Guidelines for Calculating Emissions from Internal Combustion Engines

(March 2023)

Internal combustion engines are used to drive various equipment such as emergency stand-by generators and emergency fire pumps. Internal combustion engines are governed by a variety of programs in the South Coast AQMD's jurisdiction. Engines rated greater than 50 brake horsepower (bhp) are typically permitted by South Coast AQMD (stationary or various locations permits). Qualifying portable engines may be registered in CARB's Portable Equipment Registration Program (PERP). Engines may be subject to additional requirements in facilities subject to Title V, RECLAIM, or AB 2588.

This document provides guidance on estimating and reporting emissions, emission factors, and fuel consumption for AER purposes only.

Note for Abbreviated Reports: To qualify for abbreviated reporting, a facility must have only diesel-powered emergency standby generators or fire pumps or other approved equipment. For reporters who are not familiar with the AER Reporting Tool may refer to the Guidelines for Abbreviated Reporting for assistance with abbreviated reporting. This document will provide additional detail on default emission factors applicable for abbreviated reporting.

Emission Calculation

Emissions from engines in the AER Reporting Tool are estimated by the following equation:

$$\textbf{Ems} = \textbf{Fuel Consumption} \times \textbf{EF} \qquad \text{Eq. 1}$$

Where:

Ems = emissions, **lb**
Fuel Consumption = **Mgal** for liquid fuels or **MMscf** for gaseous fuels
EF = Emission factor, **lb/Mgal** or **lb/MMscf**

and

M = Thousand
MM = Million
scf = Standard cubic feet

Fuel Consumption

The AER Reporting Tool currently only allows for volumetric throughput (fuel consumption) and not hours of operation or heat input.

Fuel consumption is most accurately measured by calibrated fuel meters but can also be estimated from fuel logs or purchase records. Data collected by facilities should be consistent with permit or program requirements.

Liquid fuel consumption (diesel or gasoline) can be estimated based on hours of operation recorded on integrated hour meters. Whenever possible, engine-specific information should be used when converting operating hours to gallons of fuel consumed. Fuel consumption rates can be found on technical data sheets available from the manufacturer.

If no information is available, the brake-specific fuel consumption factors in Table 1 can be used to estimate liquid fuel consumption with the following formula:

$$\textbf{Fuel Consumption} = \textbf{Operation Time} \times \textbf{Engine Rating} \times \textbf{Fuel Consumption Factor} \quad \text{Eq. 2}$$

Where:

Fuel Consumption	= Mgal/hr
Operation Time	= Hours
Engine Rating	= bhp
Fuel Consumption Factor	= Mgal/hp-hr (from Table 1)

Table 1: Liquid Fuel Consumption Factors

Fuel	Fuel Consumption Factor Mgal/bhp-hr
Diesel	0.0000511
Gasoline	0.0000538

See AP-42 average brake-specific fuel consumption (Table 3.3-1 Emission Factors for Uncontrolled Gasoline and Diesel Engines, U.S. EPA AP-42, October 1996.) and heating values (Table Typical Parameters of Various Fuels, Appendix A, U.S. EPA, AP-42, January 1994.)

Example: A 600 bhp diesel-powered internal combustion engine driving an emergency generator operated 25 hours in the data year. Using Equation 2, estimate how many gallons of diesel were consumed.

$$\textbf{Fuel Consumption} = 25\ \textbf{hours} \times 600\ \textbf{bhp} \times 0.0000511$$
$$\textbf{Fuel Consumption} = 0.7665\ \textbf{Mgal}$$

Default Emission Factors

The AER Reporting Tool automatically populates default emission factors for engines. Default criteria air pollutant (CAP) emission factors can be found in the Default Combustion Emission Factors document and toxic air contaminant (TAC) emission factors can be found in the AB 2588 Quadrennial Air Toxics Emissions Reporting Procedures. The documents can be found on the AER website at the following links:

Default Combustion Factors (CAP): http://www.aqmd.gov/docs/default-source/planning/annual-emission-reporting/default-combustion-emission-factors.pdf
AB 2588 Quadrennial Report (TAC): http://www.aqmd.gov/docs/default-source/planning/risk-assessment/quadrennial_atir_procedure.pdf

PM Default Emission Factors

The AER Reporting Tool automatically populates default emission factors for internal combustion engines with no PM control. For diesel engines with PM control equipment such as diesel particulate filters , the following default emission factors for PM and Diesel PM (toxic compound) may be used which are based on an 85% control efficiency:

Table 2: Default Emission Factors for Diesel Engines with Diesel Particulate Filters

Pollutant	Controlled Emission Factor (lb/Mgal)
PM	5.025
Diesel PM	5.025

Note for Abbreviated Reporters: Using non-default emission factors will disqualify facilities from abbreviated reporting. Although the uncontrolled PM and Diesel PM emission factors are pre-loaded, the AER Reporting tool will also accept the controlled default PM/Diesel PM emission factors provided in Table 2 for diesel engines equipped with diesel particulate filters without disqualifying facilities from abbreviated reporting.

Step-by step instructions for reporting while using the controlled default emission factors are provided in the subsequent tutorial.

Ammonia Default Emission Factors

There are three default emission factors for ammonia emissions depending on control technology. Some larger engines are equipped with NOx emissions control technology that uses ammonia to convert NO emissions to NO_2. Engines with ammonia-based control technology will have a storage tank for ammonia, ammonium hydroxide, or urea. Small engines are unlikely to be equipped with this type of control technology. Permits describe what kind of control, if any, is used on the engine.

Table 3: Ammonia Default Emission Factors

Type of NOx Control	Default Ammonia EF (Diesel Fuel)	Default Ammonia EF (Natural Gas, Propane, or LPG)
Selective Non-catalytic Reduction (SNCR)	2.9 lb/Mgal	18 lb/MMscf
Selective Catalytic Reduction (SCR)	1.4 lb/Mgal	9.1 lb/MMscf
No Ammonia-based Control	0.8 lb/Mgal	3.2 lb/MMscf

The AER Reporting Tool automatically populates the ammonia emission factor with the SNCR default emission factor. If this is not correct, the user should replace that emission factor with the correct ammonia emission factor (see Table 3 for other default ammonia emission factors).

Note for Abbreviated Reporters: As noted earlier, using non-default emission factors will disqualify facilities from abbreviated reporting. Although the default ammonia emission factor for

SNCR control is pre-populated, the AER Reporting tool will accept any of the three default emission factors provided in Table 3 without disqualifying facilities from abbreviated reporting. The process of changing the ammonia default EF is demonstrated in the example below.

Step-by step instructions for reporting while using the controlled default emission factors are provided in the subsequent tutorial.

Other Emission Factor Sources

With the exception of abbreviated reporting, non-default emission factors may be used for reporting, provided that the emission factors have an appropriate reference source. Acceptable reference sources of non-default emission factors for AER include permit or rule-required emission limits, CARB/EPA diesel engine tiers, CEMS data, or approved source tests.

Permit or rule-required emission limits may be used if the engine has been demonstrated to meet those limits. Diesel engines equipped with diesel particulate filters may have a controlled PM emission limit listed on the permit.

CARB's emission factors based on engine tier can be found here (note that the last two rows on the chart apply to generators): https://ww2.arb.ca.gov/resources/documents/non-road-diesel-engine-certification-tier-chart.

