CASE STUDY

99.9% VOC REMOVAL USING E550 SCRUBBER, BIO-SCRUB X & ACTIVATED CARBON POLISHING

Application: Petrochemical Hydrocarbon Vapor Control
Location: Lake Charles, Louisiana
Project Date: November 2019
Contaminants: Xylene and Mixed Aromatic VOCs
Equipment: Vapor Technologies E550 Vapor Scrubber + Activated Carbon Polishing
Scrubbing Media: BIO-SCRUB X
Airflow: 450 CFM
Inlet VOC Concentration: 460 ppm
Scrubber Removal Efficiency: 97.9%
Overall System Removal Efficiency: 99.9%

EXECUTIVE SUMMARY

In November 2019, a Vapor Technologies E550 forced-induction vapor scrubber utilizing BIO-SCRUB X hydrocarbon absorption media was used for the treatment of a mixed hydrocarbon vapor stream at an industrial facility in the Lake Charles, Louisiana petrochemical region.

The vapor stream contained approximately **460 ppm total volatile organic compounds (VOCs)** at an airflow rate of approximately **450 CFM**. The hydrocarbon mixture included **xylene and other aromatic VOCs**.

The E550/BIO-SCRUB X scrubber provided the primary stage of treatment.

Initial testing indicated that the scrubber alone achieved approximately:

97.9% VOC REMOVAL

Based upon the 460 ppm inlet concentration, this corresponds to an estimated concentration immediately downstream of the scrubber of approximately:

9.7 ppm VOC

The vapor was subsequently passed through activated carbon as a final polishing stage.

Following carbon treatment, the combined system achieved approximately:

99.9% OVERALL VOC REMOVAL

Based upon the original 460 ppm inlet concentration, the equivalent final outlet concentration was approximately:

0.46 ppm VOC

The results demonstrate the effectiveness of using the E550/BIO-SCRUB X system for bulk VOC removal while reserving activated carbon for final polishing.

This treatment arrangement reduced approximately **97.9% of the contaminant loading before the vapor reached the activated carbon**, dramatically decreasing the VOC mass presented to the polishing stage.

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1. PROJECT BACKGROUND

Petrochemical and chemical-processing facilities frequently generate mixed hydrocarbon vapor streams rather than streams containing a single chemical compound.

These vapor streams can contain combinations of:

- Xylene
- Toluene
- Benzene
- Ethylbenzene
- Gasoline-range hydrocarbons
- Petroleum aromatics
- Solvents
- Other volatile organic compounds

The November 2019 Lake Charles application involved approximately **450 CFM of hydrocarbon-laden vapor containing 460 ppm total VOCs**, including xylene and other aromatic hydrocarbons.

Because the vapor contained multiple organic compounds, the objective was not simply removal of one specific contaminant.

The treatment system needed to provide broad-spectrum hydrocarbon removal while also producing a very low final VOC concentration.

A two-stage treatment strategy was therefore utilized:

STAGE 1 — E550 + BIO-SCRUB X

Bulk hydrocarbon absorption

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STAGE 2 — ACTIVATED CARBON

Final VOC polishing

This combination provided high initial contaminant removal while minimizing the hydrocarbon loading placed directly onto the activated carbon.

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2. SYSTEM CONFIGURATION

The treatment train can be represented as:

UNTREATED VAPOR

450 CFM

460 ppm VOC

Xylene + Mixed Aromatic Hydrocarbons

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E550 FORCED-INDUCTION SCRUBBER

BIO-SCRUB X

97.9% Removal

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APPROX. 9.7 ppm VOC

↓

ACTIVATED CARBON POLISHING

↓

APPROX. 0.46 ppm VOC

↓

99.9% OVERALL REMOVAL

This configuration takes advantage of two fundamentally different VOC-removal mechanisms.

The E550/BIO-SCRUB X system removes the bulk hydrocarbon loading through **liquid-phase absorption**, while activated carbon removes the remaining trace hydrocarbons primarily through **surface adsorption**.

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3. E550 VAPOR SCRUBBER

The Vapor Technologies E550 is a forced-induction liquid vapor absorber designed specifically for high-efficiency vapor treatment.

The main shell and internal components are constructed from 304 stainless steel.

