Plant Renovation Project

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Abstract *— The 5S is a Lean methodology widely used for companies to address their workplace organization and cleanliness For this project, it was applied at Linde, Puerto Rico. Employee and equipment downtime increased due to poor inventory organization and management. Therefore, the 5S were performed for the areas that needed urgent organization. Employee downtime was reduced from 10% to 4% average downtime and a benefit of $1,500 was acquired. Long-term benefits are expected to keep reducing employee downtime and to maintain a culture of cleanliness in workplace environment. Standards were placed to promote continuous improvement and broken windows theory to sustain company efforts.*

Key Terms *— 5S Implementation, Continuous Improvement, Culture, Lean*

INTRODUCTION

Linde is a company that its business focuses on manufacturing chemical gases, such as Dry Ice, Helium, Hydrogen, Acetylene and, in Puerto Rico, it mainly produces Nitrogen, Oxygen, and Argon. It has a variety of clients which vary from hospitals, welding shops, pharmaceutical and manufacturing companies. Recently, the plant has overgone internal assessments and audits that have indicated that many areas of the plant are cluttered with spare parts and equipment that have not been identified, organized, or monitored. Disorder in the warehouses have been reported that has impacted employee downtime since when looking for a particular item employees took too much time trying to identify it and even in some cases the item wasn't found which in some cases can incur in significant losses for the company.

The objective of this project was to optimize operational efficiency and workplace safety at Linde, Puerto Rico. For this, the 5S methodology was systematically implemented to reduce waste, enhance productivity, and provide a cleaner working environment.

BACKGROUND

5S is a Japanese system designed to reduce waste and optimize productivity by maintaining an orderly workplace and using visual cues to achieve consistent operational results. Organizations use 5S to clean and maintain workplaces, providing low-cost, long-term benefits [1]. Recently, it has been noted that waste accumulation and lack of organization can negatively impact employee productivity. However, companies like Toyota, Amazon, and McDonald's have successfully implemented 5S, enhancing their operations and motivating employees through a cleaner, more organized environment. The five principles of 5S are:

- Seiri (Sort): Identify and remove unnecessary items to reduce clutter, promoting safer, more spacious areas [2].
- Seiton (Set in Order): Organize remaining items for easy access, with important items strategically placed and an inventory maintained [3].
- Seiso (Shine): Keep the workspace clean and fix any broken equipment to prevent small messes from growing [4].
- Seiketsu (Standardize): Create guidelines and schedules to maintain the first three steps [5].
- Shitsuke (Sustain): Develop a culture of continuous improvement, ensuring the consistent application of all steps. The Broken Windows Theory is introduced here to maintain cleanliness and prevent disorder [6].

METHODOLOGY

The 5S methodology was applied in its consequential phases. As mentioned before; the five phases are Sort, Set in Order, Shine, Standardize, and Sustain.

The Sort phase was carried out by categorizing equipment and parts into necessary, unnecessary and/or needed repairs. Parts that are unnecessary were distributed into the type of waste it was, for example papers, general waste, wood, and metals. For each type of equipment category, temporary containers were distributed in the plant for proper disposal. Papers were crushed and recycled, general waste as regularly done, wood was gathered and taken care of, and metals were also disposed of and sold as scrap metals. Necessary items were piled up in the warehouses of the plant, instrumentation, and equipment warehouses to be organized. The items that were labeled as needed repairs were sent for repairs on a basis of 2 or 3 pieces of equipment per week. Once they are repaired, they were added as refurbished equipment.

Consequently, the Set in Order phase was deployed after equipment was disposed of and all necessary materials were gathered to be organized. First, instruments and small equipment were located in a 20 feet trailer prepared with shelves to organize the equipment. Frequently used items will be located closer for faster material identification. Shelves will be organized and labeled for instruments of plant major equipment, such as motors, and pumps. The equipment warehouse was arranged for major spare parts that need more space to be organized. On one side of the warehouse were organized major equipment parts and on the other side of the warehouse a small working station and shelves were added to organize personal protective equipment, small and medium scale spare parts, adsorption materials, janitor equipment, and safety equipment for spills and prevention. While everything was being organized in the warehouse an inventory record was created where equipment was labeled, and quantities recorded for further inventory control. Since there weren't any rules regarding who can access the warehouses, an authorized access personnel sheet was redacted where access is only available for employees. Subsequently, the shine phase follows and took place cleaning and shining what was left of the set in order phase.

In the Shine phase, the equipment warehouse was thoroughly clean with solutions established by company standards for equipment in oxygen service or inert gases service. Since some major equipment cannot be moved easily, they were cleaned on the space they were. In addition, the floors and overall warehouse's structure was also cleaned with pressure washer machine. Employees were incorporated during the process to promote a culture of workplace cleanliness.

