



SPM WASTEWATER TREATMENT PLANT CONTROLS IMPLEMENTATION

TABLE OF CONTENTS

Introduction.....	3
Induced Gas Flotation (IGF)	5
Temporary WEMCO Performance	6
Recommendations for Permanent Controls	7
Use of Existing Controls	8
Implementation Schedule For Permanent Controls	9
Implementation Schedule for Obtaining Department authorizations	10
Conclusions	11

INTRODUCTION

As required by Paragraph QQQ of the May 24, 2023 Consent Order Agreement, after completing its engineering evaluation of the temporary controls at the Waste Water Treatment Plant (WWTP), Shell Polymers Monaca is to provide:

- Its engineering evaluation of the temporary controls installed at the Waste Water Treatment Plant (WWTP); Recommendations for permanent WWTP controls
- The use of existing controls (e.g. combustion control devices) to handle emissions from the permanent controls
- An implementation schedule for obtaining any Department authorizations
- Implementation schedule for completing the installation of permanent controls

During startup and initial operation of the Ethane Cracking Unit (ECU) it was determined that the wastewater stream generated from the ECU had some elevations in Oil and Grease (O&G) and Volatile Organic Compound (VOC) concentrations exceeding the design basis for the Biotreater, which resulted in occasional VOC emissions on top of the biotreater's aeration basins and an oil sheen. To address these O&G and VOC excursions Control Measures were implemented downstream of ECU at the WWTP

1. A temporary WEMCO (Induced Nitrogen Flotation - INF) unit was installed downstream of the FEOR Tanks to pre-treat the Biotreater feed by removing oil and grease (O&G) and volatile organic compounds (VOCs). The WEMCO performed as designed by removing O&G and VOCs from the Biotreater feed thereby eliminating VOCs from the aeration basins, and the oil sheen in the treated effluent. Total Oil & Grease (TOG) removal efficiency averaged 47.0% for influent wastewater TOG concentration of greater than 30 mg/L. The WEMCO unit proved adequate to mitigate normal changes in O&G and VOCs concentrations in the wastewater stream from the ECU, enabling the Biotreaters to remove dissolved organics [or biological oxygen demand (BOD)] and any suspended materials [or total suspended solids (TSS)] to achieve treated effluent quality below permitted discharge levels. As a result of implementation of stringent source control measures in the upstream process units and short duration of operation, the WEMCO has yet to experience ECU process upset conditions which result in wastewater stream with higher levels of O&G and VOCs. Thus, we do not yet have data on WEMCO performance during ECU process upset conditions. However, WEMCO performance data demonstrated that O&G removal efficiency significantly increases with high O&G concentrations. During the second half of year continued operation of WEMCO will be tested for ECU upset wastewater conditions.
2. About 1,000 kg of powdered activated carbon (PAC) was added into the Biotreater aeration basins from March 20 to June 10. Addition of PAC improved the mixed liquor condition in the aeration basins by adsorbing the oil sheen. Added PAC was continuously removed from the Biotreaters via the waste activated sludge (WAS) stream by maintaining the desired mixed liquor volatile suspended solids (MLVSS) in the aeration basins. WAS is dewatered using a centrifuge and

dewatered biosludge cake is disposed offsite. Centrate containing dissolved organics and hydrocarbons is routed back to Biotreaters.