Unlike a conventional packed tower, the E550 uses the velocity and pressure of the incoming vapor stream to distribute the contaminated gas through specialized stainless-steel internal distributors.

The primary distributor creates a **360-degree vapor distribution pattern**, directing the vapor into the main gas/liquid contact region.

The large available contact area promotes rapid mass transfer between the contaminated gas and BIO-SCRUB X.

Published Vapor Technologies data identify the E550 as capable of hydrocarbon removal efficiencies as high as approximately **98–98.5%**, depending upon the vapor composition and operating conditions.

E550 Specifications

Parameter	Specification
Construction	304 Stainless Steel
Maximum Airflow	550 CFM
Project Airflow	**450 CFM**
Normal BIO-SCRUB X Volume	275 gallons
Maximum Liquid Volume	400 gallons
Vapor Inlet	4-inch flange
Vapor Outlet	4-inch flange
Unit Height	Approx. 9 ft
Sample Ports	Inlet and outlet

Parameter	Specification
Utilities Required	None
Published Pressure Drop	Approx. 36 in. W.C. at 450 CFM

The Lake Charles project operated at **450 CFM**, exactly the airflow at which Vapor Technologies publishes an E550 pressure drop of approximately **36 inches W.C.**

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4. BIO-SCRUB X HYDROCARBON ABSORPTION MEDIA

BIO-SCRUB X is a proprietary oil-based vapor scrubbing media developed specifically for hydrocarbon removal.

Vapor Technologies identifies BIO-SCRUB X for removal of:

Benzene • Toluene • Xylene • Aromatics • Gasoline • Other Organic Compounds

Published product information states that BIO-SCRUB X can achieve hydrocarbon removal efficiencies approaching **98.5%**, depending upon operating conditions.

The media is used at full strength and is not diluted with water.

BIO-SCRUB X Characteristics

Property	Information
Media Type	Oil-based hydrocarbon absorbent
Xylene Removal	Yes
Aromatic VOC Removal	Yes
Benzene Removal	Yes
Toluene Removal	Yes
Water Dilution	None
Surfactants	None
Perfumes	None
Contains	Methyl esters
Foaming	Non-foaming

Property	Information
Flash Point	Above 220°F
Biodegradability	Excellent
pH	N/A for oil
Low-Temperature Limit	Product freezes at approx. 28°F

BIO-SCRUB X is particularly appropriate for aromatic VOC service because compounds such as xylene have relatively low water solubility. Vapor Technologies' published product data specifically identify xylene and aromatic hydrocarbons among the compounds for which the media was designed.

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5. XYLENE PROPERTIES

Xylene is an aromatic hydrocarbon commonly encountered in petroleum refining, petrochemical manufacturing, coatings, solvents and hydrocarbon-processing operations.

Commercial xylene may contain mixtures of the ortho-, meta- and para-xylene isomers.

Representative properties for xylene include:

Property	Approximate Value
Chemical Formula	C_8H_{10}
Molecular Weight	106.2 g/mol
Physical State	Liquid
Appearance	Colorless
Odor	Aromatic
Water Solubility	Very Low
Vapor Density	Greater than air
o-Xylene Boiling Point	Approx. 292°F
o-Xylene Vapor Pressure	Approx. 7 mm Hg
o-Xylene Flash Point	Approx. 90°F

NIOSH identifies a recommended exposure limit for xylene of **100 ppm TWA**, with a **150 ppm short-term exposure limit**.

Because the actual Lake Charles stream contained a mixture of xylene and other aromatic VOCs, however, the project performance should be evaluated on the basis of **total measured VOC concentration rather than treating the entire 460 ppm as xylene**.

