OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION

MEMORANDUM **January 3, 2018**

TO: PF Phillip Fielder, P.E., Permits and Engineering Group Manager

THROUGH: PM Phil Martin, P.E., Engineering Manager, Existing Source Permits Section

THROUGH: Jian Yue, P.E., New Source Permits Section

FROM: Amalia Talty, P.E., Existing Source Permits Section

SUBJECT:
Evaluation of Permit Application No. **2017-0121-C (PSD)**
Tallgrass Terminals, LLC
Cushing South Tank Farm
Facility ID No.: 17009
N/2 Sections 27, Township 17N, Range 5E, Lincoln County, Oklahoma
Latitude 35.92031°N, Longitude 96.75811°W
Directions: 4.5 miles south of E Main St. in Cushing, OK on N3500 Rd.

SECTION I. INTRODUCTION

Tallgrass Terminal, LLC. (Tallgrass or the applicant) has submitted an application to construct a new bulk terminal located in Lincoln County, Oklahoma. The new facility is classified under NAICS Code 486110 – Pipeline Transportation of Crude Oil. The proposed tanks will be subject to New Source Performance Standards 40 CFR Part 60 (NSPS), Subpart Kb.

The proposed facility will consist of twenty (20) internal (IFR) and external floating roof (EFR) crude oil storage tanks with a total storage capacity of approximately 5.5 million barrels (bbl). The facility is a listed Prevention of Significant Deterioration (PSD) major source, a crude oil storage facility exceeding 300,000-barrel (bbl) storage capacity with proposed permitted emissions in excess of 100 TPY. Potential VOC emissions have been estimated at 223.17 TPY. Therefore, the application required a full PSD review.

Potential emissions of any single Hazardous Air Pollutant (HAP) are less than 10 TPY, and potential emissions of total HAP are less than 25 TPY. Therefore, the facility will be considered a minor source of HAP emissions.

SECTION II. PROCESS DESCRIPTION

The Cushing South Tank Farm is designed as a crude oil terminal facility. The facility will receive and store crude oil via pipeline and truck receiving operations. The stored liquids are then pumped via pipeline to downstream facilities and customers. The facility will consist of the following equipment.

- Six (6) 500,000 bbl EFR storage tanks [EUG-1]
- Ten (10) 250,000 bbl EFR storage tanks [EUG-1]
- Four (4) 1,000 bbl IFR storage tanks [EUG-2]
- One (1) emergency generator engine [EUG-5]
- Associated piping, metering, and electric pumps [EUG-6]

Oil will be received from trucks and stored in the IFR storage tanks. These tanks will transfer oil to the larger EFR tanks via piping and transfer pumps. The facility input capacity is estimated at 175.2 MM bbl per year via pipeline and 13.9 MM bbl per year from truck receiving operations, which totals an estimated 190 MM bbls per year for the entire facility.

SECTION III. EQUIPMENT

Table 1. Tanks

EU ID#	Contents	Roof Type	Bottom Design	Capacity (bbl)	Height (ft)	Diameter (ft)	Construction Date
T-101	Crude Oil	EFR	Liquid Heel	500,000	48	273	TBD
T-102	Crude Oil	EFR	Liquid Heel	500,000	48	273	TBD
T-103	Crude Oil	EFR	Liquid Heel	500,000	48	273	TBD
T-104	Crude Oil	EFR	Liquid Heel	500,000	48	273	TBD
T-105	Crude Oil	EFR	Liquid Heel	500,000	48	273	TBD
T-106	Crude Oil	EFR	Liquid Heel	500,000	48	273	TBD
T-107	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-108	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-109	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-110	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-111	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-112	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-113	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-114	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-115	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-116	Crude Oil	EFR	Liquid Heel	250,000	48	194	TBD
T-117	Crude Oil	IFR	Liquid Heel	1,000	30	15.5	TBD
T-118	Crude Oil	IFR	Liquid Heel	1,000	30	15.5	TBD
T-119	Crude Oil	IFR	Liquid Heel	1,000	30	15.5	TBD
T-120	Crude Oil	IFR	Liquid Heel	1,000	30	15.5	TBD

TBD – To be determined.

SECTION IV. EMISSIONS

Emission units have been arranged into Emission Unit Groups (EUGs) as follows:

A. EUG 1 & EUG 2: NSPS Subpart Kb Tanks

VOC emissions from the Kb tanks were estimated using the calculation methodology outlined in AP 42, Fifth Edition Compilation of Air Pollutant Emission Factors; Ch. 7.1 – Organic Liquid Storage Tanks (AP 42, Ch. 7.1). The emission calculation programs TanksESP_d and EPA's TANK 4.09d were used to estimate emissions. The estimates assume the contents to be crude oil with a Reid vapor pressure (RVP) of 9 and the throughputs listed in the following table. Throughput for the EFR tanks [EUG 1] are based on a maximum facility input capacity of 20,000 bbl/hr. Throughput for the truck receiving IFR tanks [EUG 2] is based on 38,000 bbl/day or an estimate of 200 trucks/day.

