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SmartWay U.S. Environmental Protection Agency

2021 SmartWay Truck Carrier Partner Tool:

Truck Tool Technical Documentation

U.S. Version 2.0.20 (Data Year 2020)

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Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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Table of Contents

Appendices

List of Tables

List of Figures

1.0 Overview

This document provides detailed background information on the data sources, calculation methods, and assumptions used within the SmartWay Truck Tool, version 2.0.20. The SmartWay Truck Tool utilizes the most up-to-date emission factors, in combination with detailed vehicle activity data, to estimate emissions and associated performance metrics. The primary purpose of the Tool is to help fleets calculate actual pollutant emissions for specific truck types and applications and track their emissions performance over time. Shippers can, in turn, use the data that truck carriers report using these Tools to develop more advanced emissions inventories associated with their freight activity and to track their emissions performance over time.

The Tool allows the user to evaluate fleet performance in terms of different mass-based performance metrics for carbon dioxide (CO_2), nitrogen oxides (NO_x), particulate matter (PM_{10} and $PM_{2.5}$), and black carbon (BC) including:[1]

- Grams per mile
- Grams per average payload ton-mile

The Tool can also generate estimates of emissions associated with the total miles, loaded miles, and revenue miles traveled by a fleet. Fleet performance can then be assessed at the truck-class and/or fuel-type level, or on an aggregated basis across all classes and fuels.

The Tool also collects extensive information on fleet operations and truck body types, allowing detailed segmentation of Partner fleets for more appropriate, equitable comparisons. For example, fleets that cube-out with low payloads (e.g., those hauling potato chips) will be able to compare themselves to similar fleets on a simple gram per mile basis, rather than a mix of fleets that includes fleets that routinely weigh-out. Similarly, fleets that operate in primarily urban environments at relatively low average speeds will have fundamentally different emission rates and constraints than fleets operating at highway speeds. By collecting detailed information on fleet operations (TL vs. LTL, urban vs. highway, etc.), as well as truck class (2b through 8b) and body type (dry van, reefer, flatbeds, etc.), individual fleets can compare their performance to other, similar fleets, which can help them to better manage their emissions performance.

[1] At this time the Truck Tool does not calculate performance metrics for specialty fleets that track their activity in terms of hours of use rather than miles traveled or freight hauled (e.g., refuse haulers and utility fleets). Future modifications may be made to the current Tool to accommodate such fleets.

2.0 Data Inputs and Sources

The SmartWay Truck Tool user provides most vehicle characteristic, operational, and activity data needed for emissions performance estimation (see Section 3 for more information). The Tool calculates emissions by multiplying fleet activity data with EPA-approved emission rate factors that are stored in look-up tables within the Tool.

The Tool contains different types of emission rate factors for different pollutants. CO_2 factors are expressed in grams of CO_2 *per gallon of fuel*.[2,3] NO_x, PM, and BC factors are expressed in grams of pollutant per mile traveled for operating emissions, and in grams per hour for idle emissions. In general, CO_2 factors are independent of the truck types, classes, and operational practices in a fleet. NO_x, PM and BC factors, however, vary depending upon a number of parameters, including:

- Truck class
- Engine model year/emission certification standard
- Vehicle speed
- Vehicle driving pattern (referred to as "drive cycle")

In addition, PM and BC emissions will also vary with the application of PM control retrofits, including diesel oxidation catalysts (DOC), closed crankcase ventilation (CCV), and diesel particulate filters ("PM traps" or flow-through filters). In the Tool, PM control retrofits are assumed to have the same impact on operating and idle emission factors, and control effectiveness for PM is assumed to equal the effectiveness for BC.[4]

2.1 CO_2 FACTORS

EPA populated the SmartWay Truck Tool with CO_2 factors that are based on fuel consumption. These factors and their sources and are summarized below in Table 1.

[2] At this time other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) are not included in the current Truck Tool.

[3] The Truck Tool also estimates emissions associated with battery-electric trucks. In this case pollutant emissions (CO_2, NOx and PM) are determined based on the kWhrs used for charging.

[4] Future versions of the Tool may account for differences in retrofit effectiveness for running versus idle emissions, and differences between PM and BC control effectiveness.

Table 1. CO_2 Factors by Fuel Type*

	g/gal	Source[5]
Gasoline	8,887	(i)
Diesel	10,180	(ii)
Biodiesel (B100)	9,460	(iii)
Ethanol (E100)	5,764	(iv)
CNG	7,030	(v)
LNG	4,394	(vi)
LPG	5,790	(vii)

* 100% combustion (oxidation) assumed

Note that the Tool calculates tailpipe emissions from biofuel blends (gasoline/ethanol, diesel/biodiesel) by applying separate emission factors to the user-specified volume of each blend component. The Tool then adds the emissions from each blend component together to determine total CO_2 emissions. Therefore, emission factors for specific blend ratios are not needed for CO_2.[6]

Within the Tool, users may provide their CNG fuel use estimates in terms of gasoline-gallon equivalent (GGE) (on a Btu basis), diesel-gallon equivalent (DGE), or in standard cubic feet (scf). If CNG consumption is expressed in DGE or scf, the Tool uses the following factors to convert the CNG fuel estimates to GGE.

For CNG:

- Diesel-Gallon Equivalent (DGE) to Gasoline-Gallon Equivalent (GGE)
  - 1 DGE = 1.112 GGE[7]
  - Note: 1 GGE = 125,000 BTU and 1 DGE = 139,000 BTU, so 1 DGE = 1.112 GGE (139,000/125,000).
- Cubic Feet (cuft) to Gasoline-Gallon Equivalent (GGE)

[5] i) Final Rule on Light-Duty Vehicle Greenhouse Gas Emissions Standards and Corporate Average Fuel Economy Standards (75 FR 25324, May 7, 2010). The gasoline factor used in this rule was sourced from the California Air Resources Board and is based on measurement of carbon from a gasoline test fuel (indolene).

ii) Fuel economy calculations in 40 C.F.R 600.113 available at http://edocket.access.gpo.gov/cfr_2004/julqtr/pdf/40cfr600.113-93.pdf, Accessed 11-29-20.

iii) Tables IV.A.3-2 and 3-3 in A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, available at https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=OTAQ&dirEntryId=73882, Accessed 11-29-20.

iv) Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, September 15, 2009). Full source documentation is available on pp. 31-32 in the Technical Support Document, *Petroleum Products and Natural Gas Liquids: Definitions, Emission Factors, Methods and Assumptions*, available at https://www.epa.gov/sites/production/files/2015-07/documents/subpartmmproductdefinitions.pdf, Accessed 11-29-20.

v) Calculations of Lifecycle Greenhouse Gas Emissions for the 2005 Gasoline and Diesel Baselines in the Notice of Availability of Expert Peer Review Record supporting the proposed revisions to the Renewable Fuel Standard Program (74 FR 41359) available in Docket EPA-HQ-OAR-2005-0161-0925.1 (Spreadsheet "Emission Factors").

vi) Assuming 74,720 Btu/gal lower heating value (http://www.afdc.energy.gov/afdc/fuels/properties.html, Accessed 11-29-20), and 0.059 g/Btu (from CNG calculation, source v).

vii) Table C-1 in the Final Rule on Mandatory Reporting of Greenhouse Gases (70 FR 56260, October 30, 2009). Full source documentation is available in Table A-39 and pg. A-60 of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2007* available at https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2007, Accessed 11-29-20.

