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NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
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MEMORANDUM

SUBJECT: Development of Motorcycle and Heavy-Duty Diesel Emissions Inventories for the Tier 2/Sulfur NPRM

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TO: Docket A-97-10

This memorandum documents methods used to create emissions inventories for on-highway motorcycles and heavy-duty diesel vehicles in the Tier 2/Sulfur NPRM.

Motorcycles

We derived 47-state emission factors for motorcycles by running MOBILE5b and PART5, using an average speed of 19.6 mph and a daily temperature range of 72° F to 96° F, and assuming no additional control programs, such as reformulated gasoline. We ran the model for calendar years 2007, 2010, 2015, and 2020. Given that motorcycle emission factors are not expected to change beyond 2020, we also used the 2020 emission factors for 2030.

We derived 47-state VMT for motorcycles from the National Emissions Trends (NET) analysis. Beyond 2010, we estimated VMT based on a linear extrapolation of VMT over the period from 1995 to 2010. Motorcycle emissions for the inventory were calculated by multiplying emission factors (grams/mile) times VMT and converting to tons.

For the urban nonattainment area analysis, we multiplied summer ozone season VMT estimates (derived from inventories prepared by E.H. Pechan and Associates for the Ozone Transport Assessment Group) for Atlanta, Charlotte, Chicago, and New York by the same emission factors used in the 47-state analysis.

Heavy-Duty Diesel Vehicles

Calculating the emissions inventory for heavy-duty diesel vehicles posed some additional problems. First, the MOBILE5 and PART5 emission factor models needed to be updated to reflect the most current information available on emissions from the vehicles. Those model updates are described in separate memoranda[1]. Second, emissions from these vehicles needed to be adjusted to reflect the impact of excess NOx emissions resulting from emissions control defeat devices installed on many of theses vehicles and on the impact of mitigation of those emissions as a result of the recent consent decree.

We derived emission factors for heavy-duty diesel vehicles using updated versions of MOBILE5b and PART5, run at an average speed of 19.6 mph and a daily temperature range of 72° F to 96°. We ran the model for calendar years 2007, 2010, 2015, and 2020.

We derived 47-state VMT for heavy-duty diesel vehicles from the NET analysis. Beyond 2010, we estimated VMT based on a linear extrapolation of VMT over the period from 1995 to 2010. Baseline heavy-duty diesel vehicle emissions for the inventory were calculated by multiplying emission factors (grams/mile) times VMT and converting to tons.

NOx Defeat Device Adjustment

EPA recently was part of a consent decree with heavy-duty diesel engine manufacturers that acknowledges that many of these engines have NOx emissions well above their standards under certain driving conditions as a result of emission control defeat devices installed by the manufacturers. The consent decree requires the manufacturers to stop manufacturing engines with these devices and to take steps to reduce the total excess emissions that result from existing vehicles.

These excess NOx emissions are not accounted for in MOBILE5b. However, EPA has estimated the national total excess emissions as part of the analysis used for the consent decree. This analysis was based on engine family test data, which indicate the amount by which each engine family exceeded the applicable emission standard, the number of engines in each weight class, estimates of how often the engines operate in defeat mode, annual mileage and scrappage factors by weight class. Table 1 shows the projected total excess emissions, the projected offset of those emissions resulting from mitigation efforts, and the resulting net excess emissions for the years included in this analysis.

Table 1. Total and net excess NOx emissions (national tons/year)

Year	Total Excess	Total Offset	Net Excess
2005	581,228	373,890	207,338
2007	387,883	250,901	136,982
2010	200,094	137,578	62,516
2015	57,895	43,442	14,453
2020	14,350	12,110	2,240
2030	245	302	(57)

We took two additional steps prior to calculating the 47-state heavy-duty diesel vehicle inventory. First, we needed to adjust the national excess emissions to exclude California, Alaska, and Hawaii. The amount of excess emissions in a geographical area is in part dependent on the proportion of driving that is done in defeat mode in that area. We could not develop a detailed analysis of driving patterns in the 47 states in the time available for this analysis. Therefore, we used the simplifying assumption that the excess emissions would be directly proportional to the total heavy-duty diesel VMT. We calculated the ratio of 47-state heavy-duty diesel VMT to 50-state heavy-duty diesel VMT and multiplied it by the net excess emissions in Table 1 to estimate the net excess in the 47 states.