CARB's emission factors are given in units of g/bhp·hr and can be converted to lb/Mgal with the following conversion:

$$EF_{lb/Mgal} = EF_{g/bhp \cdot hr} \times 43.148 \qquad \text{Eq. 3}$$

The conversion factor is based off the values cited in Table 1 and unit conversions and can only be used for diesel-fueled engines. For a detailed explanation of the conversion factor, contact AER Staff.

Larger permitted engines may have continual emission monitoring systems (CEMS) that measure pollutant concentrations in real time or may be source tested periodically. Emission factors based on source tests may be used for emissions reporting so long as they are submitted for review by SCAQMD's Source Test Engineering staff. The SCAQMD review may find that the emission factor from the source test is underreported or the source test is not acceptable, which may result in an adjusted emission factor. For these situations, Rule 301 (e)(10)(E) waves any surcharges for underreported emissions estimated using a source test that was submitted for review prior to or at the time of the official AER submittal due date. The difference or underpayment is required to be paid, but no surcharges will be applied. Facility personnel should verify with South Coast AQMD Compliance staff that their source test was submitted for review prior to using the resulting emission factors for AER.

Reporters must provide the source of non-default emission factors and upload any applicable supporting documents using the document upload feature of the AER Reporting Tool.

Data Validation
The AER Reporting Tool will generate a General Report **Warning** when a data validation is run if the facility reports emissions from an internal combustion engine.

These warning messages alert users about the three different default ammonia emission factors. The AER Reporting Tool is unable determine which default emission factor is appropriate, so this warning will always appear in the data validation. Refer to Table 3 for the appropriate ammonia emission factor. The AER can be certified and submitted with warnings, but the user must verify that the correct ammonia emission factor is used.

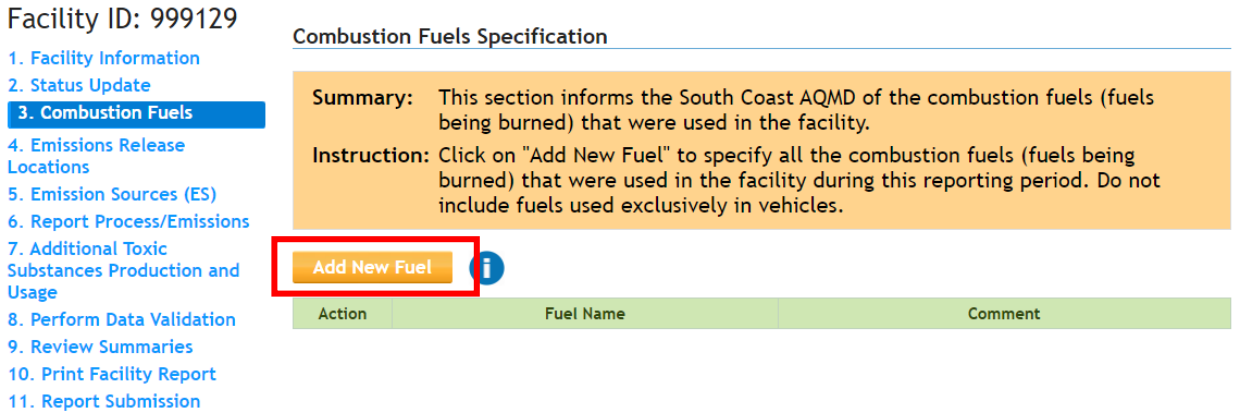
General Report Warnings

Rule	ES/Process	Description
V34		Fuel: Natural Gas - Ammonia emission factor of 18 lbs/mmscf automatically populated by the reporting tool corresponds to equipment with Selective Non Catalytic Reduction (SNCR), for equipment with Selective Catalytic Reduction (SCR) substitute listed value by 9.1 lbs/mmscf, and for equipment without SNCR or SCR by 3.2 lbs/mmscf.
V34		Fuel: Distillate Fuel Oil No. 2(Diesel) - Ammonia emission factor of 2.9 lbs / 1000 gallons automatically populated by the reporting tool corresponds to equipment with Selective Non Catalytic Reduction(SNCR), for equipment with Selective Catalytic Reduction(SCR) substitute listed value by 1.4 lbs / 1000 gallons, and for equipment without SNCR or SCR by 0.8 lbs / 1000 gallons.

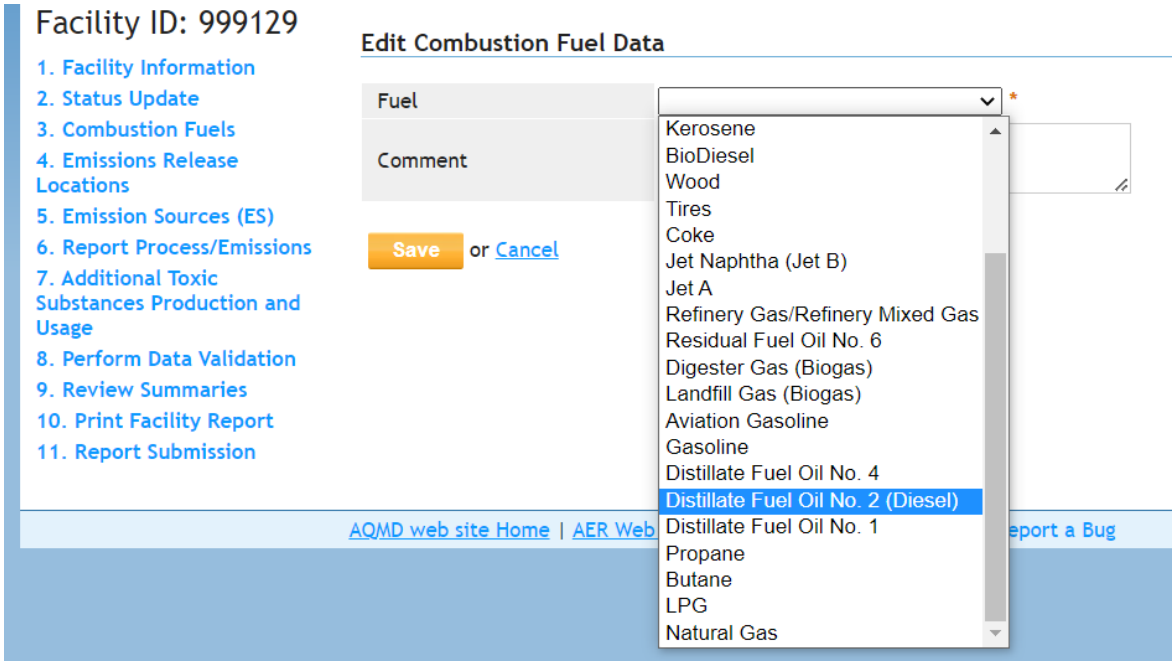
REPORTING EMISSIONS FROM AN INTERNAL COMBUSTION ENGINE
These instructions apply to all facilities, regardless of report type (i.e., Abbreviated or Regular) or facility category (Core CTR, AER, AB 2588). For specific direction regarding either abbreviated reporting or Core CTR reporting, refer to the appropriate guidance documents on the AER website. Note that some screenshots may appear different, depending on the reporting applicability.

For most reports, permitted Internal Combustion Engines will be pre-loaded as emission sources in the AER Reporting Tool. If the permit is not pre-loaded, the reporter must add a new emission source following the instructions below. Otherwise, for pre-loaded equipment, skip the Adding a New Internal Combustion Engine step and continue to Emergency Use Delineation.

