Implementation of Evaporator to Minimize Wastewater Disposal

Yolimar Colón Berríos
Master in Manufacturing Competitiveness
Advisor: José A. Morales, Ph.D.
Industrial and Systems Engineering Department
Polytechnic University of Puerto Rico

Abstract *— The medical device company currently has two areas in which the processes generate wastewater classified as Non-Hazardous. The current process involves expenses to subcontracted services for disposal, recurrent purchasing of containers and manpower dedicated to the collection, documentation and movement of wastewater. The activity performed by associates during the process of collection and managing of wastewater, represent an opportunity related to ergonomics beside the environmental impact. The installation of a wastewater evaporator which will allow to reduce current amount of waste disposal, its related costs and will eliminate the ergonomic opportunity in associates that perform this task as well to reduce the environmental impact that this process cause.*

Key Terms *— Cost Reduction, Ergonomic and Environmental Impact, Evaporator, Wastewater.*

PROBLEM STATEMENT

The medical device company currently has two areas in which the processes generate wastewater classified as Non-Hazardous. The current process involves expenses to subcontracted services for disposal, recurrent purchasing of containers and manpower dedicated to the collection, documentation and movement wastewater. The activity performed by associates during the process of collection and managing of wastewater, represent an opportunity related to ergonomics beside the environmental impact. The installation of a wastewater evaporator which will allow to reduce current amount of waste disposal, its related costs and will eliminate the ergonomic opportunity in associates that perform this task as well to reduce the environmental impact that this process cause. Currently the cost is $10k/yr and $14K/yr for discarding and container purchase respectively.

INTRODUCTION

The medical device company as a part of its policy search to bring innovative solution to achieve competitive cost reduction and safe environment.

This company generates several non-hazardous wastes, mostly composed of water. Non-hazardous waste is any type of industrial waste which, according to regulations, cannot be added to a dumpster or sewage line. As a result, at present, the way in which all the waste of the company is disposed of is by burying them in different established areas, which brings risk to the environment.

It is important to know that all water that has been affected or used in some industrial, commercial or domestic process is known as wastewater. These waters may contain chemical or biological contaminants therefore they must be evaluated before disposal. For this reason, a Full RCRA (Resource Conservation and Recovery Act) Analysis must be carried out for the identification of hazardous metals and with that documentation the correct disposal can be carried out. In addition to the environmental factor that represents the current waste disposal this situation brings economic, ergonomic and space problems.

Ergonomic refers to the set of applied scientific knowledge so that work, systems, products and environments are adopted to the physical and mental capacities and limitations of the person [1]. There are two types of loads to which they are subjected at work, physical and mental load.

In our case we will be impacting both but to a large extent the physical load since as I mentioned there are risk factors such as load handling and repetitive movements. This can lead to musculoskeletal diseases such as tears and fatigue. On the other hand, we will be releasing the mental burden since the associate may engage in other operations tasks in which he does not incur in cargo handling.

As a solution to the current problem, the implementation of an evaporator was proposed to dispose of non-hazardous waste in the two areas of the plant that have more waste. Currently these areas generate an approximate of 18,000gal/yr. The goal is to be able to dispose of all the waste of the company which is 62,000 gal/yr.

Different companies currently use evaporators to dispose their waste. For this reason, the implementation of an evaporator has been the first option, and in accordance with federal local regulations including those promulgated by the Puerto Rico Environmental Quality Board (EQB), the Puerto Rico Aqueducts and Sewer Authority (PRASA) and the Federal Environmental Protection Agency (EPA) is the more viable option.

At present, as mentioned ‘an approximate waste of 18,000gal/yr is generated and this is only in two areas of the site. Therefore, it is important that the evaporator to be selected has a minimum capacity of 10 gph.

An evaporator is a simple unit with an insulated tank to prevent safety issues. It includes temperature and level controller for a safe and stand-alone operations. An ENCON drum evaporator will be acquired. This system is electrically heated and can operate in batch mode or the optional auto-fill mode. A great advantage of the ENCON is that the dry residue does not have to be scraped or removed from the evaporation vessel. The drum can simply be capped and hauled off for disposal.

The evaporator completely encapsulates a 55gallon drum of wastewater and heats it from the outside, thereby eliminating contact of heating elements with the waste waters.