We also took a second step to adjust the baseline MOBILE emissions. In order to calculate the final inventory, the net excess emissions need to be added to the baseline MOBILE emissions. Prior to doing this, we first had to make sure that both emissions estimates were based on similar assumptions. When we first compared the net excess emissions estimates with the MOBILE baseline estimate, we concluded that there was an inconsistency with respect to the way the two emissions estimates reflected the effects of vehicle speeds. As a result, we adjusted the baseline emissions to remove the effects of speed correction factors in a way that we thought would resolve this inconsistency.

During the preparation of this document, we realized that the two estimates actually were consistent with respect to speed correction factors. We realized this error too late to correct it in the NPRM. Table 2 shows the incorrect baseline and total emissions used in the NPRM and the correct values that should have been used. The result of the error is a 5-6% underestimation of heavy-duty diesel emissions in the NPRM and a 0.46% underestimation of total NOx emissions form all sources. This error has virtually no effect on the overall inventory and changes the NOx emissions fractions for various components of the total inventory by less than 1%.

For the Tier 2/Sulfur Final Rule, we plan to correct this mistake. We also plan to do a more thorough analysis breaking down emissions (and excess emissions) by roadway type. We would also like to incorporate geographical differences in frequency of travel on different roadway types.

Table 2. 47-State baseline and net excess NOx emissions (tons per year)

Year	47-State MOBILE5b Baseline	Incorrect Adjusted 47-State MOBILE5b Baseline	47-State Net Excess	Correct Total 47-State Emissions	Incorrect Total 47-State Emissions	% Difference
2005	1,507,687	1,419,930	182,654	1,690,341	1,602,584	-5.2%
2007	1,358,133	1,279,081	120,674	1,478,807	1,399,755	-5.3%
2010	1,219,869	1,148,865	55,073	1,274,942	1,203,938	-5.6%
2015	1,131,673	1,065,810	12,732	1,144,405	1,078,542	-5.8%
2020	1,168,869	1,100,844	1,973	1,170,842	1,102,817	-5.8%
2030	1,347,544	1,269,121	(50)	1,347,494	1,269,071	-5.8%

Urban Nonattainment Area Inventories

We used the same 47-state baseline calculated as described above, including the net excess inventories for NOx, to develop heavy-duty diesel inventories in Atlanta, Charlotte, Chicago, and New York. We calculated the fraction of annual 47-state VMT for summer ozone season VMT in each nonattainment area derived from inventories prepared by E.H. Pechan and Associates for the Ozone Transport Assessment Group. We multiplied this VMT fraction by the total heavy-duty diesel 47-state inventory to get estimates of summer emissions in each urban area.

Because we used the 47-state inventory described above as the basis for this calculation, the urban area inventories contain the same error for NOx emissions. Table 3 shows the NOx emissions used in the NPRM and the corrected NOx emissions for each urban area. Once again, the effects on the overall inventory and on the individual fractions of the inventory are negligible.

Table 3. Summer ozone season NOx emissions (tons per season)

Year	Correct Total Summer NOx Emissions	Incorrect Total Summer NOx Emissions
Atlanta		
2007	10,164	9,621
2010	8,886	8,391
2015	8,045	7,582
2020	8,313	7,830
2030	9,707	9,142
Charlotte		
2007	1,468	1,390
2010	1,266	1,196
2015	1,126	1,061
2020	1,147	1,080
2030	1,312	1,236
Chicago		
2007	18,878	17,869
2010	15,841	14,959
2015	13,552	12,772
2020	13,376	12,598
2030	14,564	13,717

New York		
2007	21,193	20,060
2010	18,155	17,144
2015	15,992	15,072
2020	16,173	15,233
2030	18,293	17,228

1. Kremer, Janet C., "Modifications to Heavy-Duty Diesel Emission Rates, Heavy Duty Mileage Accumulation, and Age Distributions in MOBILE5b for Tier 2/Sulfur NPRM", Memorandum to Docket A-97-10, March 29, 1999.

Glover, Edward, "Updating the PART5 Model", Memorandum to Docket A-97-10, March 1999.