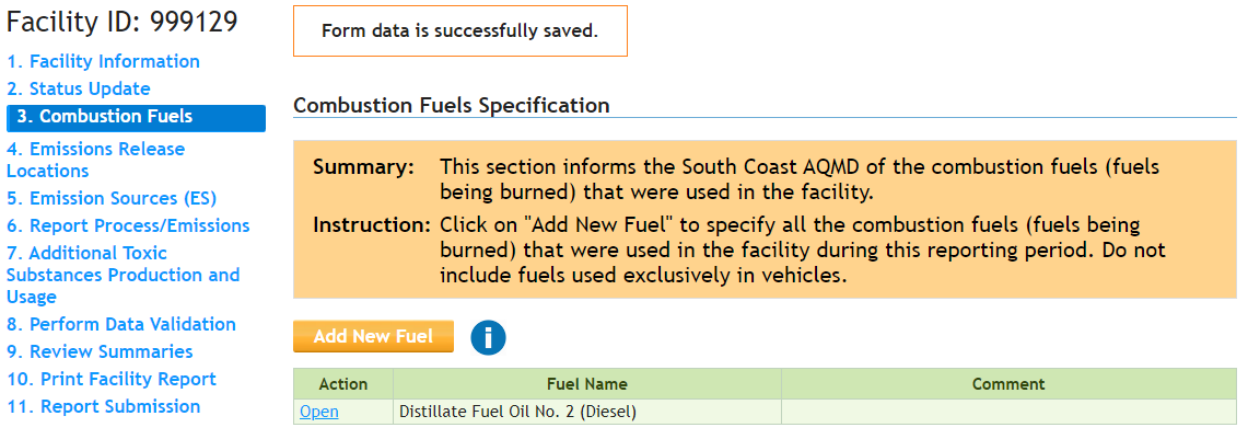
Adding Fuel
First, select **Combustion Fuels** from the left navigation menu. To add diesel as a fuel, click **Add New Fuel**, as shown in the screenshot below.



Select the appropriate fuel, in this example, the user selects **Distillate Fuel No. 2 (Diesel)** in the drop-down menu. Click **Save**.

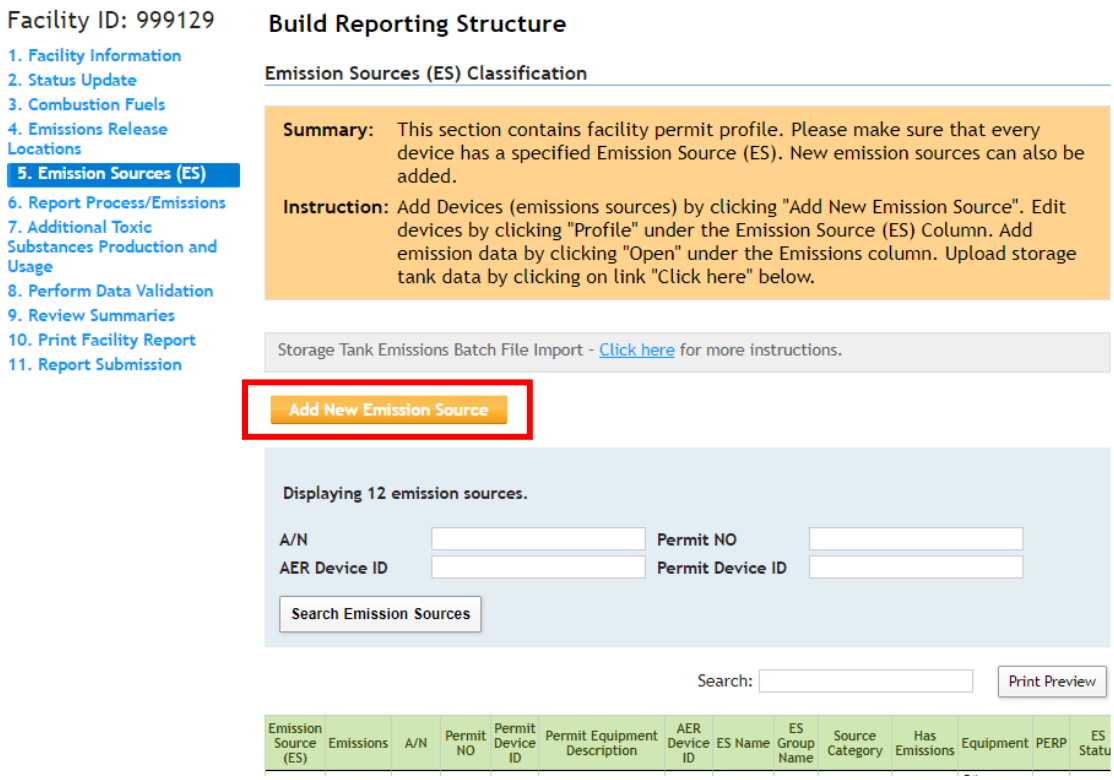


After clicking Save, the user will be returned to the previous page with a summary of all fuels added to the report. The user can add other fuels such as Natural Gas using the same steps as above.



Adding a New Internal Combustion Engine

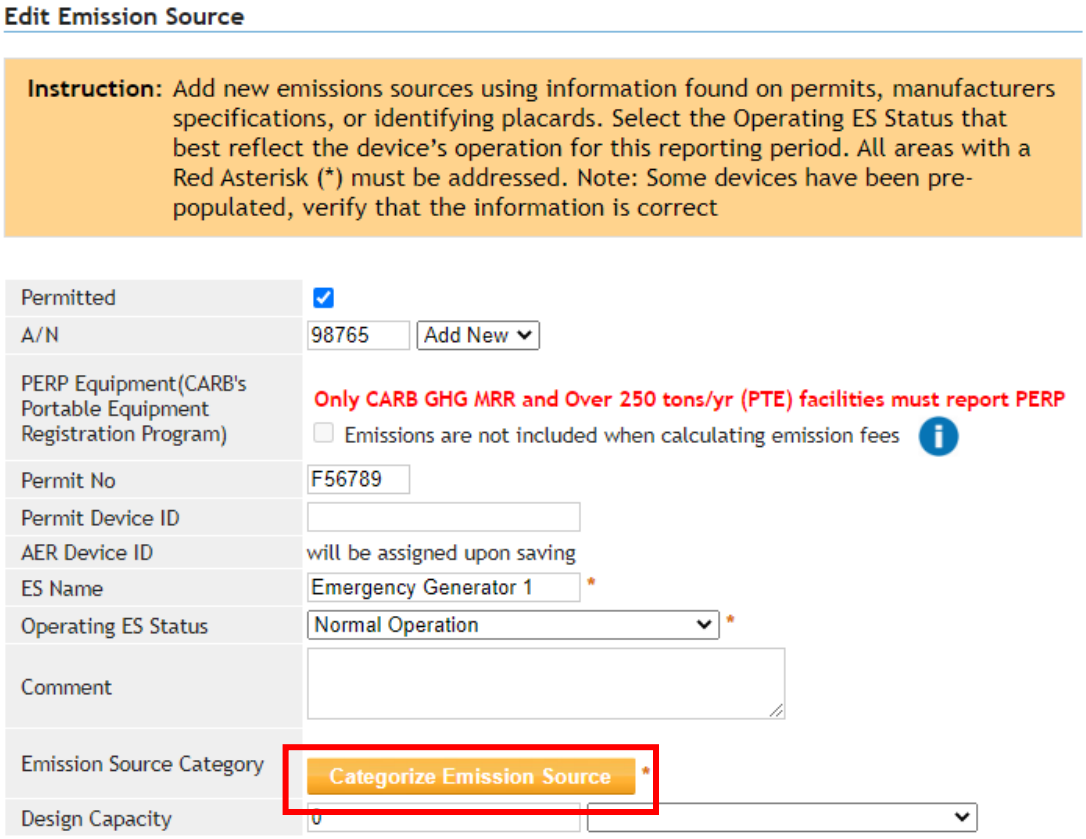
To add a new emission source, select **Emission Sources (ES)** from the left navigation menu. Then click **Add New Emission Source** as shown in the screenshot below:



The user will be taken to the Edit Emission Source page, as shown below. Check the box next to **Permitted** if the new device has a South Coast AQMD permit. Select **Add New** in the drop-down menu and enter the **Application Number**. Enter the **Permit Number**, if available.

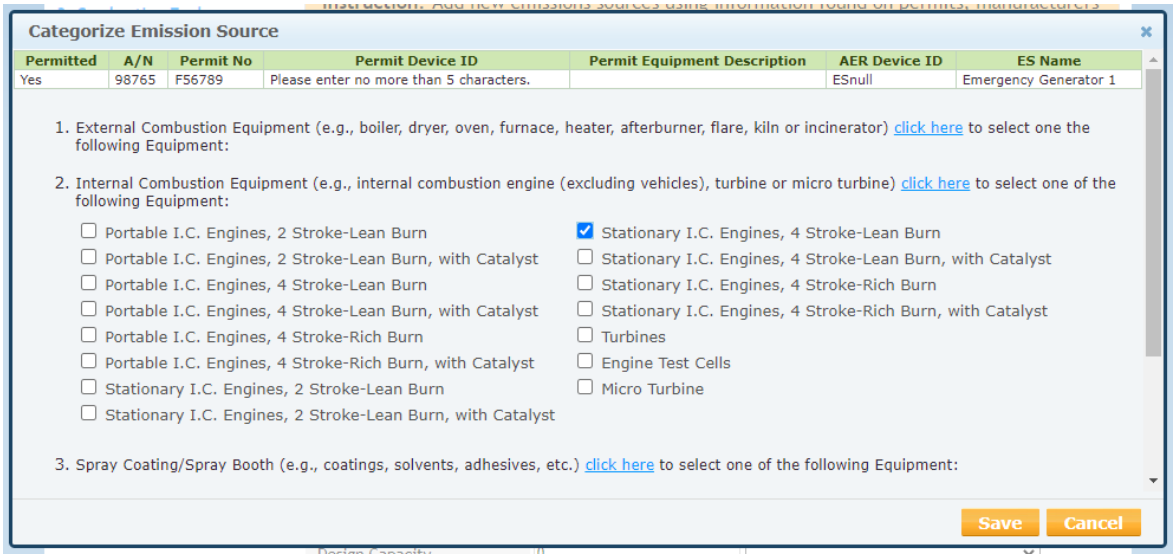
If the device is not permitted by South Coast AQMD (i.e., is Rule 219-exempt, registered under Rule 222, or permitted under CARB's Portable Equipment Registration Program (PERP)), then do not select the 'Permitted' checkbox. In this case no application number or permit number from South Coast AQMD is needed.

Add an **ES Name** that will allow you to distinguish this device from other devices. Select **Normal Operation** in the drop-down menu for Operating ES Status. If Normal Operation does not apply during the data year, please see the Help and Support manual on the AER webpage for guidance on other Operating Status options. Then click **Categorize Emission Source**. Note: for instructions on other Operating Statuses, refer to the Help and Support Manual.

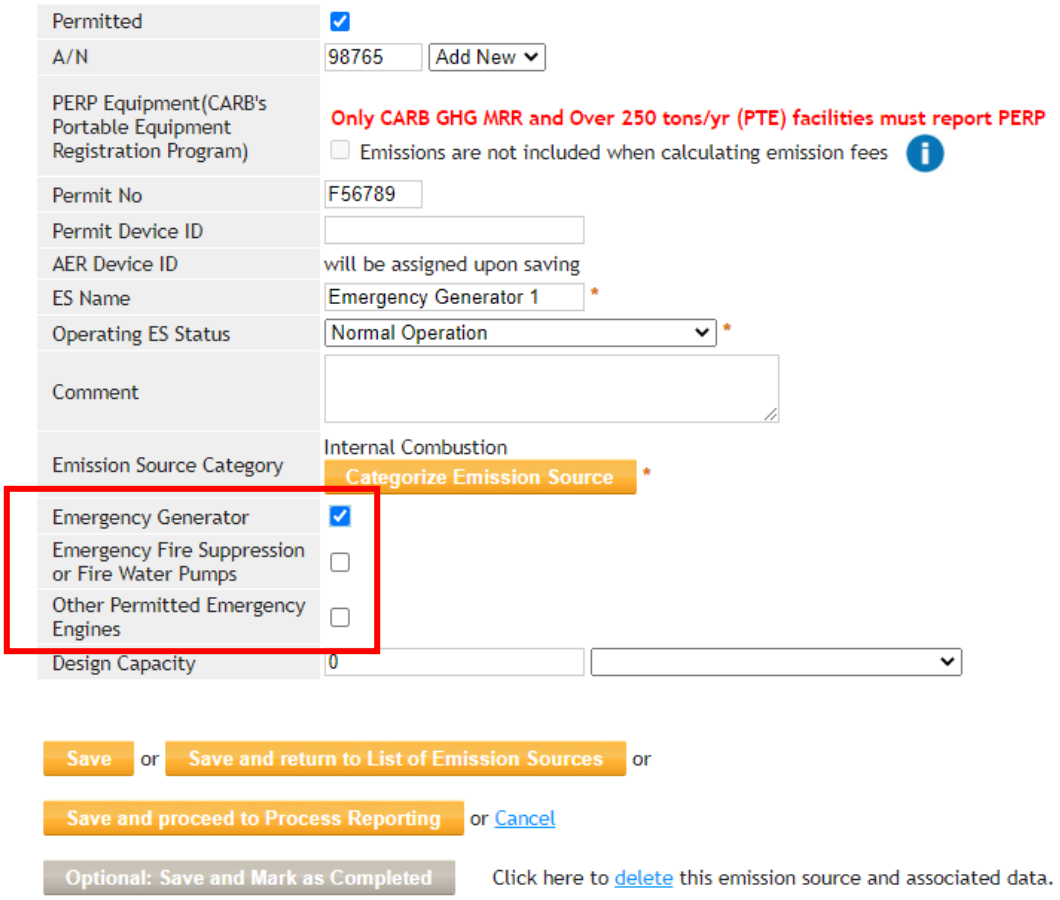


The following box, as shown below, will pop-up. Select **2. Internal Combustion Equipment** to open the options. Select the category that matches the permitted equipment. Then click **Save**.

Note: Refer to the permit description, manufacturer specifications, and technical data sheets for selecting the proper configuration. If the configuration cannot be determined, the user can select 4-Stroke-Lean Burn.