[6] The Tool also estimates the barrels of petroleum required to make the reported gallons of diesel and gasoline based on national averages: 19 gallons of gasoline and 10 gallons of diesel assumed per barrel of petroleum.

[7] Midwest Energy Solutions. Energy Volume & Weight. http://www.midwestenergysolutions.net/cng-resources/energy-volume-weight, Accessed 11-29-20.

- 123.57 cuft = 1 GGE[8]

For LNG, users may provide their fuel use estimates in terms of physical gallons, gasoline-gallon equivalent (GGE) (on a Btu basis), diesel-gallon equivalent (DGE), or in pounds (lbs). If LNG consumption is expressed in GGE, DGE, or pounds, the Tool uses the following factors to convert the LNG fuel estimates to physical gallons.

For LNG:

- Diesel-Gallon Equivalent (DGE) to Physical Gallon
  - 1 DGE = 1.7 Gallons LNG[9]
- Gasoline-Gallon Equivalent (GGE) to Physical Gallon
  - 1 GGE = 1.5 Gallons LNG[10]
- Pounds (lbs) to Physical Gallon
  - 3.49 lbs LNG = 1 LNG Gallons[11]

2.2 NO_X, PM AND BC FACTORS

The SmartWay Truck Tool contains NO_x, PM_{10}, $PM_{2.5}$ and BC[12] emission factor outputs for on-road operation from EPA's MOVES2014b model for diesel and E10[13] for all heavy truck classes (2b – 8b) under national default temperature and fuel conditions, for model years 1989 through 2021, for the 2020 calendar year (see Appendix A for a full list of factors). The emission factors are broken out by general drive cycle type (urban or highway), and average speed range, as discussed below.

Short-duration (less than 60 minutes) idle emission factors for NO_x, PM and BC were developed separately by model year, truck class, and fuel type (diesel and gasoline). MOVES2014b does not currently provide short duration idle factors in terms of grams per hour, so MOVES2014b was run using the Project Level scale with a single link and with an average speed of zero. Runs were performed for typical winter and summer conditions, taking the average of outputs from those runs to obtain g/hr factors.

MOVES2014b does provide emission factors for long-duration idle for long-haul diesel trucks. These factors are applied separately to the long-duration idle hour estimates provided for Class 8b trucks within the Truck Tool.[14] Short-duration factors are applied across the board for the remaining truck class types.

8 Alternative Fuels Data Center. Gasoline and Diesel Gallon Equivalency Methodology. http://www.afdc.energy.gov/fuels/equivalency_methodology.html, Accessed 112-29-2020.

9 Midwest Energy Solutions. Energy Volume & Weight. http://www.midwestenergysolutions.net/cng-resources/energy-volume-weight Accessed 11-29-2020.

10 Ibid.

11 Ibid.

12 Black carbon factors are assumed to equal the elemental carbon gram per mile factors output by the MOVES model.

13 All gasoline consumption in the United States and Canada is now assumed to consist of E10. Pure gasoline (E0) emission factors are no longer used in the Truck Tool. References to "gasoline" in the Tool and the associated documentation refer to E10.

14 NO_x factors for long-term extended idling are higher than short-duration factors (at least for late model engines), since engine operation temperatures and loads at idle are generally not high enough to activate late-model emission controls such as selective catalytic reduction and exhaust gas recirculation.

Note that hybrid electric trucks are assumed to have no short-duration idle emissions (due to assumed engine auto-shut off), although long-duration idle (and regular exhaust[15]) emissions are assumed unchanged relative to their conventional vehicle counterparts. Finally, battery-electric trucks are assumed to have no idle emissions of either kind.

The resulting idle factors are presented in Appendix B.

Version 2.0.20 of the Truck Tool also calculates the NO_x, PM and BC emissions associated with transportation refrigeration (reefer) units. The MOVES2014b emissions model was used to develop emission rates for these units for the 2020 calendar year, following these steps:

- A national average model run was performed for the Industrial sector, including gasoline and diesel fueled equipment;
- The A/C refrigeration (reefer) unit standard classification codes (SCCs) were extracted from the output files – 2265003060 (gasoline) and 2270003060 (diesel);
- Grams per day outputs for weekdays and weekends for each of the 12 months were converted to grams per year by aggregating emissions over day types to arrive at an average day value, multiplying by the number of days in each month, and summing over month. This resulted in annual grams of emissions (of NO_x, PM_{10}, and $PM_{2.5}$) and grams of fuel consumed (in terms of brake specific fuel consumption or BSFC), for each fuel type;
- BSFC was converted from grams to gallons fuel using the MOVES energy density values of 2,819 g/gal and 3,167 g/gal for gasoline and diesel, respectively.
- Grams/gallon emission factors were then calculated for each pollutant by dividing the annual grams of emissions of NO_x, PM_{10} and $PM_{2.5}$ by the annual gallons of fuel consumed for gasoline and diesel.

Black carbon emissions associated with reefer activity were scaled from $PM_{2.5}$ reefer emissions, applying conversion factors for nonroad equipment from the Commission for Environmental Cooperation (0.349 for diesel engines and 0.122 for gasoline engines).[16]

Table 2 provides the fuel factors used in the latest Truck Tool.

Table 2. Weighted Average Reefer Fuel Factors (g/gallon)

Fuel	NO_x	PM_{10}	$PM_{2.5}$	BC
Diesel	49.928	1.477	1.433	0.500
Gasoline	17.642	0.996	0.916	0.112

[15] While there is evidence that NO_x emissions may be decreased through the use of hybrid electric technology, EPA has not performed emission testing to assess this effect. Therefore, hybrid NO_x and PM/BC exhaust emission rates are assumed to equal conventional vehicle equivalents in the current Truck Tool.

[16] Commission for Environmental Cooperation (CEC), 2015. North American Black Carbon Emissions Estimation Guidelines: Methods for Estimating Black Carbon Emissions. Prepared for the CEC by Eastern Research Group, Inc. Final Report, May 2015.

The next section describes the process followed to select the on-road emission factors from MOVES2014b for use in the Truck Tool. Emission factors in grams per mile were developed for E10 and diesel fuel types for all MOVES source types that correspond to the regulatory heavy-duty vehicle classes, 2b-8b inclusive. The MOVES source types modeled are shown in the table below. Of these, school buses, refuse trucks and motor homes represent only a small fraction of total activity.

Table 3. MOVES Source Types Associated with Class 2b – 8b Vehicles

Source Type ID	Source Type Name
31	Passenger Truck
32	Light Commercial Truck
43	School Bus
51	Refuse Truck
52	Single Unit Short-haul Truck
53	Single Unit Long-haul Truck
54	Motor Home
61	Combination Short-haul Truck
62	Combination Long-haul Truck

Separate factors were developed for "Urban" and "Highway/Rural" roadway types. These factors were apportioned according to MOVES operating mode groups, which correspond to speed ranges of 0-25 mph, 25-50 mph, and 50+ mph.

