Synthomer Jefferson Hills LLC
PO Box 545
West Elizabeth, Pennsylvania 15088
USA

BY ELECTRONIC MAIL

December 14, 2022

Ms. JoAnn Truchan, P.E.
Program Manager, Engineering & Permitting
Allegheny County Health Department
301 39th St., Building 7
Pittsburgh, PA 15201-1891
joann.truchan@alleghenycounty.us

Re: Synthomer Jefferson Hills LLC – West Elizabeth, PA
Submission of "RACT III" VOC RACT Evaluation

Dear Ms. Truchan:

Synthomer Jefferson Hills LLC is pleased to submit the attached VOC RACT Evaluation as required by the Pennsylvania Department of Environmental Protection at 25 Pa. Code §§129.111 – 129.115.

If you have any questions or need further information, please don't hesitate to contact me at fred.mullner@synthomer.com or at (412) 813-2250.

Best regards,

Frederick T. Mullner, P.E.
Senior Environmental Coordinator

cc: A. Sulava – Synthomer Jefferson Hills LLC (aaron.sulava@synthomer.com)
Allegheny County Health Department (aqreports@alleghenycounty.us)

VOC RACT III Evaluation
Synthomer Jefferson Hills LLC – West Elizabeth, PA

1. INTRODUCTION

The Synthomer Jefferson Hills LLC (Synthomer) facility (formerly Eastman Chemical Company) located in West Elizabeth, Allegheny County, Pennsylvania, is classified as a major stationary source of volatile organic compounds (VOC) emissions. As such, the facility is subject to the Reasonably Available Control Technology (RACT III) rules enacted in Pennsylvania on November 12, 2022, outlined in 25 Pa. Code §§129.111 – 129.115. The RACT III rule requires all existing major facilities of NOx and VOC emissions to assess the need to install new or additional emission controls, or implement work practice measures to reduce emissions of those two pollutants. This document contains Synthomer's RACT III evaluation of VOC-emitting sources, to be submitted to Allegheny County Health Department (ACHD), Air Quality Control.

Supporting documents for this evaluation include:

Attachment A – RACT III Applicability Tables
Attachment B – Economic Analysis Tables

2. RACT III SOURCE APPLICABILITY EVALUATION

The tables included in Attachment 1 form the basis of the RACT III applicability evaluation of all VOC-emitting sources at the Synthomer facility. These tables include:

- Table 1, sorted by RACT III classification, lists all of the VOC sources and includes the source potential to emit (PTE), and the determination of applicability to RACT III.
- Table 2 contains the same information as Table 1, but is sorted by Process Area.
- Table 3 lists all of the storage tanks at the facility, their individual capacities, and an indication of whether they are subject to the RACT III rule.
- Table 4 provides a summary of the sources found to be 'Exempt' from the RACT III requirements, due to having a potential to emit (PTE) of less than one (1) ton/year.
- Table 5 summarizes all the sources classified as 'Presumptive'. These sources have a PTE of equal to greater than 1 ton/year but less than 2.7 tons/year.
- Table 6 shows all of the sources subject to 'Alternative RACT' (aka 'Case-by-Case') technical and economic evaluation, per section §129.114 of the RACT III rules. This table also provides Synthomer's determination of technically-infeasible control options for each of these sources, and an indication of whether the source is subject to economic evaluation.
- Table 7 contains the RACT III economic evaluation results for the Alternative RACT sources that were determined to have technically-feasible control options. Per §129.114(i)(1)(i), Alternative RACT sources that had control costs equal to or greater than $12,000/ton of VOC controlled under the previous RACT II evaluation are <u>not</u> required to be evaluated economically under RACT III.
- Table 8 contains the economic evaluation results that ACHD used for determining economic feasibility under the RACT II requirements. Note that all of the control options for every source were determined by ACHD to be economically infeasible under RACT II.

3. TECHNICAL FEASIBILITY OF CONTROLLING ALTERNATIVE RACT III SOURCES

As noted above, Table 6 in Attachment 1 includes a determination of technical feasibility of various options for controlling VOC emissions from the Alternative RACT sources. Following are additional explanations for the technical feasibility determinations.

3.1 Wastewater Treatment Plant Tanks 702A, 702B and 702C

All of these tanks are open-top tanks used for pre-treatment prior to the biological treatment operations. There is no reasonable method to capture emissions from these open-top tanks. Pursuant to RACT II, ACHD concurred that capture and control of emissions from these tanks was not technically feasible.

3.2 Wastewater Treatment Plant Biotreatment Aeration Tank

This biological treatment tank is open to the atmosphere. There is no reasonable method to capture the emissions from this operation. Pursuant to RACT II, ACHD concurred that capture and control of emissions from this tank was not technically feasible.

3.3 Fugitive Emissions Control

In its RACT II Evaluation document, ACHD determined that that it was unnecessary to conduct RACT evaluations on the equipment component leak emissions. The facility is subject to the Miscellaneous Organic NESHAPS (MON) rule. Under the MON, the facility is required to have a Leak Detection and Repair (LDAR) program. These requirements are relatively stringent, and ACHD stated that it does not believe more stringent requirements would be considered cost-effective. Finally, ACHD stated that the MON LDAR requirements "are considered RACT II for the emissions from equipment leaks." Synthomer continues to comply with those LDAR requirements and believes that ACHD's RACT II determination is still valid for RACT III.

3.4 VOC Control Technology Search

A search was conducted for VOC technologies that may have been developed subsequent to the evaluation conducted under the RACT II requirements. It has been determined by the facility that no new pollutant specific air cleaning device, air pollution control technology or technique is available at the time of submittal of this analysis. Some of the sites utilized for this search include the following:

- www.epa.gov
    - Ground-level Ozone Pollution
    - Controlling Air Pollution from the Oil and Natural Gas Industry
    - Air Pollution Control Technology Fact Sheet
    - NSCEP
- www.dep.pa.gpv
    - Control Technique Guidelines
- Choosing the Right VOC Emission Control Technology | Products Finishing (pfonline.com)

4. ECONOMIC ANALYSIS

As stated previously, Table 6 in Attachment 1 lists all of the sources subject to the 'Alternative RACT III' requirements of §129.114. For those sources that have not been modified subsequent to the RACT II submittal, §129.114(i)(1) provides two options for evaluation under RACT III, depending on the cost effectiveness determined under RACT II. The two evaluation options are discussed in the following sections.

4.1 Limited Analysis Option

The option provided in §129.114(i)(1)(i) allows for a 'limited' analysis for sources that had a RACT II cost effectiveness of equal to or greater than $12,000 per ton of VOC reduced. An economic evaluation is not required under this provision of the rule. The required 'limited' analysis shall include the elements listed below. Synthomer's response to each element is provided in bold type.

(A) A statement that explains how the owner or operator determined that there is no new pollutant specific air cleaning device, air pollution control technology or technique available. **Per Section 3.4 above, Synthomer has determined that no new technologies or techniques are available for VOC reduction.**

(B) A list of the technically feasible air cleaning devices, air pollution control technologies or techniques previously identified and evaluated under RACT II and approved by the Department or appropriate approved local air pollution control agency. **A list of technically feasible control technologies evaluated under RACT II is provided in Table 8 in Attachment 1.**

(C) A summary of the economic feasibility analysis performed for each technically feasible air cleaning device, air pollution control technology or technique listed in clause (B) and the cost effectiveness of each technically feasible air cleaning device, air pollution control technology or technique as submitted previously under RACT II. **A summary of the economic evaluation conducted under RACT II is provided in Table 8 in Attachment 1.**

(D) A statement that an evaluation of each economic feasibility analysis summarized in clause (C) demonstrates that the cost effectiveness remains equal to or greater than $12,000 per ton of VOC emissions reduced. **Due to the determination that there are no new VOC control technologies and that equipment and operating costs have only increased since the time of the RACT II submittal, Synthomer maintains that cost effectiveness remains above $12,000/ton for each of these sources.**

(E) Additional information requested by the Department or appropriate approved local air pollution control agency that may be necessary for the evaluation of the analysis. **To be provided upon request.**

4.2 Full Economic Analysis Option

Pursuant to §129.114(i)(1)(ii), an economic analysis is required for all Alternative RACT III sources that had a RACT II cost effectiveness of less than $12,000 per ton of VOC reduced. An economic evaluation was conducted for the two (2) sources (Hydro Unit vents S004 and S007) subject to this rule provision. A summary of the results is provided in Table 7 in Attachment 1, and the detailed cost analysis tables are provided in Attachment 2. All control cost analyses were conducted pursuant to procedures provided in USEPA's *Air Pollution Control Cost Manual*, 7th Edition (the most recent edition).

5. CONCLUSION AND PROPOSED RACT III

5.1 RACT III Analysis Conclusion

Due to the determination that there are no new VOC control technologies and that equipment and operating costs have only increased since the time of the RACT II submittal, Synthomer maintains that cost effectiveness remains above $12,000/ton for each of the sources subject to the 'limited' analysis.

Every technically feasible control option for the two Hydro Unit sources subject to 'full' economic evaluation exceeds the RACT III "screening level threshold" value of $12,000 per ton of VOC removed. Control options with costs above this threshold are considered to be economically infeasible.

Therefore, Synthomer concludes that it is not technically or economically feasible to install additional VOC reduction measures on any of the Alternative RACT III sources.

5.2 RACT III Proposal

Synthomer proposes that no physical, operational, or permit changes are needed in regard to the RACT III requirements, other than incorporating references to the applicable RACT III regulations.

ATTACHMENT 1
RACT III Applicability Tables

Table 1 **Summary of Facility VOC Sources and RACT III Classification - Sorted by Source Classification**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Stack ID	Description	RACT 2 VOC PTE [1] (TPY)	RACT 3 VOC PTE [2] (TPY)	RACT III Classification
C5 Unit	S216	Raw Material Tank 50	2.80	2.79	Not Applicable [3]
C5 Unit	S218	Raw Material Tank 52	2.37	2.40	Not Applicable [3]
C5 Unit	S219	Raw Material Tank 53	<1	0.41	Not Applicable [3]
C5 Unit	S060	Raw Material Tank 54	1.66	1.66	Not Applicable [3]
C5 Unit	S061	Raw Material Tank 55	1.16	1.16	Not Applicable [3]
C5 Unit	S058	Raw Material Tank 500	0.19	0.19	Not Applicable [3]
C5 Unit	S274	Raw Material Tank 511	0.10	0.10	Not Applicable [3]
C5 Unit	S064,S066,S097,S267,S268,S269,S270	Resin Storage Tanks (121, 123, 124, 366, 367, 601 & 602)	1.77	1.77	Not Applicable [3]
C5 Unit	S059, S238	Resin Storage Tanks 504 and 161	2.00	2.00	Not Applicable [3]
Dresinate	S187	Storage Tank R-1-A	0.01	0.05	Not Applicable [3]
Dresinate	S290	Storage Tank 782	0.01	0.05	Not Applicable [3]
Hydro Unit	S001	Storage Tanks 100, 101	1.20	1.27	Not Applicable [3]
Hydro Unit	S012	Storage Tanks 102, 105, 106	6.30	7.35	Not Applicable [3]
MP Poly	S039, S040, S041	Storage Tanks T-301, T-302, T-303	1.37	1.03	Not Applicable [3]
Storage Tanks	S190	Storage Tank 4	<1	0.51	Not Applicable [3]
Storage Tanks	S232	Storage Tank 78	<1	1.49	Not Applicable [3]
Storage Tanks	S091	Storage Tank 80	<1	0.05	Not Applicable [3]
Storage Tanks	S236	Storage Tank 151	<1	0.15	Not Applicable [3]
Storage Tanks	S244	Storage Tank 208	<1	0.19	Not Applicable [3]
Storage Tanks	S248	Storage Tank 252	<1	0.06	Not Applicable [3]
Storage Tanks	S256	Storage Tank 261	<1	0.61	Not Applicable [3]
Storage Tanks	S038	Storage Tank 262	<1	0.61	Not Applicable [3]
Storage Tanks	S257	Storage Tank 263	<1	0.53	Not Applicable [3]
Storage Tanks	S258	Storage Tank 264	<1	0.52	Not Applicable [3]
Storage Tanks	S259	Storage Tank 265	<1	0.57	Not Applicable [3]
Storage Tanks		Storage Tank 365	<1	<1	Not Applicable [3]
Storage Tanks		Storage Tank 761	<1	<1	Not Applicable [3]
Storage Tanks		Storage Tank 764	<1	<1	Not Applicable [3]
Storage Tanks		Storage Tank 766	<1	<1	Not Applicable [3]
Storage Tanks	S287	Storage Tank 775	<1	0.42	Not Applicable [3]
Storage Tanks	S160	Storage Tank 783	<1	0.05	Not Applicable [3]
WW Poly	S024	Storage Tanks 68, 69, 74	1.37	1.37	Not Applicable [3]
WW Poly	S025	Storage Tanks 73, 75, 76, 77	5.45	5.45	Not Applicable [3]
WW Poly	S026	Storage Tank 67	0.89	0.89	Not Applicable [3]
WW Poly	S228	Storage Tank 66	0.29	0.30	Not Applicable [3]
WW Poly	S195	Storage Tank 10	0.03	0.29	Not Applicable [3]
WW Poly	S206, S208	Storage Tank 22, 24	0.03	0.03	Not Applicable [3]
WW Poly	S207, S209	Storage Tank 23, 25	0.03	0.03	Not Applicable [3]
WW Poly	S211	Storage Tank 27	0.04		Not Applicable [3]
WW Poly	S210,S212, S213	Storage Tank 26, 28, 29	0.42	0.42	Not Applicable [3]
WW Poly	S074	Storage Tank 34	0.27	0.27	Not Applicable [3]
WW Poly	S075	Storage Tank 35	1.00	1.00	Not Applicable [3]
WW Poly	S230	Storage Tank 71	0.29	0.29	Not Applicable [3]
WW Poly	S231	Storage Tank 72	0.42	0.42	Not Applicable [3]
WW Poly	S239,S240,S241	Storage Tank 200, 201, 202	0.18	0.18	Not Applicable [3]
WW Poly	S300	Storage Tanks 204, 205, 206, 207	0.04	0.04	Not Applicable [3]
Boiler House	S141	Unilex Boiler 1	0.45	0.44	Exempt [4]
Boiler House	S141	Unilex Boiler 2	0.45	0.44	Exempt [4]
Boiler House	S143	Unilex Boiler 3	0.45	0.44	Exempt [4]
Boiler House	S142	Unilex Boiler 4	0.45	0.44	Exempt [4]
Boiler House	S144	Trane Boiler	0.92	0.90	Exempt [4]
C5 Unit	S044/S044A	Polymerization Operations & Storage Tanks 501,502,503,504,505,506	0.26	0.26	Exempt [4]
C5 Unit	S052	Resin Kettle #8	0.38	0.38	Exempt [4]
C5 Unit	S053	Resin Kettle #9	0.74	0.74	Exempt [4]
C5 Unit	S312	Sparkler Filter	0.05	0.05	Exempt [4]
C5 Unit	N/A	Sprarkler Precoat T-519 A/B	0.01	0.01	Exempt [4]
C5 Unit	N/A	Resin Product Loading	0.80	0.78	Exempt [4]
C5 Unit	S056	Hot Oil Heater B-3000	0.25	0.24	Exempt [4]
LTC Unit	S108	T-301-1 Reclaim Tank	0.58	0.29	Exempt [4]
LTC Unit	S111	Resin Kettle #5	0.32	0.16	Exempt [4]
LTC Unit	S112	Resin Kettle #6	0.24	0.13	Exempt [4]
LTC Unit	S113	Resin Kettle #7	0.68	0.35	Exempt [4]
LTC Unit	S165	#3 LTC (Berndorf) Pastillator Belt	0.53	0.53	Exempt [4]
LTC Unit	Load	Truck Loadout	0.37	0.18	Exempt [4]

