangerous working area, ground plan number: 2



Picture 4. Sharp-edged objects, ground plan number: 3

As it has been mentioned earlier in this study, Muri means overly stressful or strenuous work which will eventually lead to loss of equipment or human resources. Muri applies both, the personnel and the machinery. In the D-laboratory Muri type of waste is difficult to find. The effects of working environment to the personnel should be examined on a longer-term period. However there have been issues with the dust in the working area, which originates from the concrete floor under the equipment that are being tested. The air ventilation has been improved recently but the problem should not be forgotten.

Furthermore, another issue with Muri in the D-laboratory is noise. The motors and the equipment that are tested can create a lot of noise during the tests. Since the tested equipment is the source of the noise and covering concrete floor is expensive and difficult, the improvement must be done in another way. An effective way to improve the working environment could be to move as much of the work as possible to the office above the equipment. The office gives shelter from the noise and dust.

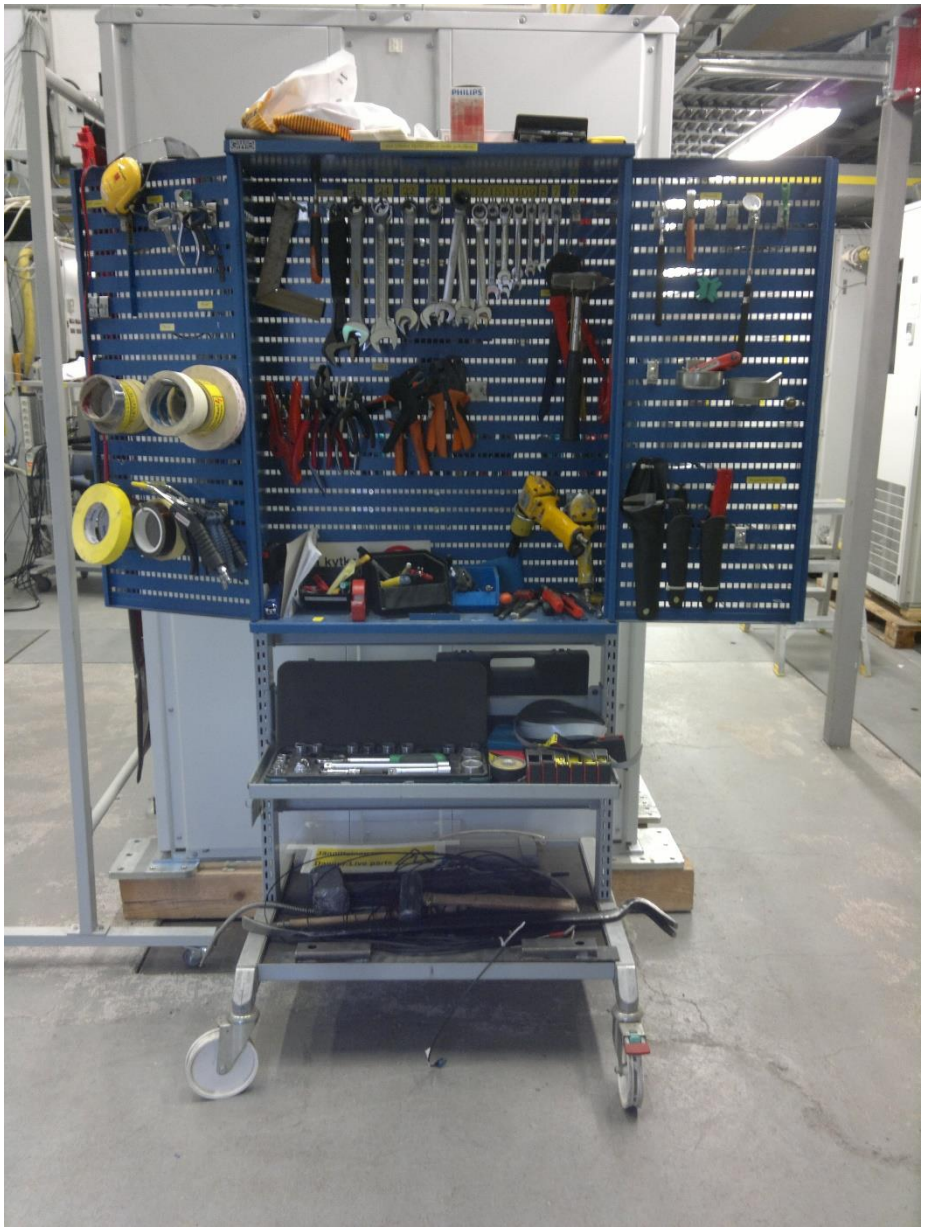
Muda includes several types of waste. As mentioned earlier, Taiichi Ohno created a list of seven wastes. However, most of these seven wastes are not essential to laboratories. In the D-laboratory Muda type of waste is being found in inefficient warehousing, excessive motions and waiting in general.

The tools in the D-laboratory were not organized and did not have any system or method to keep them updated. The major tool cabinet was in reasonable order but some of the other shelves were not. On the second floor there was tools on the wall, this place was an iconic 5S starting point.

Picture 5. Tools on shelves, ground plan number: 5

Picture 6. Tools on second floor’s wall, ground plan number: 10

The tool cabinets were organized well but were not labeled or counted. However, the major issue with these tool cabinets was not the cabinet itself, but the environment around them. These tools should be used only in the area around the testing equipment and electric motors. Yet, these tools were also being used in multiple other places. Some tools were disappearing and some were being left on the containers outside. These problems can be avoided by counting the tools and locating other tool cabinets close to the containers that are outside the laboratory.



Picture 7. Main tool cabinet, ground plan number: 6

4.1.1.2 Straighten and labeling

In the D-laboratory some of the tools have had their labeled place but this can be taken further by straightening the tools more carefully. Also, the pictures used in visual management were missing completely. There were hardly any markings on the floor clearing the order of spaces. The lockers that have little hardware such as bolts and screws were reasonably organized but there seemed to be no clear system to fill the supplies that were running out. To improve those lockers that had screw wrenches, the places of the tools should be marked better so that seeing which one is missing becomes easier.

