

Effect of 5S Implementation in a Metrology Lab

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ABSTRACT - This study aims to identify and present the effect of 5S methodology implementation in a metrology lab and how this methodology can bring the changes in the existing inspection environment. It is very important to study and understand the various methodologies in the field of Total Quality Management that can bring an impact on the performance of the system. 5S is one of the TQM techniques used in various organizations which are also considered as a visual management system.

A metrology lab of an aerospace organization has been considered for this study and the step by step implementation of the 5S methodology in the metrology lab is monitored. The workplace environment and the performance of the system after the implementation of 5S methodology have been discussed through the results obtained. This study helped to understand and evaluate the change in performance of a system with the 5S methodology implementation.

Keywords: 5S Methodology, TQM, Metrology, Workplace, Performance.

I. INTRODUCTION

Total Quality Management is the integration of quality management with the total organization. TQM emphasizes the involvement of everyone in the organization focusing on the customer satisfaction. Achieving customer satisfaction is the main objective of the TQM and is possible only by delivering the quality product or service to the customer as per their requirements. This can be achieved through systematic methods for problem solving, continuous improvement and maintaining the improved system.

There are different quality tools and concepts such as Lean Management, 5S, Just-in-Time (JIT), Six Sigma and Quality Circles are applied in TQM to stream line the system and to reach the expected targets.

5S methodology is one of the important and basic tools of TQM to implement Lean manufacturing that minimizes the waste and regulate the work flow by keeping the workplace in a systematic way. Implementing 5S is a part of continuous improvement in Total Quality Management.

The role of Metrology is very important in every manufacturing industries especially aerospace and automobile field. Quality control activities such as dimensional inspection, verification, data comparison, data analysis, coordination, documentation, calibration and maintenance of instruments and gauges, maintenance of stores and tool room are carried out in metrology lab. In order to handle all the Quality activities in a metrology lab, it is very important to maintain the workplace at the lab in a systematic way by adopting relevant scientific

methodologies. The workplace environment makes a great difference in employee's performance and productivity of the organization.

II. 5S METHODOLOGY

5S is an effective quality tool of TQM concept and is originated from Japan. The 5S methodology is evolved with the intension of reducing manufacturing waste, time waste, inefficiencies and making the system more efficient. This methodology has improved and gained importance over the years and has become one of the technique for Lean management and TQM.

It is a systematic and refined method of visual management. The main purpose of the 5S is organizing the workplace in a systematic and scientific way to enhance the working environment which in turn improves the quality of work, productivity of the organization and safety of the system.

5S is expressed with five Japanese words starts with "S" and they are

1. Seiri
2. Seiton
3. Seiso
4. Seiketsu
5. Shitsuke

5S methodology is a structured program used to organize and handle the workplace better, clean, safe and effective with a step-by-step system using above mentioned "5-S" so that the people can understand and follow easily. The five Japanese words are translated into English with equivalent meaning to understand and they are given in table.1.

Table.1

The 5S	Japanese Term	English Term
1	Seiri	Sort
2	Seiton	Set in Order (Straighten)
3	Seiso	Shine (Sweep)
4	Seiketsu	Standardize
5	Shitsuke	Sustain

2.1. SEIRE (SORT):

The first “S” of the 5S is “Seire” which means sorting out the items based on their nature and usage. In every workplace it is the fact that all the items are not used in day to day work. Some items are used regularly, some items are used once in a while or not needed for immediate continual operation and some items are not used for a long time or may not be useful at all. This activity starts with identifying the necessary and unnecessary items in the workplace. The identified items need to be classified and placed accordingly. The main objective of this activity is to recover and save the space in the workplace by discarding and removing the unnecessary items from the workplace. As the unnecessary or defective items can severely affect the work flow and productivity of the system, the identified unnecessary items should be kept offsite thereby utilizing the available space efficiently and creating an effective work system. This activity helps in availability and easy accessibility of the required items, reducing the work flow and operation cost.

The unnecessary and unaccounted items must be documented and tagged with Red colored paper (Red Tag) with a clear description on it. These items must be reevaluated before tagging with red colour and all such red tagged items must be kept separately in a red tag holding area for clear identification. This activity helps the user to identify the best available useful items and not useful items easily.

2.2. SEITON (SET IN ORDER):

The second “S” of the 5S is “Seiton” which means setting the items in a useful and systematic order. The sorted items must be kept in an appropriate place and in a designed order. The assigned place must be such that the items can be taken easily and placed back at their original place easily after their use. The first part of this activity helps in finding all the items required for the process at one place and ease the accessibility. The second part of this activity is to give proper identification for every item and visualization of the place. Labeling and marking the materials, tools, spares and other items with different colors helps in quick access and time saving. The transition path must be marked properly to identify the place of storage for easy quick approach. The main objective of this activity is to minimize the search time for the required item, having control over the operations and improving the efficiency of the system.

