COMBUSTION – DIESEL FIRED ENGINES

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1. PROCESS DESCRIPTION:

Combustion of diesel fuel in engines results in the release of several criteria pollutants and toxicair contaminants to the atmosphere. Emissions typically include NOx, SOx, ROG, PM, CO, diesel particulate matter (DPM), hydrogen chloride, naphthalene, PAHs, propylene, toluene, and xylene, and some metals such aslead, manganese, nickel, and zinc, as well as other trace pollutants. Testing may include the speciation of non-methane organic compounds in the stack gas exhaust. Factors can also be derived by applying average destruction efficiency to combustible components of the fuel. Stacktesting for metals is generally considered less reliable for emission estimation purposes than mass balance techniques based on fuel analyses due to (i.e. difficulty with test methods, etc. state the reason, if possible). Emission factors for diesel-fired engines represent "controlled releases" control efficiencies must be included in emission factors. Therefore, any reported control efficiencies should generally not be used in emissions calculations.

The District utilizes factors from different sources, including:

- Sections 3.3, and 3.4 of AP-42 (10/96) from EPA,
- Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors (5/2001) and,
- Environmental Protection Agency (EPA) and California Air ResourcesBoard (CARB) Nonroad Compression Ignition Engine Standards.
- Manufacturer Specifications

2. CALCULATION OF COMBUSTION EMISSIONS

Emission factors from documents described above are used as default values for total organic gases (TOG), reactive organic gases (ROG), oxides of sulfur (SOx), oxides of nitrogen (NOx), particulate matter 10 microns or less (PM10), carbon monoxide (CO), diesel particulate matter (DPM) and trace toxics unless more accurate emission factors are entered database for the given device. Default factors can be "overwritten" by inserting site-specific values in place of default values. EPA and CARB certifies diesel engines meeting different tiered emission standards for hydrocarbon (HC),oxides of nitrogen (NOx), non-methane hydrocarbons plus oxides of nitrogen (NMHC+NOx), carbon monoxide (CO), and particulate matter (PM) in grams/kilowatt-hour (g/kw-hr) and categorizes them in engine family numbers. It is assumed that HC and NMHC are the same as ROG for emissions estimation purposes.

2.1 Method for Estimating Potential Emissions

The following equations are used to estimate the potential emissions from each device:

Ea = BHP x Operating hours x EF x (lb/453.6 g)
Eh = BHP x EF x (lb/453.6 g)

Where:

Ea = Annual emissions of each listed substance per device, (lbs/year)

Eh = Maximum hourly emissions of each listed substance per device, (lbs/hour)

BHP = break horsepower of equipment

Operating Hours = Number of hours equipment will run per year, (hr/yr)

EF = Emission Factor, (g/bhp-hr)

2.2 Method for Estimating Annual and Max Hourly Emissions

The following equations are used to calculate releases of each compound:

Ea = Ua x EF
Eh = Uh x EF

Where:

Ea = Annual emissions of each listed substance per device, (lbs/year)

Eh = Maximum hourly emissions of each listed substance per device, (lbs/hour)

Ua = Annual fuel consumption per device, (1000 gallons burned)

Uh = Maximum hourly fuel usage per device, (1000 gallons burned)

EF = Emission factor, (lbs pollutant/1000 gallons burned)

All emission factors have been converted into units of lbs pollutant/1000 gallons fuel burned. This conversion is necessary to allow comparisons of like emission factors for different types of equipment and fuels. Specific engine emission factors for diesel particulate,CO, NOx, ROG+NOx, ROG, and TOG in grams/brake horsepower-hour (g/bhp-hr) are converted to lbs/1000 gallons assuming brake-specific fuel consumption of 7,000 BTU/hp-hr, diesel BTU content of 19,300 BTU/lb, and density of 7.1 lb/gal (137,030 BTU/gal) per AP-42 Table 3.3-1. Other acceptable engine-specific emission factors, that upon District review and approval, could be used in lieu of District default factors are District source test results, manufacturing engine data, ARB engine certification with family number or EPA engine certification with supporting documentation.