Picture 8. Storage lockers, ground plan number: 7

There are several lockers on second floor that have less organized order. These tools and wires are less needed but create some waste during the times that they are needed. Improvements can be made by sorting the tools to the needed ones and not needed ones and then labeling the tools and continuing with visual management

Picture 9. Second floor storage lockers

4.1.1.3 Cleaning for shine

The D-laboratory did not have any schedule for cleaning and the basic cleanliness was maintained by cleaning whenever possible. This often leads to no cleaning at all or cleaning rarely. The lack of cleaning must have been one of the reasons for the dust in the air.

4.1.1.4 Standards of the D-laboratory

There were no standards in the beginning, neither there was other methods or agreements for working in the laboratory. This causes illogical ways of using tools, equipment and facilities leading to waste of time, material and space.

4.1.1.5 Sustaining the improvements

The improvements that were made were not sustained intentionally leading for example to the mixing of new and old tools. Sustaining of the improvements is often seen as a bonus task which is done only if there is enough time and motivation. However, sustaining improvements and maintaining equipment will save funds in for the longer term.

4.1.2 5S implementation

4.1.2.1 On shop floor

The implementation of the 5S in the D-laboratory started with getting to know the area and the tasks that were carried out there. In the beginning of the familiarization, the needed safety procedures were walked through. To get to know the staff and find out some of their opinions, oral questioners were done. This led to the implementation of the tool cabinet in the containers.

After the area was more familiar, the faults were presented to the managers with pictures and detailed descriptions of the problems. The next step was to introduce the staff with the changes that are about to be carried out. After the introduction, the process of sorting and straightening started, which led to throwing away a lot of old tools, labeling multiple tool lockers and marking the areas on the floor.

Picture 10. Second floor tool lockers

Throwing old tools and materials away, labeling the shelves with the contents and finally removing all of the material away from the top of the lockers were the improvements on second floor's lockers. The next step will be to mark the amount of tools; however, material is not marked with amount. Also a photo should be taken from the content of each locker and attached to the top of the locker. This will increase the visual state of materials and enable auditing.

On second floor wall, the tools were organized so that for every type of tool there will be on one place. In addition, some of the tools were also taken from the drawers and put on to the wall. The next step will be the labeling of all the tools with amounts and attaching a photo.

Picture 11. Tools on the second floor's wall

The ground floor locker which included screw-wrenches and batteries was labeled and sorted. The next update to the locker will be adding the amounts of tools and the photo on top of the locker.

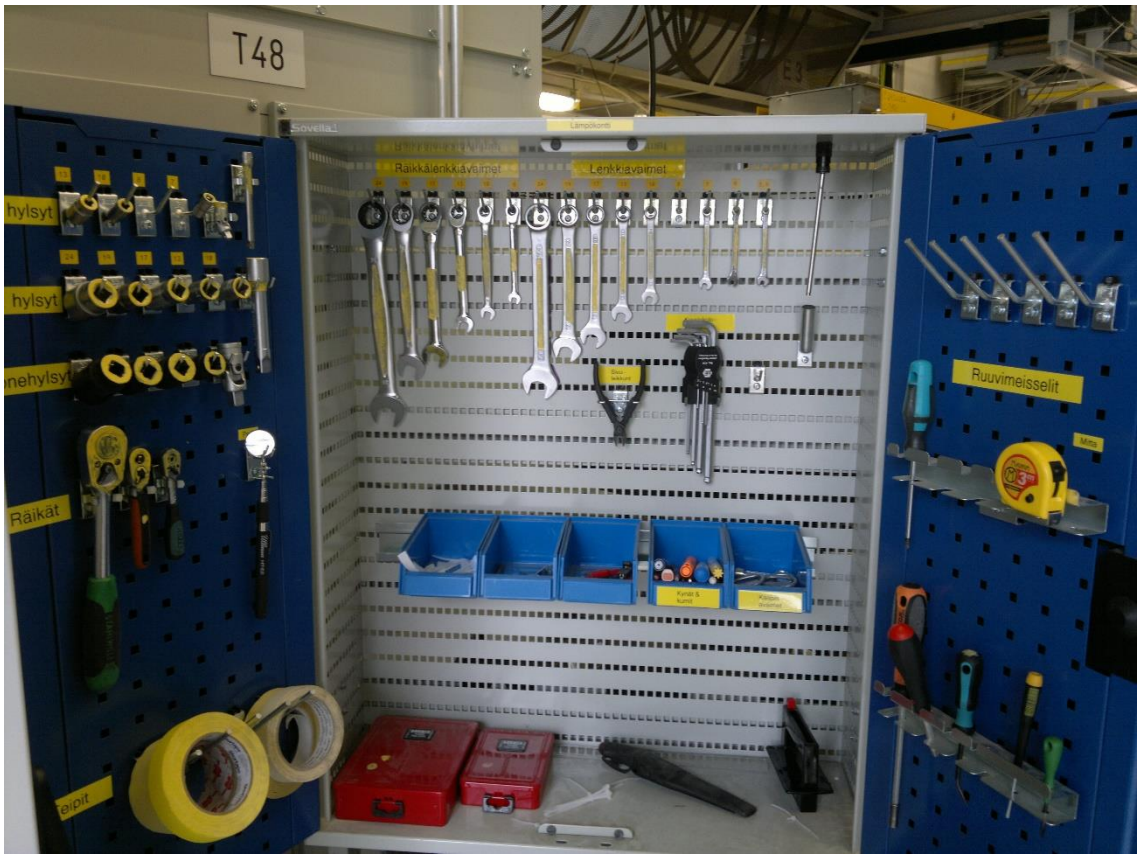
Picture 12. Tool locker ground floor

The floors were marked in multiple places to increase the clearness of the different areas in the laboratory. The markings were mostly done in places which already have a meaning in the mind of the employees. However, even if the employees know where to put the pallets and which area to leave free, making it obvious will effect on their mindset making the employees pay more attention in the order of the tools and equipment. The next step will be to mark all of the hallways and eventually mark a place for every item there is in the laboratory.

Picture 13. Markings on the floor and on cleaning equipment

Picture 14. Markings for free area and pallet

The next update meeting was about sorting and labeling the main tool cabinets. The two smaller cabinets will be removed to the containers and the large cabinet will stay in use until the new tools that have been ordered, arrive. New lockers had also arrived to replace on problematic shelf.