Emission factors calculated by the model, output by MOVES source type, were then converted to a vehicle class basis. In this way, the Truck Tool can select appropriate emission factors for use by:

- weight class
- model year
- road type (urban vs. highway/rural)
- speed distribution

The following describes the methodology for the emission factor calculation.

Calculation of MOVES emission factors by operating mode

In calculating emission factors, the primary goal is to disaggregate factors by the percentage of time a given type of vehicle spends operating at certain speeds. The ranges of speeds analyzed include 0-25 mph, 25-50 mph, and greater than 50 mph. These speed ranges correspond to MOVES operating modes #11-16, 21-29, and 30-40 inclusive, where each operating mode is defined by both the speed of the vehicle and its vehicle specific power (VSP). First, for a given source type and model year, the fraction of emissions attributable to each range of speed was determined. Emissions for a vehicle can be expressed in Equation 1:

Equation 1

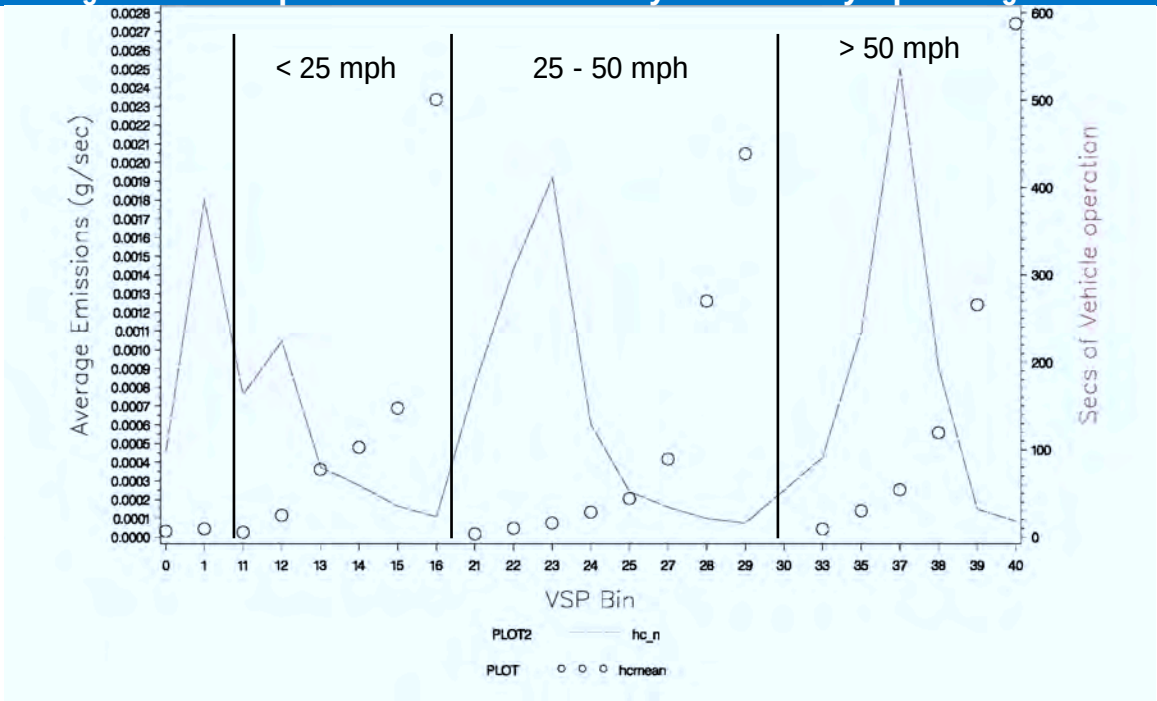
$$E` = A_1E_1` + A_2E_2` + A_3E_3` + A_IE_I + A_BE_B$$

Where:

$E`$	=	uncorrected[17] mass emissions calculated based on operating mode and emissions contribution by speed bin
A_{1-3}	=	the sum of activity fractions (in seconds) over speed range n. (A_I and A_B represent the activity associated with the individual operating modes for idling and braking, respectively.)
$E_{1-3}`$	=	the weighted average emissions over a given speed range n. (E_I and E_B represent the emissions associated with the individual operating modes for idling and braking, respectively.)

The following figure shows a range of emissions and activity fractions for an example source type and model year. The operating mode (or VSP bin) are shown on the x-axis. The dashed red line presents the fraction of vehicle activity associated with a given operating mode, while the black circles present average HC emissions for each operating mode.

Figure 1. Example Emissions and Activity Fractions by Operating Mode



For our purposes, A_n from Equation 1 is obtained by retaining the "opmodefraction2" table from the "MOVESExecution" database, which is created by the Operating Mode Distribution Generator (OMDG) during a

[17] Subsequent adjustment factors are presented in Equation 3 below.

MOVES run. This table contains operating mode fractions by source type, roadway type, average speed bin, and pollutant/process. The fractions from this table are normalized using average speed distributions from the "avgspeeddist" table, and the sum of the normalized operating mode fractions in each speed bin constitutes A_n.

E_n` is derived from data obtained from the default MOVES "emissionratebyage" table. This table contains emission rates by pollutant process, operating mode, and age group for a wide variety of *sourcebinIDs*. For this analysis, a MySQL query was used to select *sourcebinIDs* corresponding to the source type, fuel type, and calendar year of interest, and limited our rate selection to the 4-5 year age group. The emissions obtained here were then converted to a source type basis (from their current *sourcebinID* basis); this was done by retaining the "sourcebindistribution" table from the MOVESExecution database, which is created by the Source Bin Distribution Generator (SBDG) during each MOVES run, and weighting the activity fractions for each source type and model year combination in this table with the data from the "emissionratebyage" table described above. Having finished this mapping, an emission rate is generated, by source type and model year, for each operating mode (corresponding to the circles in the figure above). Since E_n` for each speed range represents the average emissions of the range weighted by the activity in that range, the weighted average emissions can be calculated from the 0-25 mph speed bin, $E_1$`, as follows in Equation 2:

Equation 2

$$E_1` = \frac{R_{11}T_{11} + R_{12}T_{12} + R_{13}T_{13} + R_{14}T_{14} + R_{15}T_{15} + R_{16}T_{16}}{\sum_{11}^{16} R_n}$$

Where:

R_n = The activity fraction for operating mode n, obtained from the "opmodedist2" table

T_n = The emissions for operating mode n.

