Guidelines for Calculating and Reporting Emissions from Tank Trucks and Rail Tank Cars Bulk Loading Operations

Revised December 2024

The purpose of this document is to provide operators with guidelines in estimating emissions from loading of volatile organic liquid materials in bulk into tank trucks or rail tank cars. Loading losses are the primary source of evaporative emissions that occur as organic vapors in "empty" cargo tanks are displaced to the atmosphere by the liquid being loaded into the tanks. These vapors are a composite of: (1) vapors formed in the empty tank by evaporation of residual product from previous loads, (2) vapors transferred to the tank in vapor balance systems as product is being unloaded, and (3) vapors generated in the tank as the new product is being loaded.

In addition to emissions from evaporative losses (VOC and toxic air contaminants), other emissions from controlling emissions by means of thermal destruction are also expected (NOx, SOx, CO, PM, and toxic air contaminants).

South Coast AQMD provides the following guidelines in assisting facilities in calculating emissions from bulk loading operations for the Annual Emissions Reporting program. The methodologies assume certain default parameters. Rule 301 requires **Site-specific information should be used, if it is available**. There are three emission scenarios for bulk loading operations:

1. Simple Operation (No Control)
2. Equipped with a Vapor Collection and Recovery System
3. Equipped with a Vapor Collection with Balance and Vapor Destruction Systems

CASE 1) SIMPLE OPERATION (NO VAPOR CONTROL)

$$E_1 = Q * L_L \qquad Eq.\ 1$$

Where,

E_1 = VOC Emission (un-captured vapor) from Loading Losses

Q = Throughput in 1,000 gallons loaded (Mgal)

L_L = Loading Loss Factor (lb/1,000 Gallon Loaded or lb/Mgal) can be found in the Default Emission Factor tables or determined using information defined in US EPA AP-42 (Eq-1), Section 5.2 as follows:

$$L_L = \frac{12.46 \times S \times P \times M}{T}$$

Where,

S = Saturation Factor (see AP-42, Table 5.2-1)

P = True Vapor Pressure, psia (see AP42, Chapter 7.1 “Organic Liquid Storage Tank”)

M = Vapor Molecular Weight, lb/lb-mole (see AP42, Chapter 7.1 "Organic Liquid Storage Tank")

T = Temperature of the Liquid being Loaded, °R (°F + 460)

CASE 2) OPERATIONS EQUIPPED WITH VAPOR COLLECTION AND RECOVERY SYSTEMS

Loading emissions from this configuration consist of two parts: 1) uncollected vapor during loading; and 2) collected vapor that was further recovered by the system before exiting the recovery stack.

$E_2 = E_{uncollected} + E_{stack} = E_{uncollected} + E_{collected} * (1 - Eff_{VR})$

$E_2 = Q * L_L * (1 - Eff_{VC}) + Q * L_L * Eff_{VC} * (1 - Eff_{VR})$

$$E_2 = Q * L_L - Q * L_L * Eff_{VC} * Eff_{VR} \qquad Eq.\ 2$$

Where,

E_2 = VOC Emission from Loading Losses

Eff_{VC} = Vapor Collection Efficiency (fraction) as defined in US EPA AP-42, Section 5.2 as follows:

Eff_{VC} = 0.992 for tanker trucks passing MACT-level annual leak test; or

Eff_{VC} = 0.987 for tanker trucks passing the NSPS-level annual leak test; or

Eff_{VC} = 0.70 for tanker trucks not passing either of the above leak tests.

Eff_{VR} = Vapor Recovery Efficiency (fraction) as defined in US EPA AP-42, Section 5.2 range from 90 to over 99 percent. In absence of site-specific tests, permit or rule limits, Vapor Recovery Efficiency (Eff_{VR}) is assumed to be 0.95 (average of the range above) and equation 2 becomes:

$$E_2 = Q * L_L * (1 - 0.95 * Eff_{VC}) \qquad Eq.\ 3$$

CASE 3) OPERATIONS EQUIPPED WITH A VAPOR BALANCE AND DESTRUCTION SYSTEM

Loading emissions from this configuration consisted of two parts: 1) uncollected vapor during loading; and 2) collected vapor that was further recovered by the system before exiting the recovery stack.

$E_3 = E_{uncollected} + E_{stack} = E_{uncollected} + E_{collected} * (1 - Eff_{VB}) * (1 - Eff_{VD})$

$E_3 = Q * L_L * (1 - Eff_{VC}) + Q * L_L * Eff_{VC} * (1 - Eff_{VB}) * (1 - Eff_{VD})$

$$E_3 = Q * L_L * [1 - Eff_{VC} (\text{Eff}_{VB} + Eff_{VD} - (\text{Eff}_{VB} * Eff_{VD}))] \qquad Eq.\ 4$$

Where,

E_3 = VOC Emission from Loading Losses

Eff_{VC} = Vapor Collection Efficiency (fraction) as defined in US EPA AP-42, Section 5.2 and as explained in CASE 2 above

Eff_{VB} = Vapor Balance Efficiency (fraction)

Eff_{VD} = Vapor Destruction Efficiency (fraction)

A typical system is operating with vapor balance efficiency (Eff_{VB}) ranging from 93 to 100% per US EPA AP-42, Section 5.2. If this parameter is not available from the facility permit, source test results, or manufacturer guarantee, the minimum of the range above can be used.

For Vapor Destruction Efficiency (Eff_{VD}) site specific tests results, permit, or rule limit should be used.

THERMAL OXIDATION

If the operation is equipped with a VOC destruction system by means of thermal oxidation, other contaminants (NOx, SOx, CO, PM, and toxic air contaminants) from burning off organic vapor are expected. **South Coast AQMD encourages operators to use test results to calculate and report these emissions**. In absence of test results, following liquid equivalent method should be used. Since the organic vapor evaporates from loading of liquid organic materials, the captured for control vapor must be converted back into liquid form for consistency with available emission factors. The South Coast AQMD uses an equivalent method to determine the throughput of vapors directed to a thermal oxidizer (TO) as equivalent 1000 of gallons of liquid (Mgal).

$$TO_{Throughput} = \frac{E_{collected}}{1{,}000 * d_l} * (1 - Eff_{VB}) \qquad Eq.5$$

Where:

d_l = the liquid density.

$TO_{Throughput}$= liquid equivalent of product vapors destructed (Mgal)

$$TO_{Throughput} = \frac{Q * L_L * Eff_{VC}}{1{,}000 * d_l} * (1 - Eff_{VB}) \qquad Eq.6$$

Default combustion emission factors in *AER Program Help & Support* can be used then to estimate the criteria pollutant emissions from destruction of the vapor. Please note that VOC emissions have been already captured by Eq. 4; therefore, do not need to be calculated using default emission factors here.

Please also note that the emissions from natural gas combustion at the thermal oxidizer need to be captured separately using default emission factors when test results are not available for each of criteria pollutant and toxic emissions from combustion.

TAC Emissions

South Coast AQMD encourages operator to use the test results in calculating and reporting toxic missions. In absence of this information and when thermal destruction is not used to control emissions, the toxic vapor speciation of the VOC emitted should be calculated using the methodology provided in AP42, Chapter 7.1 "Organic Liquid Storage Tank" from liquid speciation of the petroleum product loaded to determine and report the toxic break down of the VOC emitted. Liquid speciation of the products loaded can be obtained from their safety datasheet or the default values in *South Coast AQMD AER Supplemental Instructions for Liquid Organic Storage Tanks*.

Facilities should also report toxic emissions from destruction of the VOC in a thermal oxidizer. In absence of test results, the following emission factors for non-catalyst (portable and stationary) internal combustion engines (https://www.aqmd.gov/docs/default-source/planning/annual-emission-reporting/combustion-default-emission-factors-2024.pdf), in pounds/1000 gallons of equivalent gasoline burned can be used to determine the toxic emissions generated from loading.

EXAMPLES

The following examples will demonstrate how emissions are calculated for a typical bulk loading operation in all three cases. The examples also included images of screens for how to report emissions under the new reporting system.