The equipment to be implemented has two options which are fill pump and auto fill system. The fill pump option is a simple evaporator which has a pump to place the water in the tank manually. The auto fill system includes the fill pump and has a system capable of automatically carrying water to the tank. It is important to know that the installation of either of the two equipment must have to be in an area that does not contain any type of fuel. These evaporators are prone to spills or accidents which will not be covered by the manufacturer's warranty. Also, it’s important to know that the equipment has a useful life of approximately 10 years this will be depending on the use and maintenance.

The DMAIC tool will be used to implement the equipment. DMAIC is an iterative tool used for process improvement. DMAIC is an abbreviation of the five improvement steps it comprises: Define, Measure, Analyze, Improve and Control [2]. The Define part focuses on clearly defining or interpreting the business problem. Measure is the part where the data collection is carried out, in the case of the evaporator the crucial data will be the costs of disposal and quantity. In the Analyze step, we focus on validating the data and seeing how the root cause of the problem can be eliminated. Improve is the part where we will be looking for the most viable solution to the problem. Finally, the Control step, the purpose of this step is to embed the changes and ensure sustainability.

METHODOLOGY

This project uses DMAIC as logical steps that link tools and techniques sequentially and as a data-based strategy. During the process, a SIPOC was developed to map the current process in this way it is easier to identify the root cause of the problem since it provides us with a macro view of the process or product flow and its interrelations within the business. Basically, the SIPOC defines the limits of the process, the starting and ending point of the process that needs improvement [3]. Describe the suppliers, the process inputs, the process itself, the outputs and the customers.

In figure 1 can observe in detail the SIPOC related to the process of disposal of waste in the plant. Basically, two units are the ones impacted in this implementation which become the suppliers. As inputs we have the operator who is responsible for collecting waste and acquiring drums. The process involves a series of maintenance performed in each area of which non-hazardous waste is disposed. This waste will be placed in designated areas in the plant so that they are eventually collected by the external company in charge of their disposal which becomes our customers.

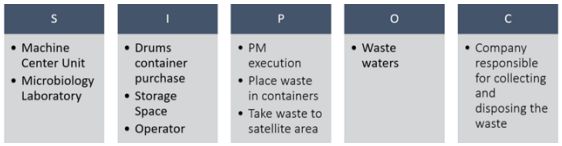


Figure 1
SIPOC Diagram for the Wastewater Disposal

After the evaporator implementation, this panorama should change in the inputs and process part. This is because the storage area for drums or waste will no longer be necessary. Likewise, on the other hand the process will no longer involve transport to the satellite area since they will be directly discarded in the evaporator. In figure 2 the SIPOC can be seen.

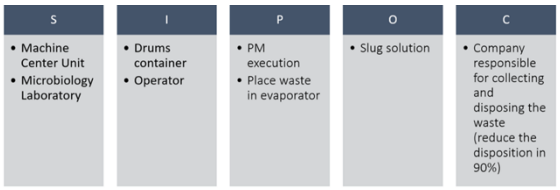


Figure 2
SIPOC after Evaporator Installation

As much data as possible from the process was collected. The data of the year from both purchase and disposal of drones was reviewed. This is to be able to obtain the savings that must be obtained at the time of implementing the evaporator.

In addition, a process flow of the evaporator implementation was carried out, this helps to have a clearer idea of the steps to be executed, to organize and to designate personnel for each part of the implementation. This project involves a lot of documentation when implementing the evaporator.

The first part consists in making a proposal at the managerial level which is tied to a capital investment. After the capital is approved, the equipment must be acquired. During the waiting period, the process of requesting regulatory environmental permits, permits relevant to the quality area, construction permits and equipment installation in the production area will begin.

An evaluation of the electrical system of the area must be done before proceeding to build. After the installation process, all types of documentation must be filled in order to place the equipment in our system. Reaching this point in the project could take about 4 months.

In addition to the evaporator implementation, an equipment qualification must be carried out to be able to certify that the service it will provide is consistent and accurate. Therefore, prerequisites and parameters in which the evaporator must operate must be verified before executing.