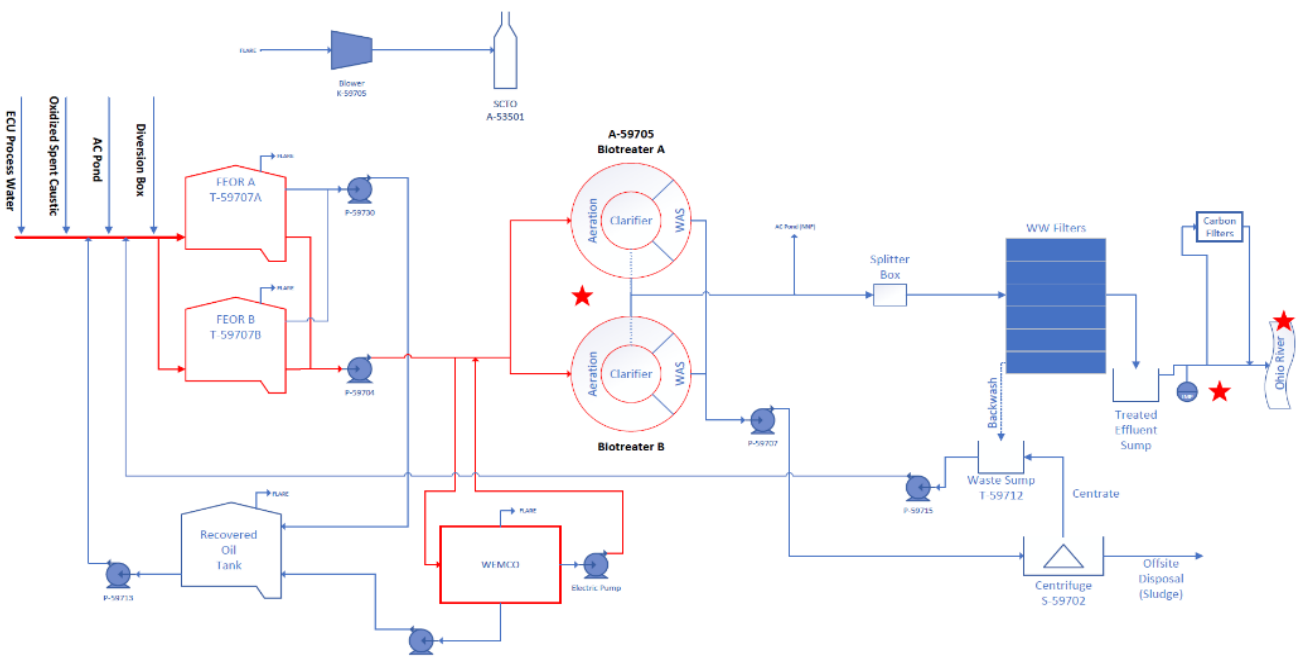
3. Temporary granulated activated carbon (GAC) beds were installed on the treated effluent downstream of Biotreaters to successfully polish the treated effluent by removing any color and/or remaining oil sheen before discharging to Outfall 001. These GAC beds are on "hot standby" if needed until the WWTP Improvement Project is implemented. A "hot standby" condition is one such that the standby equipment is immediately ready to be used if needed.
4. An off-site odor event in April 2023 was due to low level in the FEOR biotreater feed tank allowing a floating hydrocarbon layer at the top of the contents in the tank to be drawn into the Biotreater. FEOR Tank low-level and Biotreater Feed Pump low-level trip thresholds were increased to better prevent inadvertent offspec wastewater feed to Biotreater aeration basins. Changing these thresholds allows the feed pumps to stop pumping at a low-level condition. An additional level instrument for each FEOR Tank was added to provide redundancy.
5. Source control measures in ECU were implemented which significantly improved the quality of the wastewater stream (reduced TOG observed) from the cracking process and allowed the Biotreaters to operate without any operational issues. Other source control measures are in progress as a part of the WWTP Improvement Project.

INDUCED GAS FLOTATION (IGF)

Gas flotation is a process by which dispersed hydrocarbon droplets are removed from water by attachment to rising gas bubbles. The oily froth which forms on the surface of the water is removed by skimming or overflowing to a collection trough. Inert gases, air or hydrocarbon gas are normally used for induced gas flotation. In many cases the use of air is not practical due to the need to exclude oxygen from the process (the presence of oxygen leads to concerns with corrosion, biological growth and explosion hazard aspects).

Induced gas flotation units are categorized by the method flotation is achieved - mechanical and hydraulic. In mechanically induced gas flotation unit, rotation of the impeller draws gas down the standpipe where it comes into contact with the oily water. In hydraulically induced gas flotation unit instead of using a mechanically driven impeller to generate bubbles, a recirculated stream of clean water is injected into the cell through a nozzle designed to create a venturi effect.

The temporary WEMCO is a 4-cell mechanically induced gas flotation unit using nitrogen as floatation gas because of the presence of VOCs in the influent wastewater stream. The figure below shows the Temporary WEMCO lineup in WWTP.



Temporary WEMCO lineup in WWTP

TEMPORARY WEMCO PERFORMANCE

The temporary WEMCO was installed on April 20, 2023 and started receiving Biotreater feed from the FEOR Tanks. During the last 3 months, the WEMCO has proven effective in removing normal excursions in O&G (analyzed as TOG, total oil and grease). As expected, TOC (total organic carbon) representing dissolved organic components in the wastewater stream indicated no significant change. WEMCO TOG removal efficiency increased with higher TOG concentrations in the wastewater stream. TOG removal efficiency averaged 47.0% for TOG concentration of greater than 30 mg/L.

WEMCO inlet and outlet samples show significant removal of turbidity (dispersed oil and solids) in the inlet stream with very clear outlet sample.



RECOMMENDATIONS FOR PERMANENT CONTROLS

The intention of adding additional permanent controls to the Shell Polymers Monaca wastewater system is to improve the safety and environmental performance of the wastewater facility by providing more robust engineered controls to manage any potentially higher than expected oil and grease (O&G) and volatile organic compound (VOC) levels in the wastewater coming from the ethylene cracker unit (ECU).