CASE 1 - SIMPLE OPERATION (NO VAPOR CONTROL)

Company XYZ splash loaded 120,000 gallons of gasoline RVP 10 at the following conditions:

S = 1.45 (Saturation Factor from AP-42)

T = 70ºF = 530ºR (Temperature of Gasoline)

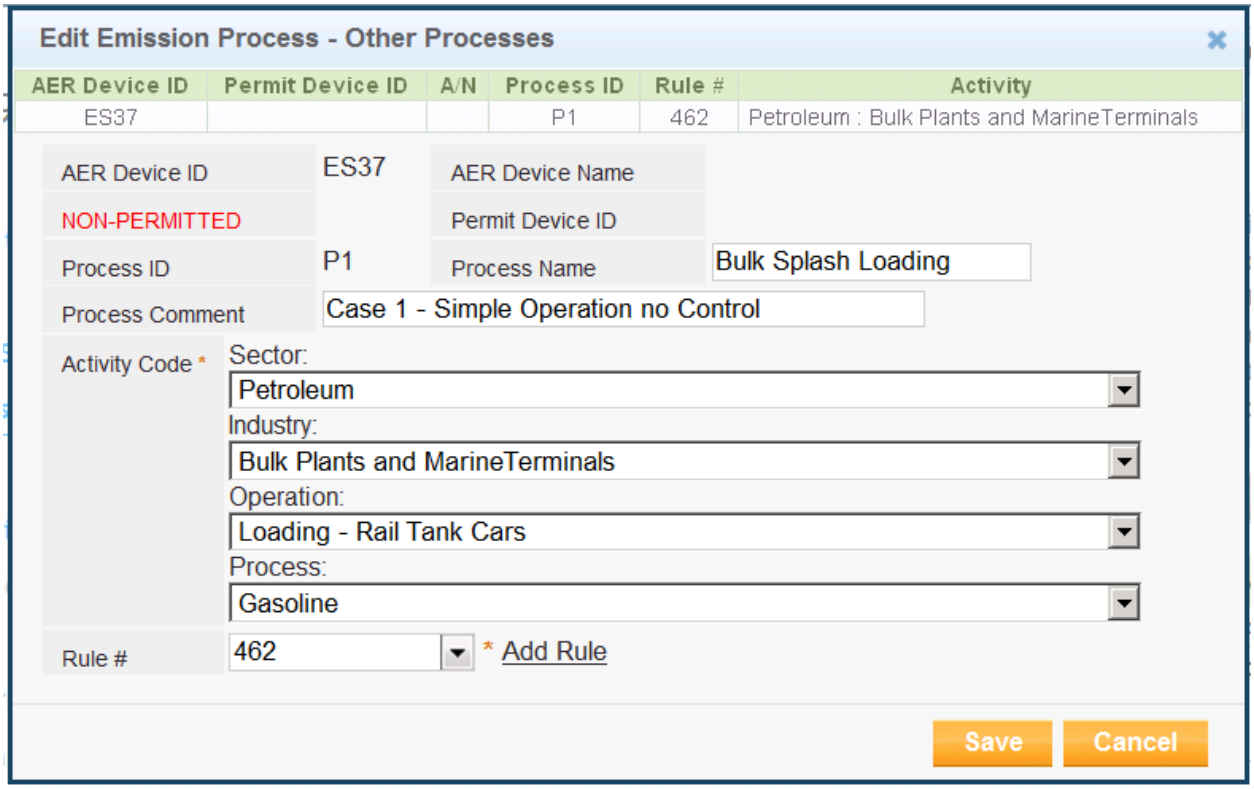
P = 6.2 psia (True Vapor Pressure)

M = 66 lb/lb-mole (Vapor Molecular Weight)

$$L_L = \frac{12.46 \times S \times P \times M}{T} = \frac{12.46 \times 1.45 \times 6.2 \times 66}{530} = 13.95\ lb\ VOC/Mgal$$

Equation 1 yields the VOC emissions as follows:

$$E_1 = 120\ Mgals * 13.95\ \frac{lbs\ VOC}{Mgal} = 1{,}674\ lb\ VOC$$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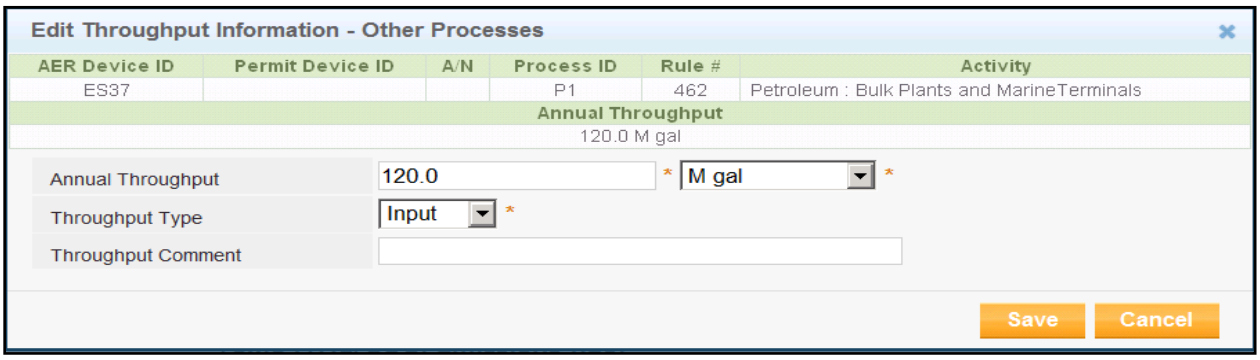
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals
AER Device ID
ES37
AER Device Name
NON-PERMITTED
Permit Device ID
Process ID
P1
Process Name
Bulk Splash Loading
Process Comment
Case 1 - Simple Operation no Control
Activity Code *
Sector:
Petroleum
Industry:
Bulk Plants and MarineTerminals
Operation:
Loading - Rail Tank Cars
Process:
Gasoline
Rule #
462
* Add Rule
Save
Cancel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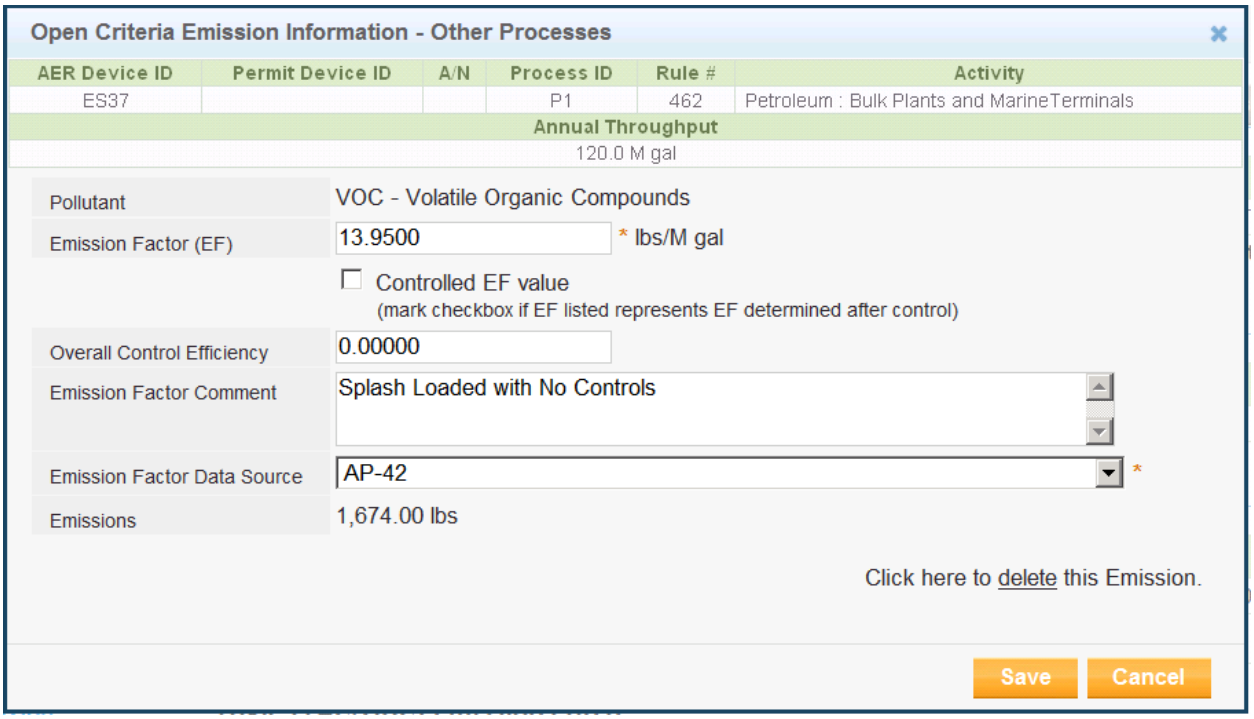
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals
Annual Throughput
120.0 M gal
Annual Throughput
120.0
* M gal *
Throughput Type
Input *
Throughput Comment
Save
Cancel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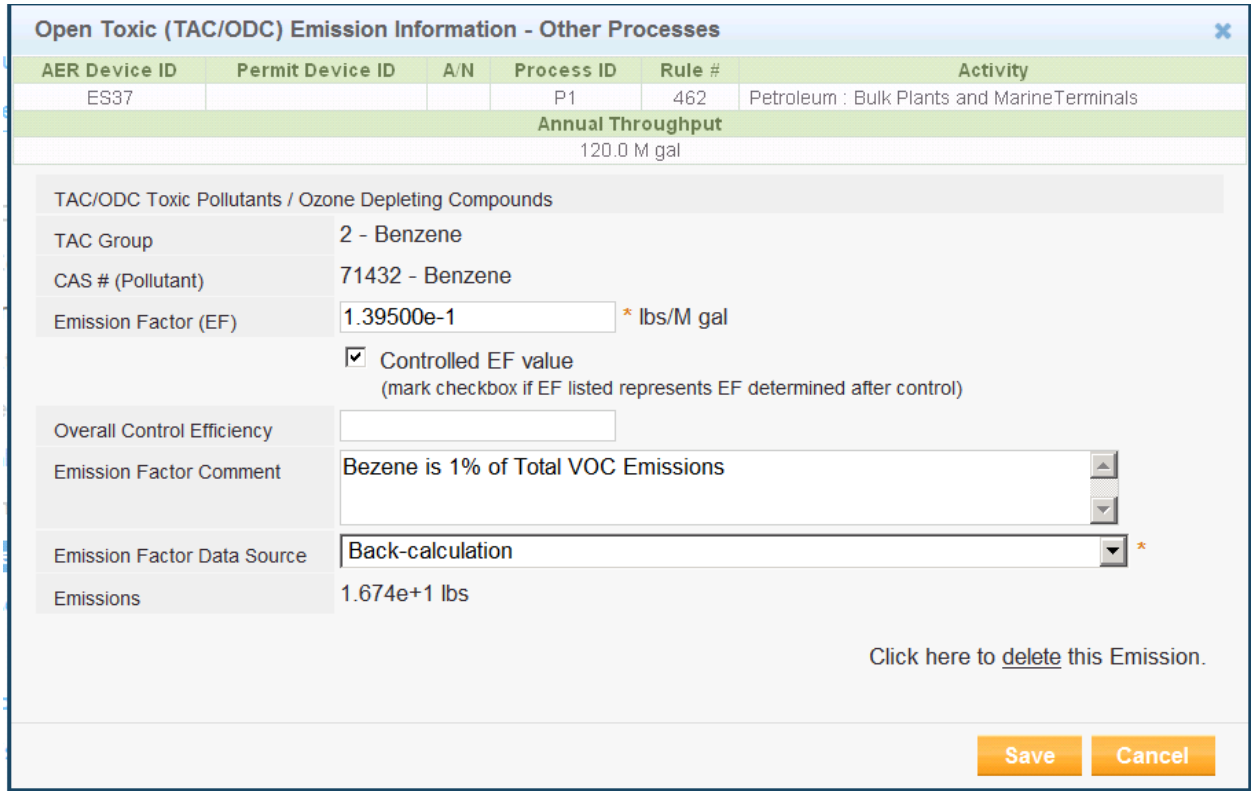
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals
Annual Throughput
120.0 M gal
Pollutant
VOC - Volatile Organic Compounds
Emission Factor (EF)
13.9500
* lbs/M gal
Controlled EF value
(mark checkbox if EF listed represents EF determined after control)
Overall Control Efficiency
0.00000
Emission Factor Comment
Splash Loaded with No Controls
Emission Factor Data Source
AP-42
Emissions
1,674.00 lbs
Click here to delete this Emission.
Save
Cancel


