Maintenance Improvement Process for Control Emission System in a Pharmaceutical Plant

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Abstract

The Scrubber system SC-25 A/B is an emission control system that supports a manufacturing process of oral solid dosage in a pharmaceutical plant located in Barceloneta, Puerto Rico. Although the scrubber in subject is not an actual manufacturing system, it is responsible of removing 99% of volatile organic compound from the air exhausted from manufacturing process. While scrubber operations are highly regulated by the Environmental Protection Agency, several concerns were raised in the pharmaceutical plant due to consistent operational failures due to low flow rate alarms. Performing voice of the customer analysis, data gathering and field visit, the issue was assessed and addressed to provide a solution of improvement. Low flow rates in the scrubber are triggered by the following drivers: effluent water quality, pipe size capacity, and strainer capacity. As a result, short- and long-term improvement proposals were presented to the system owner which includes Preventive Maintenance Revision, Piping and Strainer resizing increase and propose the implementation of local water treatment using biocide for the scrubber.

Introduction

A pharmaceutical plant located in Barceloneta, Puerto Rico is a multiproduct manufacturing plant that manufactures oral solid dosage (OSD) medicines to treat several conditions from different disease disciplines such as neuroscience, immunology, and oncology. As part of the manufacturing process of these OSDs, the solution preparation of the coating of the tablets requires solutions concentrations of ethanol and acetone in a liquid state. As the manufacturing process continuous, residual gaseous concentrations of these solvents are exhausted through the air stream towards the atmosphere becoming in a gaseous volatile compound (VOC). The emission of VOC for this industry and many other industries are highly regulated by the Environmental Protection Agency (EPA) under the Title V of the Clean Air Act [1] This permit provides the enforceable conditions, monitoring program, reporting, sources, and other provisions to assure that the operation of the scrubber system is in full compliance [2]. To comply and control the emissions of VOC to the atmosphere, control emission systems are implemented as external auxiliar equipment to the manufacturing process. The pharmaceutical plant in subject is responsible to implement controls within the operation to assure the emissions from manufacturing process are aligned with regulatory requirements. Systems such as Wet Scrubbers which are designed to control environmental emissions of hazardous components such as VOCs are implemented and integrated into the manufacturing process cycle.

In the pharmaceutical plant, although the control emission systems are not a direct product contact system, it conforms a critical process step of the production cycle. Since this equipment is part of the production process cycle, a failure on this equipment will imply the interruption of the process resulting in downtime and consequently, lead to impact manufacturing operations performance.

The scope of this project was focused directly to the wet scrubber named SC-25. This scrubber system consists of two scrubber housings identified as Scrubber 25A and Scrubber 25B, connected in a serial configuration. The scrubber system is integrated to the manufacturing process as an external auxiliar component and is in the last phase of the air stream exhausted from the process. Figure 1 shows the streamline of air in the process towards the Scrubbers System SC-25 A/B. The Scrubbers SC-25A and SC-25B operates in a serial configuration maintaining an effluent water flow rate of 104gpm that is injected to the scrubber SC-25B and then recirculated to the SC-25A.