Picture 15. Tool cabinet for container

Picture 16. New lockers to replace shelf in picture 5

4.1.2.2 In management

The 5S implementation on the management level has included auditing tool with initial check list and standards for cleaning and tools. These documents are in the appendix of this study and are for the management to update. The usage of standards and the checklist will be essential for reaching the auditing level and maintaining it.

By their nature, the standards are agreements between the laboratory staff and the managers. The standards include the code of conduct for work, tools,

equipment and cleaning. Each of which will introduce the 5S to their own department, will create their own standards. The standard can be about anything that is essential to the current location. Nevertheless, without standards there will be no foundation for the audits to be based on. Cleaning and tool standards are the type of standards that can be applied to almost any location. There are no official template for the standards even if the name so suggests. The standard starts with the name of the location, responsible manager and type of standard. It is recommended to use the templates that most companies often have for text documents.

The two standards of this laboratory were created to a company template including the essential agreements and policies of tools and cleaning. The cleaning standard of D-laboratory consists of five topics, the first three are storages, equipment and estates. Hiroyuki Hirano was the first to propose this kind of split for the responsibilities in cleaning. The other two topics are auditing and 5S with continuous improvement. The auditing part is divided to personnel own auditing, unofficial weekly auditing and to official monthly auditing. The fifth topic is for the managers to make notes about the 5S in general. (5S Kaizen in 90 Minutes, 2008: 100) The tool standard is about different types of tools, starting from shared everyday tools to special project tools. The purpose of the standard is to define the placing, marking and storing of each type of tools. Other parts of the standard are about certain tool storages and about sustaining and improving.

The auditing tool is one of the most important part of the 5S implementation, it links all the standards and improvements together and gives important data about the progress and the future improvements. The auditing tool is nothing without the standards and continuous improvements, but the laboratory is not continuously improving without auditing. So in a way, they all depend on each other. The auditing tool that was created for D-laboratory has six steps and is based on so called 6S. The 6S is like the 5S but has additional focus on safety, the first five steps are the same as in the 5S but the sixth one is a step for safety. 6S is often seen as the next step of the 5S level. Auditing in the auditing tool starts from sort and ends to safety. The evaluation in each question of the audit

check list happens with simple “yes” or “no”. This binary practice will reduce the impact of different auditors and reveal the true situation of the laboratory. After auditing, the tool will give the total scores from the auditing and a radar chart picture of the success of auditing. The outcome of the audit should be printed and presented to the staff. By presenting the outcome, the staff will receive important information about the current situation and about the required improvements. The implementation of the suggested improvements will be examined and estimated in the next audit.

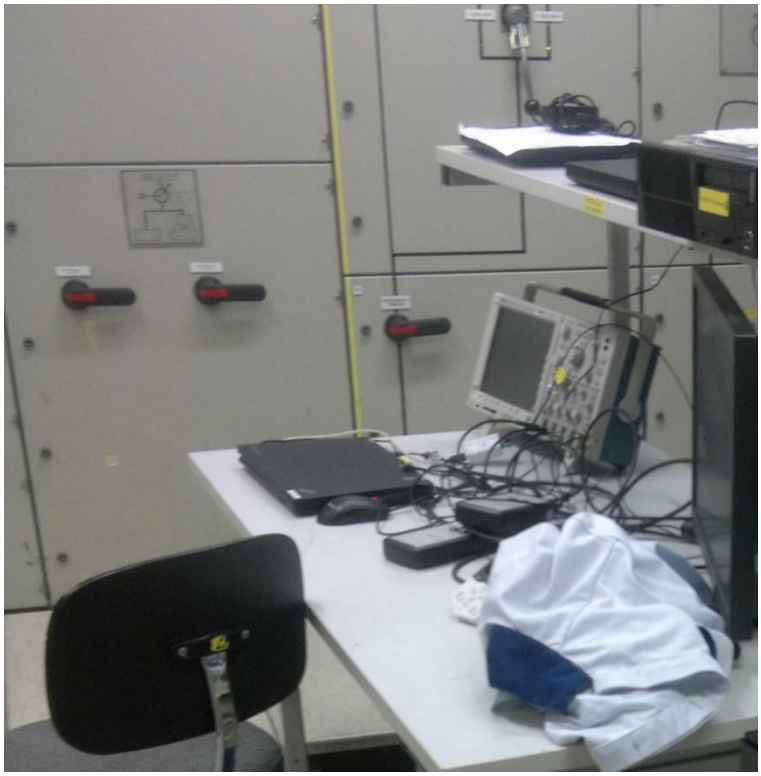
4.2 M-laboratory

Like D-laboratory, the M-laboratory was as well lacking a system that would define the current state of tools and working area and maintain the order. The major issue of M-laboratory however, seemed to be the floating personnel. This means that the regular employees are not the only ones using machines and tools. This feature has caused also disappearance of tools and time losses when the employees have been looking for equipment. Other issue in M-laboratory is the order of tools, there are personal tools and shared tools but there is no clear order for which tools should be shared and which should be personal. More difficulties have caused the rather intense resistance of any improvements, this seems to be common especially among the older employees.