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6. PROJECT OPERATING CONDITIONS

Operating Parameter	Project Value
Facility Location	Lake Charles, Louisiana
Project Date	November 2019
Vapor Type	Mixed Hydrocarbon VOC
Primary Identified VOC	Xylene
Other Compounds	Aromatic Hydrocarbons
Airflow	**450 CFM**
Initial VOC Concentration	**460 ppm**
Scrubbing Media	BIO-SCRUB X
E550 Removal	**97.9%**
Carbon Polishing	Yes
Overall Removal	**99.9%**

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7. STAGE 1 — E550 SCRUBBER PERFORMANCE

The inlet VOC concentration was:

460 ppm

The measured/reported removal efficiency across the E550/BIO-SCRUB X stage was:

97.9%

The remaining concentration can therefore be calculated as:

Cout = Cin × (1 − Efficiency)

Cout = 460 × (1 − 0.979)

Cout = 460 × 0.021

Cout ≈ 9.66 ppm

Therefore, the E550 reduced the mixed VOC concentration from:

460 ppm → approximately 9.7 ppm

before the vapor entered the activated carbon polishing stage.

The concentration reduction across the scrubber was approximately:

460 − 9.66 = 450.34 ppm

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8. SCRUBBER REMOVAL EFFICIENCY

Using the calculated outlet concentration:

Efficiency = [(460 − 9.66) ÷ 460] × 100

E550/BIO-SCRUB X EFFICIENCY = 97.9%

Another useful way to express the performance is the reduction ratio.

460 ÷ 9.66 ≈ 47.6

Therefore, the scrubber produced approximately a:

47.6:1 REDUCTION IN VOC CONCENTRATION

before the vapor ever reached the activated carbon.

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9. STAGE 2 — ACTIVATED CARBON POLISHING

After the E550 scrubber, the remaining approximately **9.7 ppm VOC** was directed through activated carbon.

The activated carbon served as a **polishing stage rather than the primary VOC removal device**.

The final combined system achieved approximately:

99.9% OVERALL VOC REMOVAL

Based upon the original 460 ppm inlet:

Final VOC = 460 × (1 − 0.999)

Final VOC = 460 × 0.001

Final VOC ≈ 0.46 ppm

Therefore, the complete treatment train produced approximately:

460 ppm → 9.7 ppm → 0.46 ppm

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10. OVERALL SYSTEM PERFORMANCE

Treatment Location	VOC Concentration	Reduction
Untreated Vapor	**460 ppm**	—
After E550/BIO-SCRUB X	**≈9.7 ppm**	**97.9%**
After Activated Carbon	**≈0.46 ppm**	**99.9% Overall**

The overall concentration reduction ratio was approximately:

460 ÷ 0.46 = 1,000

Therefore, the complete treatment train achieved approximately a:

1,000:1 REDUCTION IN VOC CONCENTRATION

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11. IMPORTANCE OF SCRUBBING BEFORE ACTIVATED CARBON

One of the most significant aspects of this project was not simply the final 99.9% efficiency.

It was **where the VOC removal occurred**.

The E550/BIO-SCRUB X stage removed:

97.9% OF THE VOC LOAD BEFORE THE CARBON

Only:

2.1% OF THE ORIGINAL VOC CONCENTRATION REACHED THE CARBON

This represents a substantial reduction in contaminant loading presented to the activated-carbon polishing stage.

If activated carbon had been used as the sole treatment technology, the carbon would have been exposed directly to the entire **460 ppm VOC stream**.

Instead, the carbon received approximately:

9.7 ppm VOC

This represents approximately:

97.9% LOWER VOC LOADING TO THE CARBON

assuming comparable gas conditions and composition.

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12. WHY THIS MATTERS FOR CARBON LIFE

Activated carbon has a finite adsorption capacity.

As VOCs accumulate on the carbon, available adsorption sites become occupied until breakthrough eventually occurs.

Reducing the contaminant concentration upstream therefore has the potential to significantly extend the useful operating period of the carbon bed.

In this application:

Without Scrubber

460 ppm → Activated Carbon

versus:

With E550/BIO-SCRUB X

460 ppm → **9.7 ppm** → Activated Carbon

The carbon polishing stage therefore handled only a small fraction of the original VOC burden.

Actual carbon service-life improvement depends upon the VOC mixture, humidity, temperature, carbon type, bed geometry and adsorption equilibrium, so the 97.9% loading reduction should not automatically be interpreted as a 47-fold increase in carbon life.

Nevertheless, the reduction in VOC loading is substantial.