Table 1 **Summary of Facility VOC Sources and RACT III Classification - Sorted by Source Classification**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Stack ID	Description	RACT 2 VOC PTE [1] (TPY)	RACT 3 VOC PTE [2] (TPY)	RACT III Classification
LTC Unit	Drum	Drumming	0.18	0.09	Exempt [4]
LTC Unit	S110A	T-610-1 LTC #2 and #4 Oil Water Separator	0.01	0.01	Exempt [4]
LTC Unit	S125	LTC #4 Oil Water Separator	0.01	0.01	Exempt [4]
LTC Unit	S107	#2 LTC Heater B-620-1	0.16	0.21	Exempt [4]
LTC Unit	S119	#4 LTC Heater B-9020-1	0.24	0.24	Exempt [4]
MP Poly	S033	T-800-1 Precoat Tank, T-104-1 Mole Sieve Drain Tank, T-104-3 Contaminated Dryer Solvent Tank	0.51	0.51	Exempt [4]
MP Poly	S035	T-203-1 Pre-Blend Tank	0.99	0.99	Exempt [4]
WW Poly	S013a	A-100 Feed Dryers (Regeneration)	0.01	0.01	Exempt [4]
WW Poly	S014	T-301-1 East Pre-Blend Tank	0.57	0.10	Exempt [4]
WW Poly	S015	T-300-1 North Pre-Blend Tank	0.57	0.09	Exempt [4]
WW Poly	S016	T-500-1 Slurry Tank	0.02	0.02	Exempt [4]
WW Poly	S018	T-700-1 North Neutralizer	0.31	0.31	Exempt [4]
WW Poly	S019	Funda Filter Steam Out	0.01	0.01	Exempt [4]
WW Poly	S019a	S-800-6 Funda Condensate Tank	0.00	0.00	Exempt [4]
WW Poly	S021	T-701-1 South Neutralizer	0.31	0.31	Exempt [4]
WW Poly	S022	T-1001-1 Reclaim Pot	0.13	0.13	Exempt [4]
WWTP	S147	Tank 701A, 701B, Back Porch Sumps (T-713-1 Raw Sump, S-302-1 Air Flotation Tank, T-717-1 Oil Sump, T-714-1 Acid Sump, T-715-1 Final Sump)	0.48	0.48	Exempt [4]
WWTP	F028	Biotreatment Clarifier	0.11	0.11	Exempt [4]
WWTP	F036	Sludge Batch Tanks	0.00	0.00	Exempt [4]
WWTP	F037	Sludge Solids Handling	0.00	0.00	Exempt [4]
C5 Unit	S054	Resin Kettle #10	1.07	1.07	Presumptive [5]
Emulsion	S162	RK1, RK2, Blend Tanks 1,2,3,4	0.28	2.16	Presumptive [5]
LTC Unit	S124	LTC Unit #4 Vacuum System	1.46	1.46	Presumptive [5]
MP Poly	S029	R-400-1 Reactor	1.65	1.65	Presumptive [5]
Pilot Plant	S155	Neutralizer, Reactor, Funda Filters	2.20	2.20	Presumptive [5]
WW Poly	S017	R-600-1 North Reactor and R-601-1 South Reactor	1.78	1.78	Presumptive [5]
C5 Unit	S055	Pastillating Belts #1 and #2 (point and fugitive)	7.44	7.43	Alternative [6]
Dresinate	S085	L- 500-1 Double Drum Dryer	5.48	5.50	Alternative [6]
Hydro Unit	S004	Metering Tanks, Tank 103 & 104, Catalyst Catch Tank, Mott Filter, Heel Tank	13.00	12.98	Alternative [6]
Hydro Unit	S007	Vent Tank, Autoclave #1, Autoclave #2	15.00	15.13	Alternative [6]
LTC Unit	S109	LTC Unit #1 Vacuum System	3.80	3.80	Alternative [6]
LTC Unit	S110	LTC Unit #2 Vacuum System	8.09	8.09	Alternative [6]
LTC Unit	S114	#1 and #2 LTC Pastillator Belt	2.80	2.80	Alternative [6]
MP Poly	S034	Filtrate System: R-701-1 Filtrate Receiver, T-500-1 Neutralizer, T-700-1 Solvent Wash Tank, T-703-1 Heel Tank, S-601-1 and S 602-1 Funda Filters, A-101 Mole Sieve Dryers (Regeneration)	10.33	10.33	Alternative [6]
Other sources	-	Fugitive Emissions from Equipment Leaks (valves, pumps, pipe connectors, etc.)	64.10	70.00	Alternative [6]
WW Poly	S013	A-100 Feed Dryers (Regeneration)	4.85	4.85	Alternative [6]
WW Poly	S020	T-900-1 Filtrate Receiver	5.11	5.11	Alternative [6]
WW Poly	S023	T-903-1 Solvent Wash Receiver	7.52	7.52	Alternative [6]
WW Poly	S027	T-901-1 Auxiliary Receiver	5.11	5.11	Alternative [6]
WWTP	F033,F034,F035	Tanks T-702A , T-702B, T-702C Pretreated Water Tanks	8.84	8.84	Alternative [6]
WWTP	F027	T-411-1 Biotreatment Aeration Tank	15.25	15.25	Alternative [6]

1. RACT2 PTE values taken from the VOC Control Proposal submitted in December 2021
2. RACT3 PTE values taken from the Title V permit application submittal of February 2022
3. Storage tanks with capacity of 2000 gallons or more are Not Applicable to RACT III due to being subject to ACHD storage tank regulations at 2105.12.
4. Exempt from RACT III due to emissions less than 1 tpy, per PADEP regulation 129.111(c).
5. Subject to applicable Presumptive RACT requirements, per PADEP regulation 129.112.
6. Sources with VOC emissions of 2.7 tpy or greater are subject to Alternative RACT (case-by-case) analysis requirements, per PADEP regulation 129.114.

Table 2 **Summary of Facility VOC Sources and RACT III Classification - Sorted by Operating Area**

Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Stack ID	Description	RACT 2 VOC PTE [1] (TPY)	RACT 3 VOC PTE [2] (TPY)	RACT III Classification [3]
LTC Unit	S109	LTC Unit #1 Vacuum System	3.80	3.80	Alternative
LTC Unit	S110	LTC Unit #2 Vacuum System	8.09	8.09	Alternative
LTC Unit	S124	LTC Unit #4 Vacuum System	1.46	1.46	Presumptive
LTC Unit	S108	T-301-1 Reclaim Tank	0.58	0.29	Exempt
LTC Unit	S111	Resin Kettle #5	0.32	0.16	Exempt
LTC Unit	S112	Resin Kettle #6	0.24	0.13	Exempt
LTC Unit	S113	Resin Kettle #7	0.68	0.35	Exempt
LTC Unit	S114	#1 and #2 LTC Pastillator Belt	2.80	2.80	Alternative
LTC Unit	S165	#3 LTC (Berndorf) Pastillator Belt	0.53	0.53	Exempt
LTC Unit	Load	Truck Loadout	0.37	0.18	Exempt
LTC Unit	Drum	Drumming	0.18	0.09	Exempt
LTC Unit	S110A	T-610-1 LTC #2 and #4 Oil Water Separator	0.01	0.01	Exempt
LTC Unit	S125	LTC #4 Oil Water Separator	0.01	0.01	Exempt
LTC Unit	S107	#2 LTC Heater B-620-1	0.16	0.21	Exempt
LTC Unit	S119	#4 LTC Heater B-9020-1	0.24	0.24	Exempt
WW Poly	S013	A-100 Feed Dryers (Regeneration)	4.85	4.85	Alternative
WW Poly	S013a	A-100 Feed Dryers (Regeneration)	0.01	0.01	Exempt
WW Poly	S014	T-301-1 East Pre-Blend Tank	0.57	0.10	Exempt
WW Poly	S015	T-300-1 North Pre-Blend Tank	0.57	0.09	Exempt
WW Poly	S016	T-500-1 Slurry Tank	0.02	0.02	Exempt
WW Poly	S017	R-600-1 North Reactor and R-601-1 South Reactor	1.78	1.78	Presumptive
WW Poly	S018	T-700-1 North Neutralizer	0.31	0.31	Exempt
WW Poly	S019	Funda Filter Steam Out	0.01	0.01	Exempt
WW Poly	S019a	S-800-6 Funda Condensate Tank	0.00	0.00	Exempt
WW Poly	S020	T-900-1 Filtrate Receiver	5.11	5.11	Alternative
WW Poly	S021	T-701-1 South Neutralizer	0.31	0.31	Exempt
WW Poly	S022	T-1001-1 Reclaim Pot	0.13	0.13	Exempt
WW Poly	S023	T-903-1 Solvent Wash Receiver	7.52	7.52	Alternative
WW Poly	S024	Storage Tanks 68, 69, 74	1.37	1.37	Not Applicable
WW Poly	S025	Storage Tanks 73, 75, 76, 77	5.45	5.45	Not Applicable
WW Poly	S026	Storage Tank 67	0.89	0.89	Not Applicable
WW Poly	S027	T-901-1 Auxiliary Receiver	5.11	5.11	Alternative
WW Poly	S228	Storage Tank 66	0.29	0.30	Not Applicable
WW Poly	S195	Storage Tank 10	0.03	0.29	Not Applicable
WW Poly	S206, S208	Storage Tank 22, 24	0.03	0.03	Not Applicable
WW Poly	S207, S209	Storage Tank 23, 25	0.03	0.03	Not Applicable
WW Poly	S211	Storage Tank 27	0.04		Not Applicable
WW Poly	S210,S212, S213	Storage Tank 26, 28, 29	0.42	0.42	Not Applicable
WW Poly	S074	Storage Tank 34	0.27	0.27	Not Applicable
WW Poly	S075	Storage Tank 35	1.00	1.00	Not Applicable
WW Poly	S230	Storage Tank 71	0.29	0.29	Not Applicable
WW Poly	S231	Storage Tank 72	0.42	0.42	Not Applicable
WW Poly	S239,S240,S241	Storage Tank 200, 201, 202	0.18	0.18	Not Applicable
WW Poly	S300	Storage Tanks 204, 205, 206, 207	0.04	0.04	Not Applicable
C5 Unit	S044/S044A	Polymerization Operations & Storage Tanks 501,502,503,504,505,506	0.26	0.26	Exempt
C5 Unit	S052	Resin Kettle #8	0.38	0.38	Exempt
C5 Unit	S053	Resin Kettle #9	0.74	0.74	Exempt
C5 Unit	S054	Resin Kettle #10	1.07	1.07	Presumptive
C5 Unit	S312	Sparkler Filter	0.05	0.05	Exempt
C5 Unit	N/A	Sprarkler Precoat T-519 A/B	0.01	0.01	Exempt
C5 Unit	S216	Raw Material Tank 50	2.80	2.79	Not Applicable
C5 Unit	S218	Raw Material Tank 52	2.37	2.40	Not Applicable
C5 Unit	S219	Raw Material Tank 53	<1	0.41	Not Applicable
C5 Unit	S060	Raw Material Tank 54	1.66	1.66	Not Applicable
C5 Unit	S061	Raw Material Tank 55	1.16	1.16	Not Applicable
C5 Unit	S058	Raw Material Tank 500	0.19	0.19	Not Applicable
C5 Unit	S274	Raw Material Tank 511	0.10	0.10	Not Applicable
C5 Unit	S064,S066,S097,S267, S268,S269,S270	Resin Storage Tanks (121, 123, 124, 366, 367, 601 & 602)	1.77	1.77	Not Applicable

Table 2 **Summary of Facility VOC Sources and RACT III Classification - Sorted by Operating Area**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Stack ID	Description	RACT 2 VOC PTE [1] (TPY)	RACT 3 VOC PTE [2] (TPY)	RACT III Classification [3]
C5 Unit	S059, S238	Resin Storage Tanks 504 and 161	2.00	2.00	Not Applicable
C5 Unit	S055	Pastillating Belts #1 and #2 (point and fugitive)	7.44	7.43	Alternative
C5 Unit	N/A	Resin Product Loading	0.80	0.78	Exempt
C5 Unit	S056	Hot Oil Heater B-3000	0.25	0.24	Exempt
MP Poly	S029	R-400-1 Reactor	1.65	1.65	Presumptive
MP Poly	S033	T-800-1 Precoat Tank, T-104-1 Mole Sieve Drain Tank, T-104-3 Contaminated Dryer Solvent Tank	0.51	0.51	Exempt
MP Poly	S034	Filtrate System: R-701-1 Filtrate Receiver, T-500-1 Neutralizer, T-700-1 Solvent Wash Tank, T-703-1 Heel Tank, S-601-1 and S 602-1 Funda Filters, A-101 Mole Sieve Dryers (Regeneration)	10.33	10.33	Alternative
MP Poly	S035	T-203-1 Pre-Blend Tank	0.99	0.99	Exempt
MP Poly	S039, S040, S041	Storage Tanks T-301, T-302, T-303	1.37	1.03	Not Applicable
WWTP	S147	Tank 701A, 701B, Back Porch Sumps (T-713-1 Raw Sump, S-302-1 Air Flotation Tank, T-717-1 Oil Sump, T-714-1 Acid Sump, T-715-1 Final Sump)	0.48	0.48	Exempt
WWTP	F033,F034,F035	Tanks T-702A , T-702B, T-702C Pretreated Water Tanks	8.84	8.84	Alternative
WWTP	F027	T-411-1 Biotreatment Aeration Tank	15.25	15.25	Alternative
WWTP	F028	Biotreatment Clarifier	0.11	0.11	Exempt
WWTP	F036	Sludge Batch Tanks	0.00	0.00	Exempt
WWTP	F037	Sludge Solids Handling	0.00	0.00	Exempt
Pilot Plant	S155	Neutralizer, Reactor, Funda Filters	2.20	2.20	Presumptive
Hydro Unit	S004	Metering Tanks, Tank 103 & 104, Catalyst Catch Tank, Mott Filter, Heel Tank	13.00	12.98	Alternative
Hydro Unit	S001	Storage Tanks 100, 101	1.20	1.27	Not Applicable
Hydro Unit	S012	Storage Tanks 102, 105, 106	6.30	7.35	Not Applicable
Hydro Unit	S007	Vent Tank, Autoclave #1, Autoclave #2	15.00	15.13	Alternative
Emulsion	S162	RK1, RK2, Blend Tanks 1,2,3,4	0.28	2.16	Presumptive
Dresinate	S085	L- 500-1 Double Drum Dryer	5.48	5.50	Alternative
Dresinate	S187	Storage Tank R-1-A	0.01	0.05	Not Applicable
Dresinate	S290	Storage Tank 782	0.01	0.05	Not Applicable
Storage Tanks	S190	Storage Tank 4	<1	0.51	Not Applicable
Storage Tanks	S232	Storage Tank 78	<1	1.49	Not Applicable
Storage Tanks	S091	Storage Tank 80	<1	0.05	Not Applicable
Storage Tanks	S236	Storage Tank 151	<1	0.15	Not Applicable
Storage Tanks	S244	Storage Tank 208	<1	0.19	Not Applicable
Storage Tanks	S248	Storage Tank 252	<1	0.06	Not Applicable
Storage Tanks	S256	Storage Tank 261	<1	0.61	Not Applicable
Storage Tanks	S038	Storage Tank 262	<1	0.61	Not Applicable
Storage Tanks	S257	Storage Tank 263	<1	0.53	Not Applicable
Storage Tanks	S258	Storage Tank 264	<1	0.52	Not Applicable
Storage Tanks	S259	Storage Tank 265	<1	0.57	Not Applicable
Storage Tanks		Storage Tank 365	<1	<1	Not Applicable
Storage Tanks		Storage Tank 761	<1	<1	Not Applicable
Storage Tanks		Storage Tank 764	<1	<1	Not Applicable
Storage Tanks		Storage Tank 766	<1	<1	Not Applicable
Storage Tanks	S287	Storage Tank 775	<1	0.42	Not Applicable
Storage Tanks	S160	Storage Tank 783	<1	0.05	Not Applicable
Boiler House	S141	Unilex Boiler 1	0.45	0.44	Exempt
Boiler House	S141	Unilex Boiler 2	0.45	0.44	Exempt
Boiler House	S143	Unilex Boiler 3	0.45	0.44	Exempt
Boiler House	S142	Unilex Boiler 4	0.45	0.44	Exempt
Boiler House	S144	Trane Boiler	0.92	0.90	Exempt
Other sources	-	Fugitive Emissions from Equipment Leaks (valves, pumps, pipe connectors, etc.)	64.10	70.00	Alternative

