

APPENDIX F

ESTIMATED EMISSIONS BENEFITS

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Heavy-Duty Vehicle Emissions Inventory and Estimated Emission Benefits for Proposed Heavy-Duty Engine Warranty Amendments

The proposed Heavy-Duty Engine Warranty Amendments are designed to reduce emissions of nitrogen oxides (NO_x) and particulate matter (PM) from diesel powered heavy-duty vehicles (HDV) with gross vehicle weight rating (GVWR) over 14,000 pounds; namely, classes 4 to 8 diesel vehicles, which include diesel trucks and diesel buses. Emission reduction would primarily come from the diesel trucks. Some emission reductions would also come from diesel buses but they are much smaller than the reductions from diesel trucks; diesel buses have much less vehicle miles travelled (VMT) when compared to diesel trucks and, additionally, no emission deterioration with mileage is assumed for diesel urban (transit) buses.

Emission reductions are estimated using EMFAC2017, CARB's most recently updated on-road emissions inventory model.¹ In EMFAC, diesel heavy-duty trucks with GVWR over 14,000 pounds are grouped into an MHDDT weight category (14,001 – 33,000 lbs.) and an HHDDT weight category (>33,000 lbs.), with each of the two including many types of trucks on the basis of their services types. Different types of buses have their own groups. In this appendix, the discussion of emission calculations follows EMFAC truck weight grouping, and thus MHDDT would include classes 4 to 7 trucks and HHDDT class 8 trucks.²

Heavy-Duty Vehicle Emissions Inventory

On-road mobile source emissions in California are calculated using the EMFAC2017 model. For a detailed discussion of EMFAC2017, including the updates to HDV emission rates and emissions modeling, refer to the EMFAC2017 Technical Documentation (Footnote 1). The following provides a short description of the EMFAC HDV emission calculation methodology and HDV emissions inventory baselines from which emission benefits are estimated.

For on-road motor vehicles, the emission rate (ER) of a pollutant for a given model year is calculated using the following equation:

$$ER_{odo} = (ZMR + DR \times Odo) \times SCF \quad (1)$$

where ZMR, DR, and SCF are, respectively, zero-mile emission rate, emission deterioration rate, and speed correction factor, and Odo is the average odometer of all vehicles in that model year at a given age. ZMR is the emission rate of the fleet when it is new and DR is the incremental rate of emission increase due to tampering,

¹ [EMFAC2017 Technical Documentation](#)

² In the Initial Statement of Reasons (ISOR), class 8 vehicles are heavy heavy-duty vehicles with GVWR greater than 33,000 pounds, classes 6 and 7 vehicles are medium heavy-duty vehicles with GVWR greater than 19,500 pounds and less than or equal to 33,000 pounds, and classes 4 and 5 vehicles are light heavy-duty vehicles with GVWR greater than 14,000 pounds and less than or equal to 19,500 pounds.

mal-maintenance, and malfunctioning (TM&M) of engine and after-treatment systems (such as selective catalytic reduction or SCR) with mileage.

For a given calendar year, ERs of all individual model years at different ages can be calculated for different speeds using Eq. 1, and the calculated ERs are then combined with VMTs to obtain the emissions for the selected calendar year using the following equation:

$$Emissions = \sum_{Age} (ER_i \times VMT) \quad (2)$$

The ZMR, DR, and SCF in Eq. 1 are determined using emissions test data obtained from testing randomly selected in-use vehicles on a chassis dynamometer over various test cycles, and VMT in Eq. 2 is derived from data and information on vehicle population, annual mileage accrual rates, and vehicle attrition rates.

In EMFAC2017, ZMR, DR, and SCF for diesel HDV were revised based on emission test data collected from several truck and bus testing projects conducted during the last few years. Using this latest EMFAC model, emissions inventories for NOx and PM were calculated.

To obtain baseline emissions for estimating emission benefits for the proposed regulation, staff had to make adjustments to the EMFAC2017 default emissions inventories because of existence of several different warranties. Although the current emission warranty requirements for classes 4 to 8 trucks is 100,000 miles, a recent CARB sponsored survey (see Chapter II.D, of the Initial Statement of Reasons) indicates that 40% of these trucks carry extended warranties to their respective useful lives (110,000 miles for classes 4 & 5, 185,000 miles for classes 5 & 6, and 435,000 miles for class 8). In addition, according to data and information from manufacturers as well as other sources, ~75% of the remaining 60% of class 8 trucks have an extended warranty of 250,000 miles. However, these data do not provide sufficient details as to the warranty distribution among different vocational vehicles (e.g., long haul vs short haul). Staff believes that the warranty distribution found by the survey is a reflection of the HDV emission warranty market and therefore made an adjustment to the EMFAC emissions inventory of HDV to obtain a baseline for the calculation of emission benefits. As an example, it can reasonably be assumed that the 40% class 8 trucks that currently have a 435,000 mile warranty all belong to those long-haul truck categories, which all have an average 5-year odometer greater than 435,000 miles; therefore, 40% of the emissions associated with long-haul truck categories was excluded since it would not be affected by the proposed warranty.