4.2.1 The starting point in M-laboratory

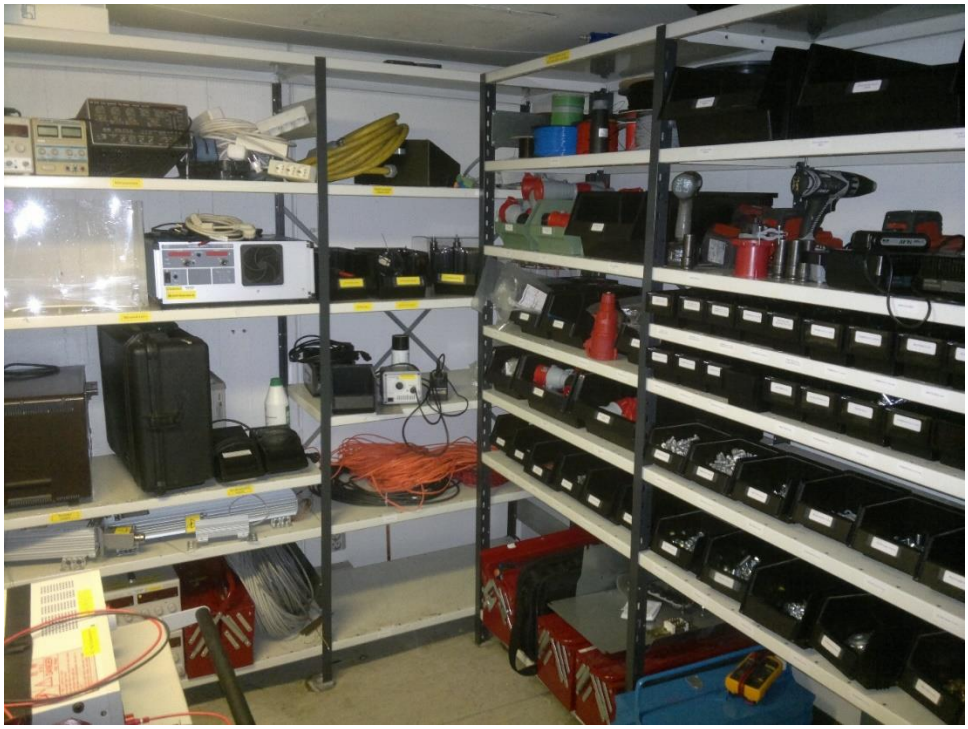
4.2.1.1 The wastes and visual management

The tables in M-laboratory are the places where the most of the work is carried out, there were several measuring equipment on the tables with personal laptops and tools. This was Mura and Muri type of waste since the order of things will increase the stress levels and make the employees work inefficiently. The solution is to plan the order of tables and enable it by providing the needed instruments or a system for using them through lending between each other. The paper documents would also need a system for filing.



Picture 17. Table in M-laboratory

In the storage, the most of the tools and materials were labeled, smaller hardware had also its location labeled. However there is Mura type of waste. To improve the storage, the rest of the tools, materials and equipment needs to be labeled. After that, a photo should be taken from the shelves and attached to close distance.



Picture 18. Storage

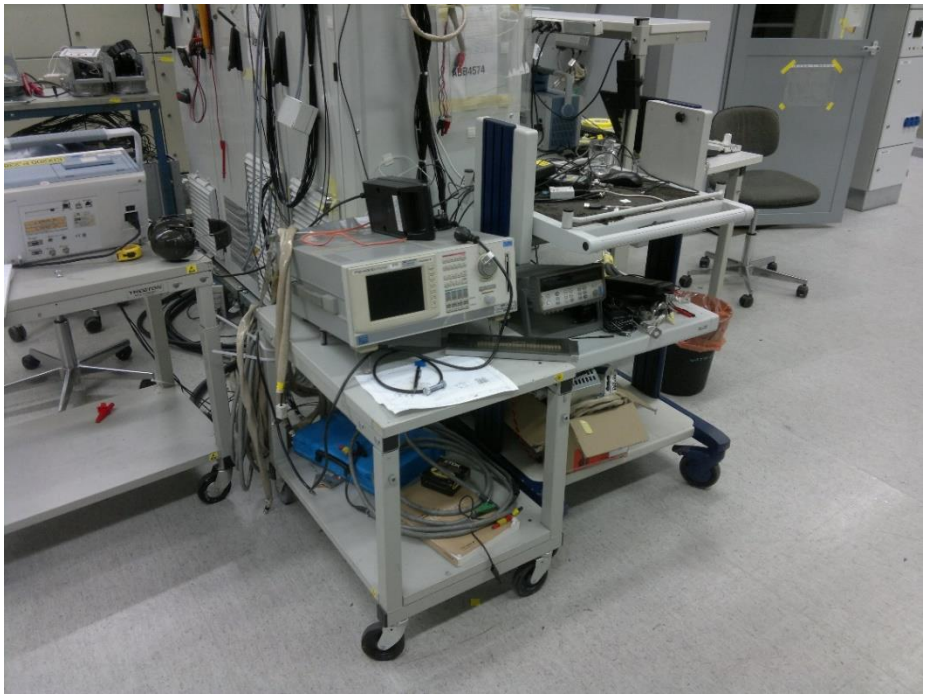
There were no agreed places for the pump trolleys and pallets. Fixing it is easy since it only requires taping the places on the floor. This will increase safety and decrease the waste of irregular work flow done by visitors as well. In optimum solution, there should be no pallets waiting in M-laboratory. However to solve the problem, first the situation must be stabilized with tape. The problem of the pallets goes further than just M-laboratory. The laboratory is a part of a larger organization and solving the pallet problem will require changes on higher level.

Picture 19. Pump trolleys and pallets

The corridors accumulate equipment and other material that should have their own places. This is often easily resolved with tape. The situation in the picture 20 creates Mura type of waste when the employees have to look for material from where they should not be located. It is also a safety risk when the corridors are piled up with barriers.

Picture 20. Corridors

There are tables for instruments and equipment but there is no clear order for using the tables. Still, the major issue with the tables is the mindset which they create in the laboratory. Since there are no clear instructions for using the tables or locating the tables, it is left for every employee to figure out their own way of using the tables. This creates Mura and Muda type of waste by creating irregular work flow and waste of time. These tables can also block important corridors and this way become a safety risk. The situation of the picture 21 can be improved by agreeing on certain order for the usage of the tables and locating the tables and the instruments more organized way.



Picture 21. Supporting tables

The tool cabinet in picture 22 is lacking labels and order. This situation creates Mura type of waste, a waste of time and a waste of material. It becomes hard for an employee to go look for the tools when there is no order. This leads on wasting tools and materials when they are not used. If they are used it leads to waste of time because it takes so long to find the required tools from this kind of cabinet. The situation can be improved by organizing the tools, labeling them and attaching a picture of the cabinet on top of it.

Picture 22. Tool cabinet

The situation of M-laboratory in overall is slightly more challenging than in the D-laboratory. Equipment, instruments and materials are left around with no effort on trying to make the laboratory look more organized. This is a symptom of low motivation which gets downgraded also by the surrounding environment. It is hard to effect on motivation but higher motivation can be enabled by organizing the tools and equipment that can be organized. The 5S method leads eventually to higher motivation, but reaching the 5S level will require more work.