1. RACT2 PTE values taken from the VOC Control Proposal submitted in December 2021
2. RACT3 PTE values taken from the Title V permit application submittal of February 2022
3. See footnotes at bottom of Table 1

Table 3 List of Storage Tanks and Capacities
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Tank ID	Stack ID	Process Area	VOC Controls	Capacity (gallons)	RACT III Classification *
773 (T-203-1)		Emulsion	None		Exempt
T-402-3		Emulsion	None		Exempt
T-405-1		Emulsion	None		Exempt
T-406-1		Emulsion	None		Exempt
T-407-1		Emulsion	None		Exempt
T-408-1		Emulsion	None		Exempt
T-411-1		Emulsion	None		Exempt
T-412-1		Emulsion	None		Exempt
762	S284	Miscellaneous	None		Exempt
763	S285	Miscellaneous	None		Exempt
T-105-2		Miscellaneous	None		Exempt
T-2004-1	S260	Miscellaneous	None		Exempt
T-401-1		Miscellaneous	None		Exempt
T-703-3		Miscellaneous	None		Exempt
T-7065-1		Miscellaneous	None		Exempt
T-801-4		Miscellaneous	None		Exempt
50	S216	C5 Unit	None	528,765	Not Applicable
52	S218	C5 Unit	None	528,765	Not Applicable
53	S219	C5 Unit	None	528,765	Not Applicable
54	S060	C5 Unit	None	1,469,451	Not Applicable
55	S061	C5 Unit	None	579,585	Not Applicable
121	S064	C5 Unit	None	19,432	Not Applicable
123	S066	C5 Unit	None	20,080	Not Applicable
124	S097	C5 Unit	None	24,864	Not Applicable
161	S238	C5 Unit	None	158,630	Not Applicable
365	S266	C5 Unit	None	20,728	Not Applicable
366	S267	C5 Unit	None	20,132	Not Applicable
367	S268	C5 Unit	None	20,132	Not Applicable
500	S058	C5 Unit	None	112,251	Not Applicable
501	S044/S044A	C5 Unit	Thermal Oxidizer	60,914	Not Applicable
502	S044/S044A	C5 Unit	Thermal Oxidizer	60,914	Not Applicable
503	S044/S044A	C5 Unit	Thermal Oxidizer	51,184	Not Applicable
504	S059	C5 Unit	None	62,817	Not Applicable
505	S044/S044A	C5 Unit	Thermal Oxidizer	8,484	Not Applicable
506	S044/S044A	C5 Unit	Thermal Oxidizer	8,484	Not Applicable
511	S274	C5 Unit	None	15,228	Not Applicable
601	S269	C5 Unit	None	108,291	Not Applicable
602	S270	C5 Unit	None	108,291	Not Applicable
80	S091	Dresinate	None	24,881	Not Applicable
782	S290	Dresinate	None	9,518	Not Applicable
783	S160	Dresinate	None	9,518	Not Applicable
R-1-A	S187	Dresinate	None	17,626	Not Applicable
761	S283	Emulsion	None	9,518	Not Applicable
775	S287	Emulsion	None	9,518	Not Applicable
100	S001	Hydro Unit	Condenser E-101-4	6,016	Not Applicable
101	S001	Hydro Unit	Condenser E-101-4	6,016	Not Applicable
102	S012	Hydro Unit	Condenser E-104-1,	6,016	Not Applicable
105	S012	Hydro Unit	Condenser E-104-1,	6,016	Not Applicable
106	S012	Hydro Unit	Condenser E-104-1, Condenser E-104-2	10,282	Not Applicable
2	S189	Miscellaneous	None	169,205	Not Applicable
4	S190	Miscellaneous	None	88,128	Not Applicable
9	S194	Miscellaneous	None	110,159	Not Applicable
12	S197	Miscellaneous	None	110,159	Not Applicable
13	S198	Miscellaneous	None	110,159	Not Applicable
14	S199	Miscellaneous	None	110,159	Not Applicable
15	S200	Miscellaneous	None	110,159	Not Applicable
16	S201	Miscellaneous	None	110,159	Not Applicable
35	S075	Miscellaneous	None	169,205	Not Applicable
78	S232	Miscellaneous	None	169,205	Not Applicable

Table 3 **List of Storage Tanks and Capacities**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Tank ID	Stack ID	Process Area	VOC Controls	Capacity (gallons)	RACT III Classification *
150	S235	Miscellaneous	None	1,504,044	Not Applicable
151	S236	Miscellaneous	None	1,504,044	Not Applicable
160		Miscellaneous	None	158,630	Not Applicable
208	S244	Miscellaneous	None	25,381	Not Applicable
250	S246	Miscellaneous	None	30,457	Not Applicable
251	S247	Miscellaneous	None	30,457	Not Applicable
252	S248	Miscellaneous	None	30,457	Not Applicable
254	S249	Miscellaneous	None	15,275	Not Applicable
257	S252	Miscellaneous	None	15,275	Not Applicable
261	S256	Miscellaneous	None	20,728	Not Applicable
262	S038	Miscellaneous	None	20,080	Not Applicable
263	S257	Miscellaneous	None	20,080	Not Applicable
264	S258	Miscellaneous	None	20,080	Not Applicable
265	S259	Miscellaneous	None	20,080	Not Applicable
382	S271	Miscellaneous	None	19,625	Not Applicable
408	No venting	Miscellaneous	None	9,776	Not Applicable
510	No venting	Miscellaneous	None	100,000	Not Applicable
513	S275	Miscellaneous	None	3,714	Not Applicable
514	S276	Miscellaneous	None	3,714	Not Applicable
766	S288	Miscellaneous	None	3,760	Not Applicable
301	S039	MP Poly Unit	None	75,202	Not Applicable
302	S040	MP Poly Unit	None	75,202	Not Applicable
303	S041	MP Poly Unit	None	75,202	Not Applicable
10	S195	WW Poly Unit	None	110,159	Not Applicable
22	S206	WW Poly Unit	None	15,863	Not Applicable
23	S207	WW Poly Unit	None	15,863	Not Applicable
24	S208	WW Poly Unit	None	15,863	Not Applicable
25	S209	WW Poly Unit	None	15,863	Not Applicable
26	S210	WW Poly Unit	None	16,257	Not Applicable
28	S212	WW Poly Unit	None	16,257	Not Applicable
29	S213	WW Poly Unit	None	16,257	Not Applicable
34	S074	WW Poly Unit	None	169,205	Not Applicable
66	S228	WW Poly Unit	None	75,202	Not Applicable
67	S026	WW Poly Unit	Condenser E-67-3	75,202	Not Applicable
68	S024	WW Poly Unit	Condenser E-201-1	75,202	Not Applicable
69	S024	WW Poly Unit	Condenser E-201-1	75,202	Not Applicable
71	S230	WW Poly Unit	None	75,202	Not Applicable
72	S231	WW Poly Unit	None	75,202	Not Applicable
73	S025	WW Poly Unit	Condenser E-202-1	75,202	Not Applicable
74	S024	WW Poly Unit	Condenser E-202-1	75,202	Not Applicable
75	S025	WW Poly Unit	Condenser E-202-1	75,202	Not Applicable
76	S025	WW Poly Unit	Condenser E-202-1	75,202	Not Applicable
77	S025	WW Poly Unit	Condenser E-202-1	75,202	Not Applicable
200	S239	WW Poly Unit	None	25,381	Not Applicable
201	S240	WW Poly Unit	None	25,381	Not Applicable
202	S202	WW Poly Unit	None	25,381	Not Applicable
204	S300	WW Poly Unit	Condenser E-204-4, Carbon Adsorber A-204-5A or 5B	41,878	Not Applicable
205	S300	WW Poly Unit	Condenser E-205-4, Carbon Adsorber A-204-5A or 5B	25,381	Not Applicable
206	S300	WW Poly Unit	Condenser E-206-4, Carbon Adsorber A-204-5A or 5B	25,381	Not Applicable
207	S300	WW Poly Unit	Condenser E-207-4, Carbon Adsorber A-204-5A or 5B	25,381	Not Applicable

* Storage tanks with capacity of 2000 gallons or more are 'Not Applicable' to RACT III due to being subject to ACHD storage tank regulations at 2105.12. The tanks in this list marked as "Exempt" have emissions of less than 1 tpy.

Table 4 **Facility Sources Exempt from RACT III (PA Code 129.111(c) [< 1 TPY VOC])**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Source ID	Description	VOC PTE * (TPY)
LTC Unit	S108	T-301-1 Reclaim Tank	0.29
LTC Unit	S111	Resin Kettle #5	0.16
LTC Unit	S112	Resin Kettle #6	0.13
LTC Unit	S113	Resin Kettle #7	0.35
LTC Unit	S165	#3 LTC (Berndorf) Pastillator Belt	0.53
LTC Unit	Load	Truck Loadout	0.18
LTC Unit	Drum	Drumming	0.09
LTC Unit	S110A	T-610-1 LTC #2 and #4 Oil Water Separator	0.01
LTC Unit	S125	LTC #4 Oil Water Separator	0.01
LTC Unit	S107	#2 LTC Heater B-620-1	0.21
LTC Unit	S119	#4 LTC Heater B-9020-1	0.24
WW Poly	S013a	A-100 Feed Dryers (Regeneration)	0.01
WW Poly	S014	T-301-1 East Pre-Blend Tank	0.10
WW Poly	S015	T-300-1 North Pre-Blend Tank	0.09
WW Poly	S016	T-500-1 Slurry Tank	0.02
WW Poly	S018	T-700-1 North Neutralizer	0.31
WW Poly	S019	Funda Filter Steam Out	0.01
WW Poly	S019a	S-800-6 Funda Condensate Tank	0.00
WW Poly	S021	T-701-1 South Neutralizer	0.31
WW Poly	S022	T-1001-1 Reclaim Pot	0.13
C5 unit	S044/S044A	Polymerization Operations	0.26
C5 unit	S052	Resin Kettle #8	0.38
C5 unit	S053	Resin Kettle #9	0.74
C5 unit	S312	Sparkler Filters S-519 A/B	0.05
C5 unit	N/A	Sprarkler Precoat T-519-2	0.01
C5 unit	N/A	Resin Product Loading	0.78
C5 unit	S056	Hot Oil Heater B-3000	0.24
MP Poly	S033	T-800-1 Precoat Tank, T-104-1 Mole Sieve Drain Tank, T-104-3 Contaminated Dryer Solvent Tank	0.51
MP Poly	S035	T-203-1 Preblend Tank	0.99
WWTP	S147	Tank 701A, 701B, Back Porch Sumps (T-713-1 Raw Sump, S-302-1 Air Flotation Tank, T-717-1 Oil Sump, T-714-1 Acid Sump, T-715-1 Final Sump)	0.48
WWTP	F028	Biotreatment Clarifier	0.11
WWTP	F036	Sludge Batch Tanks	0.00
WWTP	F037	Sludge Solids Handling	0.00
Boiler House	S141	Unilex Boiler 1	0.44
Boiler House	S141	Unilex Boiler 2	0.44
Boiler House	S143	Unilex Boiler 3	0.44
Boiler House	S143	Unilex Boiler 4	0.44
Boiler House	S144	Trane Boiler	0.90
Emulsion		773 (T-203-1)	< 1
Emulsion		T-402-3	< 1
Emulsion		T-405-1	< 1
Emulsion		T-406-1	< 1
Emulsion		T-407-1	< 1

Table 4 **Facility Sources Exempt from RACT III (PA Code 129.111(c) [< 1 TPY VOC])**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Source ID	Description	VOC PTE * (TPY)
Emulsion		T-408-1	< 1
Emulsion		T-411-1	< 1
Emulsion		T-412-1	< 1
Miscellaneous	S284	762	< 1
Miscellaneous	S285	763	< 1
Miscellaneous		T-105-2	< 1
Miscellaneous	S260	T-2004-1 (formerly 278)	< 1
Miscellaneous		T-401-1	< 1
Miscellaneous		T-703-3	< 1
Miscellaneous		T-7065-1	< 1
Miscellaneous		T-801-4	< 1

* PTE values taken from the Title V permit application submittal of February 2022

Table 5 **Facility Sources Subject to Presumptive RACT III (PA Code 129.112)**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Source ID	Description	VOC PTE* (TPY)	Basis for Presumptive	Presumptive RACT Requirement
C5 Unit	S054	Resin Kettle #10	1.07	1 ≤ TPY < 2.7	Install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices
Emulsion	S162	RK1, RK2, Blend Tanks 1,2,3,4	2.16	1 ≤ TPY < 2.7	Install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices
LTC Unit	S124	LTC Unit #4 Vacuum System	1.46	1 ≤ TPY < 2.7	Install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices
MP Poly	S029	R-400-1 Reactor	1.65	1 ≤ TPY < 2.7	Install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices
Pilot Plant	S155	Neutralizer, Reactor, Funda Filters	2.20	1 ≤ TPY < 2.7	Install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices
WW Poly	S017	R-600-1 North Reactor and R-601-1 South Reactor	1.78	1 ≤ TPY < 2.7	Install, maintain and operate the source in accordance with the manufacturer's specifications and with good operating practices

* PTE values taken from the Title V permit application submittal of February 2022

Table 6 **Facility Sources Subject to Alternative (Case-by-Case) RACT III (PA Code 129.114)**
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Operating Area	Stack ID	Description	VOC PTE [1] (TPY)	Exhaust Flow [1] (acfm)	Technically Infeasible Controls [2]	RACT III Economic Evaluation Required? [3]
LTC Unit	S109	LTC Unit #1 Vacuum System	3.80	1	Rotary Concentrator	NO
LTC Unit	S110	LTC Unit #2 Vacuum System	8.09	3	Rotary Concentrator	NO
LTC Unit	S114	#1 and #2 LTC Pastillator Belt	2.80	3,100	Rotary Concentrator	NO
WW Poly	S013	A-100 Feed Dryers (Regeneration)	4.85	4	Rotary Concentrator	NO
WW Poly	S020	T-900-1 Filtrate Receiver	5.11	186	Rotary Concentrator	NO
WW Poly	S023	T- 903-1 Solvent Wash Receiver	7.52	186	Rotary Concentrator	NO
WW Poly	S027	T-901-1 Auxiliary Receiver	5.11	186	Rotary Concentrator	NO
C5 unit	S055	Pastillating Belts #1 and #2 (Point and Fugitive)	7.43	9,000	Condensation	NO
MP Poly	S034	Filtrate System: R-701-1 Filtrate Receiver, T-500-1 Neutralizer, T-700-1 Solvent Wash Tank, T-703-1 Heel Tank, S-601-1 and S 602-1 Funda Filters,	10.33	223	Rotary Concentrator	NO
WWTP	F033,F034,F035	T-702A , T-702B, T-702C Pretreated Water Tanks	8.84	N/A	All infeasible - see Section 3.1 of *VOC RACT III Evaluation* report	NO
WWTP	F027	T-411-1 Biotreatment Aeration Tank	15.25	N/A	All infeasible - see Section 3.2 of *VOC RACT III Evaluation* report	NO
Hydro Unit	S004	Metering Tank, Tanks 103&104, Catalyst Catch Tank, Mott Filter, Heel Tank	12.98	28	Rotary Concentrator	**YES**
Hydro Unit	S007	Vent Tank, Autoclave #1, Autoclave #2	15.13	200	Rotary Concentrator	**YES**
Dresinate	S085	L-500-1 Double Drum Dryer	5.50	2,000	Rotary Concentrator	NO
Other Sources	N/A	Fugitive Emissions from Equipment Leaks (valves, pumps, pipe connectors, etc.)	70.00	N/A	All infeasible - see Section 3.3 of *VOC RACT III Evaluation* report	NO

1. PTE values and exhaust flow rates taken from the Title V permit application submittal of February 2022
2. Rotary Concentrators are for large flow streams (> 7500 cfm); Vapor Condensers are suited for low flow streams
3. Per 129.114(i)(1)(i), RACT II sources that had a cost effectiveness of equal to or greater than $12,000 per ton reduced are not required to undergo an economic evaluation for RACT III. Refer to Table 8 for the RACT II cost effectiveness values.