Every item must have a proper place and every item must be placed kept in its place after use.

2.3. SEISO (SHINE)

The third “S” of the 5S is “Seiso” which means shine or keeping the workplace and items clean. The workplace must be maintained always with cleanliness. This can be achieved with regular inspection, cleaning at regular intervals, maintenance, preventive and immediate corrective action. Workplace with dust, unclean floors with dirt and oil stains or other wastes can cause sickness, accidents and reduces the efficiency of the system. One important point is to finding the root cause of the uncleanliness and taking the immediate action. Floors and walls of the workplace must be renovated or painted with appropriate colors for enhance the light source and easy identification of dust and stains to be cleaned. Tools and machinery must be kept clean after use. The main objective of this activity is to maintain clean and tidy working environment improve the efficiency of the system.

2.4. SEIKETSU (STANDAEDIZE)

The fourth “S” of the 5S is “Seiketsu” which means standardizing the following system or creating a consistent method to carry out the procedures followed. This activity is nothing but forming a standard system for the improved work practices that followed for 1S, 2S and 3S. Those best practices and procedures must be compiled and establish a standard to continue such that the system should not go back to a state before implementing 1S, 2S and 3S.

The standards should be very clear and understood. The developed standards must be written as per the procedures, communicated and made available for everyone. Standard operating procedures, standard work instructions and manuals must be promoted and followed strictly. The main objective of the activity is to standardizing the developed system and maintaining the consistency in the quality and productivity.

2.5. SHITSUKE (SUSTAIN)

The fifth “S” of the 5S is “Shitsuke” which means sustain in the standards set or making it as a habit of continuing the achieved success. The main objective of this activity is to maintain consistency in practicing the habits, culture, standards, discipline, achievements and integrity of the system. This can be achieved through regular audits, continual improvement and performance enhancement. It’s the responsibility of management to encourage the personnel by rewards and recognition.

2.6. TARGETED OUTCOMES

The basic objective of 5S methodology is “there is a place for everything and everything must be in its place”. 5S methodology helps in creating clean and systematic environment in any workplace.

1. Identifying non-value added activities and reducing them.
2. Identifying unused items in the shop floor and clearing them.
3. Identifying time waste activities followed by employees and controlling them.
4. Controlling unnecessary human motion in search of tools, instruments, gauges, any other items and saving time.
5. Identifying similar items placed at different locations and storing at one location.
6. Maximum utilization of floor space.
7. Improving the efficiency of the system.
8. Discipline and safety of the employees.
9. Bringing awareness and continual improvement.

III. LITERATURE SURVEY

Moradi M et al. [1] discussed about the attempts made by industries to implement Total Productive Management. It is felt that 5S is the foundation of the TPM and should be implemented before implementing TPM. Both 5S and TPM play a key role in increasing the performance of the system. They studied the relation between 5S and Total Productive Management.

Becker J E [2] discussed that 5S principle are often implemented only on a superficial level like posting slogans or painting floors and overlooking the optimization of safety process. The author felt that, safety efforts and manufacturing initiatives can be combined to achieve results.

Ho S et al. [3] emphasized the logic behind the 5S. Activities like organizing, neatness, cleanliness, standardization and discipline at the workplace are basic requirements for producing high quality products and service. 5S provides an essential Total Quality Environment which is an important base for implementing TQM successfully. The authors felt that TQM training policy should incorporate the 5S practice guidelines.

Michalska J et al. [4] stated that introducing the 5S rules bring the great changes in the company, for example: process improvement by costs' reduction, increasing of effectiveness and efficiency in the processes, maintenance and improvement of the machines' efficiency, safety increasing and reduction of the industry pollution, proceedings according to decisions.

Norzima Zulkifli et al. [5] studied 5S practice and implementation is very useful, applicable and beneficial. They concluded that 5S has positive effect on overall performance and could improve the quality, efficiency and productivity of industrial organizations

Jose H et al. [6] conducted an empirical study on some organizations with the aim of understanding their implementation experience, empirical relationships, and

ongoing challenges associated with the 5S practice. They concluded that 5S practice plays an important role facilitating the introduction and development of other quality and continuous improvement methods and techniques.

Marko Milosevic et al. [7] studied the 5S system both in the theoretical foundations, and through practical work in an international and domestic company. They concluded that 5S is an effective technique and can be taken as a main factor for improving quality management. Moreover they emphasized that the organizations have to put lot of efforts to bring this concept to the level of the creator of the concept of operations.