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13. SYSTEM DESIGN PHILOSOPHY

The Lake Charles project illustrates a useful treatment philosophy for relatively concentrated hydrocarbon vapor streams:

LIQUID ABSORPTION FOR BULK REMOVAL

followed by:

ACTIVATED CARBON FOR FINAL POLISHING

The E550/BIO-SCRUB X system performs the heavy contaminant-removal duty.

Activated carbon is then reserved for the low-concentration residual vapor.

Vapor Technologies currently offers E550 systems using this same general treatment architecture—a forced-induction E550 scrubber followed by activated-carbon vessels. Published information for the E550-1000 describes the scrubber as capable of approximately 98% hydrocarbon removal with downstream carbon polishing to near-total removal.

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14. PERFORMANCE COMPARISON

E550 SCRUBBER ALONE

INLET

460 ppm

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E550 + BIO-SCRUB X

↓

9.7 ppm

97.9% REMOVAL

COMPLETE SYSTEM

460 ppm

↓

E550 + BIO-SCRUB X

↓

9.7 ppm

↓

ACTIVATED CARBON

↓

0.46 ppm

99.9% OVERALL REMOVAL

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15. ENGINEERING SIGNIFICANCE

The November 2019 Lake Charles project demonstrated three important characteristics of the E550/BIO-SCRUB X treatment technology.

First, high removal efficiency was achieved on a mixed VOC stream.

The vapor was not limited to a single hydrocarbon. The stream contained xylene and other aromatic VOCs, yet the E550/BIO-SCRUB X stage achieved **97.9% total VOC removal**.

Second, the E550 handled a substantial airflow.

The project operated at approximately **450 CFM**, equivalent to approximately **82% of the E550's published 550 CFM maximum airflow capacity**.

Third, the scrubber dramatically reduced the duty placed on downstream activated carbon.

Instead of exposing the carbon to 460 ppm VOC, the E550 reduced the concentration to approximately 9.7 ppm before carbon polishing.

The final combined system subsequently achieved approximately **99.9% overall removal**.

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16. PROJECT RESULTS

LAKE CHARLES, LOUISIANA

NOVEMBER 2019

Airflow

450 CFM

Initial VOC Concentration

460 ppm

Primary VOCs

XYLENE + AROMATIC HYDROCARBONS

E550/BIO-SCRUB X Outlet

≈9.7 ppm

E550/BIO-SCRUB X Removal

97.9%

Final Carbon-Polished Outlet

≈0.46 ppm

Overall System Removal

99.9%

Overall Concentration Reduction

1,000:1

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17. CONCLUSION

The November 2019 Lake Charles project demonstrated the effectiveness of combining the Vapor Technologies E550 forced-induction vapor scrubber with BIO-SCRUB X and downstream activated-carbon polishing for high-efficiency control of mixed aromatic VOC emissions.

At an airflow of approximately **450 CFM** and an initial total VOC concentration of approximately **460 ppm**, the E550/BIO-SCRUB X stage achieved approximately **97.9% VOC removal**.

This reduced the estimated VOC concentration entering the activated carbon from:

460 ppm to approximately 9.7 ppm.

The activated carbon subsequently polished the remaining vapor to an overall system efficiency of approximately:

99.9%

equivalent to an estimated final concentration of approximately:

0.46 ppm VOC

The complete treatment train therefore provided an approximately **1,000:1 reduction in total VOC concentration**.

Just as importantly, the E550 removed approximately **97.9% of the incoming contaminant burden before the vapor reached the activated carbon**.

This project demonstrates the advantages of using **liquid-phase hydrocarbon absorption as the primary removal mechanism and activated carbon as a final polishing stage**, particularly for relatively concentrated petrochemical vapor streams containing xylene and other aromatic hydrocarbons.

ENGINEERING NOTE

The 9.7 ppm intermediate and 0.46 ppm final concentrations are calculated from the supplied inlet concentration and reported removal efficiencies. Because the VOC stream consisted of multiple hydrocarbons, a precise VOC mass-loading calculation requires the actual chemical composition or an established average molecular weight. For this reason, this case study does not incorrectly assume that all 460 ppm consisted of xylene.

Actual performance and media service life depend upon vapor composition, temperature, humidity, airflow, contaminant loading, BIO-SCRUB X condition, activated-carbon selection, carbon-bed configuration and other operating conditions.

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