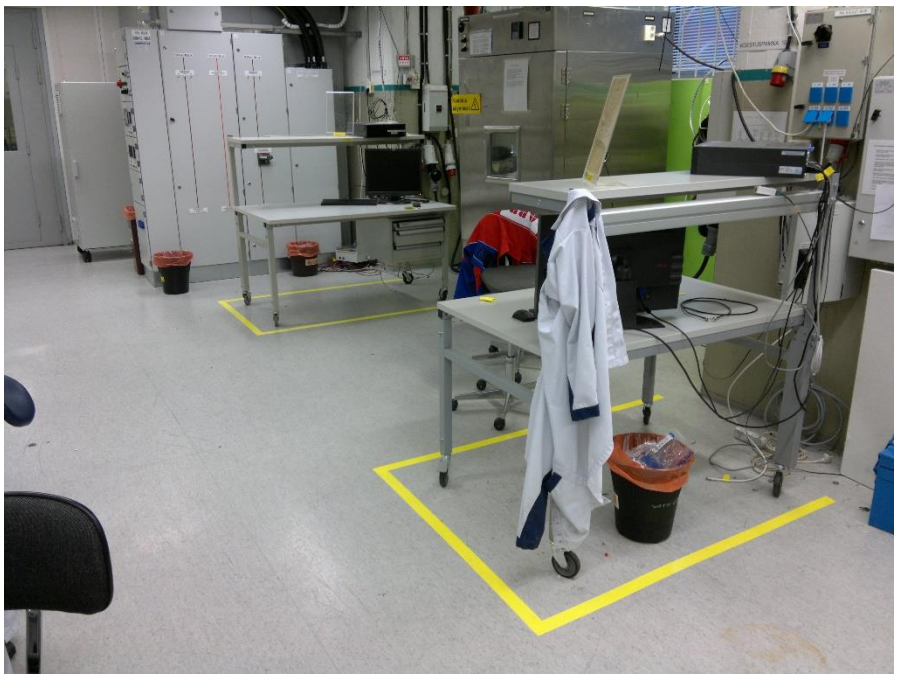
Picture 23. Overall situation

4.2.2 The implementation of 5S

The implementation of the 5S tool in the M-laboratory started the same way it started in the D-laboratory, except this time there was material to present to the staff in the early beginning. After the needed safety walk through, questions were asked from the staff members like in the D-laboratory. In both laboratories the welcome of the method was cold but in the M-laboratory it hardly raised any interests. Since the method of 5S is basically for the employees and is done for their good, resistance for this kind of improvements is extremely hard situation to begin with.

There was one meeting with the managers where they were informed about the situation and plans in the D-laboratory. The managers had positive opinion towards the method and clear interest for the improvements. During the implementation, persuasive manager with positive attitude towards the change is essential in succeeding. After the meeting, staff was brought together to receiver the plan.

The event for the 5S implementation was held and the problems were on the surface right in the beginning. The implementation was slow because only few people took part to the event. One tool locker was sorted and few markings were made on the floor.



Picture 24. Markings for tables

Picture 25. Marking for a door

Picture 26. Marking for a fire extinguisher

Picture 27. Tool lockers sorted

The implementation on the shop floor will continue still in several sorting and straightening events. Work on the first two steps in the 5S is slower in M-laboratory because the laboratory has a lot of floating staff, problematic distribution of tools and the whole laboratory is a part of a group of other laboratories. The development on the shop floor will require more attention from the staff and management. The implementation of the 5S is a large change that will effect on every employee, whether they wanted or not. Thus, without the attention that is needed, the implementation will not happen and the final achievement will be only a waste of time.

4.2.2.1 In management

The M-laboratory does not have standards or auditing tool at this point. However, it is recommended to use the templates of D-laboratory. The auditing tool works in M-laboratory as it works in the D-laboratory. After all, it is the responsibility of the managers to update and modify the standards. The preparation of the tool standard can be started after sort and straighten, standard for cleaning will be created shortly after the shine.

5 RESULTS

The results of the implementations of the 5S method are hard to estimate at this point. The 5S decreases many types of wastes, usage of material, wear off of tools and equipment as well as stress on employees. The results can be measured in improved usage of space and improved happiness of employees. However, before the auditing level is reached, it is almost impossible to obtain credible measurements. Reaching the auditing level will take far more time than what there is to use during one thesis.

In the D-laboratory and M-laboratory, the process has been started; it will take many months and significant investment to reach the auditing level mentioned above. After reaching the auditing level, follows the next level, 6S, which concentrates more on safety. Fortunately, within the company in question, the safety risks have already reached the attention of managers. As a part of the Toyota Production System, 5S method is one of the tools of continuous improvement. The method aims at continuously move forward, making it slightly more challenging to evaluate the total achievement.

However, the results in the D-laboratory are increased knowledge of continuous improvement among the staff and managers; also time saving will be achieved with the sorting event and clearer order of equipment and tools. The current mindset of the staff is difficult to evaluate but the markings on the floor with other visualization have probably had an impact on how they see their workplace. After understanding the benefits of visualization, the employees might see other locations that could be improved.

In M-laboratory the results are still modest, the information has been passed to the staff and the ice has now been broken. The change takes time and rushing will only create more resistance. One locker has been sorted and visualization increased in multiple places. People that were part of these events have now knowledge of the kind of an issue the old and unnecessary tools can create. With the old and broken tools in the cabinets, it takes a lot longer to find the right tools or to find a place to locate a new tool. If the procedure remains the same, the

situation will only get worse year after year. However, if the continuous improvement is taken seriously, the laboratory can reach tremendous improvements in the usage of time and space and become a trendsetter for other laboratories.

The impact of visualization should not be underestimated in M-laboratory because many of the employees work there only rarely and new students from the university arrives every summer. Visual workplace will decrease the time needed for learning the new practices, it will also mitigate the stress level of a new employee.

As mentioned earlier in this study, reaching the auditing level in the laboratories is a goal of the implementation. However, from auditing, the actual continuous improvement only starts. Reaching the auditing level or so called “lean” level, is not about the methods used, but about the goal that is achieved. Once the auditing level is achieved, the state of the laboratory cannot remain static. The condition of a laboratory after implementation should be dynamic, leading to continuous search for improvement. The implementation of the 5S is more about changing the mindset than it is about the methods that will do the change. It is a forever ongoing journey. (Tätä on lean, 2013; 149-151)

5.1 Implementation process

In the implementation of the 5S to the laboratories, four essential questions were revealed. The answers to these questions will tell the 5S process owner of which parts of the process to emphasize on. In future implementations, these questions should be asked at the beginning of the implementation process so that the steps of the process can be modified. The questions are the following:

1. Are the employees permanent or is there floating staff?
2. Is there shared, personal or both type of tools in the laboratory?
3. Does the laboratory already follow some continuous improvement program?