Open Toxic (TAC/ODC) Emission Information - Other Processes
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals
Annual Throughput
120.0 M gal
TAC/ODC Toxic Pollutants / Ozone Depleting Compounds
TAC Group
2 - Benzene
CAS # (Pollutant)
71432 - Benzene
Emission Factor (EF)
1.39500e-1
* lbs/M gal
Controlled EF value
(mark checkbox if EF listed represents EF determined after control)
Overall Control Efficiency
Emission Factor Comment
Bezene is 1% of Total VOC Emissions
Emission Factor Data Source
Back-calculation
Emissions
1.674e+1 lbs
Click here to delete this Emission.
Save
Cancel

CASE 2 - OPERATIONS EQUIPPED WITH VAPOR COLLECTION AND RECOVERY SYSTEMS

Company ABC operates a loading terminal with vapor balance service with submerged bottom filling technology into tanker trucks that have passed the MACT level leak test. The vapor vent line is connected to a refrigeration unit that recovers 95% of the vapor and returns it back as liquid to storage tank. ABC transferred 1,000,000 gallons of RVP 10 gasoline over the year at the following conditions:

S = 1.0 (Saturation Factor from AP-42)

T = 70ºF = 530ºR (Temperature of Gasoline)

P = 6.2 psia (True Vapor Pressure)

M = 66 lb/lb-mole (Vapor Molecular Weight)

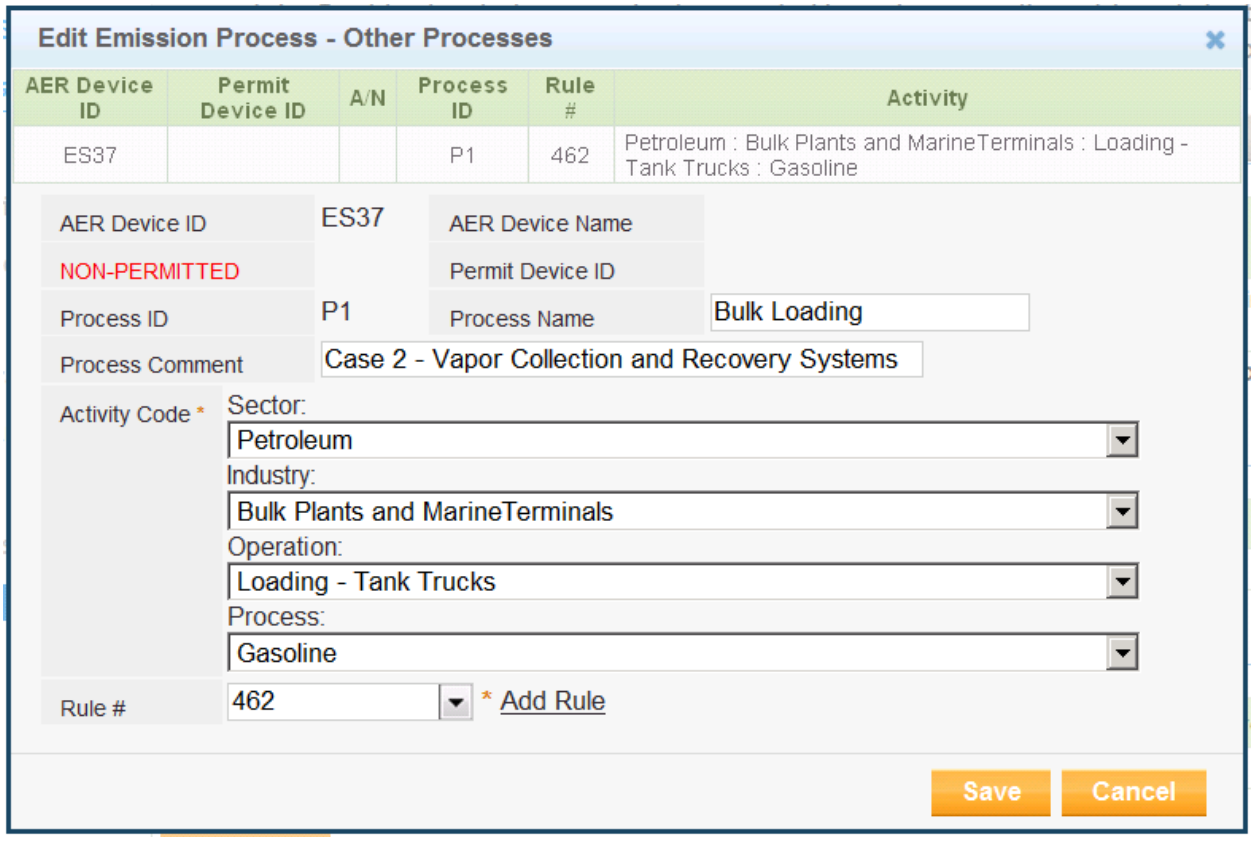
Eff_{VR} = 0.95 (Vapor Recovery Efficiency)

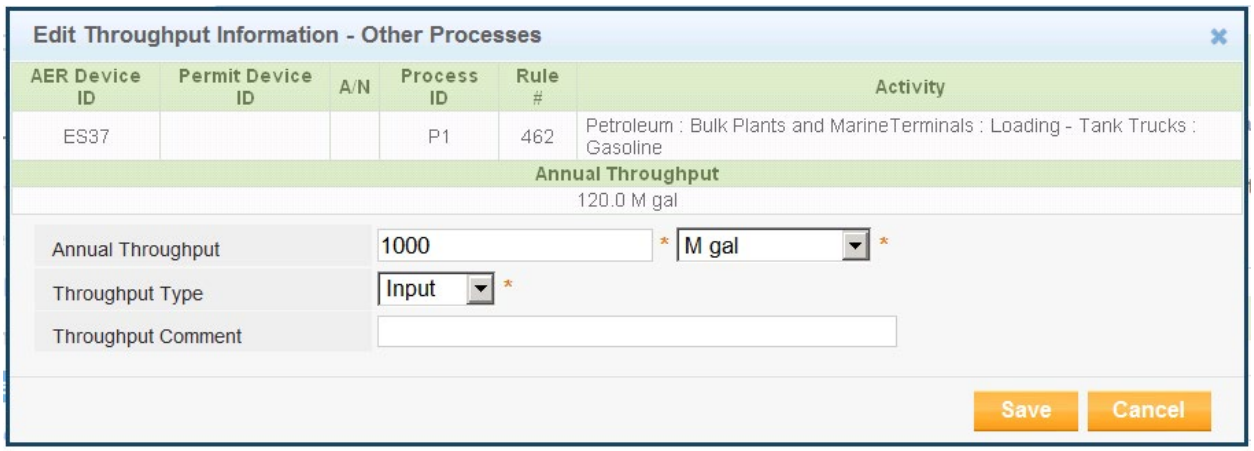
Eff_{VC} = 0.992 (Vapor Collection Efficiency)

$$L_L = \frac{12.46 \times S \times P \times M}{T} = \frac{12.46 \times 1 \times 6.2 \times 66}{530} = 9.62\ lb\ VOC/Mgal$$