Table 7 **VOC Control Costs of Technically Feasible Control Options for Alternative RACT III Sources***
Synthomer Jefferson Hills LLC - West Elizabeth, PA

Control Option		S004 Hydro	S007 Hydro
Recuperative Oxidation (98%)	tpy VOC Removed	12.6	14.7
	Annual Cost	$187,768	$212,285
	$/ton	**$14,910**	**$14,462**
Regenerative Oxidation (98%)	tpy VOC Removed	12.6	14.7
	Annual Cost	$251,046	$258,716
	$/ton	**$19,935**	**$17,625**
Catalytic Oxidation (98%)	tpy VOC Removed	12.6	14.7
	Annual Cost	$175,745	$189,025
	$/ton	**$13,956**	**$12,877**
Rotary Concentrator/ Oxidation (90-98%)	tpy VOC Removed	N/A	N/A
	Annual Cost	N/A	N/A
	$/ton	**N/A**	**N/A**
Carbon Adsorption (fixed bed) (90-95%)	tpy VOC Removed	12.3	14.4
	Annual Cost	$422,415	$598,354
	$/ton	**$34,297**	**$41,681**
Refrigerated Condenser (90 - 95%)	tpy VOC Removed	11.7	13.7
	Annual Cost	$168,806	$223,573
	$/ton	**$14,485**	**$16,307**
	Minimum $/ton:	**$13,956**	**$12,877**

* Only required for those sources that had a cost effectiveness less than $12,000/ton under the RACT II analysis (see Table 8 for those cost effectiveness values)

N/A - the control type is not technically feasible for this process (see Table 6)

Table 8 VOC Control Cost Comparisons for Alternative (Case-by-Case) RACT II Sources*

Synthomer Jefferson Hills LLC - West Elizabeth, PA

Control Option		S109 LTC	S110 LTC	S114 LTC	S013 & S013a WW Poly	S020 WW Poly	S023 WW Poly	S027 WW Poly
Thermal Oxidation (98%)	tpy VOC Removed	3.6	7.6	2.6	4.6	4.8	7.1	4.8
	Annual Cost	$143,908	$148,047	$311,632	$156,264	$183,607	$175,518	$175,934
	$/ton	**$40,137**	**$19,443**	**$118,251**	**$34,162**	**$38,176**	**$24,798**	**$36,653**
Catalytic Oxidation (98%)	tpy VOC Removed	3.6	7.6	2.6	4.6	4.8	7.1	4.8
	Annual Cost	$134,852	$135,637	$254,524	$138,270	$154,741	$148,790	$149,202
	$/ton	**$37,705**	**$17,814**	**$96,581**	**$30,228**	**$32,174**	**$21,022**	**$31,084**
Rotary Concentrator/ Oxidation (98%)	tpy VOC Removed	3.6	7.6	2.6	4.6	4.8	7.1	4.8
	Annual Cost	$184,606	$184,634	$219,307	$184,832	$187,503	$186,464	$186,464
	$/ton	**$51,616**	**$24,249**	**$83,218**	**$40,408**	**$38,986**	**$26,345**	**$38,847**
Carbon Adsorption (fixed bed) (90-95%)	tpy VOC Removed	3.5	7.4	2.4	4.4	4.7	6.9	4.7
	Annual Cost	$181,762	$179,679	$180,804	$154,297	$156,903	$156,790	$155,442
	$/ton	**$52,426**	**$24,343**	**$74,706**	**$34,797**	**$33,654**	**$22,852**	**$33,073**
Refrigerated Condenser (95%)	tpy VOC Removed	3.5	7.4	2.6	4.4	4.7	6.9	4.7
	Annual Cost	$136,399	$138,457	$1,296,659	$149,704	$219,179	$189,142	$192,802
	$/ton	**$39,342**	**$18,758**	**$507,565**	**$33,761**	**$47,011**	**$27,567**	**$41,022**
	Minimum $/ton:	37,705	17,814	74,706	30,228	32,174	21,022	31,084

Control Option		S025 WW Poly	S055 C-5	S034 MP Poly	S004 Hydro	S007 Hydro	S012 Hydro	S085 Dresinate
Thermal Oxidation (98%)	tpy VOC Removed	5.1	5.8	9.7	12.2	14.1	5.9	5.2
	Annual Cost	$154,798	$526,415	$177,803	$165,140	$174,148	$146,413	$345,875
	$/ton	**$30,178**	**$90,761**	**$18,288**	**$13,536**	**$12,335**	**$24,692**	**$66,816**
Catalytic Oxidation (98%)	tpy VOC Removed	5.1	5.8	9.7	12.2	14.1	5.9	5.2
	Annual Cost	$137,691	$412,727	$150,236	$142,844	$147,584	$135,286	$280,531
	$/ton	**$26,843**	**$71,160**	**$15,452**	**$11,708**	**$10,454**	**$22,816**	**$54,193**
Rotary Concentrator/ Oxidation (98%)	tpy VOC Removed	5.1	5.8	9.7	12.2	14.1	5.9	5.2
	Annual Cost	$184,776	$285,728	$186,833	$185,480	$186,486	$184,620	$229,409
	$/ton	**$36,022**	**$49,263**	**$19,216**	**$15,203**	**$13,209**	**$31,136**	**$44,317**
Carbon Adsorption (fixed bed) (90-95%)	tpy VOC Removed	5	5.4	8.9	10.3	13	5.4	4.8
	Annual Cost	$156,423	$207,403	$158,992	$161,638	$161,521	$180,771	$186,358
	$/ton	**$31,458**	**$38,408**	**$17,807**	**$15,693**	**$12,458**	**$33,197**	**$39,200**
Refrigerated Condenser (95%)	tpy VOC Removed	5	5.7	9.4	11.5	13.7	5.7	5
	Annual Cost	$146,875	$2,920,397	$193,751	$160,986	$182,016	$137,554	$1,504,896
	$/ton	**$29,538**	**$512,350**	**$20,557**	**$13,999**	**$13,300**	**$23,931**	**$299,894**
	Minimum $/ton:	26,843	38,408	15,452	11,708	10,454	22,816	39,200

* All information taken from the ACHD Technical Support Document for RACT2 Installation Permit #0058-I026, dated 4/21/2020

ATTACHMENT 2
Economic Analysis Tables

Oxidation Cost Tables

Table 1.	Cost Summary of RACT III VOC Oxidation Control Options	Source Name:	Hydro Unit
	Synthomer Jefferson Hills, LLC - West Elizabeth, PA	Stack ID:	S004

1a. - Ranking of VOC Oxidation Control Options, by Reduction Efficiency

Ranking	Control Technology	Destruction Efficiency (%)	Capture Efficiency (%)	Reduction [1] Efficiency (%)	Inlet VOC Emissions (tons/year)	VOC Reduction (tons/year)
1.	Recuperative Thermal Oxidizer	98.0	99.0	97.0	12.98	12.59
2.	Catalytic Oxidizer	98.0	99.0	97.0	12.98	12.59
3.	Regenerative Thermal Oxidizer	98.0	99.0	97.0	12.98	12.59

1b. - Ranking of Annual Control Costs per Ton of Pollutant Reduced

Ranking	Control Technology	Capital Cost ($)	Capital Recovery Cost ($/year)	Capital-Only Control Cost ($/ton/yr)	Total Annualized Cost ($/year)	**VOC Control Cost ($/ton/yr)**
1.	Catalytic Oxidizer	317,476	25,472	2,023	175,745	**13,956**
2.	Recuperative Thermal Oxidizer	409,179	32,834	2,607	187,768	**14,910**
3.	Regenerative Thermal Oxidizer	896,238	71,916	5,711	251,046	**19,935**

[1] Overall reduction based on product of Control efficiency and Capture efficiency

Table 2. **INPUT PARAMETERS FOR CONTROL TECHNOLOGY ANALYSIS**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: **Hydro Unit S004**

Emissions Data

VOC emissions, tpy:	**12.98**	From Title V application, 2/2022
Operating hours per year:	**8,760**	

Collection System Data

Units Controlled	Expected Capture Eff.	Expected Air Flow, cfm
Vent S004	**99%**	**30**
	Total:	30

Control System Data

	Removal Efficiency, %	Heat Recovery, %
Recuperative Thermal Oxidizer	**98**	**50**
Catalytic Oxidizer (fixed bed)	**98**	**50**
Regenerative Thermal Oxidizer (RTO)	**98**	**85**

Auxiliary Equipment and Costs

	Cost	Year Basis	CEPCI at Basis**
Accumulator, piping, & ductwork***	**153,000**	**2012**	**584.6**
Other equipment	**0**		
Total Auxiliary Equipment Costs:	153,000		

Facility-specific Economic Data

Operator labor cost, $/hr	**48.00**
Maintenance labor cost, $/hr	**49.00**
Electricity cost, $/kwh	**0.075**
Natural Gas cost, $/mcf	**6.87**
Debt Interest rate, fraction	**0.05**

Other Economic Data

Taxes, insurance, admin, fraction	**0.05**	EPA spreadsheet*
Catalyst cost, $/ft3	**350**	EPA spreadsheet*
Catalyst life (years):	**4**	EPA spreadsheet*
Control system life (years):	**20**	EPA spreadsheet*
Operating labor factor (hr/sh):	**0.5**	EPA spreadsheet*
Maintenance labor factor (hr/sh):	**0.5**	EPA spreadsheet*
Current CEPCI (cost inflation factor)**	**832.6**	Final value, June 2022

* USEPA-developed spreadsheet, named: US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm
(available at https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution)

** *Chemical Engineering Plant Cost Index*, updated monthly in "Chemical Engineering Magazine"

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study (in 2012 dollars).

Table 3. **Total Annual Cost Spreadsheet - Recuperative Thermal Oxidizer**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: **Hydro Unit S004**

COST REFERENCE DATE*:	1999	
Reference Date CEPCI value*	390.6	
Most recent CEPCI value**	832.6	Final value, June 2022
Cost Escalation Factor	2.13	

INPUT PARAMETERS

Gas flowrate (scfm):	30	
Reference temperature (oF):	77	
Inlet gas temperature (oF):	40	
Inlet gas density (lb/scf):	0.0739	air
Primary heat recovery (fraction):	0.5	
Pollutant heat of combustion (Btu/scf):	3,873	based on Cyclohexane
Pollutant molecular weight (lb/lb-mole)	84.2	based on Cyclohexane
Pollutant concentration (ppmv):	7,137	based on Cyclohexane
Waste gas heat content (BTU/scf):	27.6	
Waste gas heat content (BTU/lb):	374	
Gas heat capacity (BTU/lb-oF):	0.38	
Combustion temperature (oF):	1,400	
Preheat temperature (oF):	720	Equation 2.18
Fuel heat of combustion (BTU/lb):	21,502	methane
Fuel density (lb/ft3):	0.0408	methane
Pressure drop (in. w.c.):	11.0	Table 2.11

ANNUAL COST INPUTS

Operating factor (hr/yr):	8,760
Operating labor rate ($/hr):	48.00
Maintenance labor rate ($/hr):	49.00
Operating labor factor (hr/sh):	0.50
Maintenance labor factor (hr/sh):	0.50
Electricity price ($/kwh):	0.075
Natural gas price ($/mscf):	6.87
Annual interest rate (fraction):	0.05
Control system life (years):	20
Capital recovery factor:	0.0802
Taxes, insurance, admin. factor:	0.05

CALCULATED UTILITY USAGES

Auxiliary Fuel Reqrmnt (lb/min):	0.003	Equation 2.21
(scfm):	0.06	
Total Gas Flowrate (scfm):	30	

CALCULATED CAPITAL COSTS

Equipment Costs (EC):		
Incinerator:		
@ 0 % heat recovery:	0	Equation 2.29
@ 35 % heat recovery:	0	Equation 2.30
@ 50 % heat recovery:	39,965	Equation 2.31
@ 70 % heat recovery:	0	Equation 2.32
Auxiliary equipment***:	102,227	converted to 1999 dollars
Total Equipment Cost--base:	142,192	Sum of EC and auxiliary equipment
Total Equipment Cost--escalated (A):	303,096	Base cost times escalation factor
Purchased Equipment Cost (B = 1.08A):	327,343	Table 2.8
Total Capital Investment (TCI = 1.25B):	**409,179**	Table 2.8

CALCULATED ANNUAL COSTS

Item	Cost ($/yr)	
Operating labor	26,280	
Supervisory labor	3,942	Table 2.10
Maintenance labor	26,828	
Maintenance materials	26,828	Table 2.10, equals maintenance labor cost
Natural gas	230	
Electricity	43	Equation 2.42
Overhead	50,326	Table 2.10
Taxes, insurance, administrative	20,459	Table 2.10
Capital recovery	32,834	Table 2.10
Total Annual Cost	**187,768**	

* Reference date and corresponding CEPCI value taken from USEPA cost estimating spreadsheet 'US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm' , based on OAQPS Cost Manual, 7th Edition.