To make it a culture of workplace cleanliness, the Standardized phase was arranged. Standards were developed for inventory control and management, equipment organization, and workplace cleanliness; to ensure that a continuous improvement culture is promoted.

Finally, for the Sustain phase, all four previous phases will be enforced on a frequent basis and the broken windows theory will be introduced. The broken windows theory acted as a bridge since it supports the implementation of the 5S by replacing, repairing and/or cleaning anything that broke down as soon as possible to eliminate the belief or idea of disorganization.

RESULTS

Employees were given an employee ID and tasked to record every time they visited the warehouse and their time spent finding equipment or parts. The data acquired is presented in Table 1.

The data presented in Figure 1 showed that employees have a downtime average of 10 minutes for looking for a specific part. In some cases, parts were not found, they weren't modeled but were taken into consideration in the Set in Order phase to establish inventory records and organize items as they are most frequently used closer to the employee than other equipment or parts. To

compare the data obtained before the 5S implementation a scheduled “search & rescue” was implemented to record employees time for finding equipment after the 5S implementation, the information obtained was recorded in Table 2. However, in Figure 2 it can be observed how the implementation of the methodology effectively reduced employee downtime.

After the 5S implementation, a series of runs were recorded where each employee had to find equipment and its time was recorded. In this exercise was found that the average downtime of employees searching for equipment in the warehouse was reduced from 10-12 minutes per employee to 4 minutes on average. It reduced the downtime, but it can be reduced even more by taking into consideration what was learned from the runs. In addition, the implementation included disposing of scrap metals, which added up to $1,500 since it was a lot of metals sold as scrap. Standards to maintain the implementation were created in which inventory and restocking is managed by plant management, organization is an ongoing task for every employee where on a monthly basis everyone will have a brief cleaning of their workplaces, and to maintain cleanliness the broken windows theory will be deployed.

Table 1
Employee Downtime Data

ID	1	2	3	4	5	6	7	8	9	10
A	8	4	20	10	5	15				
B	12	28	11	8	13	20				
C	18	16	13	15	7	4	10	13		
D	20	15	18	10	12	14	17	15	11	12
E	15	3	8	11	9	17	5	8	10	
F	12	10	17	27	30					

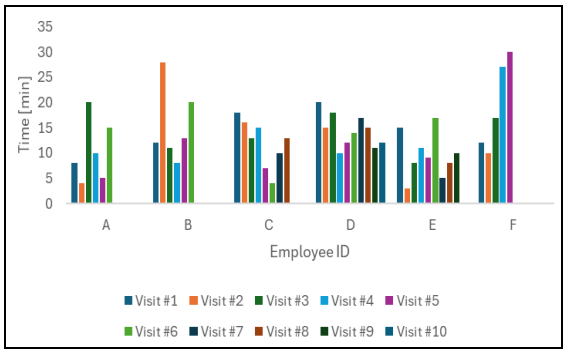

Figure 1
Employee Downtime

Table 2
Employee Corrected Downtime Data

ID	1	2	3	4	5	6	7	8	9	10
A	3	7	2	5	1	8	6	4	2	7
B	6	1	4	8	3	5	7	2	6	1
C	5	2	8	3	7	4	1	6	8	5
D	4	6	1	7	2	8	3	5	1	4
E	2	5	7	1	6	3	8	4	7	2
F	8	3	6	4	5	1	2	7	3	6

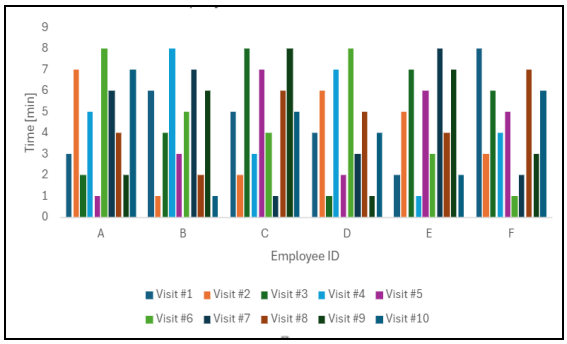

Figure 2
Employee Corrected Downtime

CONCLUSION

The implementation of the 5S methodology must be a standard for all companies in which they create and promote a culture of continuous

improvement and workplace cleanliness. By providing clean and pleasant environments people are more efficient and more motivated to perform. In addition, it is a low-cost project that has major long-term benefits for the organization. It also has the opportunity to gain some capital by selling materials that are unnecessary for operations but maybe usable for other people. The project effectively reduced employee downtime while looking for equipment at the warehouses, inventory was created and can be controlled, and culture of organization was built up. Also, the broken windows theory will help us maintain the culture expected in the workplace.

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