Ayush Khandelwal et al. [8] observed in their study that there is a reduction in time consumption and expenditure after the implementation of 5S and it has a positive impact on productivity. The result of time analysis clearly states that systematic organization and material handling can save a considerable amount of time. 5S methodology plays a crucial role in saving time and energy. The confidence and morale of the personnel has been improved with the implementation of 5S which resulted in improvement in total productivity.

5S is one of the most widely adopted techniques from the lean manufacturing toolbox. Along with Standard Work and Total Productive Maintenance, 5S is considered a "foundational" lean concept, as it establishes the operational stability required for making and sustaining continuous improvements [9].

Gapp, R et al. [10] found from their study several key concepts behind the Japanese approach to 5S management. These findings demonstrate the importance of both the technical (visible) and philosophical (invisible) approaches required for each of the 5S components and are discussed in a managerial rather than cultural framework.

Arash Ghodrati et al. [11] understood during their research process, that 5S technique is very useful and easily applicable. They identified some performance factors, performance indicators and effectiveness of 5S implementation on the organization performance. The authors concluded that 5S has positive effect on overall performance and could improve the quality, efficiency and productivity of industrial organizations.

Celebi, H. Tet al. [12] discussed the implementation of 5S and its influence on maintenance and total productivity with total quality perspective.

Ho, S. K. [13] reviewed 5S technique and explored the reasons for its wide use in Japanese factories. 5S has become foundation for TQM in most of the manufacturing and service industries. He discussed about the 5S implementation plan. Top level commitment and complete involvement of staff can help in implementing 5S

effectively. The author also discussed about the factors that act as barriers in implementing 5S.

O'h Eocha, M [14] explained in his study that how 5S implementation for environmental management be influenced by factors like company culture, employee attitude and communication system. He opined that 5S practice can result in considerable improvement in environmental performance, housekeeping and safety.

Rahman, M. N et al. [15] discussed about the evaluation of 5S practice through the implementation of 5S audit at each division in any company. 5S audit enables to identify the potential level of quality improvement. Abilities and weakness can be analyzed through 5S audit. They concluded that effective 5S practice can improve work place standards and performance of the company.

Warwood, S. Jet al. [16] reviewed the literature and conducted survey through questionnaire and interviews on the literature. They concluded that "practice and theory are closely related and any differences in the implementation of 5-S can be attributed mainly to the maturity of the 5-S programme".

Hiroyukiet al. [16] explained the 5S methodology. These steps are designed to provide continuous improvement and improve efficiency of the system. These 5S are the 5 pillars of the visual workplace.

IV. IMPLEMENTATION OF "5S" IN A METROLOGY LAB

It is understood through the literature survey that 5S is an effective tool and its implementation can bring a great change in the overall performance of the organization.

This study is carried out systematically in a metrology lab of an organization and analyzed the results.

4.1. Preliminary steps carried out before 5S implementation:

1. Thoroughly understood the activities in the metrology lab.
2. Studied the system followed in the lab and its targets.
3. Recorded the approximate time taken for each activity.
4. Identified the barriers which are stumbling blocks for the implementation and how to overcome.
5. Explained the personnel about 5S and its need of implementation through success stories.
6. Carried out motivational and training program on 5S.
7. Brought awareness on the individual responsibility and team work that helps the successful implementation of 5S.

8. Defined responsibilities to every individual to carry out the activities involved for the implementation of 5S methodology.

4.2. How the 5S is implemented:

5S is implemented in a systematic way and the series of steps carried out is explained briefly. Implementation of 5S is shown in Flow chart-1.

Seiri (Sort):

1. Identified what is needed and what is not needed.
2. Removed all the items from the work place that are not needed at present and Red Tagged with all details.
3. Red tagged items are moved to a place called "Red Tagged Area". Red tagged items will be reviewed later whether they can be used or disposed accordingly.
4. Lot of place is recovered to keep the needed items.

Seiton (Set in Order):

1. Prepared a layout to place Surface tables, Inspection tables, machines, tools, instruments and gauges, components etc.
2. Locations have been defined and marked for every item according to their frequency of usage and easy pickup.
3. Practiced to keep every item at its defined place after every use.
4. Defined places and walkways are marked with different colors for easy and smooth flow.

Seiso (Shine):

1. Floors have been cleaned.
2. Machines, tools, instruments and gauges have been cleaned.
3. Storing shelves and inspection tables have been cleaned.