Table 2. Kb Tank Emissions (Normal Operations)

EUG	EU ID#	Throughput (bbl/yr)	Standing Losses (lb/yr)	Withdrawal Losses (lb/yr)	Total Emissions (TPY)
1	T-101	16,000,000	8,301.90	2,354.39	5.33
	T-102	16,000,000	8,301.90	2,354.39	5.33
	T-103	16,000,000	8,301.90	2,354.39	5.33
	T-104	16,000,000	8,301.90	2,354.39	5.33
	T-105	16,000,000	8,301.90	2,354.39	5.33
	T-106	16,000,000	8,301.90	2,354.39	5.33
	T-107	7,920,000	6,103.07	1,640.00	3.87
	T-108	7,920,000	6,103.07	1,640.00	3.87
	T-109	7,920,000	6,103.07	1,640.00	3.87
	T-110	7,920,000	6,103.07	1,640.00	3.87
	T-111	7,920,000	6,103.07	1,640.00	3.87
	T-112	7,920,000	6,103.07	1,640.00	3.87
	T-113	7,920,000	6,103.07	1,640.00	3.87
	T-114	7,920,000	6,103.07	1,640.00	3.87
	T-115	7,920,000	6,103.07	1,640.00	3.87
	T-116	7,920,000	6,103.07	1,640.00	3.87
2	T-117	3,467,500	798.08	8,986.82	4.89
	T-118	3,467,500	798.08	8,986.82	4.89
	T-119	3,467,500	798.08	8,986.82	4.89
	T-120	3,467,500	798.08	8,986.82	4.89
		TOTAL	**114,034.42**	**66.473.62**	**90.24**

B. EUG 3: Roof Landings

The twenty (20) tanks are flat bottom floating roof tanks. During normal operation, a floating roof is in contact with the liquid inside the tank, reducing evaporative losses. However, when the tank is emptied to the point that the roof lands on its deck legs, a vapor space is created. After the roof is landed, evaporative losses occur during idle standing and subsequent filling.

VOC emissions from roof landings were calculated using AP-42 (11/06), Section 7.1. Emissions are estimated by assuming the following number of landings per tank type per year: two (2) per 1,000-bbl IFR tanks, five (5) per 250,000-bbl EFR tanks, and three (3) per 500,000 bbl EFR tanks.

In Equation 2-10, roof landing emissions are the sum of standing idle losses and filling losses during each roof landing episode. Standing idle losses for each roof-landing event were calculated based on Equation 2-19 for EFR tanks and Equation 2-16 for the IFR tanks. Filling losses were calculated for each roof-landing event based on Equation 2-26 for the EFR tanks.

The following table summarizes the estimated roof landing losses for each roof landing event for each tank type.

Table 3. Roof Landing Emissions

EU ID#	Type	Landing Turnovers (per tank per yr)	Losses (lb/event)	Losses (lb/yr)	Total (tons/yr)
L-1a	500,000-bbl EFR Tanks	3	12,817.3	38,452	19.2
L-1b	250,000-bbl EFR Tanks	5	6,577.4	32,887	16.4
L-1c	1,000-bbl IFR Tanks	2	41.7	83	0.04
			TOTAL	71,423	35.7

C. EUG 4: Tank Cleanings

Each tank is periodically cleaned, requiring liquid evacuation and vapor purging. Emissions occur during an initial purge, potential subsequent daily purges, and sludge removal. Tank cleaning VOC emissions were calculated based on the American Petroleum Institute's (API) Technical Report 2568, "Evaporative Loss from the Cleaning of Storage Tanks" (November 2007). There is estimated to be one (1) 500,000-bbl, two (2) 250,000-bbl and one (1) 1,000 bbl tank cleaning per year to meet inspection and maintenance requirements under NSPS Subpart Kb and API standards. Landing and cleaning events are assumed to occur in the month with the highest average monthly temperature (July) for purposes of calculating PTE.