Equation 2 yields the VOC emissions as follows:

$$E_2 = 1{,}000\ Mgals * 9.62\ \frac{lb\ VOC}{Mgal} * (1 - 0.95 * 0.992) = 554\ lb\ VOC$$

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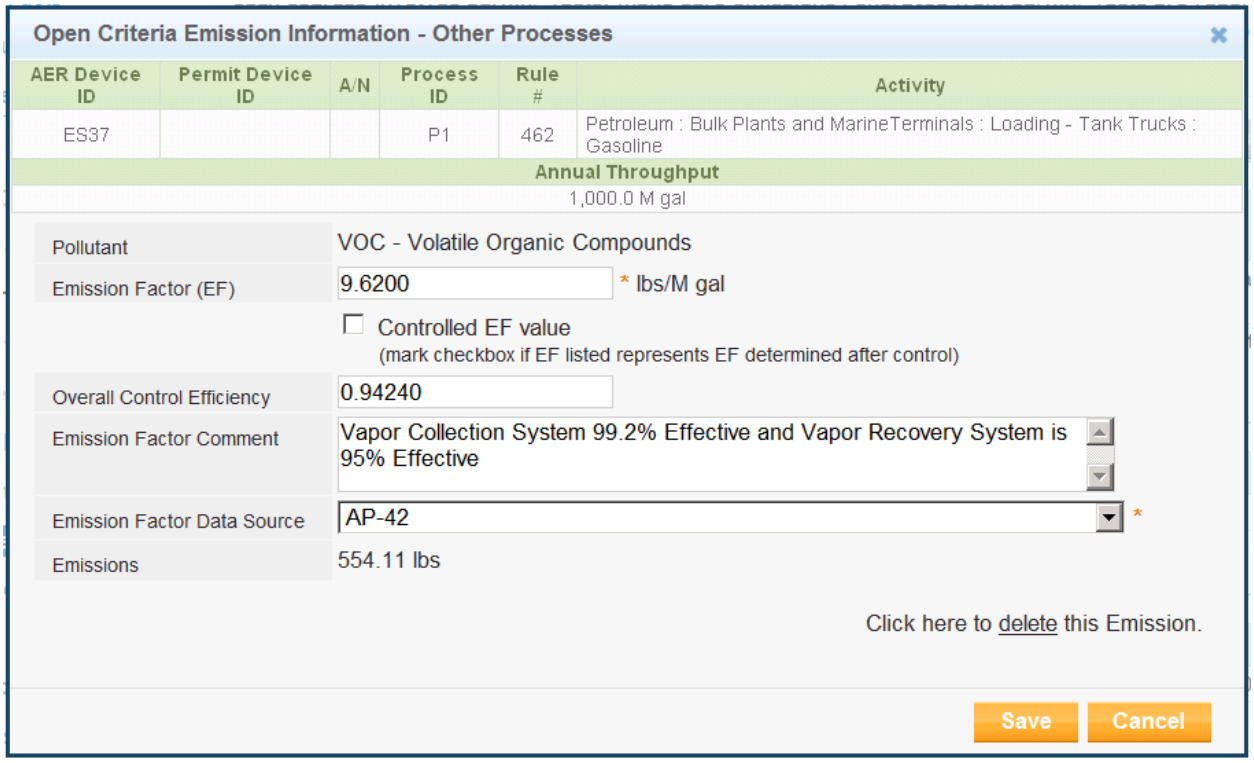
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals : Loading - Tank Trucks : Gasoline
Annual Throughput
120.0 M gal
Annual Throughput
1000
M gal
Throughput Type
Input
Throughput Comment
Save
Cancel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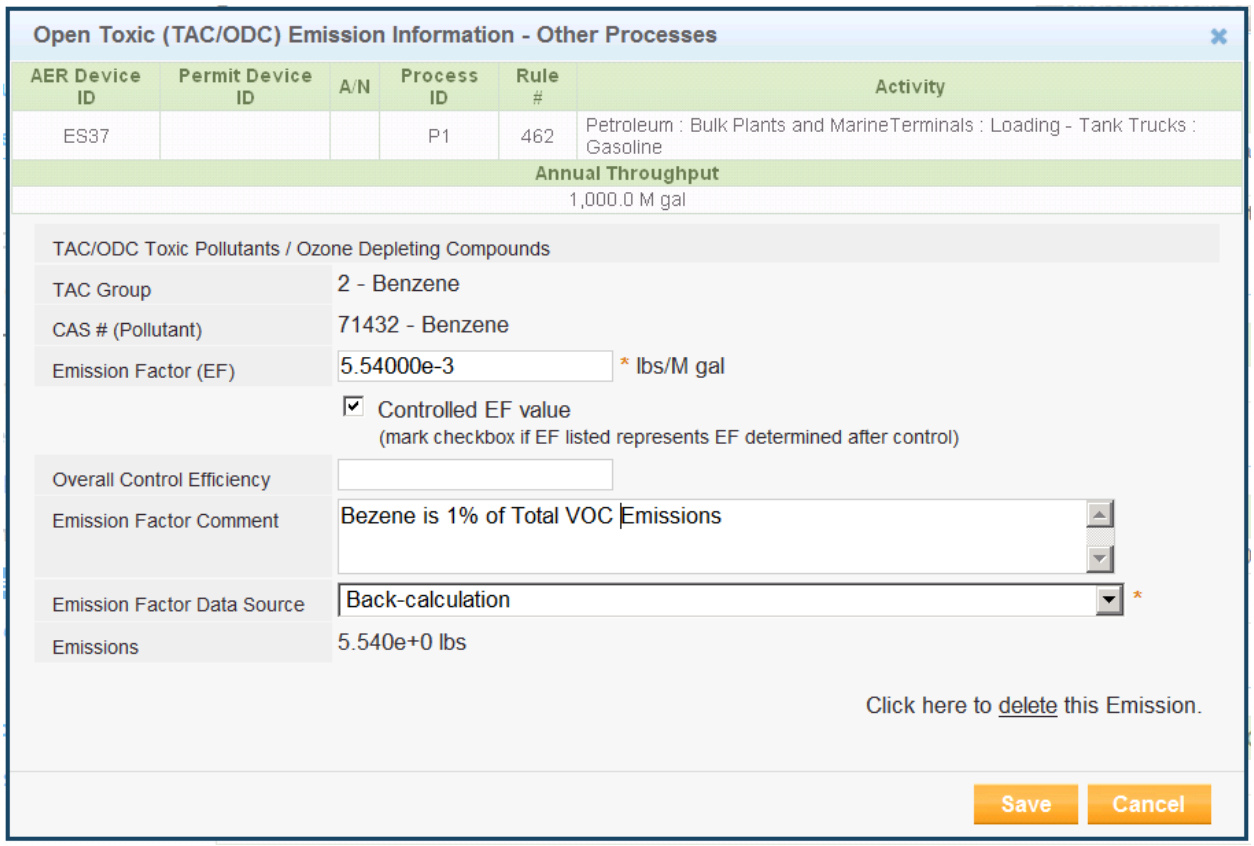
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals : Loading - Tank Trucks : Gasoline
Annual Throughput
1,000.0 M gal
Pollutant
VOC - Volatile Organic Compounds
Emission Factor (EF)
9.6200
lbs/M gal
Controlled EF value
(mark checkbox if EF listed represents EF determined after control)
Overall Control Efficiency
0.94240
Emission Factor Comment
Vapor Collection System 99.2% Effective and Vapor Recovery System is 95% Effective
Emission Factor Data Source
AP-42
Emissions
554.11 lbs
Click here to delete this Emission.
Save
Cancel



CASE 3 - OPERATIONS EQUIPPED WITH A VAPOR BALANCE AND DESTRUCTION SYSTEM

Over the year, company RST operates a loading terminal with submerged bottom filling 125,000,000 gallons of gasoline RVP 10 into tanker trucks that have passed the MACT level leak test at the same conditions as Case 2. The vapor vent line is connected to a system of vapor balance and then to an afterburner (thermal oxidizer). The system of vapor balance achieves an overall efficiency of 49%. The oxidizer operates at 99.4% destruction efficiency.