Seiketsu (Standardize):

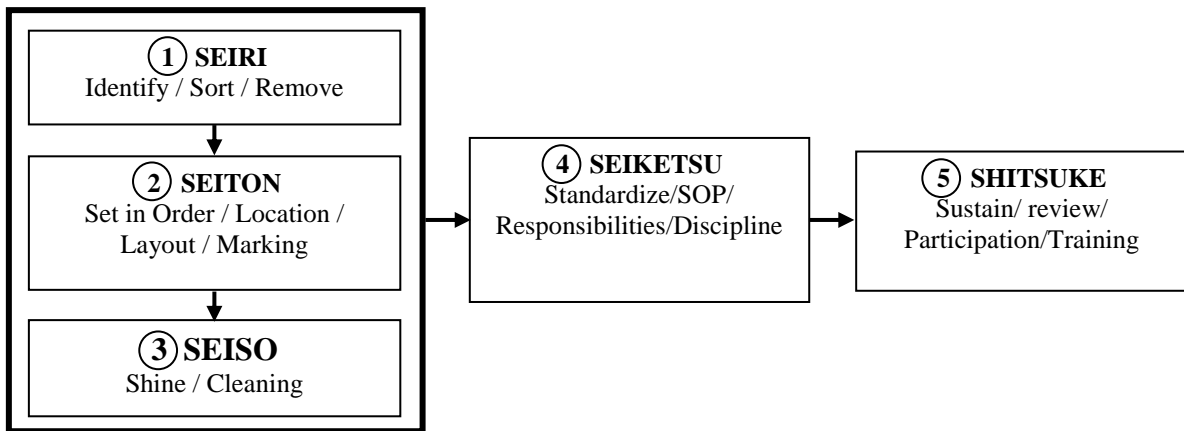
1. Established a Standard Operating Procedure (SOP) by integrating 3S activities into regular duties and practiced to follow the SOP for all activities.
2. Everyone has been given responsibilities to take up the activities individually.
3. Instructed to maintain the discipline at work.
4. Instructed to follow the rules and regulations of the organization.
5. Instructed to follow the standards of the Metrology lab.

Shitsuke (Sustain):

1. Practiced to maintain the consistency in practicing 5S and making 5S as a habit.
2. Practiced to review the system by regular audits.

3. Encouraged everyone to be part of 5S.
4. Used the tools such as “5S manuals, 5S slogans, 5S posters, 5S training programs etc.

**Flow Chart-1
IMPLEMENTATION OF 5S**



VISUAL CHANGES AFTER 5S IMPLEMENTATION

Visual observations before implementing 5S are shown in Figure-1 to Figure-8. Similarly visual observations after implementing 5S are shown in Figure-1(a) to Figure-8(a).

BEFORE 5S

AFTER 5S



Figure-1



Figure-1(a)



Figure-2



Figure-2(a)



Figure-3



Figure-3(a)



Figure-4



Figure-4(a)



Figure-5



Figure-5(a)



Figure-6



Figure-6(a)



Figure-7



Figure-7(a)



Figure-8



Figure-8(a)

4.3. Identified the Activities carried out / process followed in the Metrology Lab:

1. Receiving the components for inspection.
2. Entering in the incoming register / log book.
3. Identifying the instruments for inspection.
4. Identifying gauges for the inspection.
5. Cleaning the components before inspection.
6. Carrying out the dimensional inspection of components.
7. Preparing for NDT checks.
8. Marking and weighing the components.
9. Preparation of reports.
10. Dispatching after completion of all activities.

V. RESULTS AND DISCUSSIONS

5.1. Data collected from personnel through questionnaire:

Employees were asked to give their points ranging 1 to 5 for time taken to each activity based upon the “times and points table” provided in Table-1. An aero engine component is provided for them to estimate the times and points for all the activities mentioned in 4.3.

Data has been collected from 10 employees of the metrology lab through questioner regarding the approximate times taken for each activity before implementing 5S and it is shown in Table-2. The questions are named as A1 to A10 for the 10 activities identified in 4.3, and employees are named as E1 to E10.

Table-1
Times and Points Table

Activity	Time taken for the activity in Minutes/ Points to be given				
1	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
2	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
3	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
4	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
5	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
6	< 10 = 1	11-30 = 2	31-60 = 3	61-90 = 4	>90 = 5
7	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
8	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5
9	<20 = 1	21-30 = 2	31-40 = 3	41-50 = 4	>50 = 5
10	< 05 = 1	06-10 = 2	11-15 = 3	16-20 = 4	>20 = 5