Table 1 gives the baseline statewide NOx and PM2.5 emissions inventories of diesel HDV for selected calendar years.

Table1. Baseline Statewide NOx and PM Emissions Inventories of Diesel HDV for Calendar Year 2022-2040 (in tons/day)

Calendar Year	NOx	PM2.5
2022	200.9	2.37
2023	157.3	1.39
2024	160.1	1.42
2025	161.1	1.43
2026	161.7	1.45
2027	162.4	1.46
2028	162.7	1.46
2029	162.7	1.47
2030	163.2	1.47
2031	163.9	1.47
2032	164.7	1.48
2033	165.5	1.49
2034	166.3	1.50
2035	167.1	1.50
2036	168.1	1.51
2037	169.3	1.53
2038	170.7	1.54
2039	172.2	1.55
2040	173.9	1.57

Emission Benefits from Proposed Regulation

The proposed regulation would lengthen the minimum warranty periods to 350,000 miles for heavy-duty vehicles with engines that are certified as heavy heavy-duty engines, 150,000 miles for heavy-duty vehicles with engines that are certified as medium heavy-duty engines, and 110,000 miles for heavy-duty vehicles with engines that are certified as light heavy-duty engines, or 5 years, whichever comes first. This would lower the TM&M frequencies, which in turn lead to a reduction in emissions from diesel HDV over the vehicles' service lives.

To calculate the NOx and PM emission benefits, NOx and PM baseline inventories are first generated from EMFAC2017, and the baseline inventories are then adjusted by applying a set of modified NOx and PM emission rates to derive NOx and PM regulation inventories (i.e., inventories with the assumption that the proposed regulation is in place). To adjust the emission rates, staff modified the frequency of a given TM&M at the end of a proposed longer warranty to be equal to the frequency at the end of the current warranties. In effect, this results in lowered emission rates and emissions inventories. The NOx and PM emission benefits were then obtained by subtracting the regulation inventories from the baseline inventories. It should be noted that the emission rate adjustments are capped at 5 years or the proposed new warranties (i.e.,

110,000 miles for classes 4&5, 150,000 miles for classes 6&7, and 350,000 miles for class 8), whichever comes first.

The proposed regulation would be applicable to only new, California-registered heavy-duty vehicles greater than 14,000 pounds GVWR in which 2022 and subsequent model-year California-certified heavy-duty diesel engines are installed. Thus, no emission reduction is assumed for out-of-state vehicles travelling in California as well as California registered vehicles that would be originally purchased in other states (i.e., 49-state certified trucks).

Using the approach described above and adjusting emissions for non-CA truck purchases (i.e., 49-state certified trucks), the NOx and PM2.5 emission benefits were estimated for calendar years 2022 to 2040, with 2022 as the year when the proposed regulations would be implemented. Table 2 provides the estimated statewide NOx and PM2.5 emission benefits for the selected calendar years.

Table2. Statewide NOx and PM Emission Benefits for Proposed Regulation (in tons/day)

Calendar Year	NOx	PM2.5
2022	0.02	0.000
2023	0.06	0.001
2024	0.12	0.001
2025	0.21	0.002
2026	0.31	0.003
2027	0.42	0.005
2028	0.52	0.006
2029	0.64	0.007
2030	0.75	0.008
2031	0.84	0.009
2032	0.93	0.010
2033	1.02	0.011
2034	1.10	0.012
2035	1.17	0.013
2036	1.24	0.013
2037	1.31	0.014
2038	1.37	0.015
2039	1.44	0.015
2040	1.49	0.016

It should be noted that in calculating the emission benefits in Table, staff did not account for the emissions impact of installing engines certified for intended MHDD service class on trucks of HHDD service class. In such cases, the lengthened emission warranty would be limited to 150,000 miles proposed for classes 6 & 7 trucks instead of 350,000 miles proposed for class 8 trucks. Staff does not have precise data on the population of such HHDD trucks with MHDD engines, nor their duty cycles, but estimate range from 10 to 15 percent of HHDD trucks may be manufactured now with MHDD engines. However such trucks are likely to be those HHDD trucks with relatively low mileage and therefore would not benefit from longer warranties. At most, even if the HHDD vehicles with MHDD engines were all those anticipated to benefit from longer warranties, the total emission benefits would be reduced by less than 5%. Because the potential impact is so small, staff opted to not adjust for it.