Other speed bins will use different operating modes in their calculations; the equation above is merely an example illustrating the calculation method for the first speed bin. Having calculated an appropriate E_n` for each speed range for a given source type and model year, Equation 1 can be used, along with the appropriate activity fraction, to arrive at a total uncorrected emissions value. In and of itself, this emission factor has little value in estimating emissions. However, it can be used along with the modeled emission factor for a particular source type and model year to arrive at an overall adjustment factor, as shown in Equation 3:

Equation 3

$$Z = \frac{E}{E`}$$

Where:

E = The modeled emission, obtained from MOVES outputs, for an individual source type and model year

E` = The uncorrected emissions for an individual source type and model year, calculated using operating mode distributions and emission factors from the "emissionratebyage" table

This overall adjustment factor, in turn, can be applied to each individual emissions component, $E_n`$, as shown in Equation 4:

Equation 4

$$E_n = ZE_n`$$

The adjusted emissions, E_n, are subsequently used to calculate a total, corrected emission factor for a given source type and model year combination, as described by Equation 5:

Equation 5

$$E = A_1E_1 + A_2E_2 + A_3E_3 + A_IE_I + A_BE_B$$

In this way, a representative emission factor is calculated by operating mode/speed group. This will allow the Truck Tool to adjust the default operating mode percentages (A_n) to more accurately represent a user-provided speed profile for the vehicles they are evaluating. Default operating mode percentages may also be used, as calculated above.

Conversion of Emission Factors from Source Type to Weight Class Basis

Ultimately, emission factor lookup tables are required for use in the Truck Tool by weight class, fuel type, and model year. However, modeled output from MOVES is aggregated by source type. Therefore a post-processing Tool was developed to convert vehicle emission factors from source types to weight class based on internal MOVES tables. The conversion methodology used in this Tool is described below.

First, the adjusted emissions and activity output from MOVES are combined, *by pollutantID*, by joining the "movesoutput" and "movesactivityoutput" tables by calendar year, source type, fuel type and model year. The sourcetype and model year for each record are combined in a new field, *sourcetypemodelyearID*.

Next, the emissions and activity output from the first step are combined with the MOVES "sizeweightfraction" table by joining on the *sourcetypemodelyearID*. The "sizeweightfraction" table contains, for a given combination of source type and model year, the fraction of vehicles apportioned across *weightclassID*. Given the *weightclassID*, the portion of emissions and activity attributable to a given range of vehicle weights is determined, and subsequently, those weights (along with fuel type) are mapped back to MOBILE6 vehicle classes, which are based on GVWR. (This is achieved with a separate lookup table, "M6VehType", which is derived from Appendix B, Table 3 of the EPA's MOBILE6.2 User's Guide.) For each calendar year, *sourcetypemodelyearID* and *pollutantID*, the sizeweightfraction is multiplied by the emissions (in grams) and activity (in miles) to obtain *EmissionFrac* and *ActivityFrac*, respectively.

Finally, the *EmissionFrac* and *ActivityFrac* calculated above are summed by *yearID*, *pollutantID*, *fueltypeID*, and vehicle class (e.g., HDDV8b). This provides total emissions and activity independent of the MOVES source type or vehicle model year. Finally, the aggregated emissions are divided by the activity to arrive at g/mi emission factors presented in Appendix A.

Modeling Gasoline Emission Rates

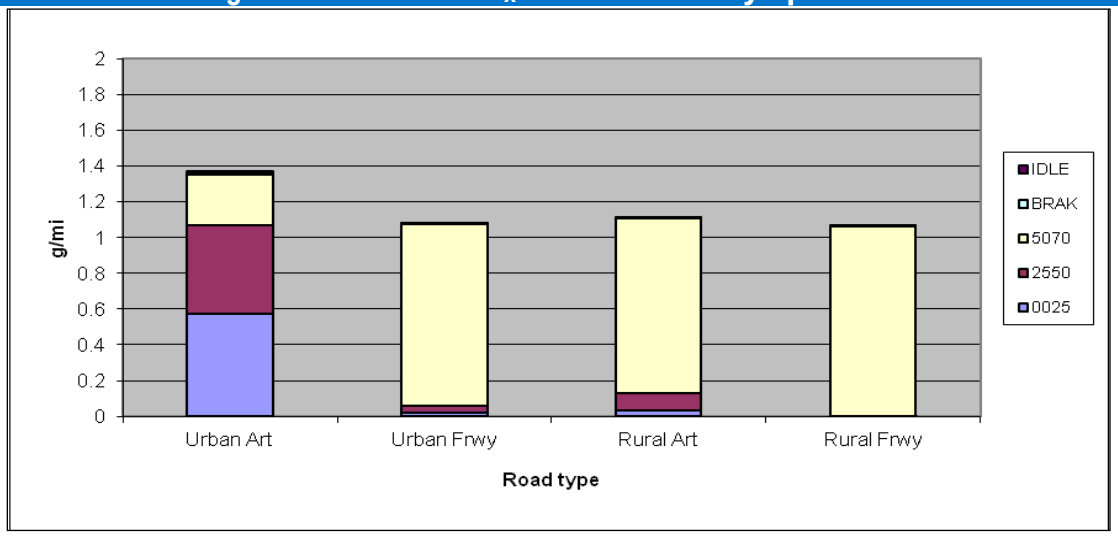
In a MOVES run that uses nationwide defaults for fuel supply, the model includes dozens of fuel formulations on a by-fuel region basis in its calculations. In addition to diesel fuels, many counties in the model defaults are characterized by varying market shares of and E10 and E15.[18]

In order to isolate Gasoline emission factors, the new Fuels Wizard included in MOVES2014b was used to alter the ethanol percentage of fuels nationwide to zero.

Sensitivity Analysis Results

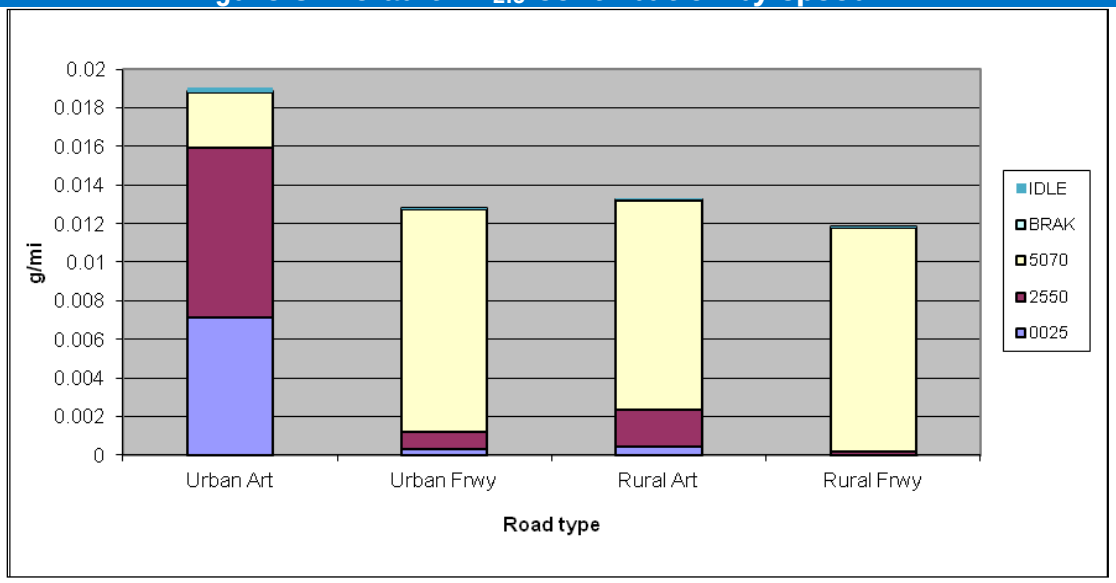
The relative emissions impact of different speed regimes were evaluated for four road types – urban arterial, urban freeway, rural arterial, and rural freeway. To simplify the sensitivity analysis, MOVES outputs were generated for diesel long-haul combination trucks, model year 2012, run for the 2014 calendar year, using national average defaults (e.g., fuel specifications, temperatures, etc.). The results of the analysis are shown for NOx and $PM_{2.5}$ below.