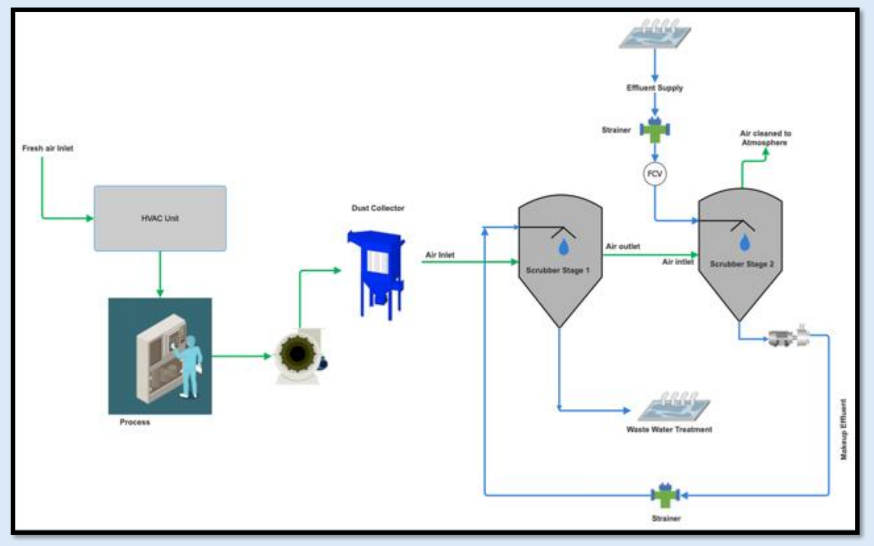


Figure 1
Airflow stream from the process phase to the Scrubbers

Recently, the pharmaceutical plant was experiencing several downtimes due to several situations with the scrubber operation SC-25. Besides a maintenance schedule exists for this system, several consistent unplanned interventions were reported impacting performance standing of production and maintenance. One of the major issues reported upon Scrubber SC-25 is that it failed to maintain the setting flowrate setpoint of 104gpm. The process startup requires the scrubber to operate at a flowrate of 104gpm. This flowrate is measured in two points, the first flow meter is before it enters to the scrubber SC-25B and the second point is in the effluent makeup transition prior entering into the Scrubber SC-25A. Consequently, the system triggered alarms of low flow rate keeping the manufacturing process from start or continue.

Commonly, the low flow rate alarm situations were attributed to clogs in the pipeline due to water sludge. Although a maintenance program schedule is in place to periodically clean Scrubber components that includes pipeline, packing bed camera, sump camera, and basket strainers. However, sustaining the required flow rate is still a challenge that is significantly impacting system reliability and manufacturing process performance.

Background

Scrubbers' mechanisms are designed to remove VOC suspended along the exhausted airstream before is released to the environment. To remove the pollutant component, the scrubbers use electrostatic ionization, mirror force image attraction effect, through different mechanisms to trap the water droplets and VOC particulate. The wet scrubbers will require an injection of water spray that will serve as solution media to ionize the VOC particulate and trap the pollutant component by means of impaction mechanism [3]. The wet scrubber will also require a surface with a pack of helix design telleretes that is designed to trap the water droplet creating a surface tension that will trap the VOC particles through absorption. This packing surface of telleretes may come in different sizes that will depend on the particle size designed to capture. After the droplets of water capture the VOC particles, the wastewater is disposed from the scrubber housing to be treated or as in many cases the water is recirculated to the other connected scrubber [4].

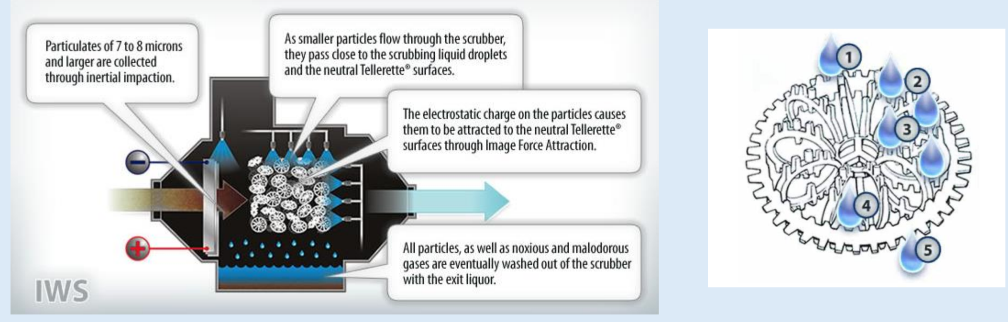


Figure 2
Scrubber components [5]

The design of packed wet scrubber system and operation will rely on different characteristics such as waterflow injection rate, airflow rate, particulate density and size, differential pressure and among others to acquire the removal efficiency percent defined and accepted by the regulatory agency. The removal efficiency percent for Scrubber SC-25 A/B as established by the Title V permits must be maintained to 99% with a designed effluent injection flow rate of 94gpm to 104gpm. This water injection rate must be remained constant while the scrubber is running.