Per Equation 4, total tank cleaning emissions are the sum of standing idle losses, vapor purge losses, sludge removal losses, and refilling losses per cleaning. Standing idle losses for each cleaning events were calculated based on AP-42 (11/06), Section 7.1 Equation 2-19 for EFR tanks and Equation 2-16 for the IFR tanks. Vapor purge losses were calculated based on AP-42 (11/06), Section 7.1 Equation 2-26. Sludge removal losses were calculated based on API TR 2568 (11/07) Equation 19. Refilling losses were calculated based on API TR 2568 (11/07) Equation 23. When the tank is cleaned, filling losses are assumed to be similar to Drain-Dry tanks with a floating roof.

The following table summarizes the estimated tank cleaning losses for each cleaning event for each tank type. All tanks of a type will share the cleaning turnovers amount per year.

Table 4. Tank Cleaning Emissions

EU ID#	Type	Cleaning Turnovers (per tank type per year)	Losses (lb/event)	Losses (lb/yr)	Total (tons/yr)
C-1a	500,000-bbl EFR Tanks	1	92,286	92,286	46.1
C-1b	250,000-bbl EFR Tanks	2	47,109	94,218	47.1
C-1c	1,000-bbl IFR Tanks	1	2,811	2,811	1.4
			TOTAL	**189,316**	**94.7**

D. EUG 5: Emergency-Use Engines

Emergency-use diesel engine emissions are based on an assumed runtime of 500 hours per year. Emission factors are derived from EPA's Tier 3 standards (NSPS Subpart IIII, Table 4), and are listed in the table below.

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Table 5. NSPS Subpart IIII Emission Standards

EU #	Model year	NOx (g/hp-hr)	CO (g/hp-hr)	VOC (g/hp-hr)	PM (g/hp-hr)
GEN-1	2015	3.0	2.6	1.0	0.15

Table 6. Emergency Use Engines

Unit ID	Rating (HP)	NOx (TPY)	CO (TPY)	VOC (TPY)	PM (TPY)
GEN-1	450	0.74	0.64	0.25	0.04

E. EUG 6: Fugitive Equipment Leaks

Fugitive VOC emissions from piping components were calculated using emission factors for light oil service at petroleum marketing terminals in EPA's "Protocol for Equipment Leak Emission Estimates" (EPA-453/R-95-017) and an estimated number of components.

Table 7. Fugitive Emissions

Service	Component	Component Count	Emission Factor (lb/hr/comp)	Emissions (lb/hr)	Emissions (TPY)
Light Liquid	Connectors	3,500	0.0000176	0.062	0.27
	Flanges	800	0.0000176	0.014	0.06
	Pumps	80	0.00119	0.095	0.42
	Valves	1,800	0.0000948	0.171	0.75
	Other	200	0.000287	0.057	0.25
Gas Vapor	Connectors	100	0.0000926	0.009	0.04
	Valves	75	0.0000287	0.002	0.01
			Total	**0.41**	**1.80**

F. Trivial Activities

In addition to the equipment/operations in the EUG's listed above, the facility also includes pigging equipment and one (1) 4,000-gallon underground horizontal sump tank, which are included for PSD purposes. VOC is emitted from the pig traps after each pigging event. VOC emissions from the pig traps were estimated from AP-42 (11/06), Section 7.1 for clingage losses. Residual crude oil on the entire inner surface area of the aboveground segment of the pig trap is assumed to evaporate. Evaporative losses for each pigging event were calculated based on Equation 2-22, as follows:

$$L_C = 0.042 C_S W_l (Area)$$

Where:

L_C = clingage loss from each event, lb,
0.042 = conversion factor, gal/bbl,
C_S = clingage factor, 0.006 bbl/1,000 ft^2 (from AP-42 (11/06) Table 7.1-10),
W_l = density of the liquid, 7.1 lb/gal, and
$Area$ = Surface area of the pipe, 126 ft^2 (based on a 20 ft pipe with 2 ft diameter).

Based on the above methodology, emissions from each pigging event were calculated to be 0.22 pounds per event. Based on the assumption that 48 events will occur each year, total VOC emissions from pigging events were calculated to be 0.01 TPY.

VOC emissions from the underground sump tank were estimated using EPA's TANK 4.0.9d program, assuming the contents to be crude oil with a Reid vapor pressure (RVP) of 9 and the throughputs listed in the following table.

Table 8. Sump Tank Emissions

EU ID#	Throughput (bbl/yr)	Standing Losses[1] (TPY)	Working Losses (TPY)	Total Emissions (TPY)
S-1	208,000	---	0.49	0.49

[1] There are no standing losses associated with underground storage tanks.