L_L = 9.62 $lb\ VOC/Mgal$ (see Case 2 studies for loading loss factor calculation)

Q = 125,000 Mgal

Eff_{VC} = 0.992 (Vapor Collection Efficiency)

Eff_{VB} = 0.49 (Vapor Balance Efficiency)

Eff_{VD} = 0.994 (Vapor Destruction Efficiency)

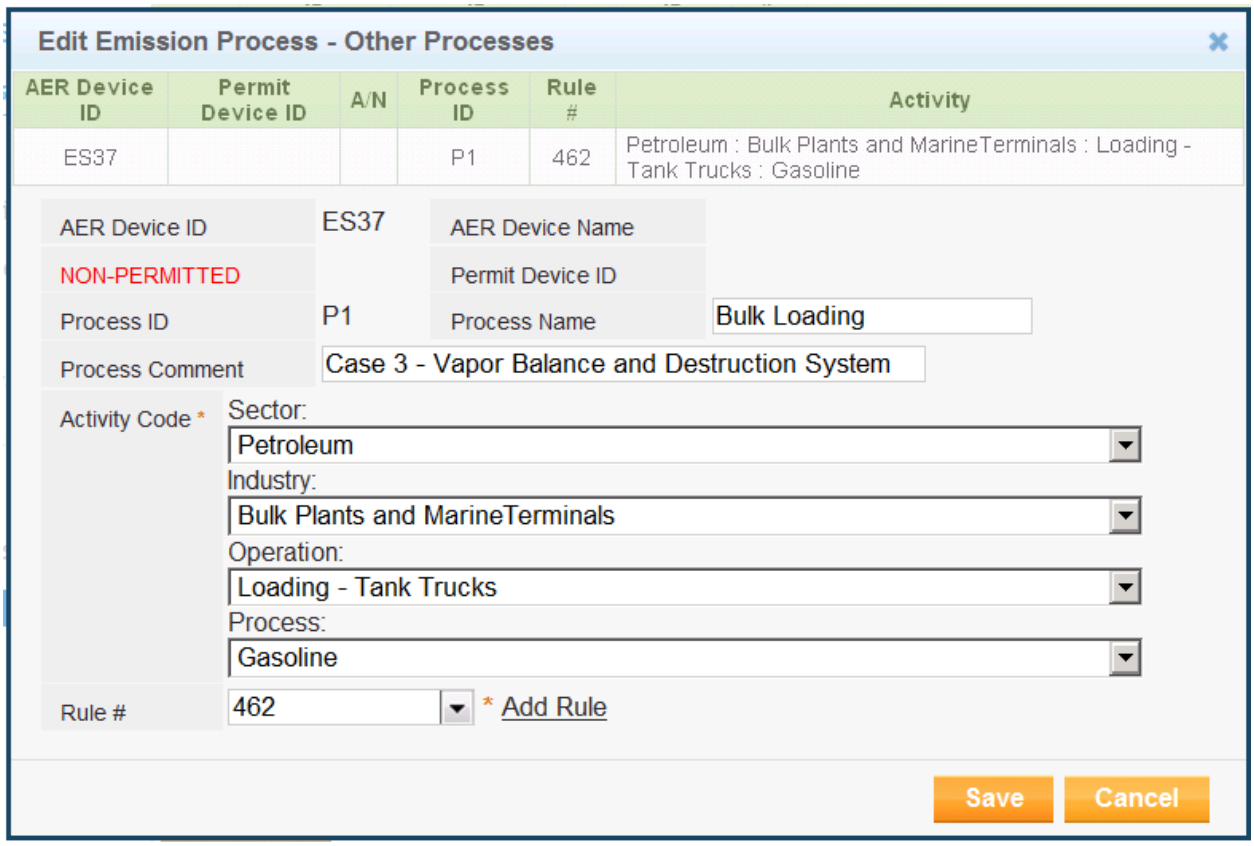
Equation 4 yields the VOC emissions as follows:

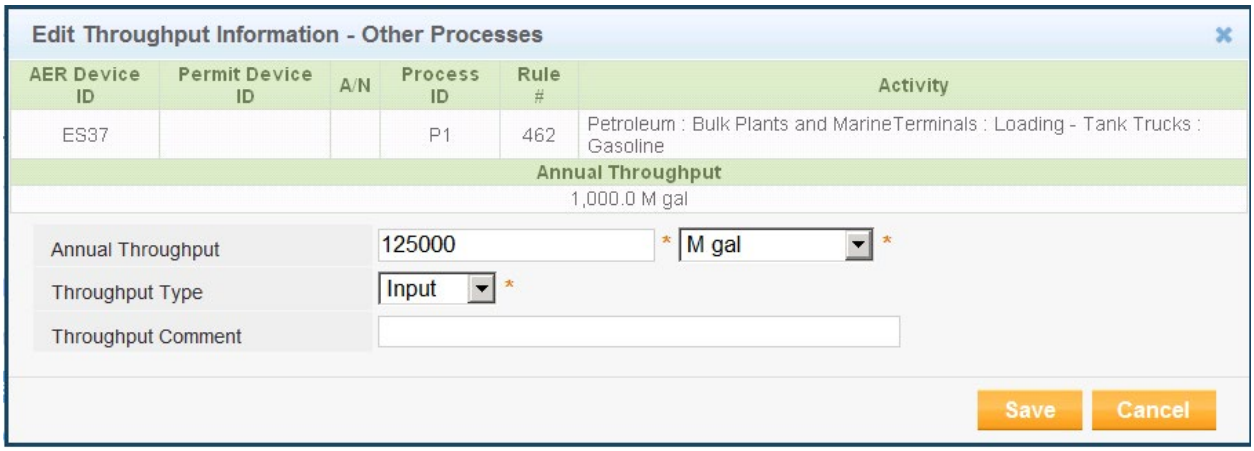
$$E_3 = 125{,}000\ Mgals * 9.62\ \frac{lb\ VOC}{Mgal} * \left[1 - 0.992 * \left(0.49 + 0.994 - (0.49 * 0.994)\right)\right] = 13{,}276\ lb\ VOC$$

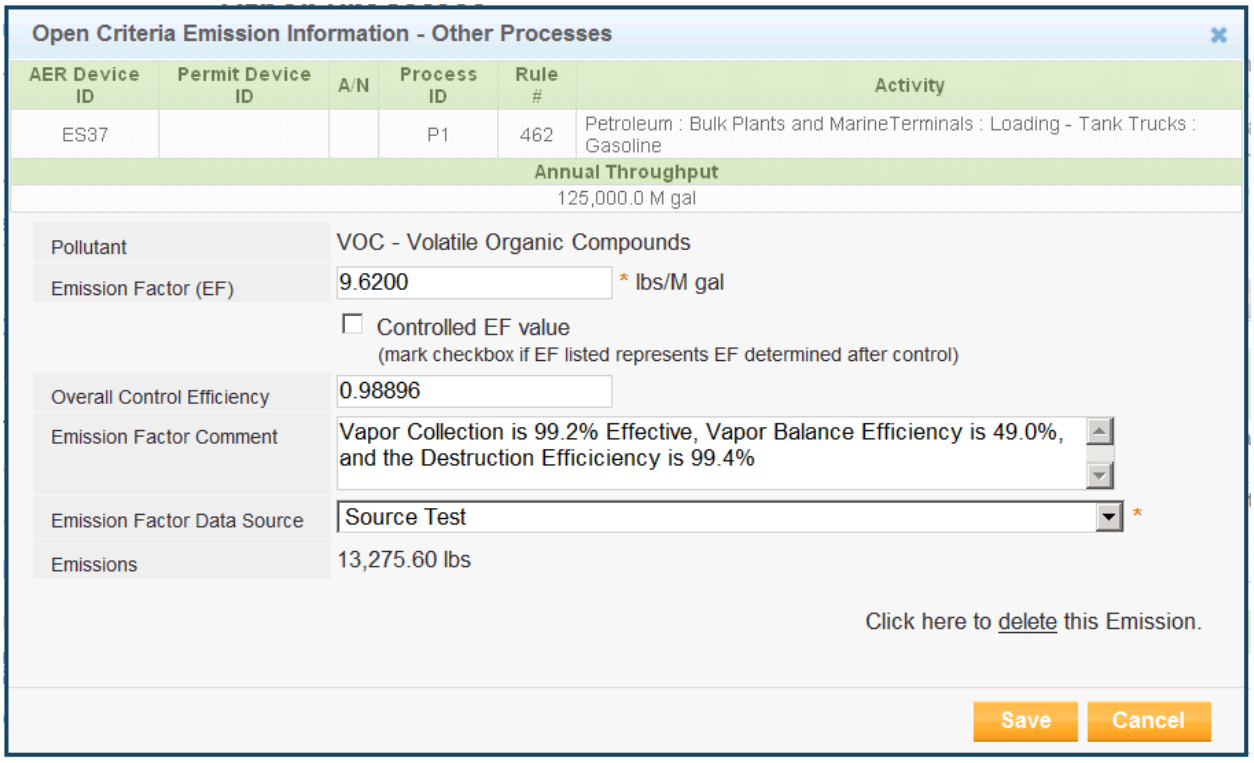
All thermal oxidizers used at bulk loading facilities are required to have a CARB Certification Test. In some cases, NOx, SOx, CO, and PM emission rates are tested and determined in terms of lb of pollutant/Mgal material loaded. **South Coast AQMD encourages operator to use the test results in calculating and reporting emissions.**

In this example, other contaminants were not tested for the TO. Emissions for other air contaminants are calculated using the best available default factors published in *AER Program Help & Support*. Throughput for the TO is determined using Equation 6 as follows for gasoline RVP 10 with liquid density of 5.6 lb/gallon:

$$TO_{Throughput} = \frac{125{,}000 * 9.62 * 0.992}{1{,}000 * 5.6} * (1 - 0.49) = 108.64\ Mgal\ of\ gasoline$$