Table-2
Points obtained from employees for each activity before implementing 5S

Activity	Points obtained from 10 Employees E1-E10										Average Time Taken
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	
A1	2	2	1	2	2	1	1	2	2	2	1.7
A2	3	2	2	3	3	3	3	3	3	2	2.7
A3	4	4	4	4	3	2	3	3	4	4	3.5
A4	4	5	5	3	5	4	5	5	4	4	4.4
A5	3	4	4	4	3	4	3	3	3	4	3.5
A6	5	5	5	5	5	5	5	5	5	5	5.0
A7	2	3	2	3	3	2	3	3	3	3	2.7
A8	4	4	4	3	4	4	3	4	4	4	3.8
A9	4	4	5	5	5	5	5	4	5	5	4.7
A10	3	3	2	3	3	2	2	2	2	3	2.5
Time Consumption for A1-A10	34	36	34	35	36	32	33	34	34	36	34.5

Similar exercise has been carried out to collect the data from the employees for the same activities after implementing 5S methodology in the metrology lab and details are shown in Table-3.

Table-3
Points obtained from employees for each activity after implementing 5S

Activity	Points obtained from 10 Employees E1-E10										Average Time Taken
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	
A1	1	2	1	1	2	1	1	1	2	1	1.3
A2	1	2	1	1	2	2	2	2	2	1	1.6
A3	3	3	3	2	2	1	1	2	3	3	2.3
A4	3	3	4	2	4	3	4	4	3	3	3.3
A5	2	3	3	2	2	3	3	2	2	3	2.5
A6	3	4	4	4	4	3	4	4	4	4	3.8
A7	1	2	2	2	2	1	2	2	2	1	1.7
A8	3	3	3	3	3	3	2	3	3	3	2.9
A9	3	3	3	3	4	4	3	3	4	4	3.4

A10	2	2	1	2	2	1	1	1	1	1	1.4
Time Consumption for A1-A10	22	27	25	22	27	22	23	24	26	24	24.2

5.2. Analysis of Data:

The data obtained from Table-2 and Table-3 is used to study the “Effect of 5S on Time consumption for each activity” and “The effect of 5S on Time consumption by each employee to complete all the activities”. The results are shown in Table-4 and Table-5.

Table-4
Effect of 5S on Time Consumption for Each Activity

Activity	Average Time Taken		Time saved in each activity due to 5S implementation	% of Time saved in each activity due to 5S implementation
	Before 5S	After 5S		
A1	1.7	1.3	0.4	23.53 (min)
A2	2.7	1.6	1.1	40.74
A3	3.5	2.3	1.2	34.29
A4	4.4	3.3	1.1	25.00
A5	3.5	2.5	1.0	28.57
A6	5.0	3.8	1.2	24.00
A7	2.7	1.7	1.0	37.04
A8	3.8	2.9	0.9	23.68
A9	4.7	3.4	1.3	27.66
A10	2.5	1.4	1.1	44.00 (Max)

Table-5
Effect of 5S on Time consumption by each employee to complete all the activities

Employee	Time Consumption from A1 to A10		Time saved due to 5S implementation	% of Time saved due to 5S implementation
	Before 5S	After 5S		
E1	34	22	12	35.29
E2	36	27	09	25.00 (min)
E3	34	25	09	26.47
E4	35	22	13	37.14 (Max)
E5	36	27	09	25.00
E6	32	22	10	31.25
E7	33	23	10	30.30
E8	34	24	10	29.41
E9	34	26	08	23.53
E10	36	24	12	33.33

It is observed from the data calculated in Table-4 that the time consumption for each activity after 5S implementation is decreased. Percentage of time saved due to 5S implementation is increased to a minimum of 23.53% and up to a maximum of 44%.

Similarly it is observed from the data calculated in Table-5, the time consumption to complete all the activities by each employee after 5S implementation is decreased. Percentage of time saved due to 5S implementation is increased to a minimum of 25% and up to a maximum of 37.14%.

The variation in time consumption for each activity before implementing 5S and after implementing 5S is shown in Figure-9 and Figure-10. The percentage of time saved in each activity due to the implementation of 5S is shown in Figure-11.