A capital project was initiated in June 2023 to evaluate alternatives and deploy an improvement to the wastewater system at Shell Polymers Monaca. The project is currently in Shell's Assess phase (aka FEL1 or feasibility study outside of Shell), wherein the project team is evaluating technology and process configuration options along with operational and monitoring improvements. The early phases of Shell's Opportunity Realization Process encourages the evaluation of alternatives to ensure the right solutions are applied. The project is also ensuring that the addition of permanent controls can handle a wider range of operating conditions to ensure the wastewater system will remain resilient during transient operation of the ECU. The following scope/technology options are being *considered* as part of the capital project to add permanent engineered improvements:

- New Induced Gas Flotation (IGF) or Dissolved Gas Flotation (DGF) flotation unit(s) upstream of biotreatment
- Routing liberated volatile compounds from new flotation/separation equipment upstream of the bio-treaters to the spent caustic thermal oxidizer
- Process lineup modifications to provide additional stream segregation and containment of problem streams, and transient situation handling capabilities

Technology/configuration decisions by the project are synchronized with critical SPM operational milestones to ensure relevant data to aid in the process design for the permanent improvements can be captured before engineering has progressed too far on the design concepts (temporary flotation unit test data, SPM wastewater influent quality at design ECU throughput, etc.).

The early project phases will be addressing the following uncertainties/major technology choices:

- IGF vs DGF technology selection
- Optimal sludge handling configuration
- Installation cutover challenges from temporary system to permanent installation
- Characterization of potential upset conditions

Performance of the temporary flotation unit is being used as a proof of concept for of a permanent installation to ensure that the selected flotation technology will provide sufficient O&G and VOC removal. The site's operational experience over the next several months with the temporary controls in place and management of wastewater quality will ultimately dictate the extent of system upgrades required. Shell desires also to evaluate the performance of the equipment under full operational conditions which have not yet been achieved.

USE OF EXISTING CONTROLS

Any new equipment added to the wastewater facility that generates a vapor stream that could potentially contain hazardous compounds will be provided a connection to the spent caustic thermal oxidizer (SCTO) to safely combust the liberated volatile components.

IMPLEMENTATION SCHEDULE FOR PERMANENT CONTROLS

The following schedule is a preliminary estimate of the duration necessary to complete the evaluation of alternatives, front end engineering, detailed engineering, procurement, construction, commissioning, and startup of the permanent improvements to the SPM wastewater facility.

The schedule duration has been benchmarked against the median duration of projects in the chemicals industry (dataset from Independent Project Analysis aka IPA) for a similar expected headline size.

Milestone	Estimated Timeline
Project Kickoff and Framing	June 2023
End of Feasibility Study (Assess)	Q3 2023
Begin Regulatory Strategy Determination (Water and Air)	Q1 2024
End of Pre-Feed (Select)	Q2 2024
Submit Air/Water Application	TBD
End of FEED (Define)	Q4 2024
Construction Start	1H 2025
Startup	2H 2026

IMPLEMENTATION SCHEDULE FOR OBTAINING DEPARTMENT AUTHORIZATIONS

Shell will require authorizations for both air and water for the temporary wastewater equipment. This temporary equipment will be in place for the period of time until the new and permanent wastewater equipment can be installed and operated (estimated 2H2026). This permanent equipment will be incorporated into the facility's Title V permit application as well as a modification to the Part II Water Quality Management Permit for the wastewater treatment plant.

CONCLUSIONS

WWTP Controls per Section 5 of the Consent Order Agreement were successfully implemented as stipulated in Paragraph QQQ of the Consent Order Agreement. The implementation of the temporary WWTP Controls discussed in this document achieved compliant operation of the Biotreaters. Biotreater mixed liquor condition improved significantly achieving treated effluent quality well below the permitted discharge limits.

The temporary WEMCO demonstrated adequate pre-treatment by removing sufficient O&G and VOC from the Biotreater feed. Continued operation of the WEMCO (mechanically induced gas flotation) with additional EC-15 (hydraulically induced gas flotation) will be tested, during the second half of the year, to finalize the “pre-treatment kit” for WWTP Improvement Project. This testing will include mimicking ECU upset wastewater composition under control conditions to confirm the proof-of-concept for the WWTP Improvement Project for PADEP approval.

Regarding the permanent controls/solution(s), a capital project was initiated in June 2023 to evaluate alternatives and deploy a robust improvement to the wastewater system at Shell Polymers Monaca as discussed above. The project is currently in Shell’s Assess phase wherein the project team is evaluating technology and process configuration options along with operational and monitoring improvements. The project is also ensuring that the addition of permanent controls can handle a wider range of operating conditions to ensure the wastewater system will remain resilient during transient operation of the ECU.