Edit Throughput Information - Other Processes
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals : Loading - Tank Trucks : Gasoline
Annual Throughput
1,000.0 M gal
Annual Throughput
125000
M gal
Throughput Type
Input
Throughput Comment
Save
Cancel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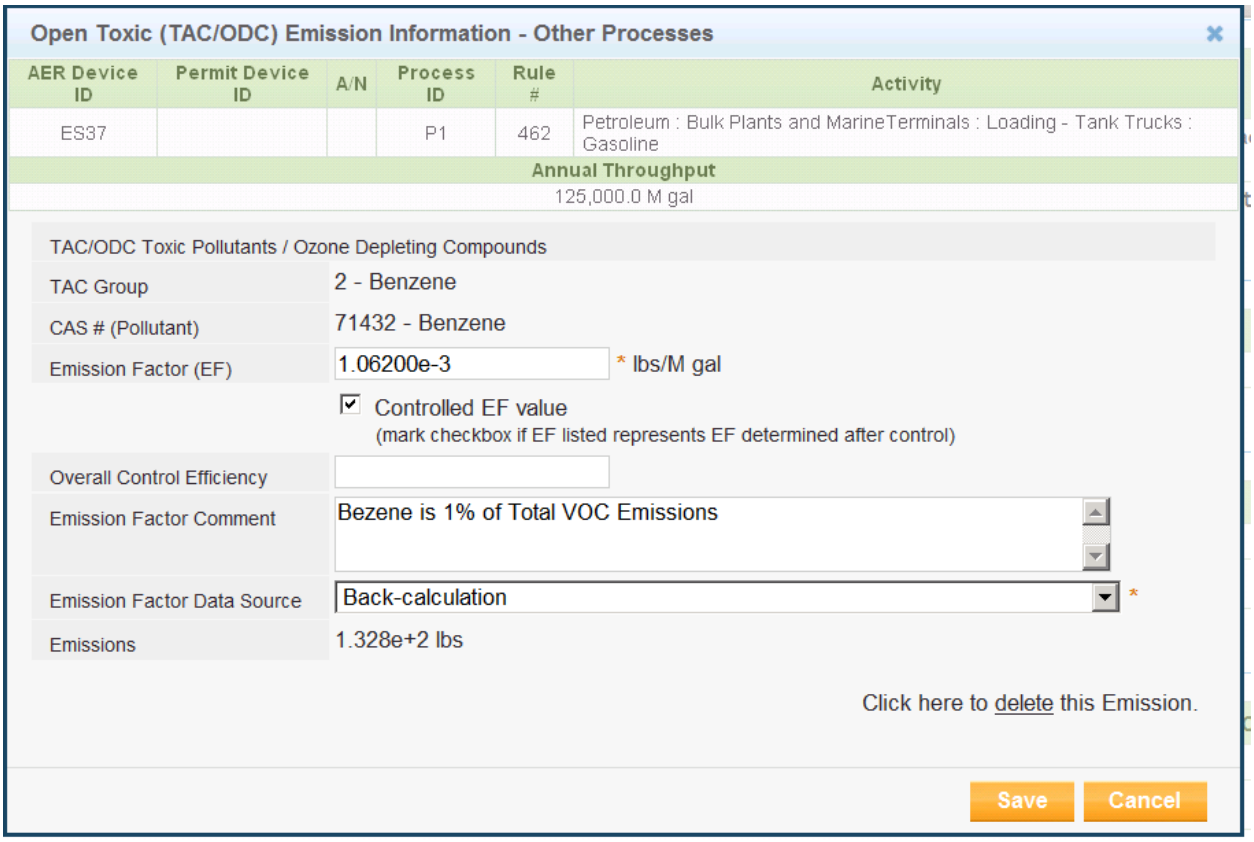
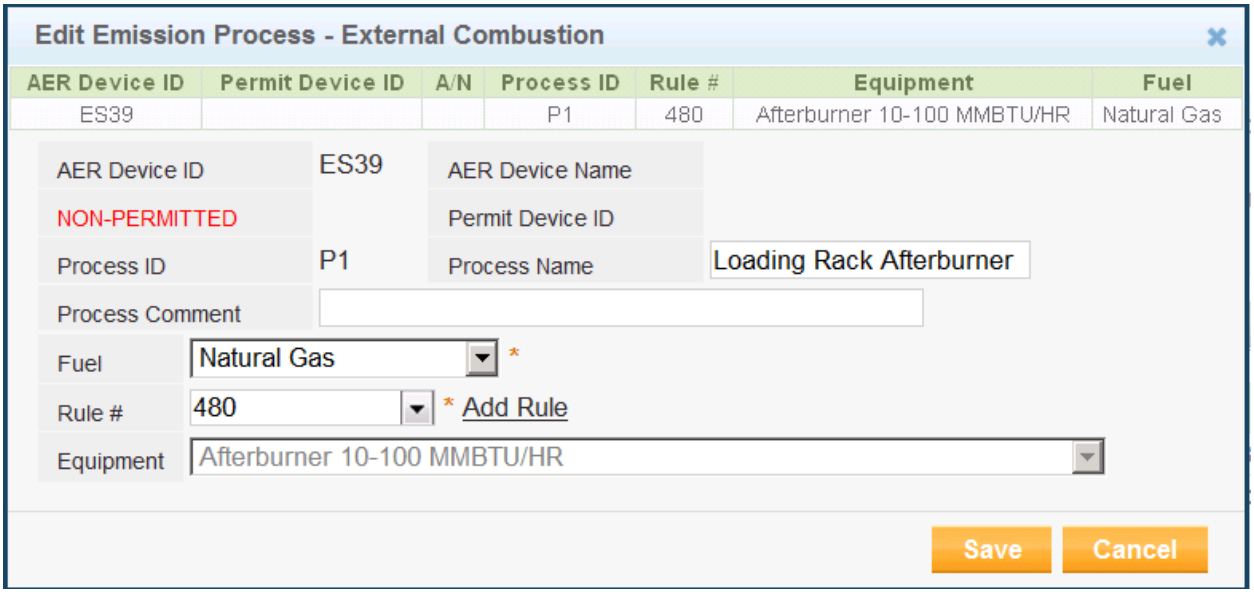
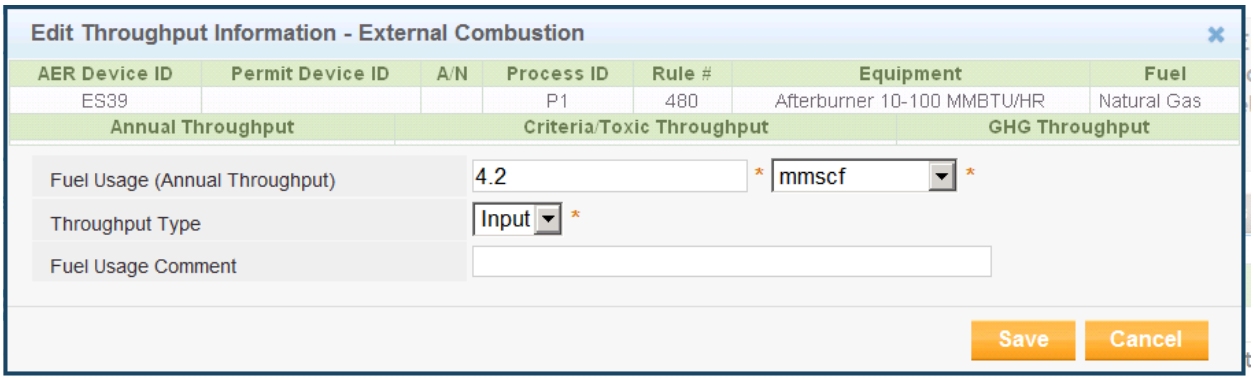
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Activity
ES37
P1
462
Petroleum : Bulk Plants and MarineTerminals : Loading - Tank Trucks : Gasoline
Annual Throughput
125,000.0 M gal
Pollutant
VOC - Volatile Organic Compounds
Emission Factor (EF)
9.6200
lbs/M gal
Controlled EF value
(mark checkbox if EF listed represents EF determined after control)
Overall Control Efficiency
0.98896
Emission Factor Comment
Vapor Collection is 99.2% Effective, Vapor Balance Efficiency is 49.0%, and the Destruction Efficiciency is 99.4%
Emission Factor Data Source
Source Test
Emissions
13,275.60 lbs
Click here to delete this Emission.
Save
Cancel



Report natural gas combustion in the thermal oxidizer as below when no test results for combustion pollutants are available:





Criteria Emissions (lbs)