Fuel usage and hours of operation are categorized into non-emergency and emergency usage. Emissions are evaluated for non-emergency use per ARB Emission Inventory Criteria and Guidelines for the Air Toxics "Hot Spots" Program, Section XI Diesel Engine Reporting Requirements. Emergency fuel usage and hours of operation are collected to obtain a complete understanding of diesel engine operations.

3. CONTROLS

Some diesel engines utilize in-stack emission control devices, such as oxidation catalysts, selective catalytic reduction (SCR), or diesel particulate filters (DPF), which reduce emissions of certain air contaminants. The following guidelines outline how to apply emission control efficiencies for these devices. In addition, when source test data or other equipment-specific information is available, that information should be used in lieu of default emission control efficiencies described in this section

3.1 Diesel Particulate Filters (DPFs)

Diesel particulate filters are designed to remove particulate components from diesel exhaust and can function in a variety of ways. Some physically trap inorganic (ash) and organic (soot) particulates within the filter, the most common design known as a "Wall-Flow". Others function by further combusting organic particulate and converting it into water and CO2. Some utilize both functions. Depending on the type of filter, the following guidelines apply:

Most new engines are certified to EPA and CARB emission standards and come already equipped with a DPF. In these cases, no additional control efficiency is applied to the certified emission factors. However, for engines that are equipped with a DPF of wall-flow design, a control efficiency may be applied on a case-by-case basis if data is available to support this for speciated metals if using the default emission factors. No control efficiency should be applied to speciated metals if the filter does not employ a physical means of trapping inorganic particulate since combustion on its own cannot remove inorganics from the exhaust.

For engines that are equipped with an aftermarket DPF that is verified by CARB, the verified control efficiencies may be applied to pollutants including PM, VOC and CO. In addition, the verified particulate control efficiency may also be applied on a case-by-case basis if data is available to support this.

For engines that are equipped with a non-verified DPF, control efficiencies should only be applied if sufficient and reliable data is available to support the proposed control efficiencies.

3.2 Oxidation Catalysts

Oxidation catalysts are designed to reduce both VOC and CO by converting these incompletely combusted compounds to water and CO2. They may be installed as standalone controls or may be integrated into a DPF.

Similarly to DPFs, many new engines may have an oxidation catalyst integrated into the engine design. In these cases, no additional controls should be applied to certified pollutants. However, for speciated organic compounds, a 50% control efficiency may be applied if using the default emission factors. Note: if applying the VOC-ratio approach for speciated TACs (see assumptions), the default 50% control efficiency should only be applied if the engine was certified without the oxidation catalyst. The District considers a 50% control efficiency for these pollutants to be a reasonable assumption given that while the specific reduction of each compound is not known, there is no reason to expect that specific compounds would not be effectively removed through catalyzed oxidation.

In addition, for engines that are equipped with aftermarket oxidation catalysts, a default 50% control efficiency may be applied for speciated organic TACs, VOC and CO. For CO and VOC emissions, a higher control efficiency may also be applied for CARB verified DPFs based on the verified control efficiency.

3.3 Selective Catalytic Reduction (SCR) Systems

SCR systems are designed to reduce emissions of NOx, and function by injection of a reducing agent (ammonia or urea) into the exhaust stream which reacts with NOx across a catalyst bed to reduce NOx to N2 and H2O. SCR does not reduce emissions of any other air contaminants.

Some engines may be equipped with integrated SCR systems, in which case no control efficiency should be applied. For engines equipped with aftermarket SCRs, site-specific emission factors or control efficiencies for NOx based on the permitted emission concentration or source test results should be used rather than applying a default value. Calculations for these engines should also reflect higher allowable emissions during startups and shutdowns.

4. RENEWABLE DIESEL

Recent emission testing programs have shown criteria emission reductions can occur when traditional diesel is replaced with renewable diesel. The District has reviewed the following studies and testing programs for emission reductions associated with the use of renewable diesel and/or biodiesel.