4. Does the laboratory operate as a single unit or as a part of a larger division?

The answers to these questions will have a significant impact on the implementation process. The first question will steer the importance of the visual management. For people that work permanently in one place, certain functions in the laboratory are almost too well known. Too massive visualization can actually irritate the worker and decrease motivation. However, if the staff of the laboratory is changing often, there is no other option but to mark tape and inform every little aspect of the working area.

As the second question gives an answer about the tools, it also answers to the question about sorting. If the laboratory comes with a great amount of shared tools, sorting may not be easier but it will be simpler. The challenge in sorting shared tools is the lack of knowledge at the current event. Employees that are specialists of other matters cannot sort the tools that are mainly used by someone else. In personal tools, the sorter is always the user of the tools but the problem lies in monitoring and managing the event of sorting. Furthermore, unless there is an important reason for personal tools, those tools should be minimized.

The answer to the third question will either lead to a standard approach of the 5S implementation or to mapping of the current situation of the continuous improvement program. This study leads to the implementation of the 5S in laboratories and without a doubt, it would be waste of time to do the same steps twice. If the laboratory has already a continuous improvement program, the improvements and the current situation should be clarified.

The fourth question is about the surrounding environment of the laboratory. The rule of implementation in this situation is simple: if the laboratory is operating on its own, the 5S can be implemented in isolation. However, if the laboratory operates as a part of a larger division, eventually the whole division must implement the 5S. If the larger organization will not implement it, the improvements will be difficult to maintain and the probability of failure will rise significantly.

Both of the laboratories in this study had dissenting answers to these four questions. The D-laboratory had permanent staff, personal tools, no earlier program and operated as a single unit. Whereas M-laboratory had floating staff, both type of tools, few 5S improvements and operated as a part of a larger division. As the answers suggest, the implementation process will be more demanding for the M-laboratory.

5.1.1 Implementation process schedule

As a result of the implementation process in two laboratories, an implementation schedule was developed. From this schedule, the 5S process owner will see the order, duration and the requirements for each task. Eventually, the laboratory will achieve the auditing level and continue improving; this schedule is the roadmap through the implementation process.

Task / Time / Type	Explanation	Responsibility
Selecting the responsible ones 2 hours Meeting	Meeting between laboratory managers, testing manager and staff supervisor	
Inspection of the laboratory 2 hours Observation	Clarifying the current state of a particular laboratory. Which steps have already been taken to move towards the 5S The example tool cabinets should be photographed to make the staff presentation clearer and to make it easier to create a before and after report.	The 5S process owner
Staff interview 1 hour Face to face	Interviews can take place before or after the staff meeting. The benefit of doing the meeting before will be the open attitude to the changes. Once staff has been informed, they might limit the suggestions to the current process.	The 5S process owner

Staff meeting 2 hours Meeting	One important part of the 5S process is involving the staff. The level of success of the process depends on the response of the staff. The benefits of the 5S process must be made clear to the people working in the area.	The 5S process owner
Staff interview 1 hour Face-to-face	To involve staff about the changes and to create positive background to the process, members of the staff should feel needed. Asking opinions and even help will indicate appreciation and need.	The 5S process owner
1S plan with pictures and examples Hours Blueprint	To create a clear start for the actual implementation, a plan with pictures and explanations should be made and demonstrated to the staff.	The 5S process owner
1S sorting event One day Event	The event starts with the presentation of the 1S implementation plan. After the presentation, the planned changes are made with the staff and supervised by managers. The event includes mainly sorting tools and equipment. Pictures should be taken from the event for the process report.	The 5S process owner, laboratory manager, testing manager, staff supervisor
2S visualization event One day Event	In the 2S event the equipment, tools and materials are labeled and the work in the laboratory straightened. The possible staff suggestions for improvements are also implemented. In the 2S the visualization has three major tasks: labeling all details, taking pictures from tools and attaching them to close distance and finally, marking the floors with tape.	The 5S process owner, laboratory manager, testing manager, staff supervisor
1S and 2S success evaluation 1 hour Observation	The success of the 1S and the 2S should be evaluated a week or more after the latest event. This will reveal the changes that have worked and the places where work is still required. If there is still need for improvement, the next event for the 1S and the 2S should be agreed on.	The 5S process owner

Cleaning clarification Hours Blueprint	If any part of the cleaning is handled by someone outside the company, their schedule and responsibilities should be recognized and included into the plans.	The 5S process owner, laboratory manager
3S event One day Event	The event starts with a short brief to the staff. During cleaning, the 5S process owner and the laboratory manager should make notes for cleaning standards. The goal of the event is to clean all the places, even the ones that cannot be seen.	The 5S process owner, laboratory manager, testing manager, staff supervisor
Standards and auditing tool Days Document, tool	The standards are made based on the findings during the events. Tool and cleaning standards should be done at least. The 5S standard can be done later. Auditing tool is done on excel and is based on tool and cleaning standards.	The 5S process owner, laboratory manager
4S meeting 2 hours Meeting	In the meeting, the staff should be informed about the standards and the auditing tool. The staff should also have an effect on the tools and standards. The feeling of agreeing on the decisions is important for their motivation.	The 5S process owner, laboratory manager, testing manager, staff supervisor
First auditing 2 hours Observation, event	The entire staff and all the managers should be present in the first auditing. The major goal of the first audit is to teach everyone the characteristics of the auditing process.	The 5S process owner, laboratory manager, testing manager, staff supervisor
Plan for sustaining 1 hour Document	To maintain the improvements the laboratory requires regular audits that should be agreed on with the managers. The laboratory manager should perform unofficial audits every week. Official audits should be done in every month.	The 5S process owner, laboratory manager, testing manager, staff supervisor
Weekly 5S meeting 1 hour Meeting	To keep the 5S and continuous improvement in the mind of the employees, the laboratory should have a weekly meeting for it. In the meeting, the staff suggestions are evaluated and implemented if they are urgent.	Laboratory manager, testing manager, staff supervisor

Continuous improvement Events	The staff and managers should keep on finding better ways to work or at least fix the problems that have been pointed out in audits. After all, the ultimate benefits of the 5S tool is that it brings out the potential improvements objectively and easily, and the new mindset of doing things better than yesterday.	Laboratory manager, testing manager, staff supervisor

Table 2. 5S implementation schedule

As mentioned earlier, the answers of the four questions will have an impact on the actual implementation process. This schedule is a template for each individual implementation and will work as a frame for other schedules. The implementation predictability and time management will improve by creating similar schedules for implementation and showing it to the staff. The information from the implementation and about the process should go to the employees as straight as possible. The resistance among the employees often arises from a poor communication.