G. Facility-Wide Emissions

Table 9. Facility-Wide Emissions

EUG	Description	NO_x (TPY)	CO (TPY)	VOC (TPY)
1	Six (6) 500,000-bbl EFR Tanks	--	--	32.0
	Ten (10) 250,000-bbl EFR Tanks	--	--	38.7
2	Four (4) 1,000-bbl IFR Tanks	--	--	19.6
3	Tank Landings	--	--	35.7
4	Tank Cleanings	--	--	94.7
5	Emergency Use Engines	0.74	0.64	0.25

Table 9. Facility-Wide Emissions

EUG	Description	NO_x (TPY)	CO (TPY)	VOC (TPY)
6	Fugitive Emissions	--	--	1.80
--	Trivial Activities	--	--	0.50
	TOTAL	**0.74**	**0.64**	**223.17**

H. Greenhouse Gas (GHG) Emissions

GHG emissions for the crude oil are based on the weight percentage of Carbon Dioxide and Methane from the extended analysis for the Bakken Light Sweet Crude sample taken at a Tallgrass facility on May 28, 2016. Weight % for CO_2 is 0.003 and Methane is 0.068 with 100% emitted. GHG emissions for EGEN1 were calculated using CFR Part 98, Subpart C factors. CO_{2e} was calculated using a GWP of 25 for methane and 298 for Nitrous Oxide.

Table 10: GHG Emissions

	CO_2	Methane	Nitrous Oxide (N_2O)	CO_{2e}
TPY*	125.91	0.16	0.001	129.46

* includes both TANKS and EGEN1

I. HAP Emissions

HAP emissions were calculated using the HAP weight percentage from the extended analysis for the Niobara Crude, conservatively assuming 100% emitted from each source based on the total VOC estimated from that unit. Emission factors taken from AP-42 (10/96), Section 3.3-2 were used for EGEN1.

Table 11. HAP Emissions

HAP	Speciation Profile (wt%)	Emissions	
		lb/hr	TPY
Benzene	0.23	0.12	0.52
Toluene	0.63	0.32	1.41
Ethylbenzene	0.17	0.08	0.37
Xylene	0.51	0.26	1.13
n-Hexane	1.60	0.81	3.57
2,2,4-TMP	0.62	0.31	1.37
	Total	**1.91**	**8.38**

J. Hydrogen Sulfide (H_2S) Emissions

Emissions of H_2S were estimated using a mass emission ratio based on the methodologies provided in "Using K factors to Estimate Quantities of Individual Vapor Species Emitted during the Storage and Transfer of Hydrocarbon Liquids" by Jeffery L. Meling, et al. and the information presented in the following table.

Table 12. Crude Oil Parameters

Parameter	Value
H_2S Concentration[1] (ppmw)	135
H_2S Molecular Weight (lb/lb-mol)	34.1
Vapor Molecular Weight (lb/lb-mol)	50.0
Liquid Molecular Weight (lb/lb-mol)	207.0
True Vapor Pressure (psia)	10
K Factor[2]	19

[1] – H_2S ppmw based on concentration typically found in crude oils with 5 wt% sulfur content.

[2] – K factor obtained from the nomograph for H_2S in crude oil and an ambient temperature of 60°F.

Emission estimates for H_2S are provided in the following table

Table 13. H_2S Emissions

Emissions Source	lb/24-hr	ppmv	lb/hr
EFR Standing Losses	484.7	15,610[1]	3.15E-01
EFR Working Losses	83.4	135[2]	4.69E-04
Total EFR Emissions		--	0.316
IFR Standing Losses	15.5	15,610[1]	1.01E-02
IFR Working Losses	98.2	135[2]	5.52E-04
Total IFR Emissions		--	0.011

[1] – Involves evaporation from standing liquid utilizing the weight fraction of H_2S in the crude vapor (calculated using K factors).

[2] – Involves complete evaporation of the liquid layer utilizing the weight fraction of H_2S in the crude liquid.

SECTION V. PSD REVIEW

The project is subject to PSD review because it is a listed PSD-major source, a crude oil storage facility exceeding 300,000-barrel (bbl) storage capacity with proposed permitted emissions in excess of 100 TPY. The pollutants subject to PSD review are listed in the following table. Since VOC triggered PSD, the threshold for all other pollutants is the PSD significant emission rate (SER) for a major source modification.

Table 14. PSD Applicability

Pollutant	Project Emissions (TPY)	PSD Threshold (TPY)	Subject to PSD?
NO_X	<1.0	40	No
CO	<1.0	100	No
VOC	223.17	100	**Yes**
PM_{10}	<1.0	15	No
$PM_{2.5}$	<1.0	10	No
SO_2	<1.0	40	No
H_2S	<1.0	10	No

The full PSD review consists of the following:

A. Determination of Best Available Control Technology (BACT);
B. Evaluation of existing air quality and determination of monitoring requirements;
C. Air Quality Impact Analysis
D. Evaluation of source-related impacts on growth, soils, vegetation, and visibility; and
E. Evaluation of Class I area impacts.