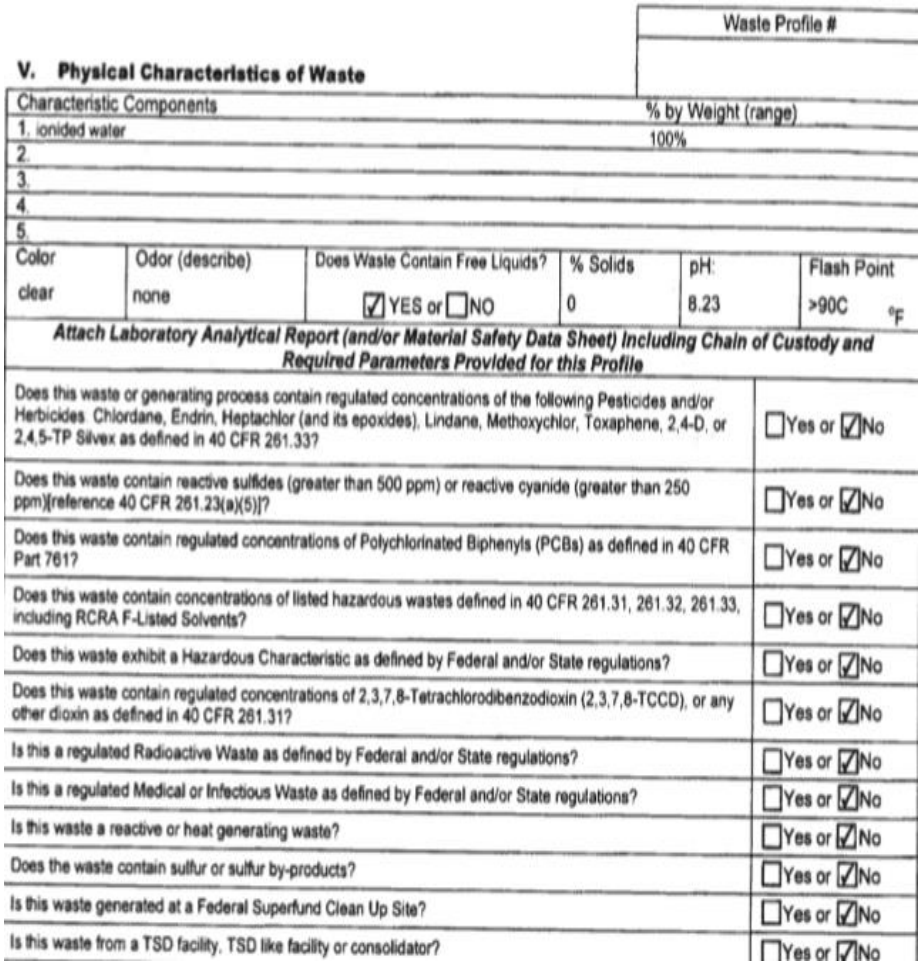
It must be ensured that the equipment fulfils the function established in a safe way. For this, it must be installed according to the manufacturer's instructions and verify that it is consistent.

To ensure that all of these needs are met, installation qualification (IQ), operational qualification (OQ) and performance qualification (PQ) will be performed [4].

The estimated date for complete the project is for jun/2020 and the project is estimated to be $39,967. The payback is approximately 3 year.

RESULTS AND DISCUSSION

Two equipment was proposed for the solution of the problem. Before proceeding to select an equipment, the water to be disposed was evaluated with an external company with a Full RCRA Analysis, since only non-hazardous waste is allowed. As a result of this evaluation, all the disposal can be evaporated since they do not contain any type of toxic substance. The report can be seen in figure 3.



Waste Profile #

V. Physical Characteristics of Waste

Characteristic Components	% by Weight (range)
1. ionided water	100%
2.	
3.	
4.	
5.	