6 CONCLUSION

This study has provided evidence that suggests the deeper meaning of continuous improvement programs. The applied 5S method was introduced and its implementation was applied in two laboratories. As a result, the distribution of tools, their visualization and the knowledge of the staff improved. The study ended with the introduction of the implementation of applied 5S. For future implementation, this study offers templates, schedules, advice and informative pictures.

During this study, the implementation of the 5S has begun in two laboratories and the instructions have been provided for others to recreate the tasks. The work on laboratory implementation demands a significant amount of work and time which was declared as part of this study. In conclusion, this study can work as a guidebook for the implementation of the 5S in laboratories, if used properly.

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The standard for cleaning

	Document		Document number	Version	Replacing	
ABB	**D-laboratory standard for cleaning - example**				-	
Publisher	Country	Author	Date		Language	Page
	FI	Oskari Pentti	8.6.2014		fi	6(1)
Department		Acceptor	Distribution		Status	
Laboratory						

Storages

All places that store material or other, including the whole room in upstairs

- Broken, unnecessary and extra equipment and tools are dealt like described in standard for tools
- All the materials are returned to their right places and organized like in the pictures or like in standard
- All the material should stay and fit to the places agrees for them
- The floors and tables are sweeped like agreed on cleaning schedule
- The trashcans are emptied if more than half full

Equipment

All the equipment whether they were large and mounted or small and borrowed

- Large equipment are cleaned from dust from top to the floor in every (fill the time unit)
- The required maintenance will be done weekly for the machines in use
- Small equipment should be returned to its place or owner in every (fill the time unit)
- Small equipment maintenance in every (fill the time unit)
- The project shelf tools should be cleaned and the need of each tool evaluated at least every six months

Estates

Floors, public areas and tapes

- Floors and public areas should be cleaned from trashes
- Updating the tapes on floors and replacing the broken ones

Responsibilities of the external cleaning company

- - - -

Auditing

Daily

- Done by the employees themself

Weekly

- Done by the managers of the laboratory
- Improving can be rewarded

Monthly

- Needs auditing agreement with other group
- Done by a manager outside the laboratory
- Positive results will lead to reward

5S and Continuous Improvement

Sustaining and improving the method is on the responsibility of the managers. The standards are essential part of updating and improving the system. Audits should be based on the standards, especially to cleaning standard.

The standard for tools

	Document		Document number	Version	Replacing	
ABB	**D-laboratory standard for tools - example**				-	
Publisher	Country	Author	Date		Language	Page
	FI	Oskari Pentti	8.6.2014		fi	6(2)
Department		Acceptor	Distribution		Status	
Laboratory						

The markings and placements of tools

- All of the everyday tools must have their own separate places with markings of type and amount and in addition a photo in immediate distance from the cabin of the tools or other tool storage.
- The tools must be located as close as possible to the place they are required.
- Also, all of the stations where employees work, must include the tools that are needed in that location.

Rarely needed tools

In laboratories there are tools that are needed even less than every 6 months, this is why red tagging does not work as it would in production.

- Rarely needed tools should be located in the area of the laboratory so that the immediate area on shop floor is left for everyday tools.
- Rarely needed tools should be recognized and their places marked like the everyday tools.
- Laboratory can have a project shelf for equipment that are not marked but are possibly needed in the future. The cleaning and emptying of this shelf needs to be agreed in the cleaning standard.

Unnecessary, extra and broken tools and equipment

Tools that not needed anymore should be returned to the supervisor who will either return it to where they were borrowed or deal with them other way, extra tools will have the same approach. Tools that exists in too many numbers are extra tools, these tools are often everyday tools.

- Tools that are broken needs to be discovered as they break down, the event should be marked-up so that a replacement can be ordered. When this is done, the tool will be thrown away.
- In laboratory unnecessary tools should be detected in a meeting or with a system similar to red tagging but more far-reaching.

Special tools and project tools

Special tools are marked and located like normal tools, the location of special tools can be more distant than normal tools.

- In laboratory it is important to recognize the special tools that are e.g. modified from normal tools. Modified tools are harder to replace and should not be mixed with project tools
- Project tools should be stored to project shelf or equivalent. The storage should be cleared up every six months.

Materials and cables

Materials overall are marked with name without amounts. A picture is added close to the storage to indicate the way of storing.

- Materials that are used in the set-ups like tools are stored like materials; marked with description and a picture.
- Cables are marked in laboratory with the type of a cable and with picture on the shelf

Containers

The tools in the containers are stored and marked like other tools. Tools outside of containers should not end up to containers and should not be stored in there. Change of set-up is an exception.

Cleaning equipment

Equipment for cleaning are marked like tools with name and amount. Picture is not needed if stored in single pieces.

Sustaining

Sustaining the order of tools requires continuous updating and fast reacting when new tools are brought to the system. The responsibilities of markings and locations should be divided to the users of the tools.