A. Best Available Control Technology (BACT)

Any major stationary source or major modification subject to PSD review must undergo an analysis to ensure the use of best available control technology (BACT). The requirement to conduct a BACT analysis is set forth in 40 CFR 52.21. BACT is defined in 40 CFR 52.21 as:

"…best available control technology means an emissions limitation (including a visible emission standard) based on the maximum degree of reduction for each pollutant subject to regulation under Act which would be emitted from any proposed major stationary source or major modification which the Administrator, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such source or modification through application of production processes or available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of such pollutant…"

A BACT analysis is required for each new or physically modified emission unit for each pollutant that exceeds an applicable PSD significant emission rate (SER). Since the VOC emissions from the proposed project exceed the applicable PSD SER, a BACT analysis is required to assess the necessary levels of control for this pollutant.

The following methodology for performing a top-down BACT analysis has been developed from the US EPA's 1990 Draft New Source Review Workshop Manual - BACT Guidance. The analysis utilizes five key steps to identify the most suited BACT option for the project. The first step in this approach is to determine, for the emission unit in question, the most stringent control available for a similar or identical source or source category. If it is shown that this level of control is technically, environmentally, or economically infeasible for the unit in question, then the next most stringent level of control is determined and similarly evaluated. This process continues until the BACT level under consideration cannot be eliminated by any substantial or unique technical, environmental, or economic objections.

Step 1: Identify Available Control Technologies

Available control technologies are identified for each emission unit in question. The following methods are used to identify potential technologies: 1) researching the Reasonably Available Control Technology (RACT)/BACT/Lowest Achievable Emission Rate (LAER) Clearinghouse (RBLC) database, 2) surveying regulatory agencies, 3) drawing from previous engineering experience, 4) surveying air pollution control equipment vendors, and 5) surveying available literature.

Step 2: Eliminate Technically Infeasible Options

After the identification of control options, an analysis is conducted to eliminate technically infeasible options. A control option is eliminated from consideration if there are process-specific conditions that prohibit the implementation of the control technology or if the highest control efficiency of the option would result in an emission level that is higher than any applicable regulatory limits, such as an NSPS.

Step 3: Rank Remaining Control Options by Control Effectiveness

Once technically infeasible options are removed from consideration, the remaining options are ranked based on their control effectiveness. If there is only one remaining option, or all of the remaining technologies could achieve equivalent control efficiencies, ranking based on control efficiency is not required.

Step 4: Evaluate and Eliminate Control Technologies Based on Energy, Environmental, and Economic Impacts

Beginning with the most efficient control option in the ranking, detailed economic, energy, and environmental impact evaluations are performed. If a control option is determined to be economically feasible without adverse energy or environmental impacts, it is not necessary to evaluate the remaining options with lower control efficiencies.

The economic evaluation centers on the cost effectiveness of the control option. Costs of installing and operating control technologies are estimated following the methodologies outlined in the EPA's OAQPS Control Cost Manual (CCM)[1] and other industry resources. Cost effectiveness is expressed as dollars per ton of pollutant controlled. Objective analyses of energy and environmental impacts associated with each option are also conducted. Both beneficial and adverse impacts are discussed and quantified.

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[1] *EPA Air Pollution Control Cost Manual, Sixth Edition, January 2002 [EPA/452/B-02-001]*

Step 5: Select BACT and Document the Selection as BACT

In the final step, one pollutant specific control option is proposed as BACT for each emission unit under review based on evaluations from the previous step. The resulting BACT standard is an emission limit unless technological or economic limitations of the measurement methodology would make the imposition of an emissions standard infeasible, in which case a work practice standard can be imposed.

BACT Analysis for Storage Tanks – Normal Operations (Standing and Withdrawal Losses)

Step 1: Identify Available Control Technologies

Several different control options have been selected for BACT top-down analysis for control of emissions from normal tank operations (standing and withdrawal losses). The following table lists commercially available controls for petroleum liquid storage. The control technologies are listed in order of decreasing emission reduction potential.