Color	Odor (describe)	Does Waste Contain Free Liquids?	% Solids	pH:	Flash Point
clear	none	☑ YES or ☐ NO	0	8.23	>90C °F

Attach Laboratory Analytical Report (and/or Material Safety Data Sheet) Including Chain of Custody and Required Parameters Provided for this Profile

Does this waste or generating process contain regulated concentrations of the following Pesticides and/or Herbicides: Chlordane, Endrin, Heptachlor (and its epoxides), Lindane, Methoxychlor, Toxaphene, 2,4-D, or 2,4,5-TP Silvex as defined in 40 CFR 261.33?	☐Yes or ☑No
Does this waste contain reactive sulfides (greater than 500 ppm) or reactive cyanide (greater than 250 ppm)[reference 40 CFR 261.23(a)(5)]?	☐Yes or ☑No
Does this waste contain regulated concentrations of Polychlorinated Biphenyls (PCBs) as defined in 40 CFR Part 761?	☐Yes or ☑No
Does this waste contain concentrations of listed hazardous wastes defined in 40 CFR 261.31, 261.32, 261.33, including RCRA F-Listed Solvents?	☐Yes or ☑No
Does this waste exhibit a Hazardous Characteristic as defined by Federal and/or State regulations?	☐Yes or ☑No
Does this waste contain regulated concentrations of 2,3,7,8-Tetrachlorodibenzodioxin (2,3,7,8-TCCD), or any other dioxin as defined in 40 CFR 261.31?	☐Yes or ☑No
Is this a regulated Radioactive Waste as defined by Federal and/or State regulations?	☐Yes or ☑No
Is this a regulated Medical or Infectious Waste as defined by Federal and/or State regulations?	☐Yes or ☑No
Is this waste a reactive or heat generating waste?	☐Yes or ☑No
Does the waste contain sulfur or sulfur by-products?	☐Yes or ☑No
Is this waste generated at a Federal Superfund Clean Up Site?	☐Yes or ☑No
Is this waste from a TSD facility, TSD like facility or consolidator?	☐Yes or ☑No

Figure 3
Report Form

Analytical Report

Additionally, a cost evaluation of both equipment (figure 5) was carried out taking into consideration the energy consumption, resources required and the payback period. The seconds option proposed was the ideal as it allows to dispose the waste automatically, which implies the elimination of purchase and disposal of drums and therefore the elimination of ergonomic risks. Due to the investment cost, the project must be divided into two phases where we will first be installing the evaporator to eventually move it to an automated process.

With the implementation of the first option the company would be saving an approximate $9,000/yr with a payback of 2.83 years which will allow the second phase to be implemented in an approximate time of 3 years after the installation of the evaporator. In figure 6 can observe in more detail the saving.

EQUIPMENT			
Evaporator	$ 8,995.00	$	8,995.00
AFS (Auto Fill System)	-----	$	1,895.00
Holding Tank	-----	$	1,000.00
Valves, pipe, fitting, and miscellaneous materials	-----	$	2,562.00
Equipment Cost	**$ 8,995.00**	**$**	**14,452.00**
CONSTRUCTION			
Construction assumptions			
2 craft at $75/hr	-----		-----
weeks	3		6
5 days/week, 8 hours/day	-----		-----
Construction costs	**$ 18,000.00**	**$**	**36,000.00**
Project Cost	**$ 26,995.00**	**$**	**50,452.00**
OPERATION			
Energy cost ($/KWH)	0.2200000		0.2200000
Operation hours	4380		4380
Heating System (KWH)	27		27
Operation Costs	**$ 26,017.20**	**$**	**26,017.20**

Figure 5

Cost Evaluation of Equipment, Construction and Electricity

SAVINGS			
2018 Disposition			
15 gls capacity	Disposed drums	311	311
	Disposition Cost ($/drum)	20.25	20.25
55 gls capacity	Disposed drums	311	311
	Disposition Cost ($/drum)	35.25	35.25
Disposition Costs (DC) = 15 gals + 55 gals dispositions costs		$ 17,260.50	$ 17,260.50
Disposition Savings (DS) = DC x 0.9		**$ 15,534.45**	**$ 15,534.45**
2018 Raw Material Purchases			
	15 gls drums purchased	311	311
	15 gls drums costs ($/drum)	31.00	31.00
	55 gls drums purchased	**311**	**311**
	55 gls drums costs ($/drum)	55.92	55.92
Raw Material Costs (RMC)		$ 27,032.12	$ 27,032.12
Raw Material Savings = RMC x 0.9		-----	$ 24,328.91
Raw Material Savings (RMS)= RMC x 0.75		$ 20,274.09	-----
Savings = DS + RMS		$ 35,808.54	$ 39,863.36
Total Savings = Savings – O&M Costs		**$ 9,551.34**	**$ 13,366.16**
ROI CALCULATIONS			
Payback Period (years) = Project Cost/Total Savings		**2.83**	**3.77**

Figure 6

Cost Saving Analysis

Ideally, the equipment should be placed outside the plant, since the construction cost would be reduced, but the ergonomic factors would increase. For this reason, the equipment will be installed in Machine Center unit which implies in area preparation, electrical installations and other factors which will be evaluated along the way.