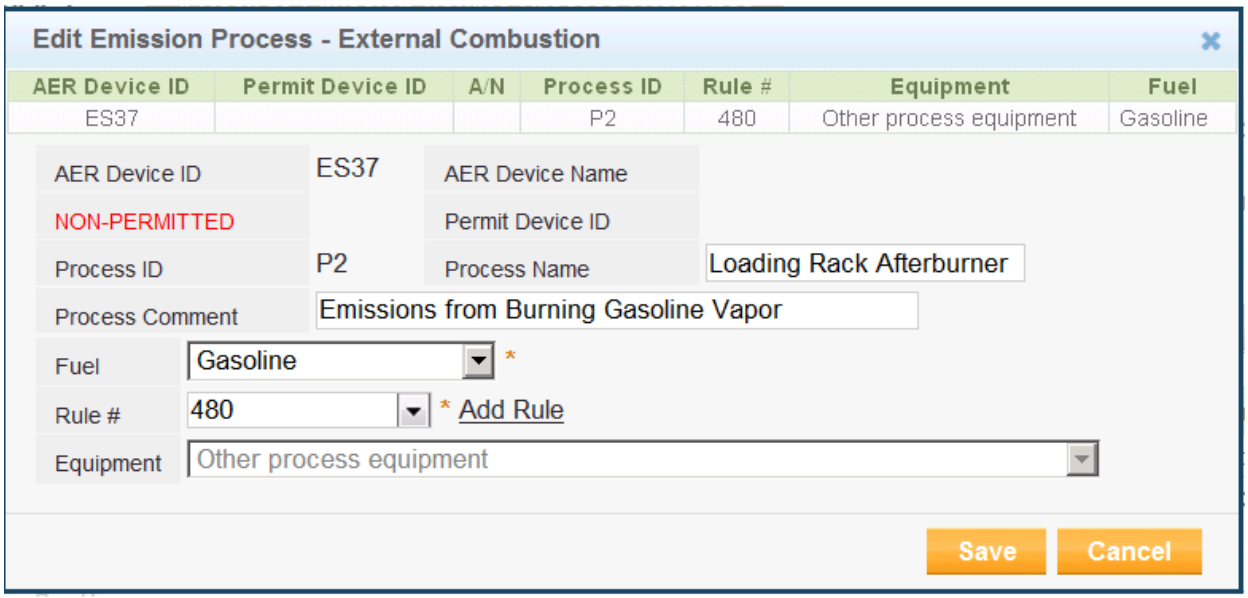
	Pollutant	EF	Unit	EF Data Source	Overall CE	Emissions
Open	VOC	7.00	lbs / mmscf	AQMD default		29.40
Open	NOx	130.00	lbs / mmscf	AQMD default		546.00
Open	SOx	0.60	lbs / mmscf	AQMD default		2.52
Open	CO	35.00	lbs / mmscf	AQMD default		147.00
Open	PM	7.50	lbs / mmscf	AQMD default		31.50

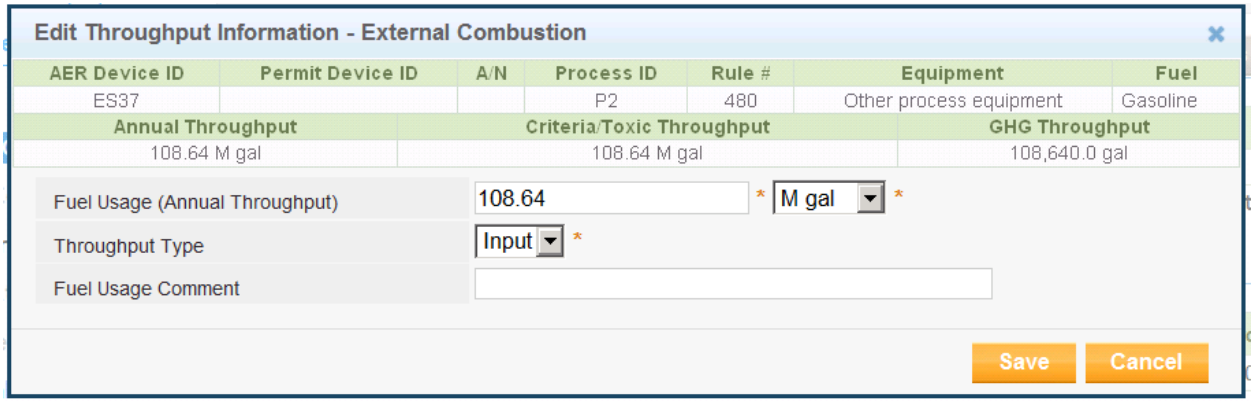
Toxic (TAC/ODC) Emissions (lbs)

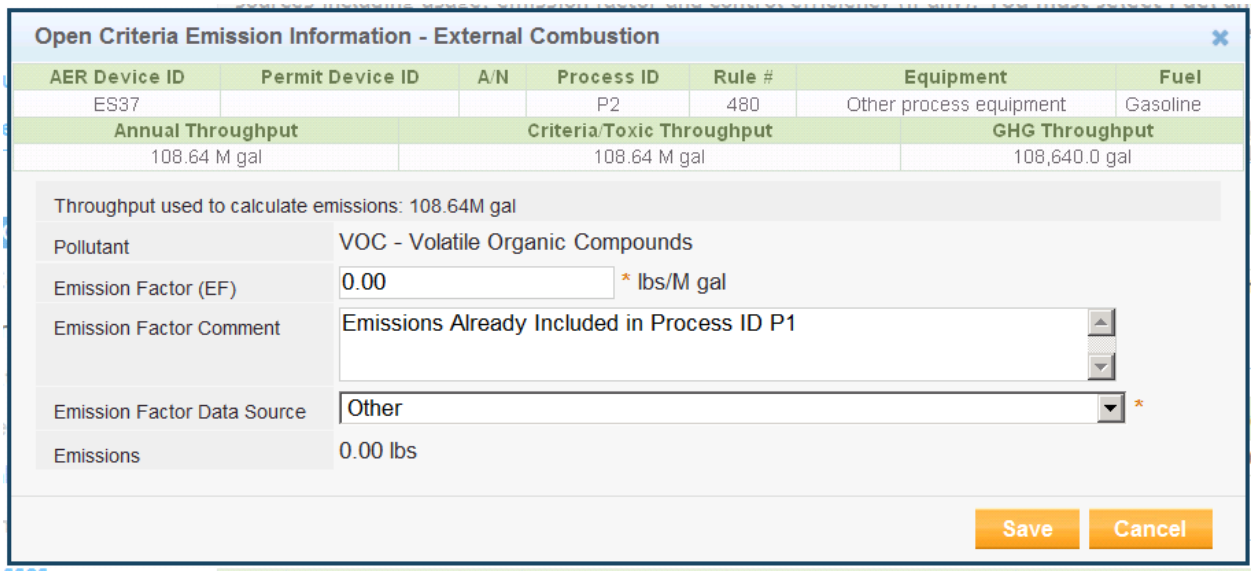
	TAC/ODC Group	CAS #	EF	Unit	EF Data Source	Overall CE	Emissions
Open	Benzene	71432	5.80000e-3	lbs / mmscf	AQMD default		2.436e-2
Open	Formaldehyde	50000	1.23000e-2	lbs / mmscf	AQMD default		5.166e-2
Open	PAHs [PAH, POM]	1151	1.00000e-4	lbs / mmscf	AQMD default		4.200e-4
Open	PAHs [PAH, POM]	91203	3.00000e-4	lbs / mmscf	AQMD default		1.260e-3
Open	Acetaldehyde	75070	3.10000e-3	lbs / mmscf	AQMD default		1.302e-2
Open	Acrolein	107028	2.70000e-3	lbs / mmscf	AQMD default		1.134e-2
Open	Ammonia	7664417	1.80000e+1	lbs / mmscf	AQMD default		7.560e+1
Open	Ethyl benzene	100414	6.90000e-3	lbs / mmscf	AQMD default		2.898e-2
Open	Hexane	110543	4.60000e-3	lbs / mmscf	AQMD default		1.932e-2
Open	Toluene	108883	2.65000e-2	lbs / mmscf	AQMD default		1.113e-1
Open	Xylenes	1330207	1.97000e-2	lbs / mmscf	AQMD default		8.274e-2