Table 15. Control Technologies for Normal Operations

Control Technologies
Routing Vapor Space to a Control Device
• Thermal Incinerator
• Flare
• Vapor Combustor
• Refrigerated Condenser
• Carbon Adsorption
Roof Selection
• EFRs, IFRs
• Fixed Roof
Seal Selection
• Double Seal
• Liquid, Mechanical Shoe
• Wiper
Submerged Fill
Good Operating and Maintenance Practices

Routing Vapor Space to a Control Device

Evaporative losses from tanks can be routed to a variety of control devices with varying destruction efficiencies. Combustion type controls, including flares, combustors, and incinerators, destroy VOCs with auxiliary fuel injection. Destruction efficiencies range from 98-99.9%, depending on the material. Adsorption technologies, which physically filter VOC, have capture efficiencies that range from 50-90%, depending on the material. Condensation techniques can achieve removal efficiencies above 90% relative to VOC composition and concentration in the emission stream. Refrigerated condensers are used as air pollution control devices for treating emissions streams with high VOC concentrations for sources such as gasoline bulk terminals. Pressure/vacuum conservation vents reduce evaporation of tank contents when vapor space is increased or decreased due to liquids being pumped in or out of the tank. These vents are typically mounted to a flange or pipe that connects to the vapor space above the liquid level in the tank.

Roof Selection

Three basic roof types are considered: external floating roof (EFR), internal floating roof (IFR), and fixed roof.

Fixed roof tanks – These tanks consist of a cylindrical steel shell with a permanently fixed roof that can be either cone-shaped, dome-shaped, or flat. Evaporative losses occur in these tanks through vapor expansion and contraction and from working losses as filling vapors are expelled from the tank. NSPS Subpart Kb requires a floating roof for Tallgrass's tanks, i.e. the tanks must be IFR or EFR. Therefore, fixed roof tanks are not considered further in this analysis. The baseline option for this facility is constructing EFR storage tanks and IFR tanks for receiving trucking operations.

Internal floating roof tanks (IFRs) – These tanks consist of an open cylindrical steel shell with a roof, or deck, which floats on the surface of the stored liquid. The roof height changes with the liquid level of the material stored within the tank, effectively minimizing vapor space. A rim seal system is attached to the deck's perimeter and makes contact with the tank wall. These two systems combine to reduce VOC emissions from the stored material. Losses from these tanks originate from exposed liquid at the rim seal system and deck fittings. The fixed roof serves as a vapor barrier and blocks air movement. Additionally, the internal floating roof tank deck is lighter than those used in external roof tanks. Losses from these tanks are the same as EFRs, with the exception that emissions induced by air movement are reduced. This option is estimated to provide a control efficiency of roughly 40%[2]. Actual reduction will vary depending on tank fittings. In addition to the basic tank configuration, there is an add-on option to further reduce emissions and is listed as follows:

- IFR with Vapor Space Routed to a Control Device – This option would involve installing a dedicated vapor collection system to route emissions from each tank to a dedicated control device as listed in the previous control technology category (routing vapor space to a control device). This option is estimated to provide a control efficiency of 99%[3].

External floating roof tanks (EFRs) – These tanks are similar to IFR tanks with the exception that they do not have a fixed roof, and the floating roof is heavier than those used in IFR tanks. In addition to the basic EFR tank configuration, there are several add-on options that can further reduce emissions.

- Cone Roof Add-on Only – This option involves installing a fixed coned roof over the top of each tank at the terminal, thereby creating IFR tanks from the previous EFR tanks. The coned exterior roofs would be supported by columns that penetrate through the floating roof inside each tank. The fixed coned roof design acts to control emissions as listed in the previous control technology (IFR).

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[2] *Reduction above baseline (EFR emissions) based on TANKS 4.0.9d estimates.*

[3] *Reduction above baseline (EFR emissions) based on typical thermal oxidizer control efficiency.*

- Cone Roof Add-on with Vapor Space Routed to a Control Device - This option is the same as the IFR control option listed above (IFR with Vapor Space Routed to a Control Device).

- Domed External Floating Roof – This option involves constructing a self-supporting geodesic dome over the existing external floating roof on each tank at the terminal. Similar to the cone roof add-on option, geodesic domes are utilized to minimize the wind over the top of the external floating roof. The domed tanks are generally vented with circulation vents at the top of each roof. Emissions from each domed EFR tank would not be piped to a control device. Since the geodesic domes would be self-supporting, the installation of column supports penetrating through the floating roof would not be necessary and gaps in the floating roof would be minimized. This design is still referred to as an external floating roof because it utilizes the existing heavier-duty, double-sealed fully intact EFR, though for emission estimation purposes it is treated as an IFR with no support columns. This option is estimated to provide a control efficiency of up to 70%[4]. Actual reduction can be vary depending on tank fittings.

Seal Selection

Rim seals are used in floating roof tanks, and allow the roof to rise and fall with the level of the liquid in the tank. Seals minimize the annular space between the tank wall and rim, reducing emissions. A rim seal can consist of a single primary seal or also be paired with a secondary seal, which is mounted above the primary seal (double seal).