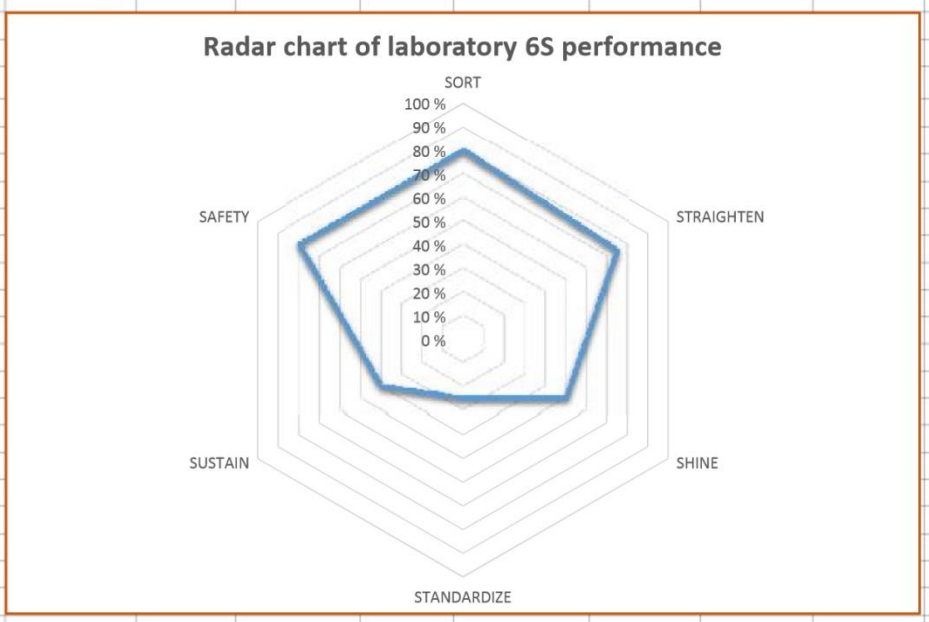
The 6S auditing tool

4												
5		**6S Auditing**										
6						**Unit type:**	Laboratory					
7		Location:				**Contact person:**						
8		**D -laboratory**				**Date:**						
9												
10		ABB										
11												
12												
13												
14		**1S: SORT**				Points given:	4	Ratio:	80 %		Yes / No	Fault description and advices for improvement
15		Topic	Detail			Total points:	5				(1/0)	
16	1	Only required or agreed tools are present										
17			Tool cabin 1								1	
18			Tool cabin 2								1	
19			Tool cabin 3								1	
20			Container tools 1								1	
21			Container tools 2								0	
22			Tools next to break room									
23			Tools on wall upstairs									
24			*ect.									
25												
26	2	Only required or agreed equipment are present										
27			Shelfs of the lockers upstairs									
28			Shelfs of the lockers downstairs									
29			Stools and chairs are in their places and unbroken									
30			Pump trolleys									
31			Cleaning equipment on the wall next to sectional door									
32			Cables									
33												
34												
51		**2S: STRAIGHTEN**				Points given:	3	Ratio:	75 %		Yes / No	Fault description and advices for improvement
52						Total points:	4				(1/0)	
53	1	Tools are labeled, located well and easily detected if absent										
54			Labels and pictures done in tool cabin 1								1	
55			Labels and pictures done in tool cabin 2								1	
56			Labels and pictures done in tool cabin 3								1	
57			Labels and pictures done in container 1								0	
58			Labels and pictures done in container 2									
59			Tools next to break roon									
60			Tools on wall upstairs									
61												
62	2	Equipment are labeled, located well and easily detected if absent										
63			Shelfs of the lockers upstairs									
64			Shelfs of the lockers downstairs									
65			Pump trolleys									
66			Cleaning equipment									
67			Cables									
68												
69	3	Floor markings										
70			For pump trolley									
71			For waste baskets									
72			For hallways									
73			For other free areas such as door areas									
74			For other moving equipment									
75												
76												

	D	E	F	G	H	I	J	K	L	M	N	Q
88		**3S: SHINE**				Points given:	2	Ratio:	50 %		Yes / No	Fault description and advices for improvement
89						Total points:	4				(1/0)	
90	1	Floors occupation										
91			Are the hallways empty								1	
92			Are the free areas free of matter								1	
93												
94	2	Cleanliness										
95			Are the hallways clean / free of dust								0	
96			Are the floors around working areas clean								0	
97			Are the tool cabins clean									
98			Are the containers reasonably clean									
99			Are the lockers for equipment free of dust									
100			Is there a schedule for cleaning									
101			Is the schedule updated									
102			Is everybody involved in cleaning duties									
103			Are the waste baskets empty of half empty									
104												
105												
125		**4S: STANDARDIZE**				Points given:	1	Ratio:	25 %		Yes / No	Fault description and advices for improvement
126						Total points:	4				(1/0)	
127	1	Standards										
128			Are the standards updated								1	
129			Is there standard for cleaning and tools (etc.)								0	
130												
131	2	Audits										
132			Are there regular 6S audits								0	
133			Is there a rewarding system								0	
134			Are the improvements suggested in last auditing done									
135			Are the results of last audit displayed									
136												
137	3	Maintenance										
138			Do the equpment maintenance records exist									
139			Are the records updated									
140												
141												
142												
162		**5S: SUSTAIN**				Points given:	2	Ratio:	40 %		Yes / No	Fault description and advices for improvement
163						Total points:	5				(1/0)	
164	1	Staff										
165			Is there a weekly meeting								1	
166			Is there staff suggestion system or habit (could be weekly meeting)								1	
167			Is there recognition given for staff that is active in 6S activities								0	
168			Is time used for sustaining 6S (min. 1h/week)								0	
169												
170	2	Managers										
171			Has any manager participated to 6S audit in past 3 audit								0	
172												
173												
174												
199		**6S: SAFETY**				Points given:	4	Ratio:	80 %		Yes / No	Fault description and advices for improvement
200						Total points:	5				(1/0)	
201	1	Safety with people										
202			Are the personal protective equipment available and clearly marked								1	
203			Are the protective equipment for visitors available								1	
204			Working conditions are ergonomically friendly (f.ex. chairs in office)								1	
205			Is the air of the laboratory clean of dust								1	
206			Are there lights in working areas as required								0	
207												
208	2	Safety with equipment										
209			Are there safety instructions for all major equipment									
210												
211	3	Safety equipment										
212			Fire hoses and extinguishers are displayed and maintained									
213			Stop switches are clearly marked and located									
214			Are the first aid kits well displayed									
215												
216												
217												

Results

	SORT	STRAIGHTEN	SHINE	STANDARDIZE	SUSTAIN	SAFETY	TOTAL
Points given	4	3	2	1	2	4	16
Maximum	5	4	4	4	5	5	27
Ratio	80 %	75 %	50 %	25 %	40 %	80 %	58 %



Other suggestions for the future	
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Ground plan of the D-laboratory

Only in internal version