** Chemical Engineering Plant Cost Index (CEPCI) values are published in *Chemical Engineering* monthly journals

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study (see Table 2)

Table 4. **Total Annual Cost Spreadsheet - Regenerative Thermal Oxidizer**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: **Hydro Unit S004**

COST REFERENCE DATE*:	2016	
Reference Date CEPCI value*	541.7	
Most recent CEPCI value**	832.6	Final value, June 2022
Cost Escalation Factor	1.54	

INPUT PARAMETERS

Exhaust Gas flowrate (scfm):	30	
Reference temperature (oF):	77	
Waste gas inlet temperature, Tw_i (oF):	40	
Inlet gas density (lb/scf):	0.0739	air
Primary heat recovery (fraction):	0.85	
Waste gas heat content, annual avg. (BTU/scf):	27.6	based on Cyclohexane
Waste gas heat content (BTU/lb):	374	based on Cyclohexane
Gas heat capacity (BTU/lb-oF):	0.381	based on Cyclohexane
Combustion temperature (oF):	1,800	
Temperature leaving heat exchanger, Tw_o (oF):	1536	Equation 2.18
Fuel heat of combustion (BTU/lb):	21,502	methane
Fuel density (lb/ft3):	0.0408	methane
Pressure drop (in. w.c.):	30.4	Table 2.11

ANNUAL COST INPUTS

Operating factor (hr/yr):	8,760
Operating labor rate ($/hr):	48.00
Maintenance labor rate ($/hr):	49.00
Operating labor factor (hr/sh):	0.50
Maintenance labor factor (hr/sh):	0.50
Electricity price ($/kwh):	0.075
Natural gas price ($/mscf):	6.87
Annual interest rate (fraction):	0.05
Control system life (years):	20
Capital recovery factor:	0.0802
Taxes, insurance, admin. factor:	0.05

CALCULATED UTILITY USAGES

Auxiliary Fuel Requirement:	(lb/min):	-0.022	Equation 2.45
	(scfm):	-0.54	
	(mcf/yr):	(285.6)	
Total Maximum Exhaust Gas Flowrate:	(scfm):	29	

CALCULATED CAPITAL COSTS

Oxidizer Equipment Cost (EC):		
@ 85% heat recovery:	266,812	Equation 2.33
@ 95% heat recovery:	0	Equation 2.33
Auxiliary equipment***:	165,117	converted to 2016 dollars
Total Equipment Cost--base:	431,929	Sum of EC and auxiliary equipment
Total Equipment Cost--escalated (A):	663,880	Base cost times escalation factor
Purchased Equipment Cost (B = 1.08A):	716,990	Table 2.8
Total Capital Investment (TCI = 1.25B):	**896,238**	Table 2.8

ANNUAL COSTS

Item	Cost ($/yr)	
Operating labor	26,280	
Supervisory labor	3,942	Table 2.10
Maintenance labor	26,828	
Maintenance materials	26,828	Table 2.10, equals maintenance labor cost
Natural gas	0	
Electricity	115	Equation 2.42
Overhead	50,326	Table 2.10
Taxes, insurance, administrative	44,812	Table 2.10
Capital recovery	71,916	Table 2.10
Total Annual Cost	**251,046**	

* Reference date and corresponding CEPCI value taken from USEPA cost estimating spreadsheet 'US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm' , based on OAQPS Cost Manual, 7th Edition.

** Chemical Engineering Plant Cost Index (CEPCI) values are published in *Chemical Engineering* monthly journals

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study in 2012 and expressed in 2016 dollars.

Table 5. **Total Annual Cost Spreadsheet - Catalytic Oxidizer (Fixed Bed)**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: Hydro Unit S004

COST REFERENCE DATE*:	1999	
Reference Date CEPCI value*	390.6	
Most recent CEPCI value**	832.6	Final value, June 2022
Cost Escalation Factor	2.13	

INPUT PARAMETERS

Gas flowrate (scfm):	30	
Reference temperature (oF):	77	
Inlet gas temperature (oF):	40	
Inlet gas density (lb/scf):	0.0739	air
Primary heat recovery (fraction):	0.50	
Waste gas heat content (BTU/scf):	27.6	based on Cyclohexane
Waste gas heat content (BTU/lb):	374	based on Cyclohexane
Gas heat capacity (BTU/lb-oF):	0.381	based on Cyclohexane
Combustion temperature (oF):	850	
Preheat temperature (oF):	445	Equation 2.18
Fuel heat of combustion (BTU/lb):	21,502	methane
Fuel density (lb/ft3):	0.0408	methane
Pressure drop (in. w.c.):	13.0	Table 2.11

ANNUAL COST INPUTS

Operating factor (hr/yr):	8760
Operating labor rate ($/hr):	48.00
Maintenance labor rate ($/hr):	49.00
Operating labor factor (hr/sh):	0.50
Maintenance labor factor (hr/sh):	0.50
Electricity price ($/kwh):	0.075
Catalyst price ($/ft3):	650
Natural gas price ($/mscf):	6.87
Annual interest rate (fraction):	0.05
Control system life (years):	20
Catalyst life (years):	4
Capital recovery factor (system):	0.0802
Capital recovery factor (catalyst):	0.2820
Taxes, insurance, admin. factor:	0.05

CALCULATED UTILITY USAGES

Auxiliary Fuel Reqrmnt (lb/min):	0.002	Equation 2.21
(scfm):	0.0	
Total Gas Flowrate (scfm):	30	
Catalyst Volume (ft3):	0.1	Equation 2.28

CALCULATED CAPITAL COSTS

Equipment Costs (EC):		
@ 0 % heat recovery:	0	Equation 2.34
@ 35 % heat recovery:	0	Equation 2.35
@ 50 % heat recovery:	8,098	Equation 2.36
@ 70 % heat recovery:	0	Equation 2.37
Auxiliary equipment***:	102,227	converted to 1999 dollars
Total Equipment Cost--base:	110,325	Sum of EC and auxiliary equipment
Total Equipment Cost--escalated (A):	235,167	Base cost times escalation factor
Purchased Equipment Cost (B = 1.08A):	253,981	Table 2.8
Total Capital Investment (TCI = 1.25B):	**317,476**	Table 2.8

CALCULATED ANNUAL COSTS

Item	Cost ($/yr)	
Operating labor	26,280	
Supervisory labor	3,942	Table 2.10
Maintenance labor	26,828	
Maintenance materials	26,828	Table 2.10, equals maintenance labor cost
Natural gas	134	
Electricity	50	Equation 2.42
Catalyst replacement	12	Table 2.10
Overhead	50,326	Table 2.10
Taxes, insurance, administrative	15,874	Table 2.10
Capital recovery	25,472	
Total Annual Cost	**175,745**	

* Reference date and corresponding CEPCI value taken from USEPA cost estimating spreadsheet 'US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm' , based on OAQPS Cost Manual, 7th Edition.

** Chemical Engineering Plant Cost Index (CEPCI) values are published in *Chemical Engineering* monthly journals

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study in 2012 and expressed in 1999 dollars.

Table 1. **Cost Summary of RACT III VOC Oxidation Control Options**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source Name: **Hydro Unit**
Stack ID: **S007**

1a. - Ranking of VOC Oxidation Control Options, by Reduction Efficiency

Ranking	Control Technology	Destruction Efficiency (%)	Capture Efficiency (%)	Reduction [1] Efficiency (%)	Inlet VOC Emissions (tons/year)	VOC Reduction (tons/year)
1.	Recuperative Thermal Oxidizer	98.0	99.0	97.0	15.13	14.68
2.	Catalytic Oxidizer	98.0	99.0	97.0	15.13	14.68
3.	Regenerative Thermal Oxidizer	98.0	99.0	97.0	15.13	14.68

1b. - Ranking of Annual Control Costs per Ton of Pollutant Reduced

Ranking	Control Technology	Capital Cost ($)	Capital Recovery Cost ($/year)	Capital-Only Control Cost ($/ton/yr)	Total Annualized Cost ($/year)	**VOC Control Cost ($/ton/yr)**
1.	Catalytic Oxidizer	361,608	28,994	1,975	189,025	**12,877**
2.	Recuperative Thermal Oxidizer	479,914	38,510	2,623	212,285	**14,462**
3.	Regenerative Thermal Oxidizer	901,236	72,318	4,927	258,716	**17,625**

[1] Overall reduction based on product of Control efficiency and Capture efficiency

Table 2. **INPUT PARAMETERS FOR CONTROL TECHNOLOGY ANALYSIS**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: **Hydro Unit S007**

Emissions Data

VOC emissions, tpy:	15.13	From Title V application, 2/2022
Operating hours per year:	8,760	

Collection System Data

Units Controlled	Expected Capture Eff.	Expected Air Flow, cfm
Vent S007	99%	200
	Total:	200

Control System Data

	Removal Efficiency, %	Heat Recovery, %
Recuperative Thermal Oxidizer	98	50
Catalytic Oxidizer (fixed bed)	98	50
Regenerative Thermal Oxidizer (RTO)	98	85

Auxiliary Equipment and Costs

	Cost	Year Basis	CEPCI at Basis**
Accumulator, piping, & ductwork***	153,000	2012	584.6
Other equipment	0		

Total Auxiliary Equipment Costs: 153,000

Facility-specific Economic Data

Operator labor cost, $/hr	48.00
Maintenance labor cost, $/hr	49.00
Electricity cost, $/kwh	0.075
Natural Gas cost, $/mcf	6.87
Debt Interest rate, fraction	0.05

Other Economic Data

Taxes, insurance, admin, fraction	0.05	EPA spreadsheet*
Catalyst cost, $/ft3	350	EPA spreadsheet*
Catalyst life (years):	4	EPA spreadsheet*
Control system life (years):	20	EPA spreadsheet*
Operating labor factor (hr/sh):	0.5	EPA spreadsheet*
Maintenance labor factor (hr/sh):	0.5	EPA spreadsheet*
Current CEPCI (cost inflation factor)**	832.6	Final value, June 2022

* USEPA-developed spreadsheet, named: US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm
(available at https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution)

** *Chemical Engineering Plant Cost Index* , updated monthly in "Chemical Engineering Magazine"

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study (in 2012 dollars).

Table 3. **Total Annual Cost Spreadsheet - Recuperative Thermal Oxidizer**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: **Hydro Unit S007**

COST REFERENCE DATE*:	1999	
Reference Date CEPCI value*	390.6	
Most recent CEPCI value**	832.6	Final value, June 2022
Cost Escalation Factor	2.13	

INPUT PARAMETERS		
Gas flowrate (scfm):	200	
Reference temperature (oF):	77	
Inlet gas temperature (oF):	40	
Inlet gas density (lb/scf):	0.0739	air
Primary heat recovery (fraction):	0.5	
Pollutant heat of combustion (Btu/scf):	3,873	based on Cyclohexane
Pollutant molecular weight (lb/lb-mole)	84.2	based on Cyclohexane
Pollutant concentration (ppmv):	1,248	based on Cyclohexane
Waste gas heat content (BTU/scf):	4.8	
Waste gas heat content (BTU/lb):	65	
Gas heat capacity (BTU/lb-oF):	0.38	
Combustion temperature (oF):	1,400	
Preheat temperature (oF):	720	Equation 2.18
Fuel heat of combustion (BTU/lb):	21,502	methane
Fuel density (lb/ft3):	0.0408	methane
Pressure drop (in. w.c.):	11.0	Table 2.11

ANNUAL COST INPUTS	
Operating factor (hr/yr):	8,760
Operating labor rate ($/hr):	48.00
Maintenance labor rate ($/hr):	49.00
Operating labor factor (hr/sh):	0.50
Maintenance labor factor (hr/sh):	0.50
Electricity price ($/kwh):	0.075
Natural gas price ($/mscf):	6.87
Annual interest rate (fraction):	0.05
Control system life (years):	20
Capital recovery factor:	0.0802
Taxes, insurance, admin. factor:	0.05

CALCULATED UTILITY USAGES		
Auxiliary Fuel Reqrmnt (lb/min):	0.173	Equation 2.21
(scfm):	4.23	
Total Gas Flowrate (scfm):	204	

CALCULATED CAPITAL COSTS		
Equipment Costs (EC):		
Incinerator:		
@ 0 % heat recovery:	0	Equation 2.29
@ 35 % heat recovery:	0	Equation 2.30
@ 50 % heat recovery:	64,546	Equation 2.31
@ 70 % heat recovery:	0	Equation 2.32
Auxiliary equipment***:	102,227	converted to 1999 dollars
Total Equipment Cost--base:	166,773	Sum of EC and auxiliary equipment
Total Equipment Cost--escalated (A):	355,492	Base cost times escalation factor
Purchased Equipment Cost (B = 1.08A):	383,932	Table 2.8
Total Capital Investment (TCI = 1.25B):	**479,914**	Table 2.8

CALCULATED ANNUAL COSTS

Item	Cost ($/yr)	
Operating labor	26,280	
Supervisory labor	3,942	Table 2.10
Maintenance labor	26,828	
Maintenance materials	26,828	Table 2.10, equals maintenance labor cost
Natural gas	15,287	
Electricity	289	Equation 2.42
Overhead	50,326	Table 2.10
Taxes, insurance, administrative	23,996	Table 2.10
Capital recovery	38,510	Table 2.10
Total Annual Cost	**212,285**	

* Reference date and corresponding CEPCI value taken from USEPA cost estimating spreadsheet 'US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm' , based on OAQPS Cost Manual, 7th Edition.

** Chemical Engineering Plant Cost Index (CEPCI) values are published in *Chemical Engineering* monthly journals

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study (see Table 2)

Table 4. **Total Annual Cost Spreadsheet - Regenerative Thermal Oxidizer**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: **Hydro Unit S007**

COST REFERENCE DATE*:	2016	
Reference Date CEPCI value*	541.7	
Most recent CEPCI value**	832.6	Final value, June 2022
Cost Escalation Factor	1.54	

INPUT PARAMETERS

Exhaust Gas flowrate (scfm):	200	
Reference temperature (oF):	77	
Waste gas inlet temperature, Tw_i (oF):	40	
Inlet gas density (lb/scf):	0.0739	air
Primary heat recovery (fraction):	0.85	
Waste gas heat content, annual avg. (BTU/scf):	4.8	based on Cyclohexane
Waste gas heat content (BTU/lb):	65	based on Cyclohexane
Gas heat capacity (BTU/lb-oF):	0.381	based on Cyclohexane
Combustion temperature (oF):	1,800	
Temperature leaving heat exchanger, Tw_o (oF):	1536	Equation 2.18
Fuel heat of combustion (BTU/lb):	21,502	methane
Fuel density (lb/ft3):	0.0408	methane
Pressure drop (in. w.c.):	30.4	Table 2.11

CALCULATED UTILITY USAGES

Auxiliary Fuel Requirement:	(lb/min):	0.072	Equation 2.45
	(scfm):	1.76	
	(mcf/yr):	923.9	
Total Maximum Exhaust Gas Flowrate:	(scfm):	202	

CALCULATED CAPITAL COSTS

Oxidizer Equipment Cost (EC):		
@ 85% heat recovery:	269,221	Equation 2.33
@ 95% heat recovery:	0	Equation 2.33
Auxiliary equipment***:	165,117	converted to 2016 dollars
Total Equipment Cost--base:	434,337	Sum of EC and auxiliary equipment
Total Equipment Cost--escalated (A):	667,582	Base cost times escalation factor
Purchased Equipment Cost (B = 1.08A):	720,989	Table 2.8
Total Capital Investment (TCI = 1.25B):	**901,236**	Table 2.8

ANNUAL COST INPUTS

Operating factor (hr/yr):	8,760
Operating labor rate ($/hr):	48.00
Maintenance labor rate ($/hr):	49.00
Operating labor factor (hr/sh):	0.50
Maintenance labor factor (hr/sh):	0.50
Electricity price ($/kwh):	0.075
Natural gas price ($/mscf):	6.87
Annual interest rate (fraction):	0.05
Control system life (years):	20
Capital recovery factor:	0.0802
Taxes, insurance, admin. factor:	0.05

ANNUAL COSTS

Item	Cost ($/yr)	
Operating labor	26,280	
Supervisory labor	3,942	Table 2.10
Maintenance labor	26,828	
Maintenance materials	26,828	Table 2.10, equals maintenance labor cost
Natural gas	6,347	
Electricity	787	Equation 2.42
Overhead	50,326	Table 2.10
Taxes, insurance, administrative	45,062	Table 2.10
Capital recovery	72,318	Table 2.10
Total Annual Cost	**258,716**	

* Reference date and corresponding CEPCI value taken from USEPA cost estimating spreadsheet 'US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm' , based on OAQPS Cost Manual, 7th Edition.