Mechanical shoe seals use a light-gauge metallic band as the contact with the tank shell. This seal consists of a series of sheets, or shoes, joined in a ring. The sheets are held against the tank shell mechanically. The shoes' bottoms extend below the liquid surface and confine the vapor space between the shoe and floating roof. Primary seal fabric extends from the shoe to the rim and seals the vapor space from the atmosphere.

Resilient filled seals either eliminate the vapor space between the rim seal and liquid surface (liquid mounted) or allow vapor space between the rim seal and liquid surface (vapor mounted). These seals are made of an open-cell foam covered in a coated fabric and attach to the deck's perimeter. Filled seals expand and contract while maintaining contact with the tank wall and accommodate variable annular rim space widths. These seals give room for the floating roof to move with the material surface without binding. To effectively reduce emissions, seal joints must be vapor tight, and the seal must be in contact with the tank wall.

Wiper seals consist of a continuous annular blade made of flexible material which is fixed to a mounting bracket on the floating roof perimeter. This blade spans the annular rim space and contacts the tank wall. These seals are vapor mounted, and a vapor space exists between the liquid surface and the seal. The blades are either made of a cellular, elastomeric material, or a foam core wrapped in fabric. To effectively reduce emissions, the mounting must be vapor tight, and the seal must extend around the deck while maintaining contact with the tank wall.

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[4] *Reduction above baseline (EFR emissions based on TANKS 4.0.9d estimates.*

In a double seal configuration, secondary seals are either resilient filled or flexible wiper seals, which can further reduce evaporative loss. Secondary seals can be either shoe or rim mounted; although rim mounted seals are more effective due to coverage of the entire rim vapor space.

Submerged Fill

Submerged loading can be accomplished using the bottom loading method. A bottom-loading fill pipe is permanently attached to the bottom of the tank, significantly controlling liquid turbulence. Subsequently, much lower vapor generation occurs than during splash loading, where the tank is filled from the top of the tank.

Good Operating and Maintenance Practices

Good operating and maintenance practices for normal operations include, but are not limited to, white paint color, routine inspections, and timely repairs.

Step 2: Eliminate Technically Infeasible Options

All control options are technically feasible when considered individually. These options are further considered in the following steps of the top-down BACT analysis.

Step 3: Rank Remaining Control Options by Control Effectiveness

Floating roof tanks reduce vapor space emissions more effectively than fixed roof tanks because the deck rests atop the liquid surface and reduces the vapor space within the tank.

Liquid-mounted seals provide better emission control than mechanical-shoe and vapor mounted seals, but do not greatly out-perform mechanical-shoe seals. The maintenance and reliability of mechanical-shoe seals may be advantageous as compared to liquid-mounted seals. Add-on control options add additional emission control beyond the basic required components of each tank.

Table 16: Control Technology Options for Storage Tanks

Option	Description
Baseline : EFR and IFR	EFR storage tanks with mechanical shoe seal and second rim-mounted wiper seal
	IFR storage tanks for receiving trucking operations
	Additionally, all tanks will be designed to have submerged fill loading and will be operated and maintained in accordance with NSPS Subpart Kb
Option 1 : EFR with cone roof add-on	All EFR tanks equipped to reduce emissions with cone roof add-on
Option 2: Option 1 with Vapor Collection	All EFR tanks equipped to reduce emissions with cone roof add-on, and closed vent vapor collection system routing vapors to a control device (including as-built IFR tanks)
Option 3: Geodesic Dome EFR	EFR Storage tanks built with a self-supporting geodesic dome
	IFR Storage tanks for receiving trucking operations

Table 17. Rank of Control Technologies for Normal Operations

Rank	Option
1	Option 2: EFR w/ cone roof add-on and vapor collection
2	Option 3: Geodesic dome EFR
3	Option 1: EFR w/ cone roof add-on
4	Baseline: EFR and IFR

In addition to control effectiveness and emissions considerations, each BACT option must also be evaluated for economic impacts, environmental, and energy impacts. These considerations are further discussed in Step 4.

Step 4: Evaluate and Eliminate Control Technologies Based on Energy, Environmental, and Economic Impacts

All tanks will be built to operate with submerged fill piping and will have good operating and maintenance practices in accordance with NSPS Subpart Kb. NSPS Subpart Kb requires an EFR and IFR for tanks of this size storing petroleum with a true vapor pressure less than 11.1 psia. Therefore, the baseline option for this facility is constructing EFR storage tanks and IFR storage tanks for receiving trucking operations.