Effluent Water

The Scrubber SC-25 A/B, is fed by a supply of effluent water provided by the Wastewater Treatment Plant. The water supplied may contain particulates from wastewater process including bacteria organisms along with other solid particulates that is then transferred through the effluent supply into the Scrubber SC-25 (A/B). The effluent water forms a solid sludge that is injected into the scrubber causing the scrubber system being prone constant clogs. To control clogs in the pipeline, pump, and nozzles, strainers are installed into the water pipeline to collect the solidification components from the effluent water. [4]

Figure 3
Solid Sludge and organisms trapped in packing and strainers

Generally, failures of Scrubbers equipment are mainly driven by recirculation pipeline clogging issue, inadequate design of pump capacity, inadequate size or volume of packaging bed, certain biological growth inside the scrubber housing, and among others. An effective troubleshooting, preventive maintenance and an effective monitoring system will provide the necessary tools to maintain a reliability standard of the system performance.

A maintenance program schedule for scrubber system SC-25 A/B is in place to maintain proper operation of the scrubber. The current program schedule for the scrubber system SC-25A/B consist in the following:

- Weekly: Cleaning of Strainers
- Monthly: Minor cleaning and inspection of Scrubber
- Quarterly: Cleaning and inspection including scrubber sump, packing and pipeline
- 3 Years: Replacement of packing telleretes

Problem

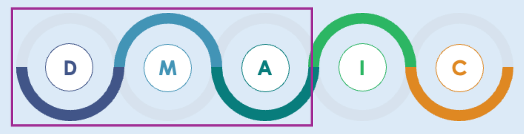
Although the Scrubber System SC-25 A/B is not a manufacturing equipment, its failure will imply keeping the process from start or continue. Consequently, production downtimes and increase of equipment troubleshooting has caused a significant impact on both production performance and equipment reliability. This issue also triggers potential financial impact, specially from the maintenance perspective as cost of labor and material will significantly increase.

The process constantly triggered alarms due to low flowrate in Scrubber A, in the makeup point of the effluent water. As the troubleshooting are perform, the cause of these alarms are always related to clogs in the pipeline and strainers. The strainers are scheduled to be cleaned in a weekly basis, however, due to the current situation strainers are being cleaned twice in a daily basis. Besides a robust maintenance schedule is in place for Scrubber SC-25 A/B, water quality conditions and equipment assembly design were the most likely factors causing the constant water clogs.

This project was aimed to design a plan for improvement of the Scrubber SC-25 A/B reliability to:

- Reduce equipment unplanned troubleshooting
- Reduce Maintenance Costs
- Reduce produce downtime due to the Scrubber

Methodology



The sigma tool DMAIC (Define, Measure, Analyze, Improve, and Control) was the methodology used to design the improvement for scrubber maintenance and reliability.

Define

According to the issues reported toward the Scrubber SC-25 system impacting maintenance performance and manufacturing process continuity, the project was defined to address the improvement of Scrubber SC-25 system reliability.

Measure

Tools such as voice of the customer were used to gather information related to issues and need from impacted areas such as manufacturing, maintenance, reliability, and Environmental department. Table 1 shows the feedback provided by the stakeholders that will be primarily impacted with the project. As a result of the voice of the customer analysis tool, the feedback from was linked together as appeared to have the same common denominator: pipeline clogging.

Table 1
Voice of the Customer

Customer	Situation	VOC	Customers Needs
Manufacturing	Equipment downtimes due to scrubber	Scubbers constantly triggers low flow Alarm delaying process to start.	Correct issue with water flow. Reduce downtime.
Maintenance	Equipment requires more frequent clea	The scrubbers has been cleaned at least twice a day	Improve water quality and system.
Reliability	Increase of downtime reported due to Scrubbers issue	The scrubber has been one of the major offenders impacting equipment performance during recent months.	Improve equipment reliability.
Environmental Manager	Waterflow does not sustain setpoint due to constant cloggings	Water quality has decreased and an amount of solids and bacteria growth was been observed inside the scrubber. Water must be treated.	The effluent water can be injected and treated locally by installing a self cleaning flushing into the system.

Data from the maintenance system was retrieved to evidence the issues of the scrubbers by means of the work order demands generated for troubleshooting and repairs and other interventions performed through the preventive maintenance. In the year 2023, about 47% of the work order generated were demands service and troubleshooting while the other portion pertained to Preventive maintenance. In 2024, up to April 2024, the demands related to the Scrubber surpass 50% in comparison to the preventive maintenance. The results shown in Figure 2 imply an additional increase of labor and material costs.