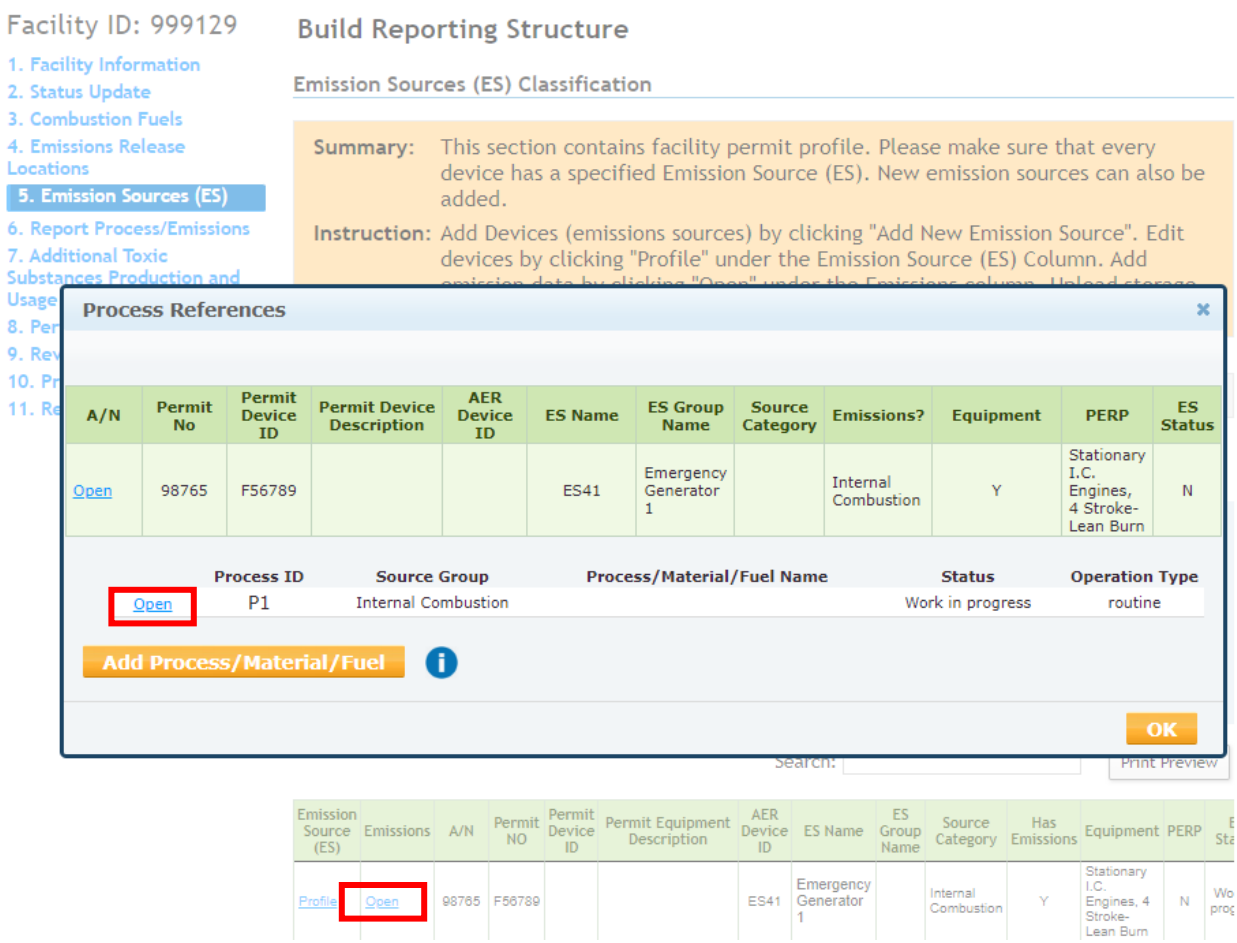
Emergency Use Delineation
Once the emission source has been categorized, the reporter must indicate whether this equipment is permitted for emergency operations. Check the box that most accurately describes how the equipment is permitted or registered for use. If the equipment is not permitted for any emergency use, do not check any box. Click any of the **Save** options.



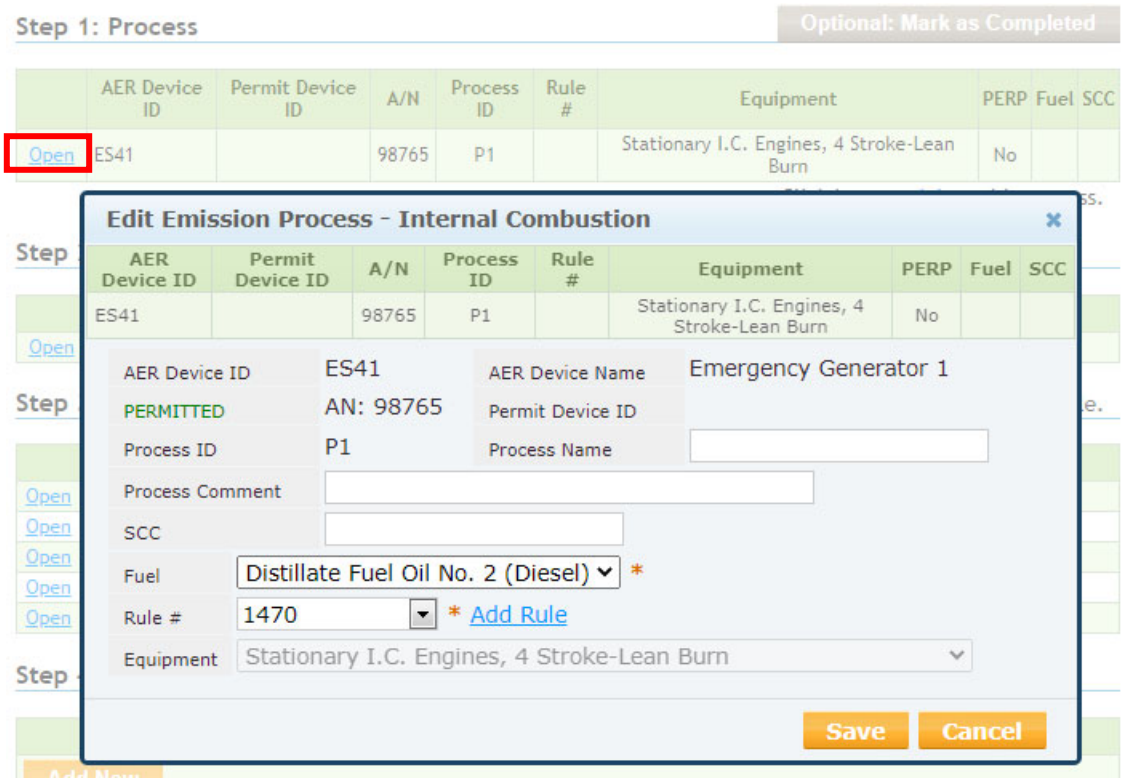
Abbreviated reporters must select one of the three emergency use checkbox options (if applicable) to qualify for abbreviated reporting. Engines that cannot be described by one of the checkbox options do not qualify for abbreviated reporting.

Note: This feature is new to the AER Web Tool for the 2022 data year. Delineating emergency use must be done for all emergency internal combustion engines for the 2022 data year even if they have been previously reported if the user wishes to use Abbreviated Reporting.