Figure 2. Default NO_x Contribution by Speed Bin



[18] Only 2001+ model year light-duty vehicles may use E15 fuel. See http://www.afdc.energy.gov/fuels/ethanol_e15.html. Accessed 11-29-2020.

Figure 3. Default $PM_{2.5}$ Contribution by Speed Bin



As shown in the above charts, the emissions for urban freeways, rural arterials, and rural freeways are all heavily dominated by high speed (50 – 70 mph) operation.[19] In addition, actual emission levels are relatively insensitive to road type across these three types. However, speed distribution appears to have a significant bearing on emissions for urban arterial operation. Accordingly, the recommendation for Truck Tool application was to develop fully disaggregated emission factor look up tables (retaining all four road types), and then weight urban freeway, rural arterial, and rural freeway road type operations in order to aggregate emission lookup tables within the SmartWay Tool to reflect "urban" (i.e., urban arterial) and "other" road types. In addition, under this approach users can choose default speed distributions for these selections or specify the percent of operation by major speed range (0 – 25, 25 – 50, 50 – 70). Given the relative insensitivity to speed for the "other" category, specifying speed distributions would only be permitted for urban arterial operation.

Under this approach, the user is given the follow input options:

- Specify % Highway/Rural ("other") operation fraction
- Specify % urban operation distribution by speed bin, or select "default speed distribution"

Data entry is handled through the addition of a popup screen for non-default selections (see the Truck Tool User Guides for details).

[19] This finding is consistent with the 2008 SmartWay Partner data submissions, wherein 87% of Partners selected the 50+ mph category as the most representative of their non-urban operations.

2.3 ALTERNATIVE FUELS

Heavy truck emission factors are not available from MOVES2014b for certain alternative fuels, including E85, natural gas, and LPG. Accordingly, EPA used adjustment factors from a number of sources described below to estimate NO_x and PM/BC factors for these other fuels.

NO_x and PM emission factors for biodiesel are based on the findings from an EPA study, A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions (EPA420-P-02-001, October 2002). This study developed regression equations to predict the percentage change in NO_x and PM emission rates relative to conventional diesel fuel, as a function of biodiesel blend percentage, expressed in the following form:

Equation 6

$$\% \text{ change in emissions} = \{\exp[a \times (\text{vol\% biodiesel})] - 1\} \times 100\%$$

Where:

a = 0.0009794 for NO_x, and

a = -0.006384 for PM and BC[20]

Using Equation 6, adjustment factors were developed for biodiesel blends based on the percentage of the biofuel component,[21] and then these adjustment factors were applied to the appropriate conventional diesel emission factors in Appendix A. (See Section 2.2 for the sources of conventional diesel emission factors). Note that the fleet-average blend value is assumed to be the same for all truck classes, since the biofuel consumption data is not collected at the truck class level. (This assumption holds for ethanol consumption data inputs as well.)

MOVES2014b now incorporates specific modeling assumptions for biodiesel, including options for modeling 5 and 20 percent biodiesel (B5 and B20). While the pre-2007 vehicle estimates are consistent with EPA's 2002 study findings, MOVES does not estimate an emissions effect on 2007+ model year diesel trucks because the literature does not show consistent or significant biodiesel effects on theses engines.[22,23] Accordingly, the Truck Tool only applies adjustment factors for diesel engine model years prior to 2007.

For gasoline-ethanol blends, the SmartWay Truck Tool only accepts fuel consumption estimates for E10 and E85 since, unlike biodiesel where the biofuel fraction can vary significantly, ethanol is generally blended with gasoline at two discrete levels: 10% (E10) and 85% (E85). As discussed in Section 2.2 above, NO_x and PM factors for E10 were output directly from MOVES2014b. Given the lack of heavy-duty E85 test data, adjustment factors for E85 were based on emissions estimates for light-duty vehicles cited by the US DOE Alternative Fuels and

[20] BC emission rates as a function of biodiesel blend have not been identified at this time and are currently assumed identical to the PM relationship.

[21] Biodiesel blend percentage is calculated by dividing B100-equivalent gallons by total fuel gallons at the fleet level – see the Truck Tool User Guides for details regarding biodiesel use inputs.

[22] McCormick, R. and A. Williams, 2011. *Impact of Biodiesel on Modern Diesel Engine Emissions*. Project ID: FT011. National Renewable Energy Laboratory, Golden, CO. May 9, 2011. http://energy.gov/eere/vehicles/downloads/impact-biodiesel-modern-diesel-engine-emissions, Accessed 11-29-2020.

[23] CARB 2011. Final Report for the CE-CERT Engine Testing Portion for the CARB Assessment of the Emissions from the Use of Biodiesel as a Motor Vehicle Fuel in California Biodiesel Characterization and NOx Mitigation Study. Final Report Prepared for CARB. October 2011. https://www.arb.ca.gov/fuels/diesel/altdiesel/20111013_CARB%20Final%20Biodiesel%20Report.pdf, Accessed 11-29-2020.

Advanced Vehicles Data Center.[24] These estimates come from a technical paper published in the Journal of Air & Waste Management.[25] Relative to conventional gas vehicles, the authors of this paper estimate that vehicles running on E85 provide an average NO_x reduction of 54% (based on 73 vehicle tests), and an average PM reduction of 34% (based on 3 vehicle tests). These adjustment factors are applied to the appropriate gasoline engine emission factors in Appendix A to develop emission factors for E85.

Emission adjustment factors were used for gaseous fuels (LPG, CNG and LNG), developed by the National Renewable Energy Lab and University of West Virginia based on field studies on natural gas vehicles.[26] For this assessment, it was assumed that CNG and LNG emissions were identical. In addition, it was also assumed LPG vehicle emissions would be equal to natural gas vehicle emissions.[27] To be conservative, the smallest emission reduction estimates were selected from the natural gas vehicle field test data (86% for PM and 17% for NOx) relative to comparable diesel vehicles. These adjustment factors are applied to the diesel emission factors in Appendix A and B to develop emission factors for these fuels.

Note, however, that the emissions associated with alternative fuels may be different for older trucks (with minimal emission controls) and newer trucks (with extensive control systems in place) due to recent vehicle emission standards. Newer studies suggest there are differences by model year in the emission rates of gaseous fuel vehicles. A 2014 study performed by West Virginia University[28] using Class 8 trucks found that a model year 2011 dual-fuel (5% diesel, 95% LNG) high-pressure direct injection (HDPI) truck emitted 63% and 48% less NO_x and PM, respectively compared to a MY 2011 diesel truck equipped with an SCR and DPF. Both vehicles operated on the urban dynamometer driving schedule (UDDS). The same WVU study found that a MY 2011 natural gas engine equipped with a three-way catalyst (TWC) emitted 79% and 56% less NO_x and PM compared to the MY 2011 diesel truck, also on the UDDS.