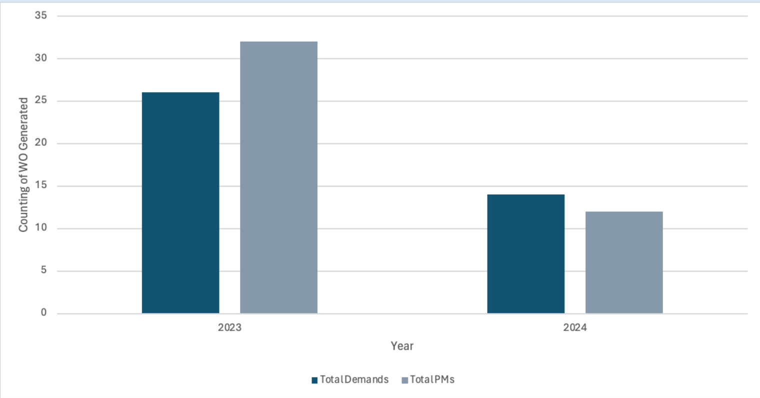


Figure 4
Comparison of Work orders Demand vs Preventive Maintenacne related to Scrubber SC-25 A/B.

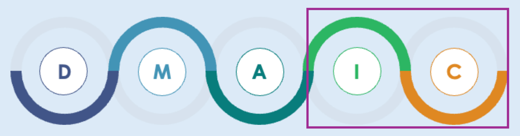
Analyze

The fishbone analysis tool was used to organize and sort the data in terms of cause and effect. Figure 3 shows the fishbone analysis performed to understand the issues related to the scrubbers from the different cross functional areas that are impacted by the consistent required troubleshooting. Using this tool, the issues to address were defined in the aim to address the reliability improvement. Based on this information, short- and long-term enhancements proposals were designed to help the scrubber A/B system improve reliability operations.

Figure 5
Fishbone Analysis to Evaluate Scrubber SC-25 A/B Issues Rule Out

A visit to the Scrubber area was rendered during a preventive maintenance execution. During this visit, several factors and potential drivers of the issues brought were discussed and evaluated. One of these factors was the capacity of the pipe and strainer located toward the makeup phase. Another major factor leading the scrubber to fail due to pipe clogging was the quality of the water treatment. Bacteria from the wastewater plant process is transferred with the effluent water distributed to the scrubber. These bacteria end up growing in the pipelines and scrubbers producing solidification and sludge consistency within the pipeline and scrubbers.

Results and Discussion



Based on the analysis of the information gathered, data recollected and field visits, the following improvements proposal were developed for the short and long terms.

- Short Term: Preventive Maintenance job plan was modified focusing on the cleaning scope and schedule. In the case of the quarterly cleaning, some of the cleaning tasks such as sump cleaning and pipelines were included in the monthly preventive maintenance.
- Short Term: A project was proposed to increase stainless-steel pipeline and strainer capacity from 2in to 3in.

Figure 6
Piping section to increase pipe sizing and strsiner

- Long Term: A project was proposed to design an auxiliary system to treat water in-situ the scrubber system. The proposal consisted in connecting a fresh water supply into the scrubber and distribute the waterflow by a pump. The application of a specific caustic concentration into the auxiliary system of fresh water. The water will be drained and transported back to the wastewater treatment plant.

Conclusions

The Scrubber SC-25 improvements were proposed for both short and long terms. Through the project and analysis, the most important factor gathered was that the issues encountered within the scrubber SC-25 A/B were closely related and tailored to the main issue, the constant clogging. Understanding the history of the troubleshooting made on the scrubber, the analysis questioned the current capacity of the scrubber components.

While the current quality of the water fosters a faster bacteria growth inside the scrubber components, pipe sizing, strainers and pumps may not be able to manage such amount of solidification. The increase of the pipe sizing and strainer will help to handle better the solids growth due to bacteria.

The long-term proposal related to the local water treatment provides a suitable alternative to automize system cleaning by means of properly controlling bacteria growth by chemical treatment. However, the implementation of such a cleaning system my required further qualification.

Future Work

After establishing the improvement plans, the approval of the fundings for the piping and strainer resizing is key to continue improvement plan.

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