- CARB Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California “Biodiesel Characterization and NOx Mitigation Study”, 2011
- CARB Staff Report Multimedia Evaluation of Renewable Diesel, 2015
- Renewable Diesel as a Major Transportation Fuel in California, Prepared for BAAQMD & SCAQMD by GNA, 2017
- Low Emission Diesel (LED) Study: Biodiesel and Renewable Diesel Emissions in Legacy and New Technology Diesel Engines, 2021
- Effects of Hydrogenated Vegetable Oil (HVO) and HVO/biodiesel blends on the Physicochemical and Toxicological Properties of Emissions from an Off-Road Heavy-Duty Diesel Engine, 2022

There may be additional studies on the use of renewable and/or biodiesel, which have further information, however, based on the review of the studies listed above the District has determined that the studies’ results all agree that reduction of emissions and air quality benefits greatly depend on some key use parameters, which include the following:

- Distinction between renewable diesel and biodiesel
- Type of emission control (mostly particulate emission control, but to some extent also NOx emission control) technology utilized by the diesel engine

- Blended composition of fuel combusted

For this discussion, it is important to note that there is a clear distinction between renewable diesel and biodiesel. While both can be made from the same feedstocks, they are produced differently which impact the emissions generated from combustion of each fuel The studies have shown that using these fuels will decrease PM emissions; however, the differences in production and use of the fuels can potentially increase NOx emissions. Due to these inconsistencies in emission reductions between renewable diesel and biodiesel, the District is only considering PM reductions at this time.

There is consensus that the use of renewable diesel and/or blends shows a reduction in PM emissions when used in uncontrolled engines, there is no similar reductions when the alternative fuels are used in an engine that is equipped with PM control technology such as diesel particulate filters (DPF) technology and cannot be accurately quantified when equipped with selective catalytic reduction (SCR). Therefore, the District will only consider PM reductions associated with the use of renewable diesel in engines without control technologies.

As seen in the studies, PM reduction can vary by the ratio of renewable diesel, biodiesel, and/or traditional diesel blended to create the fuel. Although PM reductions were observed in all renewable diesel/biodiesel blends, the largest reductions were seen with the higher biodiesel concentrations. To account for reduction in emissions from the general use of renewable and/or biodiesel in uncontrolled engines, the District will apply a 30% reduction to PM and its associated pollutants, compared to burning diesel fuel, and if a blend is used then at least a 50% blend of renewable diesel or biodiesel is used.

5. PORTABLE DIESEL ENGINES EQUAL TO OR GREATER THAN 50 BHP

Reporting of emissions and activity data from portable diesel engines, rated at a maximum 50 horsepower (brake horsepower (BHP) or higher must be reported beginning with calendar year 2022 emissions which are required to be reported in 2023.

In general, a portable diesel engine is defined as any engine that is not a stationary engine, and that does not propel a motor vehicle, and is a compression ignition (Cl) engine designed and capable of being carried or moved from one location to another. Refer to the Criteria Air Pollutants and Toxic Air Contaminants (CTR) Regulation and “Hot Spots” Program’s Emission Inventory Criteria and Guidelines (EICG) for definitions specific to those reporting programs.

Total fuel usage, maximum hourly fuel usage and total number of portable diesel engines must be reported for all engines during the data year. The District allows for the aggregation of fuel usage associated with the combustion of diesel fuel from multiple portable engines. Regardless of permit status or ownership, if the engine is operated on site during the data year, its associated fuel usage must be reported.