Reporting Emissions
To report emissions, return to the **Emission Sources (ES)** in the left navigation menu. Click **Open** under the Emissions column for the device, then click **Open** for the process.

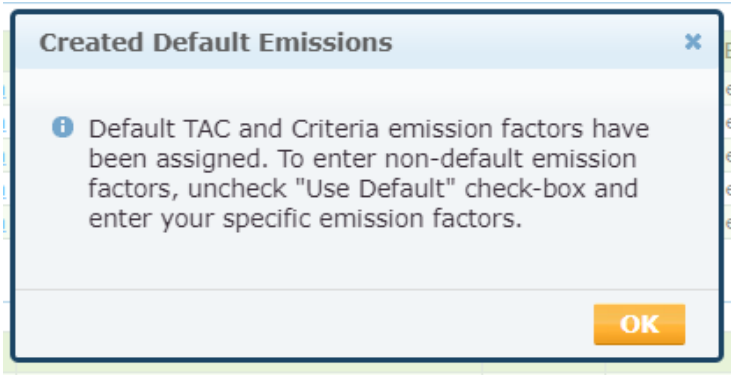

Facility ID: 999129
1. Facility Information
2. Status Update
3. Combustion Fuels
4. Emissions Release Locations
5. Emission Sources (ES)
6. Report Process/Emissions
7. Additional Toxic Substances Production and Usage
Build Reporting Structure
Emission Sources (ES) Classification
Summary: This section contains facility permit profile. Please make sure that every device has a specified Emission Source (ES). New emission sources can also be added.
Instruction: Add Devices (emissions sources) by clicking "Add New Emission Source". Edit devices by clicking "Profile" under the Emission Source (ES) Column. Add
Process References
A/N
Permit No
Permit Device ID
Permit Device Description
AER Device ID
ES Name
ES Group Name
Source Category
Emissions?
Equipment
PERP
ES Status
Open
98765
F56789
ES41
Emergency Generator 1
Internal Combustion
Y
Stationary I.C. Engines, 4 Stroke-Lean Burn
N
Process ID
Source Group
Process/Material/Fuel Name
Status
Operation Type
Open
P1
Internal Combustion
Work in progress
routine
Add Process/Material/Fuel
OK
Search:
Print Preview
Emission Source (ES)
Emissions
A/N
Permit NO
Permit Device ID
Permit Equipment Description
AER Device ID
ES Name
ES Group Name
Source Category
Has Emissions
Equipment
PERP
Profile
Open
98765
F56789
ES41
Emergency Generator 1
Internal Combustion
Y
Stationary I.C. Engines, 4 Stroke-Lean Burn
N

Click **Open** under **Step 1: Process** to open the **Edit Emission Process** window. Enter the **Fuel** and **Rule Number** from the drop-down menus, as shown below. Click **Save** to close the window.



Note: Fuels must be added to the AER Reporting Tool on the Combustion Fuels page prior to reporting emissions, or they will not display in the drop-down menu. For instructions on adding fuels refer to the previous section, the Help and Support Manual, or the Abbreviated Reporting Guideline. Any data added to the Process page before fuels are identified in the Combustion Fuels page may be lost, so be sure to enter the fuel prior making other entries.

When the previous window is closed, the following window pops up informing the reporter that default emission factors have been assigned. The reporter can replace the default emission factors if they have equipment-specific emission factors. However, as noted previously, using non-default emission factors will disqualify the facility from abbreviated reporting. Click **OK** to close the window.



Click **Open** under **Step 2: Throughput** to open the **Edit Throughput Information** window. Enter the annual fuel usage (throughput) and select the associated unit for the throughput. Select the throughput type in the drop-down menu and provide a comment on the throughput data source (e.g., estimated using timer readings and South Coast AQMD guidelines, fuel meter readings, purchase records, etc.). The reporter can use Equation 2 in this guideline to estimate throughput (fuel consumption) from operating hours. Click **Save** to close the window.

Note: The equations and emission factors in this guideline use the units of Mgal which is equivalent to 1,000 gal. In the example above, 10 Mgal = 10,000 gal. The user should pay close attention to the units of throughput, particularly if using non-default emission factors.

Once the throughput is entered, the AER Reporting Tool calculates the emissions based on the emission factors that have been selected.

Using Other Default Emission Factors

As detailed earlier, there are two default PM and Diesel PM emission factors, as well as three default emission factors for ammonia (see Table 1 and Table 2).

In this next example, the default ammonia emission factor for SNCR (an ammonia-based NOx emissions control technology) will be changed to the default emission factor for engines without ammonia-based NOx emissions control technology. Then following the same steps, the default emission factors for PM and Diesel PM can be changed.

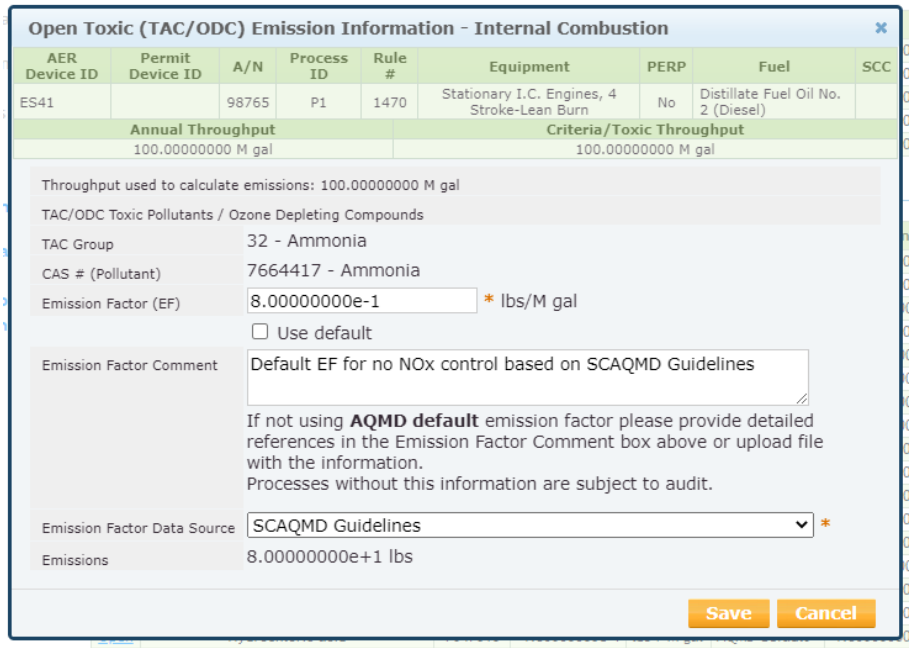
Click **Open** next to the pollutant (ammonia in this example), as shown below.