The economic consideration for each remaining BACT option is based on an itemized cost analysis. Expenses associated with the control options include tank construction, incinerator equipment, and annual operating costs. In Table 18, the cost for an EFR tank is represented as the baseline cost, and the remaining BACT options are estimated as the incremental or increased cost of emission control over the baseline. BACT cost is the incremental expenses in dollars per ton of VOC reduced. The expense is the annual control cost, which includes annualized capital costs (i.e. tank construction, destruction equipment, etc.) and annual operating costs (i.e. maintenance and pilot gas). The tons of VOC reduced are conservativly estimated as the control efficiency multiplied by the baseline emission rate assuming 100% capture for destruction controls. Baseline emissions are based on the EFR tank emissions with no additional control. For Option 2: IFR with vapor collection, the baseline emissions from IFR tanks were conservatively included since this option would also result in a reduction of IFR tank emissions for receiving trucking operations.

Table 18. Initial Costs (EFR Storage Tanks – Normal Operations)

Proposed Tanks		Baseline: EFR and IFR		Option 1: IFR	
Capacity	**Qty.**	**Cost/Tank**	**Total Cost**	**Cost/Tank**	**Total Cost**
250,000	10	3,481,000	34,810,000	3,686,000	36,860,000
500,000	6	6,962,000	41,772,000	7,372,000	44,232,000
Total	16	--	**$76,582,000**	--	**$81,092,000**

Table 18. (cont.)

Proposed Tanks		Option 2: IFR with Vapor Collection		Option 3: Geodesic Dome	
Capacity	**Qty.**	**Cost/Tank**	**Total Cost**	**Cost/Tank**	**Total Cost**
250,000	10	3,686,000	36,860,000	3,852,000	38,520,000
500,000	6	7,372,000	44,232,000	7,704,000	46,224,000
Total	**16**	--	**$81,092,000**	---	**$84,744,000**

Table 19. Unit Cost Analysis for Option 2 (Normal Operations)

Capacity (bbl)	250,000	500,000
Tank Roofs	205,000	410,000
Thermal Oxidizer	218,200	230,600
Piping to TO	33,200	33,200
Direct Costs		
Total Capital Investment	456,400	673,800
Total Annual Cost	54,800	57,100
Interest	6%	6%
Equipment Life (yrs)	15	15
Total Annual Cost	$101,792	$126,476
Emission Reductions		
Baseline Emission (TPY)	3.9	5.3
Control Efficiency	99%	99%
Emissions Reduced (TPY)	3.8	5.3
BACT Cost ($/ton)	**26,558**	**23,977**

[1] IFR installation costs are based on vendor quote from Matrix PDM for complete tanks -- actual costs for retrofitting cone and dome roofs onto EFR tanks are typically higher

[2] Thermal oxidizer and associated vapor collection piping installation costs are based on EPA Control Cost Manual

[3] Annual operation costs associated with the thermal oxidizer are based on EPA Control Cost Manual

[4] Control efficiency based on EPA Control Cost Manual typical thermal oxidizer control efficiency

Table 20: Unit Cost Analysis for Option 3

Capacity (bbl)	**250,000**	**500,000**
Tank Roofs	205,000	410,000
Direct Costs		
Total Capital Investment	205,000	410,000
Total Annual Cost	0	0
Interest	6%	6%
Equipment Life (yrs)	15	15
Total Annual Cost	$21,107	$42,215
Emission Reductions		
Baseline Emission (TPY)	3.9	5.3
Control Efficiency	40%	40%
Emissions Reduced (TPY)	1.5	2.1
BACT Cost ($/ton)	**13,630**	**19,807**

[1] IFR installation costs are based on vendor quote from Matrix PDM for complete tanks -- actual costs for retrofitting cone and dome roofs onto EFR tanks are typically higher

[2] Control efficiency is based on TANKS 4.0.9d estimates

Table 21: Unit Cost Analysis for Option 1

Capacity (bbl)	**250,000**	**500,000**
Tank Roofs	371,000	742,000
Direct Costs		
Total Capital Investment	371,000	742,000
Total Annual Cost	0	0
Interest	6%	6%
Equipment Life (yrs)	15	15
Total Annual Cost	$38,199	$76,398
Emission Reductions		
Baseline Emission (TPY)	3.9	5.3
Control Efficiency	70%	70%
Emissions Reduced (TPY)	2.7	3.7
BACT Cost ($/ton)	**14,095**	**20,484**

[1] Geodesic Dome EFR installation costs are based on vendor quote from Matrix PDM for complete tanks -- actual costs for retrofitting cone and dome roofs onto EFR tanks are typically higher

[2] Control efficiency is based on TANKS 4.0.9d estimates