Additionally, the EICG requires any facility which reports to the state board greenhouse program or any facility which emits 250 tons per year or more of each organic gases, particulate matter, nitrogen oxides or sulfur compounds must also report the following activity data:

- Engine owner or company name
- Address/location of each diesel engine
- Contact name, phone number, address, and e-mail

- Rated brake horsepower
- Make, model, engine family, and serial number of engines
- Year of manufacture (or approximate age)
- Exhaust stack height from ground
- Exhaust exit temperature
- Exhaust exit velocity or flow rate
- Control equipment (turbo, aftercooler, injection timing retard, catalyst, diesel particulate filter, other)
- Fuel used (CARB diesel, jet fuel, diesel, alternative diesel fuel, alternative fuel, combination-dual fuel, other)
- General description of how engine is used
- Typical load (% of bhp rating)
- Typical annual hours of operation
- Fuel usage rate
- Distance to nearest offsite receptor location (commercial / residential)
- Is engine already included in an existing CARB "Hot Spots" emission inventory?
- Emission factor for PM
- Estimate of diesel engine exhaust particulate matter (diesel PM), reported using emittent ID 9901 (see Appendix A-I)
- Diameter and direction (horizontal or vertical) of stack outlet
- End of stack (open or capped)
- Compliance plan describing how the facility is complying with the stationary diesel engine ATCM.
- Building dimensions if the downwind distance between the stack and a building is less than five times the width or height of the structure, whichever is less (also known as 5L); or if the upwind distance between the stack and a building is less than two times the width or height of the structure, whichever is less (also known as 2L). (See Appendix B-I formats).

ASSUMPTIONS / LIMITATIONS:

Equipment types, designs, burner configurations, operating temperatures, control devices, and other variables may significantly affect emissions from any given type of device or fuel. In some cases, the existing default factors may not adequately assess emissions from a particular type of equipment. New sets of default factors should be developed and entered when available.

- Emissions of diesel particulate include, but are not limited to, non-VOC toxic emissionsquantified such as lead, manganese, mercury, nickel, and zinc. PM10 and diesel particulate matter are considered interchangeable. Hence, default diesel particulate emission factors are equivalent to AP-42 PM10 emission factors for diesel engines.

- Due to the ARB Airborne Toxic Control Measure for Stationary Compression Ignition Engine, emission factors for NMHC+NOx may be documented to show that it is meeting emissions standards. ROG and NOx emission factors are estimated using AP-42 individual pollutant emission factor ratios and engine rating.

- In some instances, EPA documents contain multiple conflicting values for ROG emissions or missing ROG values. A combination of the EPA TOC emission factor and the EPA VOC Speciation were usually used to derive ROG factors when a conflict or omission in reported values existed.

- Default emission factors should be developed for each type of fuel used in each type of equipment. In many cases, trace toxic data is extremely limited and criteria pollutant data is somewhat variable. General assumptions regarding fuel composition and destruction efficiency may have been used to develop default factors until more accurate information becomes available. Often, pooled testing of similar equipment is more accurate for average annual estimation purposes than a single test of the actual device.

- Biodiesel is not typically used in engines as an alternative fuel to diesel. Biodiesel emission factors are currently still under development for various blends noted as Bnumber, where number is the percent biofuel. For example, B20 is 20% biofuel and 80% diesel. Until approved biodiesel emission factors are available, diesel emission factors are used as defaults.

- It may be assumed that DPM=PM10=TSP if equipment specific DPM emission factors are available and deemed to be the most accurate or conservative emission factor available

- If annual or max hourly fuel usage data is not provided by the facility, then the District may use other data sets to estimate fuel usage, including but not limited to, permit applications, permit conditions, or manufacturer specifications.

- In some instances, CARB and EPA certified emission factors may be available for specific engine types. When certificated total VOC emission factors are available, speciated VOC TACs from Ventura County Air Pollution Control District AB 2588 Combustion Emission Factors (5/2001) will be ratioed with the certificated total VOC emission factor so that the sum of TACs, which are detectable by the method used to establish the certificated total VOC emission factor, does not exceed the certificated total VOC emission factor. Note that some engines certified using an EPA test method (e.g. 40 CFR 1065) measure VOC emissions using a flame ionization detector (FID) which cannot detect formaldehyde. Instead, formaldehyde emissions may be adjusted by applying the same percentage control efficiency established in the ratio to emissions of formaldehyde.

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