Step 4: Toxic (TAC/ODC) Emissions (lbs)

	TAC/ODC Group	CAS #	EF	Unit	EF Data Source	Emissions
Open	Benzene	71432	1.86300000e-1	lbs / M gal	AQMD default	1.86300000e+1
Open	Butadiene [1,3]	106990	2.17400000e-1	lbs / M gal	AQMD default	2.17400000e+1
Open	Cadmium	7440439	1.50000000e-3	lbs / M gal	AQMD default	1.50000000e-1
Open	Formaldehyde	50000	1.72610000e+0	lbs / M gal	AQMD default	1.72610000e+2
Open	Chromium, hexavalent (and compounds)	18540299	1.00000000e-4	lbs / M gal	AQMD default	1.00000000e-2
Open	Arsenic and Compounds (inorganic)	7440382	1.60000000e-3	lbs / M gal	AQMD default	1.60000000e-1
Open	Lead compounds (inorganic)	7439921	8.30000000e-3	lbs / M gal	AQMD default	8.30000000e-1
Open	Nickel	7440020	3.90000000e-3	lbs / M gal	AQMD default	3.90000000e-1
Open	PAHs [PAH, POM]	1151	3.62000000e-2	lbs / M gal	AQMD default	3.62000000e+0
Open	PAHs [PAH, POM]	91203	1.97000000e-2	lbs / M gal	AQMD default	1.97000000e+0
Open	Acetaldehyde	75070	7.83300000e-1	lbs / M gal	AQMD default	7.83300000e+1
Open	Acrolein	107028	3.39000000e-2	lbs / M gal	AQMD default	3.39000000e+0
Open	Ammonia	7664417	2.90000000e+0	lbs / M gal	AQMD default	2.90000000e+2
Open	Copper	7440508	4.10000000e-3	lbs / M gal	AQMD default	4.10000000e-1
Open	Ethyl benzene	100414	1.09000000e-2	lbs / M gal	AQMD default	1.09000000e+0
Open	Hexane	110543	2.69000000e-2	lbs / M gal	AQMD default	2.69000000e+0
Open	Hydrochloric acid	7647010	1.86300000e-1	lbs / M gal	AQMD default	1.86300000e+1
Open	Manganese	7439965	3.10000000e-3	lbs / M gal	AQMD default	3.10000000e-1
Open	Mercury and mercury compounds	7439976	2.00000000e-3	lbs / M gal	AQMD default	2.00000000e-1
Open	Selenium and compounds	7782492	2.20000000e-3	lbs / M gal	AQMD default	2.20000000e-1
Open	Toluene	108883	1.05400000e-1	lbs / M gal	AQMD default	1.05400000e+1
Open	Xylenes	1330207	4.24000000e-2	lbs / M gal	AQMD default	4.24000000e+0
Open	Diesel exhaust particulates	9901	3.35000000e+1	lbs / M gal	AQMD default	3.35000000e+3

Add New

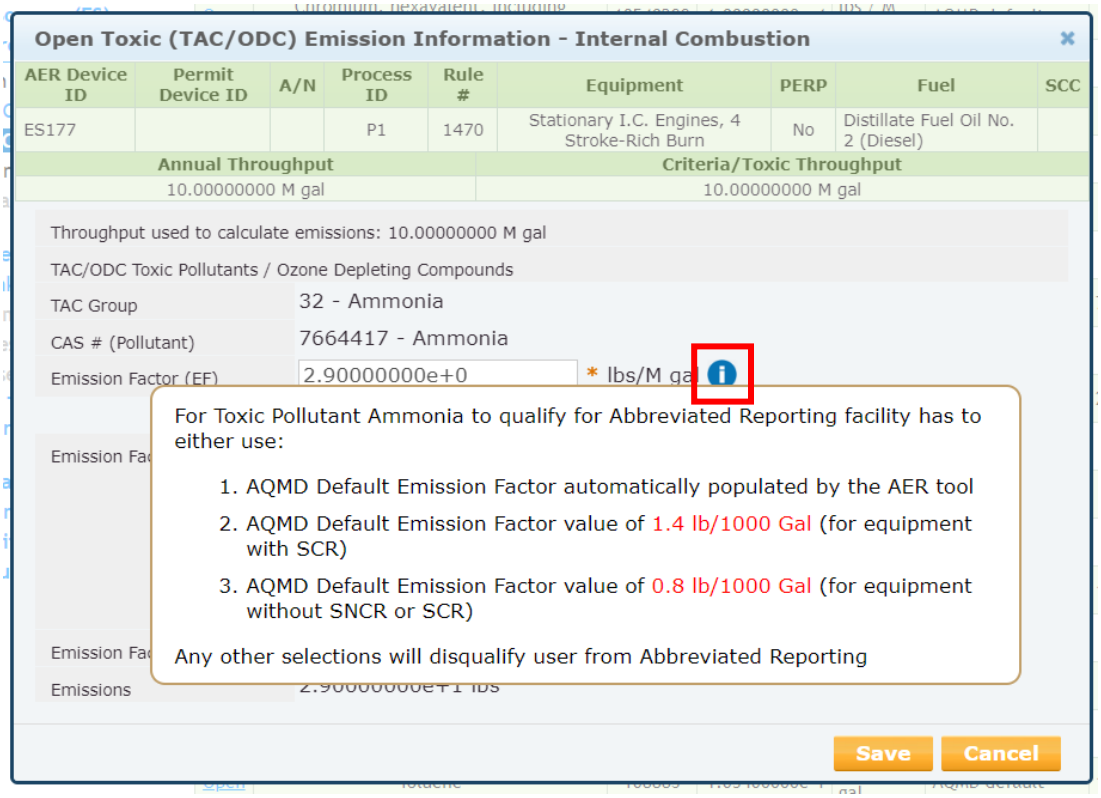
Unselect the checkbox next to **Use default** to edit the Emission Factor (EF) field. Provide a comment on the reference source for the EF and select an option from the drop-down menu for Emission Factor Data Source. In this example, the default EF was taken from the Ammonia Default Emission Factors (Table 2 of this document) for an engine with no ammonia-based NOx emission control technology.



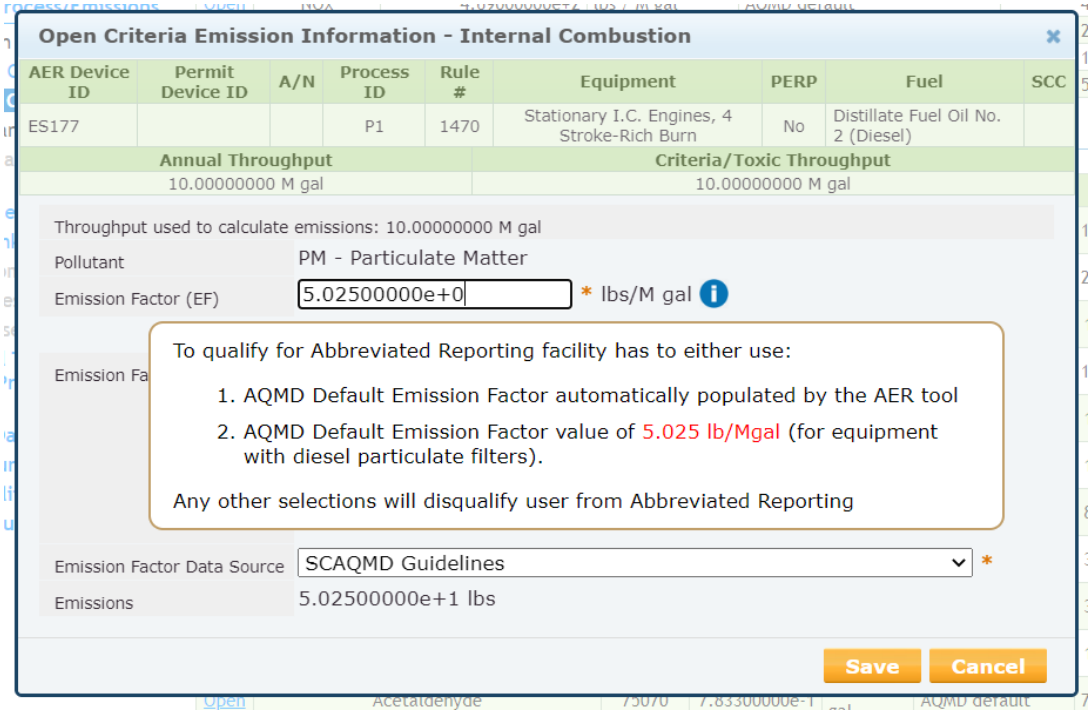
Note: The AER Reporting Tool will allow abbreviated reporters to change the ammonia EF for emergency combustion engines to any of the default EFs shown in Table 3 and the report will still qualify for abbreviated reporting. Abbreviated reporters should take care in entering the correct default EFs, if modifying the ammonia EF.