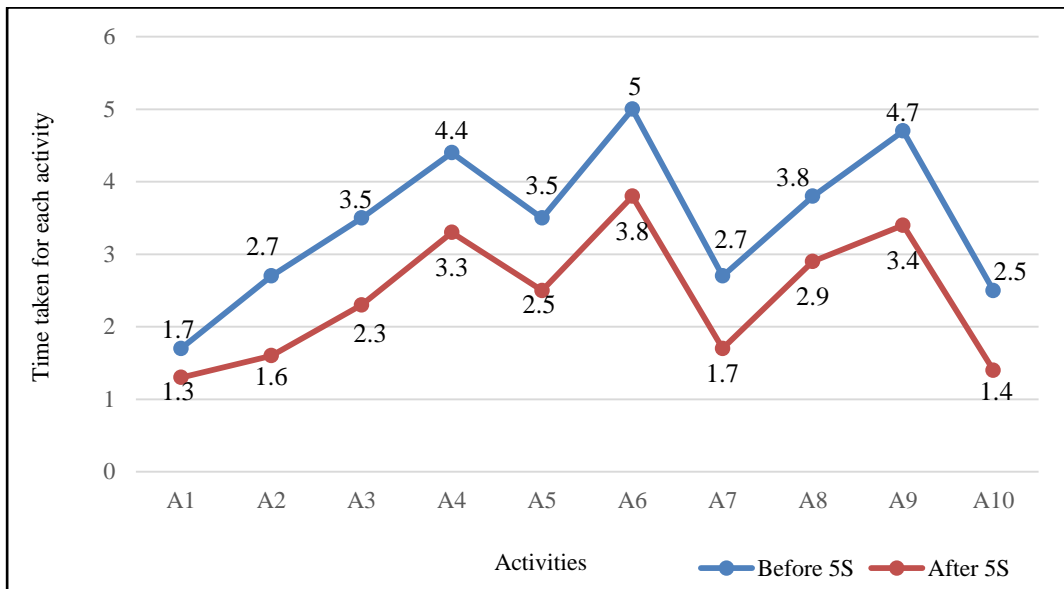


Figure-9
Variation in Time Consumption for Each Activity

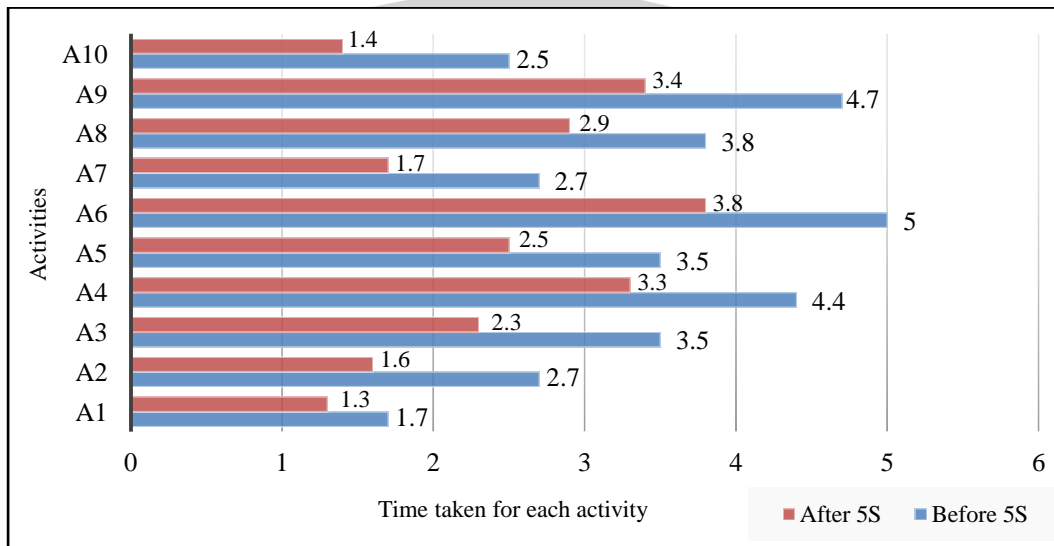


Figure-10
Variation in Time Consumption for Each Activity

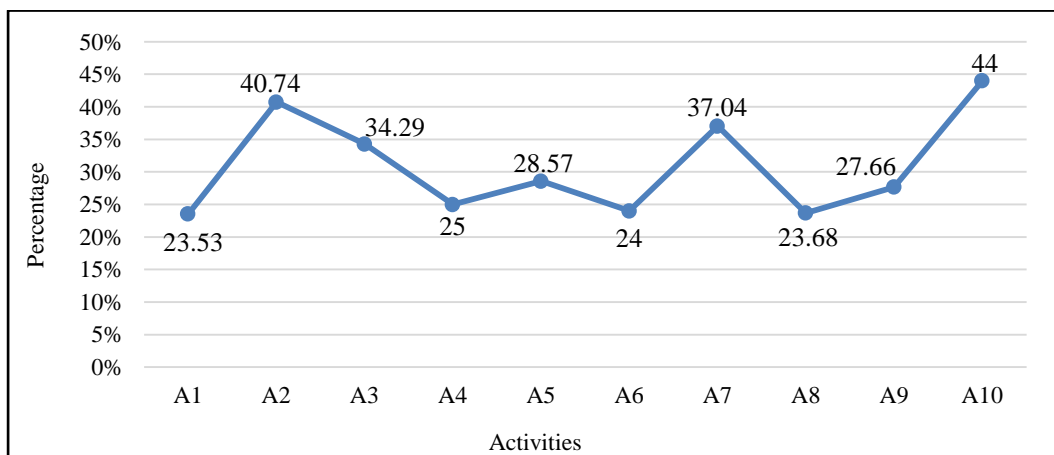


Figure-11
Percentage of Time Saved in Each Activity Due To 5S Implementation

The variation in time consumption by each employee to complete all the activities before and after the implementation of 5S is shown in Figure-12 and Figure-13. The percentage of time saved by each employee for completing all the activities due to the implementation of 5S is shown in Figure-14.