** Chemical Engineering Plant Cost Index (CEPCI) values are published in *Chemical Engineering* monthly journals

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study in 2012 and expressed in 2016 dollars.

Table 5. **Total Annual Cost Spreadsheet - Catalytic Oxidizer (Fixed Bed)**
Synthomer Jefferson Hills, LLC - West Elizabeth, PA

Source & Stack: Hydro Unit S007

COST REFERENCE DATE*:	1999	
Reference Date CEPCI value*	390.6	
Most recent CEPCI value**	832.6	Final value, June 2022
Cost Escalation Factor	2.13	

INPUT PARAMETERS		
Gas flowrate (scfm):	200	
Reference temperature (oF):	77	
Inlet gas temperature (oF):	40	
Inlet gas density (lb/scf):	0.0739	air
Primary heat recovery (fraction):	0.50	
Waste gas heat content (BTU/scf):	4.8	based on Cyclohexane
Waste gas heat content (BTU/lb):	65	based on Cyclohexane
Gas heat capacity (BTU/lb-oF):	0.381	based on Cyclohexane
Combustion temperature (oF):	850	
Preheat temperature (oF):	445	Equation 2.18
Fuel heat of combustion (BTU/lb):	21,502	methane
Fuel density (lb/ft3):	0.0408	methane
Pressure drop (in. w.c.):	13.0	Table 2.11

ANNUAL COST INPUTS	
Operating factor (hr/yr):	8760
Operating labor rate ($/hr):	48.00
Maintenance labor rate ($/hr):	49.00
Operating labor factor (hr/sh):	0.50
Maintenance labor factor (hr/sh):	0.50
Electricity price ($/kwh):	0.075
Catalyst price ($/ft3):	650
Natural gas price ($/mscf):	6.87
Annual interest rate (fraction):	0.05
Control system life (years):	20
Catalyst life (years):	4
Capital recovery factor (system):	0.0802
Capital recovery factor (catalyst):	0.2820
Taxes, insurance, admin. factor:	0.05

CALCULATED UTILITY USAGES		
Auxiliary Fuel Reqrmnt (lb/min):	0.083	Equation 2.21
(scfm):	2.0	
Total Gas Flowrate (scfm):	202	
Catalyst Volume (ft3):	0.4	Equation 2.28

CALCULATED CAPITAL COSTS		
Equipment Costs (EC):		
@ 0 % heat recovery:	0	Equation 2.34
@ 35 % heat recovery:	0	Equation 2.35
@ 50 % heat recovery:	23,434	Equation 2.36
@ 70 % heat recovery:	0	Equation 2.37
Auxiliary equipment***:	102,227	converted to 1999 dollars
Total Equipment Cost--base:	125,661	Sum of EC and auxiliary equipment
Total Equipment Cost--escalated (A):	267,858	Base cost times escalation factor
Purchased Equipment Cost (B = 1.08A):	289,286	Table 2.8
Total Capital Investment (TCI = 1.25B):	**361,608**	Table 2.8

CALCULATED ANNUAL COSTS

Item	Cost ($/yr)	
Operating labor	26,280	
Supervisory labor	3,942	Table 2.10
Maintenance labor	26,828	
Maintenance materials	26,828	Table 2.10, equals maintenance labor cost
Natural gas	7,332	
Electricity	338	Equation 2.42
Catalyst replacement	77	Table 2.10
Overhead	50,326	Table 2.10
Taxes, insurance, administrative	18,080	Table 2.10
Capital recovery	28,994	
Total Annual Cost	**189,025**	

* Reference date and corresponding CEPCI value taken from USEPA cost estimating spreadsheet 'US EPA_OAQPS_IncineratorsOxidizers_Calc_Sheet_september_2022.xlsm' , based on OAQPS Cost Manual, 7th Edition.

** Chemical Engineering Plant Cost Index (CEPCI) values are published in *Chemical Engineering* monthly journals

*** Accumulator, piping, & ductwork costs, taken from QSEM thermal control study in 2012 and expressed in 1999 dollars.

Carbon Adsorption Tables

Source Name and ID:	Hydro Unit (S004)
Facility Name:	Synthomer Jefferson Hills LLC

Data Inputs

Select the type of carbon adsorber system:	Carbon Canister Adsorber with Carbon Replacement
For fixed-bed carbon adsorbers, provide the following information:	
Select the type of operation:	Not Applicable
Select the type of material used to fabricate the carbon adsorber vessels:	Not Applicable
Select the orientation for the adsorber vessels:	Not Applicable

Enter the design data for the proposed Carbon Canister Adsorber with Carbon Replacement

Number of operating hours per year (Θ_s)	8,760	hours/year	
Waste Gas Flow Rate (Q)	30	acfm*	*acfm is actual cubic feet/min
VOC Emission Rate (m_{voc})	2.96	lbs/hour	
Required VOC removal efficiency (E)	95	percent	
Estimated equipment life of adsorber vessels and auxiliary Equipment (n)	15	Years*	* 15 years is a default equipment life. User should enter actual value, if known.
Estimated Carbon life (n)	2	Years	
Estimated Carbon Replacement Rate (CRR)	379	lbs/hour*	* 379 lbs./hour is a default value. User should enter actual value, if known.
Carbon Canister Size	1,000	lbs of carbon per canister	

Enter the Characteristics of the VOC/HAP:

Name of VOC/HAP	Cyclohexane	
Partial Pressure of Cyclohexane in waste gas stream	0.0114	psia
Parameter "k" for Cyclohexane	0.505	**Note:**
Parameter "m" for Cyclohexane	0.210	Typical values of "k" and "m" for some common VOCs are shown in Table A.

Enter the cost data for the carbon adsorber:

Desired dollar-year	2022			
CEPCI* for 2022	833	CEPCI value for 2022	603.1	2018
Annual Interest Rate (i)	5.00	percent*	* 5 percent is a default value. User should enter current prime bank rate.	

* CEPCI is the Chemical Engineering Plant Cost Index. The use of CEPCI in this spreadsheet is not an endorsement of the index for purpose of cost escalation or de-escalation, but is there merely to allow for availability of a well-known cost index to spreadsheet users. Use of other well-known cost indexes (e.g., M&S) is acceptable.

Carbon Canister Cost	$9,688	per canister (in 2022 dollar	Note: Typical costs for carbon canisters are shown in Table B.
Operator Labor Rate	$48.00	per hour	
Maintenance Labor Rate	$49.00	per hour	
Carbon Cost (CC)	$4.20	per lb	* $4.20/lb is a default value based on 2018 market price. User should enter actual value, if known.

If known, enter any additional costs for site preparation and building construction/modification:

Site Preparation (SP) =	$0	* Default value. User should enter actual value, if known.	
Buildings (Bldg) =	$0	* Default value. User should enter actual value, if known.	
Equipment Costs for auxiliary equipment (e.g., ductwork, dampers, and stack) (EC_{aux}) =	$157,842	based on QSEM control equipment design study from 2012, converted to 2018 dollars	
Contingency Factor (CF)	10.0	percent*	* 10 percent is a default value. The contingency factor should be between 5 and 15 percent.

Source Name and ID: **Hydro Unit (S004)**
Facility Name: **Synthomer Jefferson Hills LLC**

Design Parameters

The following design parameters for the carbon adsorber were calculated based on the values entered on the *Data Inputs* tab. These values were used to prepare the costs shown on the *Cost Estimate* tab.

Type of Carbon Adsorber: **Carbon Canister Adsorber with Carbon Replacement**
Name of VOC Controlled: **Cyclohexane**

Parameter	Equation	Calculated Value	Units
Quantity of Cyclohexane Removed:			
Quantity of Cyclohexane Removed (Wvoc) =	$W_{voc} = m_{voc} \times \Theta_s \times E =$	12.317	tons/year
Number of times canister(s) replaced per year =	$\Theta_s / \Theta_A =$	2	
Adsorber Parameters for Carbon Canisters:			
Time for Adsorption (Θ_A) =	*Number of operating hours before carbon canister replacement =*	4,380	hours
Equilibrium Capacity at the Inlet ($W_{e(max)}$) =	$k \times P^m =$	0.197	lb. VOC/lb. Carbon
Working Capacity (w_c) =	$0.5 \times w_{e(max)} =$	0.099	lb. VOC/lb. Carbon
Estimated Total Carbon Required (M_c) =	$(m_{voc}/w_c) \times \Theta_A =$	65,679	lbs.
Number of Carbon Canisters Required =	M_c/Carbon Canister Capacity	66	canisters
Total Quantity of Carbon Required for 66 Canisters =	Number of Carbon Canisters * Carbon Capacity per Canister =	66,000	lbs.
Capital Recovery Factor:			
Capital Recovery Factor for adsorber vessels and auxiliary equipment (CFRabsorber)=	$[i \times (1 + i)^n] / [(1 + i)^n - 1] =$ Where n = Equipment Life and i = Interest Rate	0.0963	
Capital Recovery Factor for carbon (CRF_{Carbon}) =	$[i \times (1 + i)^n] / [(1 + i)^n - 1] =$ Where n = Carbon Life and i = Interest Rate	0.5378	

Source Name and ID: **Hydro Unit (S004)**
Facility Name: **Synthomer Jefferson Hills LLC**

Cost Estimate

Capital Costs

Estimated capital costs for a Carbon Canister Adsorber with Carbon Replacement with the following characteristics:

VOC Controlled/Recovered = Cyclohexane
Adsorber Vessel Orientation = Not Applicable
Operating Schedule = Not Applicable

Total Capital Investment (TCI) (in 2022 dollars:)

Parameter	**Equation**	**Cost**	
Total Cost for All Carbon Adsorber Canisters (EC_{Adsorb}) =	Canister Cost x Number of Canisters Required =	$639,392	
Auxiliary Equipment (EC_{aux}) =	(Based on design costs or estimated using methods provided in Section 2)	$157,842	
Total Purchased Equipment Costs for Carbon Adsorber (A) =	$EC_{Adsorb} + EC_{aux}$ =	$797,233	
Instrumentation =	0.10 × A =	$79,723	
Sales taxes =	0.03 × A =	$23,917	
Freight =	0.05 × A =	$39,862	
	Total Purchased Equipment Costs (B) =	**$940,736**	

Installation Costs (in 2022 dollars:)

Parameter	**Equation**	**Cost**	
Direct and Indirect Installation =	0.20 × B =	$75,259	
Site Preparation (SP) =		$0	
Buildings (Bldg) =		$0	
	Total Direct and Indirect Installation Costs =	$75,259	
Contingency Cost (C) =	CF x (Purchase Equipment Cost + Installation costs) =	$101,599	
	Total Capital Investment (TCI) = Purchace Equipment + Installation + Contingency Costs =	**$1,117,594**	**in 2022 dollars**

Annual Costs

Direct Annual Costs

Parameter	**Equation**	**Cost**	
Operating Labor Costs:	Operator = 0.5 hours/shift × Labor Rate × (Operating hours/8 hours/shift)	$26,280	
	Supervisor = 15% of Operator	$3,942	
Maintenance Costs:	Labor = 0.5 hours/shift × Labor Rate × (Operating Hours/8 hours/shift)	$26,828	
	Materials = 100% of maintenance labor	$26,828	
Carbon Replacement Costs:	Labor = CFR_{carbon} [Labor Rate × T_C/CRR] =	$4,495	
	Carbon = CRF_{carbon}[CC x T_c x 1.08] =	$161,006	
	Direct Annual Costs (DAC) =	**$249,378**	**in 2022 dollars**

Indirect Annual Costs

Parameter	**Equation**	**Cost**	
Overhead	= 60% of sum of operator, supervisor, maintenance labor Plus maintenance materials	$50,326	
Administrative Charges	= 2% of TCI	$22,352	
Property Taxes	= 1% of TCI	$11,176	
Insurance	= 1% of TCI	$11,176	
Capital Recovery	= $CRF_{Adsorber}$ × [TCI - [(1.08 *CC *Tc) + (LR*Tc/CRR)] =	$78,007	
	Indirect Annual Costs (IAC) =	**$173,037**	**in 2022 dollars**
	Total Annual Cost (TAC) = DAC + IAC =	**$422,415**	**in 2022 dollars**

Cost Effectiveness

Parameter	**Equation**	**Cost**	
Total Annual Cost =	TAC =	$422,415	per year in 2022 dollars
Annual Quantity of VOC Removed =	$W_{voc} = m_{voc} \times \Theta_s \times E$ =	12.32	tons/year
Cost Effectiveness =	**Total Annual Cost (TAC) / Annual Quantity of VOC Removed/Recovered =**	**$34,297**	per ton of pollutants removed

Source Name and ID:	Hydro Unit (S004)
Facility Name:	Synthomer Jefferson Hills LLC

Data Inputs

Select the type of carbon adsorber system: Carbon Canister Adsorber with Carbon Replacement

For fixed-bed carbon adsorbers, provide the following information:

Select the type of operation: Not Applicable

Select the type of material used to fabricate the carbon adsorber vessels: Not Applicable

Select the orientation for the adsorber vessels: Not Applicable

Enter the design data for the proposed Carbon Canister Adsorber with Carbon Replacement

Number of operating hours per year (Θ_s)	8,760	hours/year	
Waste Gas Flow Rate (Q)	200	acfm*	*acfm is actual cubic feet/min
VOC Emission Rate (m_{voc})	3.45	lbs/hour	
Required VOC removal efficiency (E)	95	percent	
Estimated equipment life of adsorber vessels and auxiliary Equipment (n)	15	Years*	* 15 years is a default equipment life. User should enter actual value, if known.
Estimated Carbon life (n)	2	Years	
Estimated Carbon Replacement Rate (CRR)	379	lbs/hour*	* 379 lbs./hour is a default value. User should enter actual value, if known.
Carbon Canister Size	1,000	lbs of carbon per canister	

Enter the Characteristics of the VOC/HAP:

Name of VOC/HAP	Cyclohexane	
Partial Pressure of Cyclohexane in waste gas stream	0.0020	psia
Parameter "k" for Cyclohexane	0.505	**Note:**
Parameter "m" for Cyclohexane	0.210	Typical values of "k" and "m" for some common VOCs are shown in Table A.

Enter the cost data for the carbon adsorber:

Desired dollar-year	2022			
CEPCI* for 2022	833	CEPCI value for 2022	603.1	2018
Annual Interest Rate (i)	5.00	percent*	* 5 percent is a default value. User should enter current prime bank rate.	

* CEPCI is the Chemical Engineering Plant Cost Index. The use of CEPCI in this spreadsheet is not an endorsement of the index for purpose of cost escalation or de-escalation, but is there merely to allow for availability of a well-known cost index to spreadsheet users. Use of other well-known cost indexes (e.g., M&S) is acceptable.

Carbon Canister Cost	$9,688	per canister (in 2022 dollar	Note: Typical costs for carbon canisters are shown in Table B.
Operator Labor Rate	$48.00	per hour	
Maintenance Labor Rate	$49.00	per hour	
Carbon Cost (CC)	$4.20	per lb	* $4.20/lb is a default value based on 2018 market price. User should enter actual value, if known.