Based on this new information, the Tool uses a simple average across the two engines tested in the WVU study, resulting in a 71% reduction for NOx and a 52% reduction for PM, and applies these new reduction values to comparable diesel emission factors for 2010 and later model year gaseous fuel trucks. For model years prior to 2010, the adjustment factors of 17% for NO_x and 86% for PM are retained.

Emission estimates for battery-electric trucks are based on national average electric generation mix profiles from USDOE's GREET model, as described in Appendix C.

Black carbon (BC) emissions associated with gaseous fuels are determined by multiplying the ratio of elemental carbon (EC) and $PM_{2.5}$ emission factors from MOVES2014a for CNG transit buses, for calendar year 2018. The ratio EC to $PM_{2.5}$ varies by model year group (0.0925 for pre-2002 model years, and 0.1112 for 2002+ model

[24] See http://www.afdc.energy.gov/afdc/vehicles/emissions_e85.html, Accessed 11-92-2020.

[25] See http://www.afdc.energy.gov/afdc/pdfs/technical_paper_feb09.pdf, Accessed 11-29-2020.

[26] See http://www.conaturalgascoalition.com/clean.html, Accessed 11-16-18.

[27] The PM and NO_x estimates cited by this source for LPG vehicles were actually slightly lower than for natural gas vehicles - http://www.afdc.energy.gov/afdc/vehicles/emissions_propane.html Accessed 11-29-2020. However, based on engineering judgment it was assumed that LPG PM and NO_x emissions would be similar to comparable CNG vehicles.

[28] Carder, D.K., M. Gautam, A. Thiruvengadam, M. Besch. *In-Use Emissions Testing and Demonstration of Retrofit Technology for Control of On-Road Heavy-Duty Engines.* Prepared for the South Coast Air Quality Management District. September 2013. https://lazerinitiative.org/resources/in-use-emissions-testing-and-demonstration-of-retrofit-technology-for-control-of-on-road-heavy-duty-engines-2/, Accessed 11-29-2020.

years), so these different factors are applied for the different engine age groups as appropriate in order to determine BC levels for these fuel types.

2.4 PM CONTROL EFFECTIVENESS

The Truck Tool applies adjustment factors to the PM emission factors in Appendix A and B for any pre-2007 diesel truck for which Partners have installed a specific retrofit control device. The following adjustment factors were obtained from EPA OTAQ (presented as a % reduction in emissions; see Section 3.2 below for details):

- Diesel oxidation catalyst (DOC) – 25%
- Closed crankcase ventilation (CCV) – 5%
- Diesel particulate filter (DPF) – 90%

References from EPA's Clean Diesel Program are generally consistent with the DOC and DPF effectiveness estimates above (20 – 40% for DOCs, and 85% or more for DPFs).[29,30] Note that an independent estimate of CCV effectiveness was not identified, as EPA and CARB only verify CCVs when packaged with DOCs.

The Tool applies the above adjustment factors to pre-2007 PM operating and idle emission estimates. The Tool also allows for situations where CCVs are applied in combination with either DOCs or DPFs. In such a case, the reduction effectiveness is calculated additively. For example, if pre-control operating emissions were 1.0 g/mile for a diesel truck, and a CCV and DOC were applied, the resulting emission rate would be:

Equation 7

$$1.0 \times [1 - (0.25 + 0.05)] = 0.07 \text{ g/mile, post-control}$$

However, the Truck Tool assumes that DOC and DPF application are mutually exclusive.

At this time the relative effectiveness of the controls addressed above are assumed to be equal for PM and BC.

[29] EPA 2010a, National Clean Diesel Campaign Technical Bulletin: Diesel Oxidation Catalyst General Information. See https://www.epa.gov/sites/production/files/2016-03/documents/420f10031.pdf, Accessed 11-29-2020.

[30] EPA 2010b, National Clean Diesel Campaign Technical Bulletin: Diesel Particulate Filter General Information. See https://www.epa.gov/sites/production/files/2016-03/documents/420f10029.pdf, Accessed 11-29-2020.

3.0 Emission and Activity Estimation

The emission rates and adjustment factors discussed above are combined with appropriate activity data (provided by the Partners) to calculate mass emissions at the fleet and/or partner level for CO_2, NO_x, PM, and BC as described below.

3.1 CO_2 EMISSIONS

CO_2 is calculated within the Truck Tool utilizing emission factors expressed in *grams per gallon of fuel*, (with the exception of battery-electric trucks), as discussed in Section 2.1 above. The general equation for calculating CO_2 emissions using reported fuel consumption values is

Equation 8

$$E_{CO2} = ((F - B) \times EF_F) + (B \times EF_B))$$

Where:

E_{CO2}	=	grams CO_2 per year
F	=	Total Fuel (Gallons per year)
B	=	Biofuel (Gallons per year)
EF_F	=	Fossil Fuel Emissions Factor (g/gal based on fuel type)
EF_B	=	Biofuel Emissions Factor (g/gal based on biofuel type)

Emissions for *all* pollutants for battery electric trucks are calculated by multiplying the reported kWhrs used for charging by the associated g/kWhr factor (see Appendix C).

In most instances reefer fuel is aggregated with vehicle fuel inputs in the Truck Tool, with the reefer fuel type assumed to be the same as the vehicle fuel type. However, reefer units associated with gaseous fuels (LPG, CNG, and LNG) and electric trucks are assumed to use diesel fuel (by far the most common type of reefer engine). Accordingly, any reefer fuel use reported for gaseous fuels and electric trucks is included in the total CO_2 calculation using the diesel fuel factors in Equation 8.

Fuel Allocator

The Truck Carrier Tool asks users to enter Gallons of Fuel Used for Engine Power (including biofuel) by truck class in order to estimate CO_2 emissions. This information may be entered directly if available. However, if the user does not have this information but does know total fuel use and MPG by truck class, the Truck Tool's Fuel Allocator can be used to apportion fuel use across truck classes.

In the **Fuel Allocator**, the user enters total fuel consumption and truck class MPG estimates. The allocator then calculates the fuel used for each class based on the total fuel and class MPG. If the total fuel calculated matches the total fuel entered to within 2%, the allocator indicates a "Match". However, instead of writing the exact calculated value seen in the Fuel Allocator to the Activity screen, the Tool adjusts the class fuel amounts

(and therefore MPG) so the sum matches the Total Fuel entered exactly, and then writes these values on the Activity screen. That means, the MPG entered into the Fuel Allocator, and the calculated fuel used seen on the Fuel Allocator, are not necessarily equal to the MPG and the fuel used that is written to the Activity Screen.

If the user re-opens the Fuel Allocator at this point, the Allocator brings in the MPGs listed on the Activity Screen, NOT the MPGs the user input into the calculator the first time (although it doesn't overwrite the saved MPGs entered on the worksheet, if the user presses Cancel). For remaining calculations in the Tool, the values shown on the Activity Screen are used. The Allocator values the user entered are saved for the XML file, but aren't used for further calculations. Separately in the XML, the MPG and fuel totals that were put onto the Activity Screen are also written.