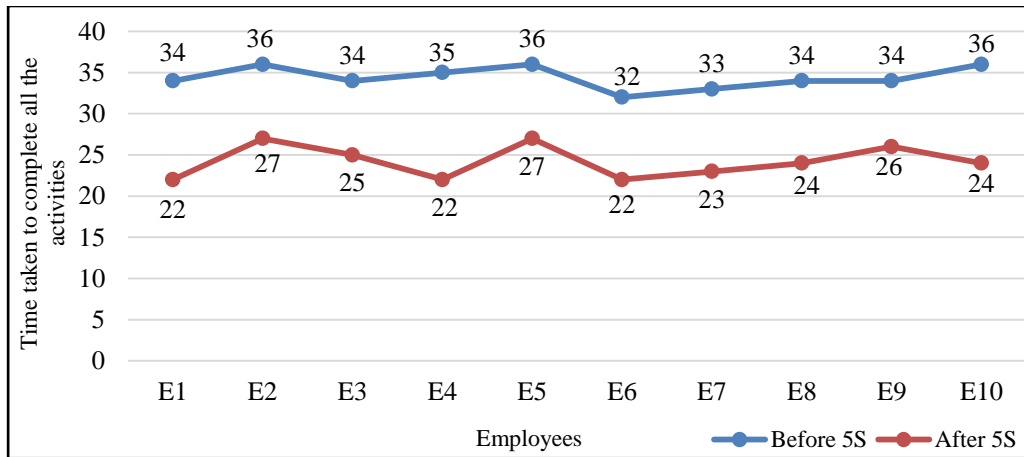


Figure-12
Variation in Time Consumption by Each Employee to complete all the Activities

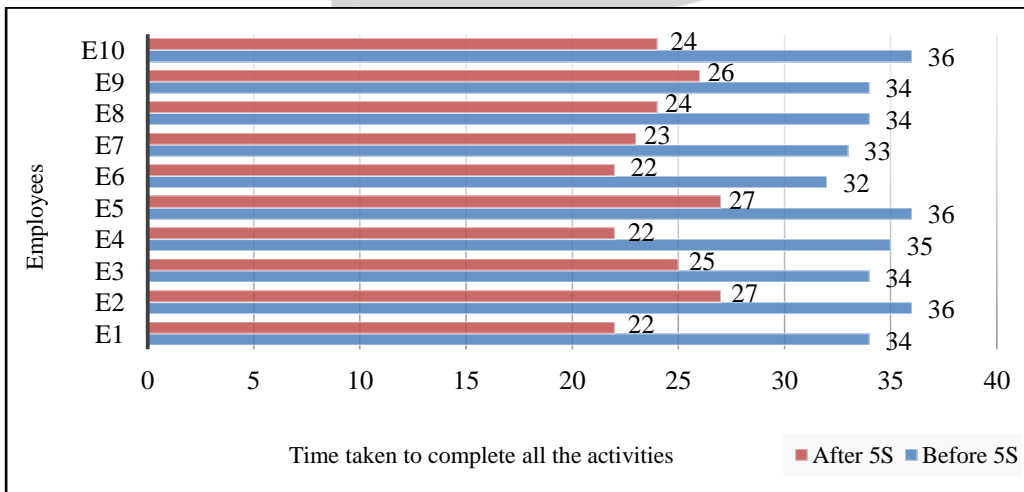


Figure-13
Variation in time consumption by each employee to complete all the activities



Figure-14
Percentage of Time Saved by Each Employee to complete all the Activities Due To 5S Implementation

It is observed from the data recorded in Table-4 and Table-5, time consumption to carry out the given activities is reduced. It is clear that 5S implementation has helped in saving time for individual activities and also as a whole in completing the given task.