If known, enter any additional costs for site preparation and building construction/modification:

Site Preparation (SP) =	$0	* Default value. User should enter actual value, if known.
Buildings (Bldg) =	$0	* Default value. User should enter actual value, if known.
Equipment Costs for auxiliary equipment (e.g., ductwork, dampers, and stack) (EC_{aux}) =	$157,842	based on QSEM control equipment design study from 2012, converted to 2018 dollars
Contingency Factor (CF)	10.0	percent* — * 10 percent is a default value. The contingency factor should be between 5 and 15 percent.

Source Name and ID: **Hydro Unit (S004)**
Facility Name: **Synthomer Jefferson Hills LLC**

Design Parameters

The following design parameters for the carbon adsorber were calculated based on the values entered on the *Data Inputs* tab. These values were used to prepare the costs shown on the *Cost Estimate* tab.

Type of Carbon Adsorber:	**Carbon Canister Adsorber with Carbon Replacement**
Name of VOC Controlled:	**Cyclohexane**

Parameter	Equation	Calculated Value	Units
Quantity of Cyclohexane Removed:			
Quantity of Cyclohexane Removed (Wvoc) =	$W_{voc} = m_{voc} \times \Theta_s \times E =$	14.355	tons/year
Number of times canister(s) replaced per year =	$\Theta_s / \Theta_A =$	2	
Adsorber Parameters for Carbon Canisters:			
Time for Adsorption (Θ_A) =	*Number of operating hours before carbon canister replacement =*	4,380	hours
Equilibrium Capacity at the Inlet ($W_{e(max)}$) =	$k \times P^m =$	0.137	lb. VOC/lb. Carbon
Working Capacity (w_c) =	$0.5 \times w_{e(max)} =$	0.068	lb. VOC/lb. Carbon
Estimated Total Carbon Required (M_c) =	$(m_{voc}/w_c) \times \Theta_A =$	110,444	lbs.
Number of Carbon Canisters Required =	M_c/Carbon Canister Capacity	111	canisters
Total Quantity of Carbon Required for 111 Canisters =	Number of Carbon Canisters * Carbon Capacity per Canister =	111,000	lbs.
Capital Recovery Factor:			
Capital Recovery Factor for adsorber vessels and auxiliary equipment (CFRabsorber)=	$[i \times (1 + i)^n] / [(1 + i)^n - 1] =$ Where n = Equipment Life and i = Interest Rate	0.0963	
Capital Recovery Factor for carbon (CRF_{Carbon}) =	$[i \times (1 + i)^n] / [(1 + i)^n - 1] =$ Where n = Carbon Life and i = Interest Rate	0.5378	

Source Name and ID: **Hydro Unit (S004)**
Facility Name: **Synthomer Jefferson Hills LLC**

Cost Estimate

Capital Costs

Estimated capital costs for a Carbon Canister Adsorber with Carbon Replacement with the following characteristics:

VOC Controlled/Recovered = Cyclohexane
Adsorber Vessel Orientation = Not Applicable
Operating Schedule = Not Applicable

Total Capital Investment (TCI) (in 2022 dollars:)

Parameter	**Equation**	**Cost**	
Total Cost for All Carbon Adsorber Canisters (EC_{Adsorb}) =	Canister Cost x Number of Canisters Required =	$1,075,341	
Auxiliary Equipment (EC_{aux}) =	(Based on design costs or estimated using methods provided in Section 2)	$157,842	
Total Purchased Equipment Costs for Carbon Adsorber (A) =	$EC_{Adsorb} + EC_{aux}$ =	$1,233,182	
Instrumentation =	0.10 × A =	$123,318	
Sales taxes =	0.03 × A =	$36,995	
Freight =	0.05 × A =	$61,659	
	Total Purchased Equipment Costs (B) =	**$1,455,155**	

Installation Costs (in 2022 dollars:)

Parameter	**Equation**	**Cost**	
Direct and Indirect Installation =	0.20 × B =	$116,412	
Site Preparation (SP) =		$0	
Buildings (Bldg) =		$0	
	Total Direct and Indirect Installation Costs =	$116,412	
Contingency Cost (C) =	CF x (Purchase Equipment Cost + Installation costs) =	$157,157	
	Total Capital Investment (TCI) = Purchace Equipment + Installation + Contingency Costs =	**$1,728,724**	**in 2022 dollars**

Annual Costs

Direct Annual Costs

Parameter	**Equation**	**Cost**	
Operating Labor Costs:	Operator = 0.5 hours/shift × Labor Rate × (Operating hours/8 hours/shift)	$26,280	
	Supervisor = 15% of Operator	$3,942	
Maintenance Costs:	Labor = 0.5 hours/shift × Labor Rate × (Operating Hours/8 hours/shift)	$26,828	
	Materials = 100% of maintenance labor	$26,828	
Carbon Replacement Costs:	Labor = CFR_{carbon} [Labor Rate × T_C/CRR] =	$7,560	
	Carbon = CRF_{carbon}[CC x T_c x 1.08] =	$270,783	
	Direct Annual Costs (DAC) =	**$362,220**	**in 2022 dollars**

Indirect Annual Costs

Parameter	**Equation**	**Cost**	
Overhead	= 60% of sum of operator, supervisor, maintenance labor Plus maintenance materials	$50,326	
Administrative Charges	= 2% of TCI	$34,574	
Property Taxes	= 1% of TCI	$17,287	
Insurance	= 1% of TCI	$17,287	
Capital Recovery	= $CRF_{Adsorber}$ × [TCI - [(1.08 *CC *Tc) + (LR*Tc/CRR)] =	$116,659	
	Indirect Annual Costs (IAC) =	**$236,134**	**in 2022 dollars**
	Total Annual Cost (TAC) = DAC + IAC =	**$598,354**	**in 2022 dollars**

Cost Effectiveness

Parameter	**Equation**	**Cost**	
Total Annual Cost =	TAC =	$598,354	per year in 2022 dollars
Annual Quantity of VOC Removed =	$W_{voc} = m_{voc} \times \Theta_s \times E$ =	14.36	tons/year
Cost Effectiveness =	**Total Annual Cost (TAC) / Annual Quantity of VOC Removed/Recovered =**	**$41,681**	per ton of pollutants removed

Condensation Cost Tables

Source Name and ID: Hydro Unit (S004)
Facility Name: Synthomer Jefferson Hills LLC

Data Inputs

Is the condenser a packaged, custom or gasoline vapor recovery system? Packaged Condenser System

Enter the design data for the proposed condenser:

Number of operating hours per year and per day (Θ_s)	8,760	hours/year	24	hours/day
Volumetric flow rate of the waste stream (Q_{in})	30	scfm (at 77 °F; 1 atm)		
Inlet stream temperature (T_{in})	40	°F		
Required VOC removal efficiency (η)	90	%*	* 90% is a default control efficiency. Enter actual value, if known.	
Specific heat of the coolant ($C_{p,cool}$)	0.65	Btu/lb-mole-°F*	* 0.65 Btu/lb-mole-°F is a default value. Enter actual value, if known.	
Estimated equipment life (n)	15	Years*	* 15 years is a default equipment life. Enter actual value, if known.	
Overall heat transfer coefficient (U)	20	Btu/hour-ft²-°F*	* 20 Btu/hour-ft²-°F is a default coefficient. Enter actual value, if known.	
Mechanical efficiency of compressor (η_{comp})	85	%*	* 85% is a default value. Enter actual value, if known.	

Enter the Characteristics of the VOC/HAP:

Name of VOC/HAP	Cyclohexane			
Molecular Weight of Cyclohexane (MW)	84.16	lb./mole		
Density of Cyclohexane	9.6	lb./gallon		
Heat Capacity of Cyclohexane (Cp,voc)	37.03	Btu/lb.-mole-°F		
Heat of Condensation of Cyclohexane (ΔHref)	12,910	Btu/lb.-mole		
Boiling Point of Cyclohexane	177	°F		
Antoine Equation Constants for Cyclohexane	A	B	C	
	6.8413	1201.53	222.65	based on degrees C and mmHg
Critical Temperature for Cyclohexane	996	°R		
Volume Fraction of Cyclohexane in waste stream entering the condenser (Yvoc,in)	0.00765			

Enter the cost data for the condenser:

Electricity ($Cost_{elect}$)	$0.0750	per kWh	
Operator Labor Rate	$48.00	per hour	
Maintenance Labor Rate	$49.00	per hour	
Re-Sale Value of Recovered VOC (Credit)	$0.00	per lb	
Contingency Factor (CF)	10.0	percent*	* 10 percent is a default value.

If known, enter any additional costs for site preparation and building construction/modification:

Site Preparation (SP) =	$0	* Default value. User should enter actual value, if known.		
Buildings (Bldg) and Ductwork =	$150,775	based on QSEM control equipment design study from 2012, converted to 2014 dollars		
Equipment Costs for auxiliary equipment for custom condenser systems (EC_{aux}) =	$0	* Default value. User should enter actual value, if known.		
Desired dollar-year	2022			
CEPCI* for 2022	833	Enter the CEPCI value for 2022	576.1	2014 CEPCI
Annual Interest Rate (i)	5.00	% (Default value is 4.25%)		

* CEPCI is the Chemical Engineering Plant Cost Index. The use of CEPCI in this spreadsheet is not an endorsement of the index for purpose of cost escalation or de-escalation, but is there merely to allow for availability of a well-known cost index to spreadsheet users. Use of other well-known cost indexes (e.g., M&S) is acceptable.

Source Name and ID: Hydro Unit (S004)
Facility Name: Synthomer Jefferson Hills LLC

Design Parameters

The following design parameters for the condenser were calculated based on the values entered on the *Data Inputs* tab. These values were used to prepare the costs shown on the *Cost Estimate* tab.

VOC	VOC volume Fraction of waste stream entering the condenser ($Y_{voc,in}$)	Heat Capacity ($C_{p,voc}$) (Btu/lb.-mole-°F)	Heat of Condensation (ΔH_{ref}) (Btu/lb.-mole)
Cyclohexane	0.00765	37.03	12910

Parameter	Equation		Calculated Value	Units
Partial Pressure of Cyclohexane VOC in Exit Stream (Pvoc) =	$760 \times (M_{voc,out} / (M_{in} - M_{voc, recovered}))$ =	$760 \times [Y_{voc,in} \times (1 - \eta)] / [1 - (\eta \times Y_{voc,in})]$ =	0.585	mmHg
Estimated Condensation Temperature for Cyclohexane (Tcon) =	$((B / (A - \log (P_{voc})) - C) \times 1.8 + 32$ =		-63.0	°F

Parameter	Equation	Calculated Value	Units	Calculated Value	Units
Quantities of VOC in Inlet and Outlet streams:					
Moles of VOC in the inlet stream ($M_{voc,in}$) =	$(Q_{in} / 392) \times (Y_{voc,in}) \times 60$ =	0.035	lb.-moles/hour	2.96	lb/hour
Moles of VOC in the outlet stream ($M_{voc,out}$) =	$M_{voc,in} \times (1 - \eta)$ =	0.004	lb.-moles/hour		
Quantity of VOC Recovered:					
Moles of VOC Recovered ($M_{voc, recovered}$) =	$M_{voc,in} \times \eta$ =	0.032	lb.-moles/hour		
Quantity of VOC Recovered (W_{voc}) =	$M_{voc, recovered} \times MW_{voc}$ =	2.66	lb./operating hour	11.65	Tons/year
Calculation of Enthalpy of Condensation:					
Critical Temperature for VOC (T_c) =		996	°R		
Reference Temperature for Heat of Condensation (T_1) =		637	°R		
Condensation Temperature (T_2) =	$T_{con} + 459.67$ =	397	°R		
Enthalpy of condensation of VOC (ΔHvoc) at -63 °F =	$\Delta H_{ref} \times [(1 - T_2 / T_c) / (1 - T_1 / T_c)]^{0.38}$ =	15,681	Btu/lb.-mole		
Calculation of Condenser Heat Load:					
Heat capacity of air ($C_{p, air}$) =		6.95	Btu/lb.-mole-°F @ 77 °F and 1 atm.		
Mean Temperature (T_{mean}) =	$(T_{in} + T_{con}) / 2$ =	-12	°F		
Enthalpy change associated with the condensed VOC (ΔH_{con}) =	$M_{voc,recovered} \times [\Delta H_{voc} + C_{p,voc} (T_{in} - T_{con})]$=	616	Btu/hour		
Enthalpy change associated with the uncondensed VOC (ΔH_{uncon}) =	$M_{voc,out} \times C_{p,voc} \times (T_{in} - T_{con})$ =	13	Btu/hour		
Enthalpy change associated with the non-condensable air (ΔHnoncon) =	$[((Q_{in} / 392) \times 60) - M_{voc,in}] \times C_{p,air} \times (T_{in} - T_{con})$ =	3,263	Btu/hour		
Condenser Heat Load (H_{load}) =	$\Delta H_{con} + \Delta H_{uncon} + \Delta H_{noncon}$ =	3,893	Btu/hour		
Calculation of Surface Area:					
Temperature of coolant entering the condenser ($T_{cool,in}$) =	T_{con} - 15 °F =	-78.0	°F		
Temperature of coolant exiting the condenser ($T_{cool,out}$) =	$T_{cool,in}$ + 25 °F =	-53.0	°F		
Logarithmic mean temperature difference (ΔT_{lm}) =	$\frac{[(T_{in} - T_{cool,out}) - (T_{con} - T_{cool,in})]}{[\ln\{(T_{in} - T_{cool, out})/(T_{con} - T_{cool,in})\}]}$ =	42.8	°F		
Condenser Surface Area (A_{con}) =	$H_{load} / (U \times \Delta T_{lm})$ =	4.6	ft²		
Calculation of Coolant Flow Rate and Refrigeration Capacity:					
Coolant Flow Rate (W_{cool}) =	$H_{load} / (C_{p,cool} \times (T_{cool,out} - T_{cool,in}))$ =	240	lb./hour		
Refrigeration Capacity (R) =	H_{load} / 12,000 Btu/ton =	0.32	Tons/hour		
Calculation of Electricity Consumption:					
Estimated Electricity Consumption (E) =	$2.7411 \times \exp(-0.015 \times T_{con})$ =	7.06	kW/ton		
Capital Recovery Factor:					
Capital Recovery Factor (CRF) =	$[i \times (1 + i)^n] / [(1 + i)^n - 1]$ = Where n = Equipment Life and i = Interest Rate	0.0963			

Source Name and ID: Hydro Unit (S004)
Facility Name: Synthomer Jefferson Hills LLC

Control Cost Estimate

Capital Costs

VOC Controlled/Recovered =	Cyclohexane
Refrigeration Capacity (R) =	0.32 tons/hour
Condensation Temperature for Waste Stream (T_{con}) =	-63 °F

Total Capital Investment (TCI) (in 2022 dollars)

Parameter	Equation	Single Stage	Multi-Stage
Equipment Costs for Single Stage Refrigeration Unit (ECr):	1.611 × exp[9.83 - 0.014 × Tcon + 0.34 × ln(R)] × [2022 CEPCI / 2014 CEPCI] =	Not applicable*	
Equipment Costs for Multistage Refrigeration Unit (ECr):	1.611 × exp[9.73 - 0.012 × Tcon + 0.58 × ln(R)] × [2022 CEPCI / 2014 CEPCI] =		$43,433
Other Equipment Costs for a Packaged Solvent Recovery System (ECp):	1.25 × ECr =	Not applicable	$10,858
Costs for Refrigerated Condenser (A) =	ECp + ECr =	Not applicable	$54,292
Instrumentation =	0.10 × A =	Included in A	Included in A
Sales taxes =	0.03 × A =	Not applicable	$1,629
Freight =	0.05 × A =	Not applicable	$2,715
	Total Purchased Equipment Costs (B) =	**Not applicable**	$58,635