A report with the option of Abbreviated Reporting will see the following information boxes when the mouse is hovered over the i-icon, as shown below. The information box lists all the available default emission factors that can be used in abbreviated reporting. The information box will only show for the Ammonia, PM, and Diesel PM pollutants.

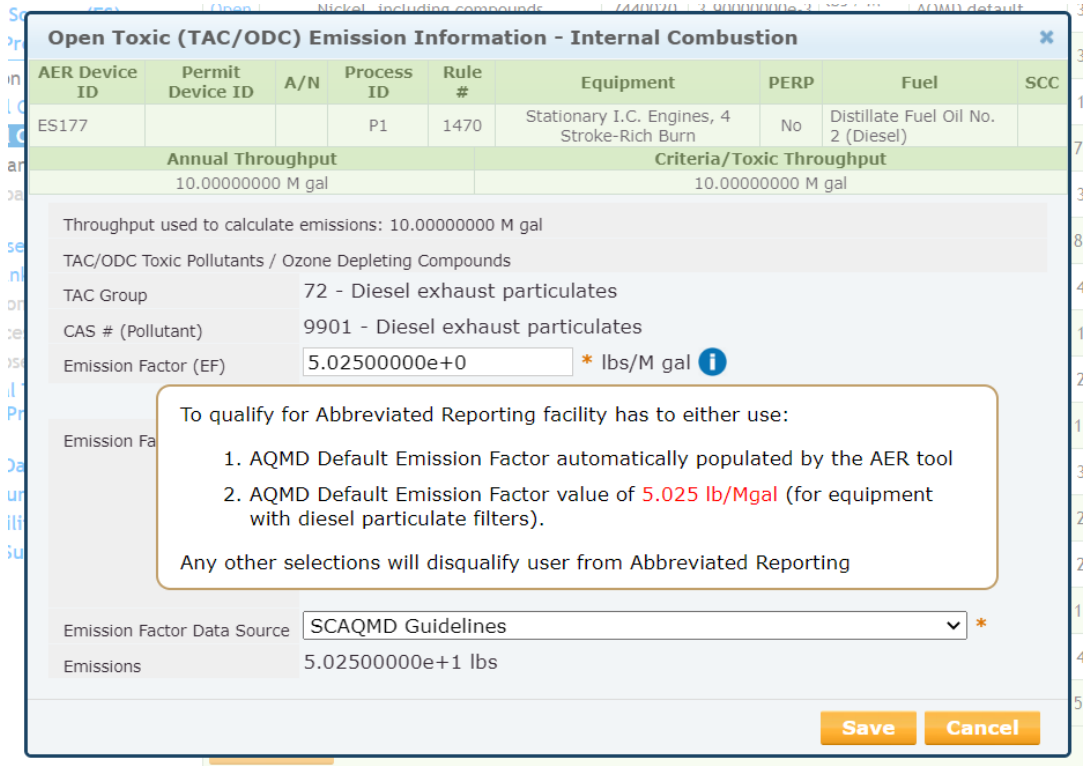
Ammonia:



Particulate Matter:



Diesel Particulate Matter:

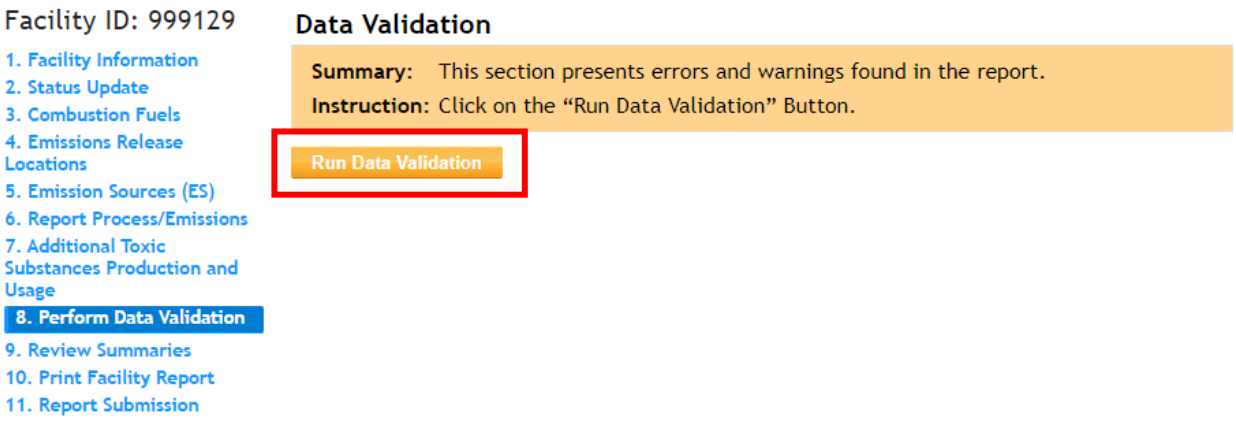


Users should follow a similar procedure to the ammonia example to change the PM and Diesel PM emission factors.

Core CTR facilities must include emission release locations following the instructions provided in the Core CTR Guidance document found on the AER webpage. All other AER/CTR reporters are otherwise done with emissions reporting for this device.

Data Validation

To run a data validation, go to the Perform Data Validation Page and click **Run Data Validation**.



As explained previously, the following warnings will be displayed if any internal combustion engine is reported.

General Report Warnings

Rule	ES/Process	Description
V34		Fuel: Natural Gas - Ammonia emission factor of 18 lbs/mmscf automatically populated by the reporting tool corresponds to equipment with Selective Non Catalytic Reduction (SNCR), for equipment with Selective Catalytic Reduction (SCR) substitute listed value by 9.1 lbs/mmscf, and for equipment without SNCR or SCR by 3.2 lbs/mmscf.
V34		Fuel: Distillate Fuel Oil No. 2(Diesel) - Ammonia emission factor of 2.9 lbs / 1000 gallons automatically populated by the reporting tool corresponds to equipment with Selective Non Catalytic Reduction(SNCR), for equipment with Selective Catalytic Reduction(SCR) substitute listed value by 1.4 lbs / 1000 gallons, and for equipment without SNCR or SCR by 0.8 lbs / 1000 gallons.

The AER can be certified and submitted with warnings, but the user should verify that the correct ammonia, PM and Diesel PM emission factors are used. For detailed instructions on submitting the AER, refer to the Help and Support Manual or the Abbreviated Reporting Guideline document.