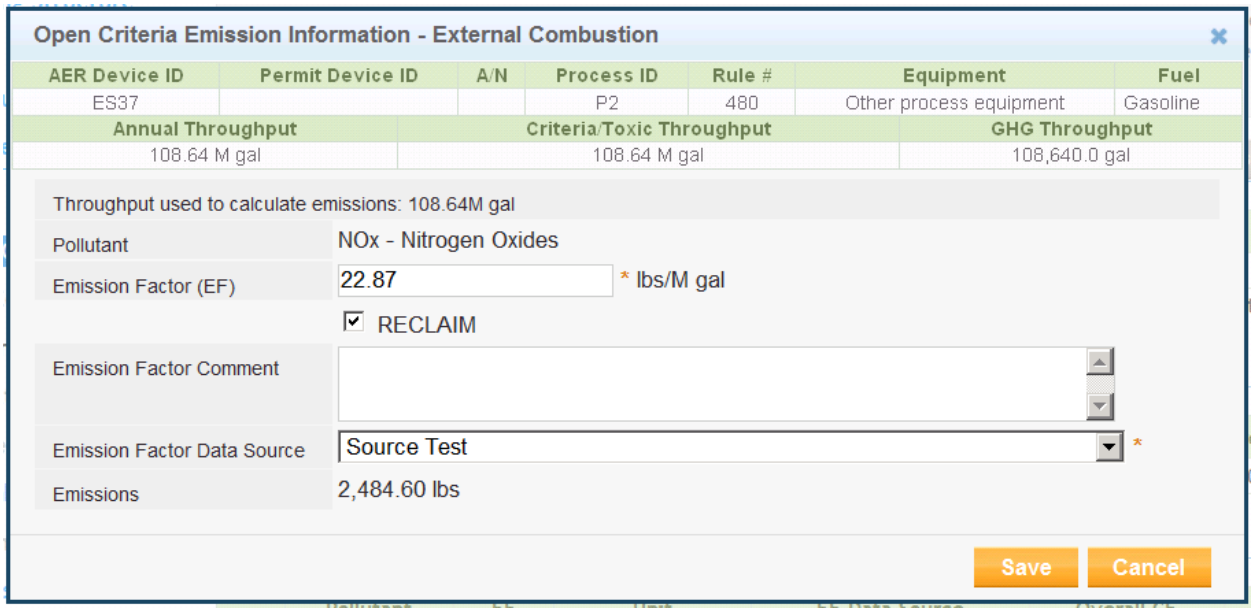
Add New

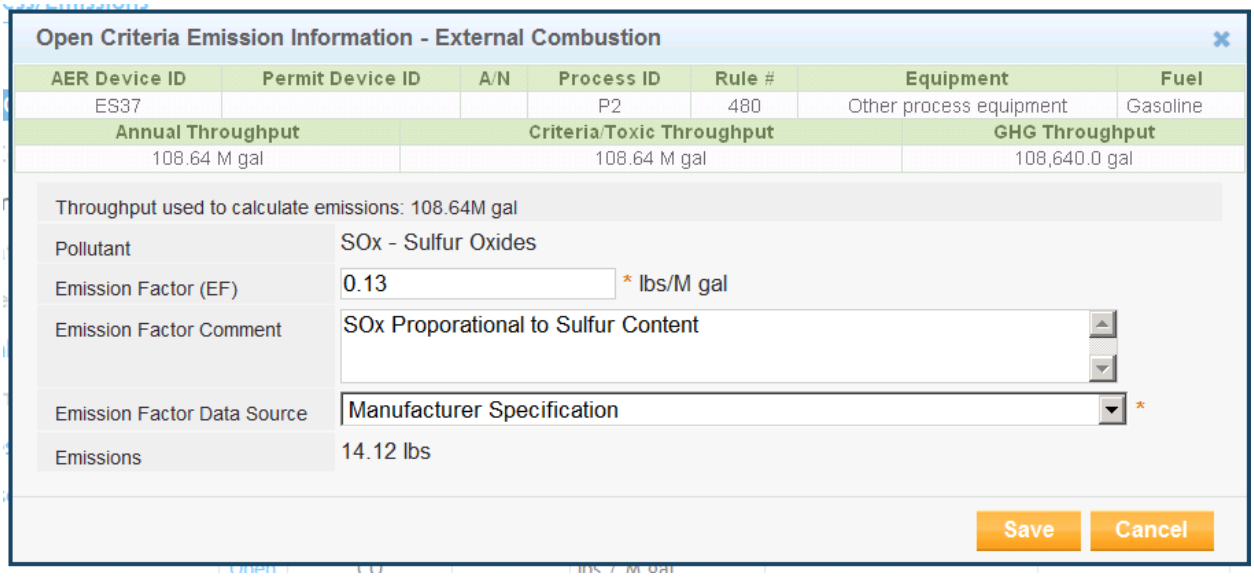
Report criteria pollutant and toxic compounds from destruction of VOC as below:

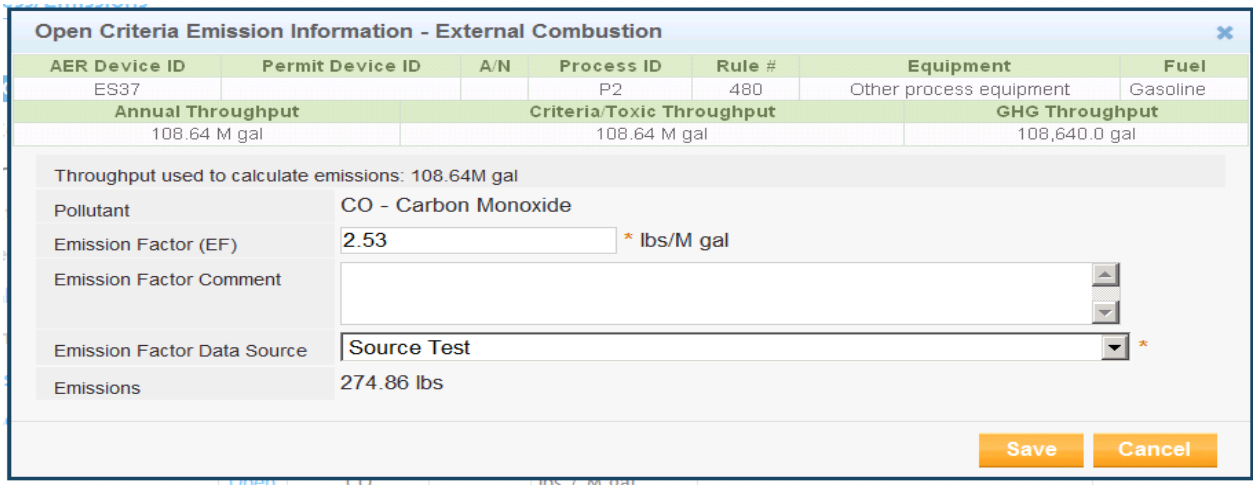


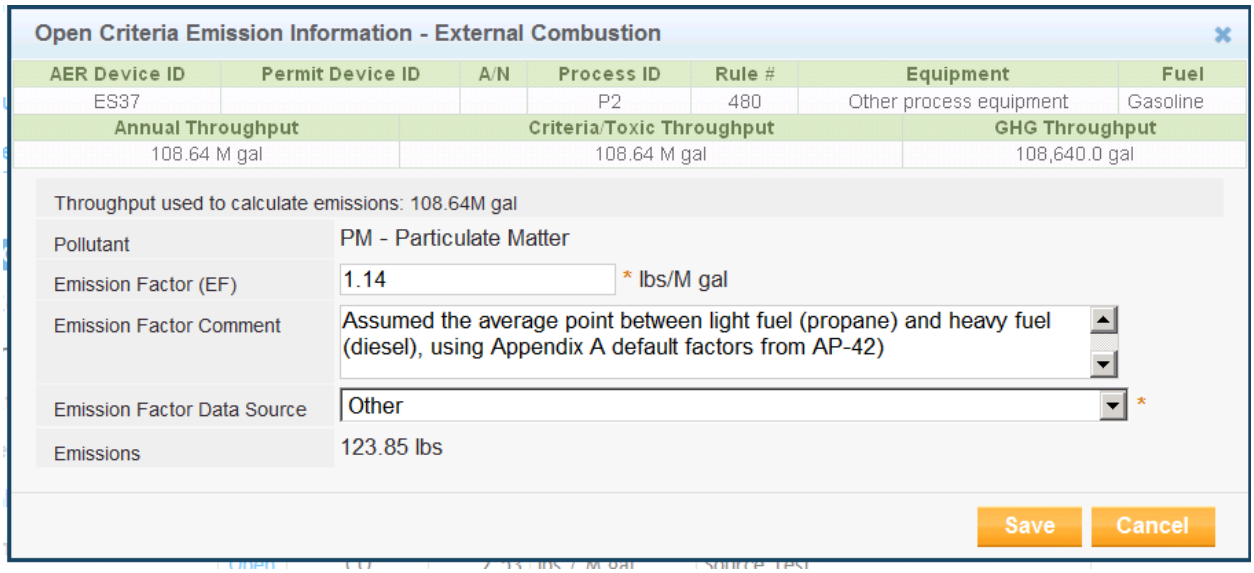





Open Criteria Emission Information - External Combustion
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Equipment
Fuel
ES37
P2
480
Other process equipment
Gasoline
Annual Throughput
Criteria/Toxic Throughput
GHG Throughput
108.64 M gal
108.64 M gal
108,640.0 gal
Throughput used to calculate emissions: 108.64M gal
Pollutant
NOx - Nitrogen Oxides
Emission Factor (EF)
22.87
* lbs/M gal
RECLAIM
Emission Factor Comment
Emission Factor Data Source
Source Test
Emissions
2,484.60 lbs
Save
Cancel


Open Criteria Emission Information - External Combustion
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Equipment
Fuel
ES37
P2
480
Other process equipment
Gasoline
Annual Throughput
Criteria/Toxic Throughput
GHG Throughput
108.64 M gal
108.64 M gal
108,640.0 gal
Throughput used to calculate emissions: 108.64M gal
Pollutant
SOx - Sulfur Oxides
Emission Factor (EF)
0.13
* lbs/M gal
Emission Factor Comment
SOx Proporational to Sulfur Content
Emission Factor Data Source
Manufacturer Specification
Emissions
14.12 lbs
Save
Cancel


Open Criteria Emission Information - External Combustion
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Equipment
Fuel
ES37
P2
480
Other process equipment
Gasoline
Annual Throughput
Criteria/Toxic Throughput
GHG Throughput
108.64 M gal
108.64 M gal
108,640.0 gal
Throughput used to calculate emissions: 108.64M gal
Pollutant
CO - Carbon Monoxide
Emission Factor (EF)
2.53
* lbs/M gal
Emission Factor Comment
Emission Factor Data Source
Source Test
Emissions
274.86 lbs
Save
Cancel


Open Criteria Emission Information - External Combustion
AER Device ID
Permit Device ID
A/N
Process ID
Rule #
Equipment
Fuel
ES37
P2
480
Other process equipment
Gasoline
Annual Throughput
Criteria/Toxic Throughput
GHG Throughput
108.64 M gal
108.64 M gal
108,640.0 gal
Throughput used to calculate emissions: 108.64M gal
Pollutant
PM - Particulate Matter
Emission Factor (EF)
1.14
* lbs/M gal
Emission Factor Comment
Assumed the average point between light fuel (propane) and heavy fuel (diesel), using Appendix A default factors from AP-42)
Emission Factor Data Source
Other
*
Emissions
123.85 lbs
Save
Cancel