3.2 NO_X, PM AND BC EMISSIONS

Unlike CO_2 emissions which only vary with fuel type, NO_x, PM and BC emission rates also vary substantially depending upon engine model year and/or emission certification level, vehicle class, drive cycle, speed, and operation mode (running or idle). For this reason, EPA developed lookup tables in the Truck Tool with emission factors that correspond to user-supplied inputs regarding their fleet activity. The NO_x, PM and BC emission rates expressed in *grams per mile* were combined with the appropriate mileage metric (i.e., total miles) in order to estimate mass emissions. The general equation for calculating NO_x emissions is as follows:

Equation 9

$$E_{NOx} = \sum [(M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2} \times UDC_2) + (GPM_{U3} \times UDC_3) + (GPM_{U4} \times UDC_4))) \times T_{CY} / T_{CT}) + (GPH_{SDI} \times H_{SDI} \times T_{CY}) + (GPH_{LDI} \times H_{LDI} \times T_{CY})]$$

Where:

E_{NOx}	=	grams NO_x per year for a given truck class
$\sum$	=	summation across model years
M_C	=	Miles driven for Truck Class C per year
GPM_H	=	Grams/mi (by truck class & engine yr) for Highway/Rural Driving
HDC	=	Highway drive cycle % (% of miles under highway/rural driving)
$GPM_{U1/2/3/4}$	=	Grams/mi (by truck class & engine yr) for Urban Driving by mode (1 = 0 – 25 mph; 2 = 25 – 50 mph; 3 = 50+ mph; 4 = deceleration)
$UDC_{1/2/3/4}$	=	Urban drive cycle % (% of miles under urban driving conditions, by mode (1, 2, 3, 4))
T_{CY}	=	Number of trucks for a given Class/Year combination
T_{CT}	=	Number of trucks total for a given Class
GPH_{SDI}	=	Grams per hour (by truck class & engine year) for short-duration Idling[31]
H_{SDI}	=	Hours of short duration Idling per year (average per truck per year by class)
GPH_{LDI}	=	Grams per hour (by truck class & engine year) for long-duration Idling

[31] The idle calculation for Class 8a and lighter trucks does not distinguish between short and long duration idling, and all idle hours are multiplied by the short duration idle factor for these trucks. Hybrid electric trucks are assumed to have no short-duration idling emissions, while battery-electric trucks have no idling emissions of any kind.

H_{LDI} = Hours of long duration Idling per year (average per truck per year by class)

PM emissions for non-diesel vehicles are calculated using an equation identical to that for NO_x, utilizing PM emission factors. PM emission for diesel vehicles may be adjusted for PM control effectiveness, as shown below. (BC emissions are calculated in identical fashion.)

Equation 10

$$E_{PM} = \sum [(((M_C \times ((GPM_H \times HDC) + (GPM_{U1} \times UDC_1) + (GPM_{U2} \times UDC_2) + (GPM_{U3} \times UDC_3) + (GPM_{U4} \times UDC_4))) \times T_{CY} / T_{CT}) + (GPH_{SDI} \times H_{SDI} \times T_{CY}) + (GPH_{LDI} \times H_{LDI} \times T_{CY})) \times (1 - ((0.25 \times T_{DOC} / T_{CT}) + (0.05 \times T_{CCV} / T_{CT}) + (0.9 \times T_{DPF} / T_{CT})))]$$

Where:

E_{PM} = grams PM per year for a given truck class

T_{DOC} = Number of trucks using Diesel Oxidation Catalysts by class

T_{CCV} = Number of trucks using Closed Crankcase Ventilation by class

T_{DPF} = Number of trucks using Diesel Particulate Filters by class

0.25 = Effectiveness of DOCs (25%) at reducing particulate matter

0.05 = Effectiveness of CCVs (5%) at reducing particulate matter

0.9 = Effectiveness of DPFs (90%) at reducing particulate matter

Note the above calculation methodology assumes that the same highway/urban drive cycle fractions apply across all model years of a given truck class. Similarly, the method assumes that estimated idle hours apply equally to all model years of a given truck class.

The above methodology also utilizes estimates for the fraction of miles traveled associated with different road types and speed categories, as shown in the equations above. The Truck Tool user must provide an estimate of the percent of total miles associated with highway/rural driving for each truck class. The user may also provide percentages for the miles spent driving in urban conditions (e.g., unrestricted access, surface roads in well-traveled urban areas), for different speed categories (0 – 25 / 25 – 50 / 50+ mph). This information may be obtained from analysis of truck ECM or possibly GPS data. If urban speed distribution data is not available, the user may select to use default distributions, obtained from the MOVES model. The default speed distributions for urban operation (as defined in Section 2.2 above) varies with vehicle class and model year. However, the variation over model years is very slight (typically with a range of 1 to 2 percent for the largest speed category), the percentages were averaged over all model years for a given speed category/vehicle type combination for use within the Truck Tool.

Table 4 presents the resulting default urban speed distributions by speed category for each truck class, for both diesel and gasoline vehicles. Note that the Truck Tool utilizes the diesel default speed distributions for LPG, LNG, and CNG.

Table 4. Default Speed Category Distributions by Vehicle Class for Urban Operation (MOVES2010a basis)[32]

Vehicle Class	Speed Group	Percent by Class*
Diesels		
HDDV2b	0 - 25	35%
	25 - 50	38%
	50+	13%
	Deceleration	15%
HDDV3	0 - 25	41%
	25 - 50	36%
	50+	12%
	Deceleration	11%
HDDV4	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	11%
HDDV5	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	11%
HDDV6	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	10%
HDDV7	0 - 25	42%
	25 - 50	35%
	50+	12%
	Deceleration	10%
HDDV8a	0 - 25	44%
	25 - 50	35%
	50+	12%
	Deceleration	9%
HDDV8b	0 - 25	45%
	25 - 50	34%
	50+	12%
	Deceleration	8%

Vehicle Class	Speed Group	Percent by Class*
Gasoline		
HDGV2b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%
HDGV3	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	11%
HDGV4	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	10%
HDGV5	0 - 25	46%
	25 - 50	33%
	50+	10%
	Deceleration	11%
HDGV6	0 - 25	46%
	25 - 50	33%
	50+	10%
	Deceleration	11%
HDGV7	0 - 25	45%
	25 - 50	32%
	50+	10%
	Deceleration	14%
HDGV8a	0 - 25	45%
	25 - 50	34%
	50+	11%
	Deceleration	10%
HDGV8b	0 - 25	43%
	25 - 50	31%
	50+	10%
	Deceleration	15%

* Class totals may not sum to 100% due to rounding error.

[32] These values represent the urban component of driving only. If the user specifies a non-zero percentage for Highway/Rural driving, the values in the above table are automatically renormalized, so as to make the sum across urban and highway operation modes equal to 100%.