This installation not only impacts the company's long-term savings, it also impacts the space through site, ergonomic and environmental factors. In figure 7 it can be seen how after the evaporator implementation will reduce the monthly wastewater disposal by 90%.

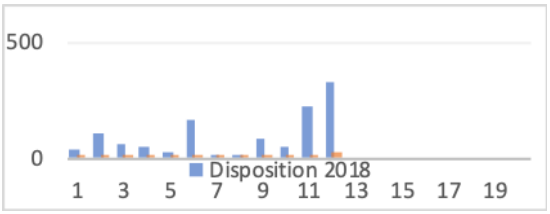


Figure 7
Wastewater Disposal Gallons

On the other hand, the company's space will be freed which will be useful for the production area. These areas can be seen in figures 8 to 12. Currently, hallways, stairs and satellite areas have been established in the company as a result of the high volume of waste disposal. As a result of the evaporator implementation all that space will be released.

Figure 8
Satellite Area Belonging to the Impacted Unit

Figure 9
Designated Area to Place Part of What will be Disposed

In the area shown in figure 9 it is currently used to place everything that the external company dispose. Then of the implementation of the evaporator, this area can be used for any other function, since the amount that will be disposing is as minimal as two monthly drums.

Figure 10
Storage Located Under Stairs

Figure 11
Warehouse Area Used for Drums Storage

Figure 12
Hallway Used for Drums Storage

CONCLUSION

The biggest limitation in this project has been the cost of energy consumption and space, due to the equipment. There are other options that could be evaluated but due to costs they were not selected.

The major contribution of this equipment to the company has been the reduction in expenses, risks in environmental and ergonomic factors inside the site and better use of space for the installation of other equipment for production. In addition to these contributions with this implementation, we reduce the responsibility of our company because when the process of disposal of waste with the subcontracted company is carried out if an accident occurs or is mishandled (which is not within our control) The responsibility remains with us. Basically, the transportation to dispose will be reduced by 90%, which is equivalent to less risks to our company. Everything will depend on the production. Then, from the implementation of the equipment it is estimated that the space released is 56 square feet, which will be used for the installation of more equipment. This is of great help since the company planned to rent external buildings to proceed with the installation of new equipment.

On the other hand, we must be aware that landfills are not a definitive solution, so all companies must be aware of this when disposing of their waste and taking measures to reduce the waste like the evaporator implementation.

After the payback period is completed, our company will proceed to consider installing equipment automatization. This will lead to more savings since it involves the elimination of purchase and disposal of drums and the ergonomic and environmental factors will be totally eliminated. Additional will be evaluating the disposal of all waste generated in the plant, which is estimated at 62,000gal/yr which implies an annual savings of $104,000/yr. This also entails the release of more space, which is a great value to the company since we are currently implementing new products and process.

REFERENCES

[1] Estrucplan. (2005, January 6). *Un enfoque ergonómico para evitar lesiones en el lugar de trabajo* [Online]. Available: https://estrucplan.com.ar/un-enfoque-ergonomico-para-evitar-lesiones-en-el-lugar-de-trabajo-2/.

[2] K. Terry. (2000). *What is DMAIC?* [Online]. Available: https://www.isixsigma.com/new-to-six-sigma/dmaic/what-dmaic/. [Accessed: October 20, 2019].

[3] Six Sigma Daily. (2017, Dec. 5). *What is a SIPOC Diagram?* [Online]. Available: https://www.sixsigmadaily.com/what-is-a-sipoc-diagram/.

[4] Ofni Systems. (n. d.). *Validation Plans (VP)* [Online]. Available: http://www.ofnisystems.com/services/validation/validation-plans/. [Accessed: October 20, 2019].