Direct Installation Costs (in 2022 dollars)

Parameter	Equation	Single Stage	Multi-Stage
Foundations and Supports =	0.14 × B =	Not applicable	Not applicable
Handling and Erection =	0.08 × B =	Not applicable	Not applicable
Electrical =	0.08 × B =	Not applicable	Not applicable
Piping =	0.02 × B =	Not applicable	Not applicable
Insulation =	0.10 × B =	Not applicable	Not applicable
Painting =	0.01 × B =	Not applicable	Not applicable
Site Preparation (SP) =		Not applicable	$0
Buildings (Bldg) =		Not applicable	$150,775
	Total Direct Costs (DC) = B + (0.43 × B) + SP + Bldg =	Not applicable	$209,410
	Total Capital Investment (TCI) = Direct Costs + Contingency = (1.15 × DC) =	**Not applicable**	**$240,822**

Annual Costs

Direct Annual Costs

Parameter	Equation	Single Stage	Multi-Stage
Annual Electricity Cost =	$(R / \eta_{Comp}) \times E \times \Theta_s \times p_e$ =	Not applicable	$1,769
Operating Labor =	Operator = 0.5 hours/shift × Labor Rate × (Operating hours/8 hours/shift)	Not applicable	$26,280
	Supervisor = 15% of Operator	Not applicable	$3,942
Maintenance Costs =	Labor = 0.5 hours/shift × Labor Rate × (Operating Hours/8 hours/shift)	Not applicable	$26,828
	Materials = 100% of maintenance labor	Not applicable	$26,828
	Direct Annual Costs (DAC) =	**Not applicable**	**$85,646**

Indirect Annual Costs

Parameter	Equation	Single Stage	Multi-Stage
Overhead	= 60% of sum of operator, supervisor, maintenance labor Plus maintenance materials	Not applicable	$50,326
Administrative Charges	= 2% of TCI	Not applicable	$4,816
Property Taxes	= 1% of TCI	Not applicable	$2,408
Insurance	= 1% of TCI	Not applicable	$2,408
Capital Recovery	= CRF × TCI	Not applicable	$23,201
	Indirect Annual Costs (IAC) =	**Not applicable**	**$83,160**

VOC Recovery Credit

Parameter	Equation	Single Stage	Multi-Stage
Annual Recovery Credit for Condensate (RC)	= $W_{voc} \times$ Credit $\times \Theta_s$ =	Not applicable	$0
	Total Annual Cost (TAC) = DAC + IAC - RC =	**Not applicable**	**$168,806**

Cost Effectiveness

Parameter	Equation	Single Stage	Multi-Stage
Total Annual Cost =	TAC =	Not applicable	$168,806
Annual Quantity of VOC Removed/Recovered =	W_{voc} =	Not applicable	11.7
Cost Effectiveness =	**Total Annual Cost/Annual Quantity of VOC Removed/Recovered =**	**Not applicable**	**$14,485**

Source Name and ID:	Hydro Unit (S007)
Facility Name:	Synthomer Jefferson Hills LLC

Data Inputs

Is the condenser a packaged, custom or gasoline vapor recovery system?	Packaged Condenser System

Enter the design data for the proposed condenser:

Number of operating hours per year and per day (Θ_s)	8,760	hours/year	24	hours/day
Volumetric flow rate of the waste stream (Q_{in})	200	scfm (at 77 °F; 1 atm)		
Inlet stream temperature (T_{in})	50	°F		
Required VOC removal efficiency (η)	90	%*	* 90% is a default control efficiency. Enter actual value, if known.	
Specific heat of the coolant ($C_{p,cool}$)	0.65	Btu/lb-mole-°F*	* 0.65 Btu/lb-mole-°F is a default value. Enter actual value, if known.	
Estimated equipment life (n)	15	Years*	* 15 years is a default equipment life. Enter actual value, if known.	
Overall heat transfer coefficient (U)	20	Btu/hour-ft²-°F*	* 20 Btu/hour-ft²-°F is a default coefficient. Enter actual value, if known.	
Mechanical efficiency of compressor (η_{comp})	85	%*	* 85% is a default value. Enter actual value, if known.	

Enter the Characteristics of the VOC/HAP:

Name of VOC/HAP	Cyclohexane			
Molecular Weight of Cyclohexane (MW)	84.16	lb./mole		
Density of Cyclohexane	9.6	lb./gallon		
Heat Capacity of Cyclohexane (Cp,voc)	37.03	Btu/lb.-mole-°F		
Heat of Condensation of Cyclohexane (ΔHref)	12,910	Btu/lb.-mole		
Boiling Point of Cyclohexane	177	°F		
Antoine Equation Constants for Cyclohexane	**A**	**B**	**C**	
	6.8413	1201.53	222.65	based on degrees C and mmHg
Critical Temperature for Cyclohexane	996	°R		
Volume Fraction of Cyclohexane in waste stream entering the condenser (Yvoc,in)	0.00135			

Enter the cost data for the condenser:

Electricity ($Cost_{elect}$)	$0.0750	per kWh	
Operator Labor Rate	$48.00	per hour	
Maintenance Labor Rate	$49.00	per hour	
Re-Sale Value of Recovered VOC (Credit)	$0.00	per lb	
Contingency Factor (CF)	10.0	percent*	* 10 percent is a default value.

If known, enter any additional costs for site preparation and building construction/modification:

Site Preparation (SP) =	$0	* Default value. User should enter actual value, if known.
Buildings (Bldg) and Ductwork =	$150,775	based on QSEM control equipment design study from 2012, converted to 2014 dollars
Equipment Costs for auxiliary equipment for custom condenser systems (EC_{aux}) =	$0	* Default value. User should enter actual value, if known.

Desired dollar-year	2022			
CEPCI* for 2022	833	Enter the CEPCI value for 2022	576.1	2014 CEPCI
Annual Interest Rate (i)	5.00	% (Default value is 4.25%)		

* CEPCI is the Chemical Engineering Plant Cost Index. The use of CEPCI in this spreadsheet is not an endorsement of the index for purpose of cost escalation or de-escalation, but is there merely to allow for availability of a well-known cost index to spreadsheet users. Use of other well-known cost indexes (e.g., M&S) is acceptable.

Source Name and ID: **Hydro Unit (S007)**
Facility Name: **Synthomer Jefferson Hills LLC**

Design Parameters

The following design parameters for the condenser were calculated based on the values entered on the *Data Inputs* tab. These values were used to prepare the costs shown on the *Cost Estimate* tab.

VOC	VOC volume Fraction of waste stream entering the condenser ($Y_{voc,in}$)	Heat Capacity ($C_{p,voc}$) (Btu/lb.-mole-°F)	Heat of Condensation (ΔH_{ref}) (Btu/lb.-mole)
Cyclohexane	0.00135	37.03	12910

Parameter	Equation		Calculated Value	Units
Partial Pressure of Cyclohexane VOC in Exit Stream (Pvoc) =	$760 \times (M_{voc,out} / (M_{in} - M_{voc, recovered}))$ =	$760 \times [Y_{voc,in} \times (1 - \eta)] / [1 - (\eta \times Y_{voc,in})]$ =	0.103	mmHg
Estimated Condensation Temperature for Cyclohexane (Tcon) =	$((B / (A - \log (P_{voc})) - C) \times 1.8 + 32$ =		-92.5	°F

Parameter	Equation	Calculated Value	Units	Calculated Value	Units
Quantities of VOC in Inlet and Outlet streams:					
Moles of VOC in the inlet stream ($M_{voc,in}$) =	$(Q_{in} / 392) \times (Y_{voc,in}) \times 60$ =	0.041	lb.-moles/hour	3.48	lb/hour
Moles of VOC in the outlet stream ($M_{voc,out}$) =	$M_{voc,in} \times (1 - \eta)$ =	0.004	lb.-moles/hour		
Quantity of VOC Recovered:					
Moles of VOC Recovered ($M_{voc, recovered}$) =	$M_{voc,in} \times \eta$ =	0.037	lb.-moles/hour		
Quantity of VOC Recovered (W_{voc}) =	$M_{voc, recovered} \times MW_{voc}$ =	3.13	lb./operating hour	13.71	Tons/year
Calculation of Enthalpy of Condensation:					
Critical Temperature for VOC (T_c) =		996	°R		
Reference Temperature for Heat of Condensation (T_1) =		637	°R		
Condensation Temperature (T_2) =	$T_{con} + 459.67$ =	367	°R		
Enthalpy of condensation of VOC (ΔHvoc) at -92.5 °F =	$\Delta H_{ref} \times [(1 - T_2 / T_c) / (1 - T_1 / T_c)]^{0.38}$ =	15,970	Btu/lb.-mole		
Calculation of Condenser Heat Load:					
Heat capacity of air ($C_{p, air}$) =		6.95	Btu/lb.-mole-°F @ 77 °F and 1 atm.		
Mean Temperature (T_{mean}) =	$(T_{in} + T_{con}) / 2$ =	-21	°F		
Enthalpy change associated with the condensed VOC (ΔH_{con}) =	$M_{voc,recovered} \times [\Delta H_{voc} + C_{p,voc} (T_{in} - T_{con})]$=	790	Btu/hour		
Enthalpy change associated with the uncondensed VOC (ΔH_{uncon}) =	$M_{voc,out} \times C_{p,voc} \times (T_{in} - T_{con})$ =	22	Btu/hour		
Enthalpy change associated with the non-condensable air (ΔHnoncon) =	$[((Q_{in} / 392) \times 60) - M_{voc,in}] \times C_{p,air} \times (T_{in} - T_{con})$ =	30,286	Btu/hour		
Condenser Heat Load (H_{load}) =	$\Delta H_{con} + \Delta H_{uncon} + \Delta H_{noncon}$ =	31,098	Btu/hour		
Calculation of Surface Area:					
Temperature of coolant entering the condenser ($T_{cool,in}$) =	T_{con} - 15 °F =	-107.5	°F		
Temperature of coolant exiting the condenser ($T_{cool,out}$) =	$T_{cool,in}$ + 25 °F =	-82.5	°F		
Logarithmic mean temperature difference (ΔT_{lm}) =	$\dfrac{[(T_{in} - T_{cool,out}) - (T_{con} - T_{cool,in})]}{[\ln\{(T_{in} - T_{cool, out})/(T_{con} - T_{cool,in})\}]}$ =	53.9	°F		
Condenser Surface Area (A_{con}) =	$H_{load} / (U \times \Delta T_{lm})$ =	28.8	ft²		
Calculation of Coolant Flow Rate and Refrigeration Capacity:					
Coolant Flow Rate (W_{cool}) =	$H_{load} / (C_{p,cool} \times (T_{cool,out} - T_{cool,in}))$ =	1,914	lb./hour		
Refrigeration Capacity (R) =	H_{load} / 12,000 Btu/ton =	2.59	Tons/hour		
Calculation of Electricity Consumption:					
Estimated Electricity Consumption (E) =	$2.7411 \times \exp(-0.015 \times T_{con})$ =	10.98	kW/ton		
Capital Recovery Factor:					
Capital Recovery Factor (CRF) =	$[i \times (1 + i)^n] / [(1 + i)^n - 1]$ = Where n = Equipment Life and i = Interest Rate	0.0963			

Source Name and ID: **Hydro Unit (S007)**
Facility Name: **Synthomer Jefferson Hills LLC**

Control Cost Estimate

Capital Costs

VOC Controlled/Recovered =	Cyclohexane
Refrigeration Capacity (R) =	2.59 tons/hour
Condensation Temperature for Waste Stream (T_{con}) =	-93 °F

Total Capital Investment (TCI) (in 2022 dollars)

Parameter	Equation	Single Stage	Multi-Stage
Equipment Costs for Single Stage Refrigeration Unit (ECr):	1.611 × exp[9.83 - 0.014 × Tcon + 0.34 × ln(R)] × [2022 CEPCI / 2014 CEPCI] =	Not applicable*	
Equipment Costs for Multistage Refrigeration Unit (ECr):	1.611 × exp[9.73 - 0.012 × Tcon + 0.58 × ln(R)] × [2022 CEPCI / 2014 CEPCI] =		$206,575
Other Equipment Costs for a Packaged Solvent Recovery System (ECp):	1.25 × ECr =	Not applicable	$51,644
Costs for Refrigerated Condenser (A) =	ECp + ECr =	Not applicable	$258,219
Instrumentation =	0.10 × A =	Included in A	Included in A
Sales taxes =	0.03 × A =	Not applicable	$7,747
Freight =	0.05 × A =	Not applicable	$12,911
	Total Purchased Equipment Costs (B) =	**Not applicable**	$278,876

Direct Installation Costs (in 2022 dollars)

Parameter	Equation	Single Stage	Multi-Stage
Foundations and Supports =	0.14 × B =	Not applicable	Not applicable
Handling and Erection =	0.08 × B =	Not applicable	Not applicable
Electrical =	0.08 × B =	Not applicable	Not applicable
Piping =	0.02 × B =	Not applicable	Not applicable
Insulation =	0.10 × B =	Not applicable	Not applicable
Painting =	0.01 × B =	Not applicable	Not applicable
Site Preparation (SP) =		Not applicable	$0
Buildings (Bldg) =		Not applicable	$150,775
	Total Direct Costs (DC) = B + (0.43 × B) + SP + Bldg =	Not applicable	$429,652
	Total Capital Investment (TCI) = Direct Costs + Contingency = (1.15 × DC) =	**Not applicable**	**$494,099**

Annual Costs

Direct Annual Costs

Parameter	Equation	Single Stage	Multi-Stage
Annual Electricity Cost =	$(R / \eta_{Comp}) \times E \times \Theta_s \times p_e$ =	Not applicable	$22,003
Operating Labor =	Operator = 0.5 hours/shift × Labor Rate × (Operating hours/8 hours/shift)	Not applicable	$26,280
	Supervisor = 15% of Operator	Not applicable	$3,942
Maintenance Costs =	Labor = 0.5 hours/shift × Labor Rate × (Operating Hours/8 hours/shift)	Not applicable	$26,828
	Materials = 100% of maintenance labor	Not applicable	$26,828
	Direct Annual Costs (DAC) =	**Not applicable**	**$105,880**

Indirect Annual Costs

Parameter	Equation	Single Stage	Multi-Stage
Overhead	= 60% of sum of operator, supervisor, maintenance labor Plus maintenance materials	Not applicable	$50,326
Administrative Charges	= 2% of TCI	Not applicable	$9,882
Property Taxes	= 1% of TCI	Not applicable	$4,941
Insurance	= 1% of TCI	Not applicable	$4,941
Capital Recovery	= CRF × TCI	Not applicable	$47,603
	Indirect Annual Costs (IAC) =	**Not applicable**	**$117,693**

VOC Recovery Credit

Parameter	Equation	Single Stage	Multi-Stage
Annual Recovery Credit for Condensate (RC)	$= W_{voc} \times Credit \times \Theta_s$ =	Not applicable	$0
	Total Annual Cost (TAC) = DAC + IAC - RC =	**Not applicable**	**$223,573**

Cost Effectiveness

Parameter	Equation	Single Stage	Multi-Stage
Total Annual Cost =	TAC =	Not applicable	$223,573
Annual Quantity of VOC Removed/Recovered =	W_{voc} =	Not applicable	13.7
Cost Effectiveness =	**Total Annual Cost/Annual Quantity of VOC Removed/Recovered =**	**Not applicable**	**$16,307**