VI. CONCLUSIONS

The results from the study clearly show that 5S is very effective tool and it can bring a great change in the working place. Utilizing the available working area in a systematic way is the basic principle of 5S and helps in reducing the delays and accelerating the process. The implementation of 5S in the metrology lab brought visual and environmental changes that could encourage the employees to perform their activities effectively. Metrology lab is where the complete inspection activities are taken place using various precision instruments, gauges and measuring machines. They need to be kept in a clean room environment to achieve error free measurements.

This study helped in achieving improved results in a metrology lab by implementing 5S. Time consumption for searching the instruments, gauges, documents and other required tools is reduced as they are arranged orderly and labeled for easy identification. The targeted outcomes such as identifying non-value added activities, identifying unused items, identifying time waste activities, controlling of unnecessary human motion, maximum utilization floor space are achieved. These outcomes resulted in saving of time and improved the efficiency of the system. This study helped in understanding the 5S methodology and its effect on efficiency of the system. It can be concluded that 5S implementation has an impact on overall performance of an organization.

VII. FUTURE SCOPE

The study can be extended by implementing 5S methodology in other sections of Quality Assurance Group and its effect on metrology lab.

VIII. ACKNOWLEDGEMENTS

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REFERENCES

- [1] Moradi, M., M. Abdollah zadeh, and A. Vakili. Effects of implementing 5S on Total Productive Maintenance: A case in Iran. 2011: IEEE.
- [2] Becker, J.E., Implementing 5S to promote safety & housekeeping. Professional Safety, 2001. 46(8): p. 29-31.
- [3] Ho, S., S. Cicmil, and C.K. Fung, The Japanese 5-S practice and TQM training. Training for Quality, 1995. 3(4): p. 19-24.

[4] J. Michalska, D. Szewieczek, The 5S methodology as a tool for improving the organization, Journal of Achievements in Materials and Manufacturing Engineering, Volume 24(2), October 2007, 211-214.

[5] Arash Ghodrati, Norzima Zulkifli, The Impact of 5S Implementation on Industrial Organizations' Performance, International Journal of Business and Management Invention, vol.2(3), 2013, 43-49.

[6] Jose H. Ablanedo-Rosas, Bahram Alidaee, Juan Carlos Moreno and Javier Urbina - Quality improvement supported by the 5S, an empirical case study of Mexican organizations, International Journal of Production Research, Vol. 48 (23), 1 December 2010, 7063-7087.

[7] Marko Milosevic , Ivan Macuzic , Petar Todorovic , Marko D japan , Evanthia Giagloglou, jordje Vuckovic, Implementation of 5S system as a factor for improving the quality management, 7th International Quality Conference, Center for Quality, Faculty of Engineering, University of Kragujevac May 24-2013.

[8] Ayush Khandelwal, Prathik R., Rahul P. Kikani, Vigneshwaran Ramesh (September 2014); "5S implementation and its effect on physical workload"; IJRET: International Journal of Research in Engineering and Technology, Coimbatore, Tamil Nadu, India; eISSN: 2319-1163, p ISSN: 2321-7308; Volume: 03 Issue: 09; pp. 437-439.

[9] Brady Worldwide Inc. (2008) 5S/Visual Workplace Handbook: Building the Foundation for Continuous Improvement.

[10] Gapp, R., Fisher, R. and Kobayashi, K. (2008) 'Implementing 5S within a Japanese context: an integrated management system', Management Decision, Vol. 46, No. 4, pp.565-579.

[11] Arash Ghodrati, Norzima Zulkifli,(2013), "The Impact of 5S Implementation on Industrial Organizations", International Journal of Business and Management Invention, Vol. 2, Issue 3, pp-43-49.

[12] Celebi, H. T. (1997). 5S and total productive maintenance with total quality perspective (Doctoral dissertation, M. Sc. Thesis, Istanbul University, Institute of Science, Istanbul, Turkey).

[13] Ho, S. K. (1997). Workplace learning: the 5-S way. Journal of Workplace Learning, 9(6), 185-191.

[14] O'h Eocha, M. (2000). A study of the influence of company culture, communications and employee attitudes on the use of 5S for environmental management at Cooke Brothers Ltd. The TQM Magazine, 12(5), 321-330.

[15] Rahman, M. N., Khamis, N. K., Zain, R. M., Deros, B. M., & Mahmood, W. H. (2010). Implementation of 5S practices in the manufacturing companies: A case study. American Journal of Applied Sciences, 7(8), 1182-1189.

[16] Warwood, S. J., & Knowles, G. (2004). An investigation into Japanese 5-S practice in UK industry. The TQM Magazine, 16(5), 347-353.

[17] Hirano and Hiroyuki, "5 Pillars of the Visual Work-place", Cambridge, MA: Productivity Press 1995.