As seen in the above table, the MOVES model assumes that some fraction of vehicle operation is associated with "deceleration" events, evaluated independently from other operation due to their unique emission rate patterns.[33] However, it is assumed that most Truck Tool users will not know their fleet's deceleration fraction. As such, the Truck Tool will adjust any values input by the user to include a deceleration fraction based on MOVES model percentages. If the user selects the default urban speed distributions, the Truck Tool will adjust the urban values from Table 4 to account for the percentage of miles specified for Highway/Rural operation as well. The following provides an illustrative example for calculating PM emissions for diesels given a specific set of road type/speed category distributions. NO_x and BC emission calculations follow the same procedure.

User specifies 1 Class 8b diesel, model year 2011, traveling 100,000 mi/yr.
User specifies the following Road type/speed category distributions:

40% highway/rural
30% 0-25 mph
20% 25-50 mph
10% 50+ mph

For highway/rural operation, the lookup value from MOVES is 0.0187 g/mi for $PM_{2.5}$
For urban operation, the lookup values are as follows (2016 calendar year basis):

0-25:	0.0272 g/mi
25-50:	0.0463 g/mi
50+:	0.0233 g/mi
deceleration:	0.0015 g/mi

Now the urban speed distribution percentage inputs must to account for deceleration, as follows:

0-25: 30% x sum of default percentages for the three speed bins (but excluding default deceleration fraction) = 30% x (45% + 34% + 12%) = 27.3%

25-50: 20% x sum of default percentages (45% + 34% + 12%) = 18.2%

50+: 10% x sum of default percentages (45% + 34% + 12%) = 9.1%

deceleration: remaining percentage, which equals 100% - 40% (highway) - 27.3% - 18.2% - 9.1% = 5.4%

Now apply these percentage weights to the total mileage, and then multiply by the corresponding emission factors to obtain mass, as follows:

Highway/rural component: 0.40 x 100,000 x 0.0187 = 748 grams
0-25 urban component: 0.273 x 100,000 x 0.0272 = 743 grams
25 - 50 urban component: 0.182 x 100,000 x 0.0463 = 843 grams
50+ urban component: 0.091 x 100,000 x 0.0233 = 212 grams
Deceleration urban component: 0.54 x 100,000 x 0.0015 = 81 grams

Therefore total = 2,627 grams of $PM_{2.5}$ (This value will then be summed with any other model year/vehicle class combinations and converted to short tons.)

[33] MOVES also assigns some fraction of emissions to idle operation. However, operating fractions and emission factors associated with idle in MOVES outputs are expressed in grams per mile rather than grams per hour. Thus, in order to utilize the grams per hour emission factors developed for use in the Truck Tool, MOVES outputs associated with idle operation were removed and the operating mode fractions for the four remaining categories were renormalized to equal 100%.

As discussed in Section 2.3, the Truck Tool assumes that B100-equivalent biodiesel volumes are distributed proportionately across all diesel vehicle classes. For example, if a fleet uses 100 B-100 equivalent gallons of biodiesel, and 1,000 gallons of fuel total, the Tool assumes that B10 (100 / 1,000 = 10%) is the blend used by each truck class. Accordingly, emission rate adjustment factors are calculated for B10 using Equation 6 and applied to the diesel emission factors for each vehicle class.

Finally, note that the PM factors output by the MOVES model for use in the Truck Tool are expressed in terms of $PM_{2.5}$. The MOVES model assumes a fixed ratio of PM_{10} / $PM_{2.5}$ for a given fuel type, as summarized below:

- Gasoline – 1.1304
- Diesel – 1.087
- CNG – 1.1304

These factors are applied directly to the $PM_{2.5}$ emission factors to obtain mass emission and performance metrics for PM_{10} within the Truck Tool. In addition, it was assumed that LNG and LPG have PM ratios equivalent to the CNG value. The ratio for biodiesel was assumed to equal that for diesel.

3.3 ACTIVITY CALCULATIONS

The Truck Tool requires users to provide specific activity information on fuel consumption, miles traveled, payload, road type/speed, and idle hours at the vehicle class level for the emissions performance assessment (see Section 4.0 below). While the user may provide direct data inputs for any or all of these activity parameters, the Truck Tool also allows the user to select default values for payload determination, in the absence of fleet-specific information. (Direct inputs for payload are highly preferred over the use of defaults.) The data sources and assumptions used to develop these default values are discussed below.

Default Payload Distributions

Average payloads can vary widely among fleets, even within a given vehicle class, depending upon commodity type and body/trailer type. With the exception of LTL and Package carriers, exact data entries were used from the 2011 Truck Tool submissions to obtain payload distributions for the 2017 Tool.[34] This data was categorized by fuel type, truck class, body-type, and SmartWay Category. Body-type refers to the categories presented in the Truck Tool payload calculator (e.g., Step Van, Beverage, Combination Flatbed, etc.). SmartWay Category is based on the Fleet Description inputs (e.g., Truckload Dry Van, Dray, Mixed, etc.). 1,850 unique records were identified using this categorization of the 2011 Partner data.

This data was then reviewed and four outliers were identified and removed from the data set.[35] Next, the data was grouped by truck class and body type and examined for notable differences in payload values across SmartWay Categories. However, with the exception of certain Class 8 trucks, no truck class/body-type/ranking category combination had greater than 20 observations. Therefore, it was concluded that there was not an

[34] An evaluation of carrier payload data in 2016 found the vast majority of fleets selected from the tool's default ranges rather than providing exact values. Accordingly, the available 2016 data was not robust enough to use as the basis for an update to the existing ranges provided in the tool.

[35] Three Class 2bs were removed due to high payloads (16, 13, and 5 tons). A Class 8b truck was removed due to incongruous text explanation ("none used").

adequately large data set available for establishing category-specific payload distributions for Truck Classes 2b-7. In these cases, payload data were aggregated across all SmartWay Categories for each truck class/body-type combination.

The larger population of Class 8 trucks in the 2011 data set allowed for a differentiation of payload distributions across SmartWay Categories. Considering both available sample size and average payloads, the following unique truck class/body-type/SmartWay Category groupings were established.

- Class 8a Dry Van Single body-types: differentiate LTL (9.9 tons average) and non-LTL (12.4 tons average) categories. No differentiation across categories for other body-types.
- Class 8b Dry Van Single body-types: differentiate Heavy-bulk (24.1 tons), LTL/Moving/Package (15.0 tons), Tanker (24 tons), and all other categories (18.5 tons).
- Class 8b Specialty body-types: differentiate Auto Carriers (16.2 tons), Heavy/Mixed (30.3 tons), Flatbed (21.6 tons), and all other categories (25.6 tons).
- Class 8b Dry Van Double body-types: differentiate TL/Reefer/Mixed (27.7 tons) and all other categories (19.4 tons)
- Class 8b Other body-types: differentiate Heavy/Flatbed/Mixed (27.4 tons) and all other categories (21.5 tons).

Based on this data, Table 5 presents the payload averages, standard deviations, minimum and maximum values by truck class/body-type/and-or SmartWay Category.[36] Note that the average values and standard deviations presented below are not weighted by fleet size.

[36] Given the lack of data on non-diesel heavy-duty vehicles, payload ranges are assumed to apply to all fuel types.

Table 5. Average Payload and Standard Deviation (short tons) by Vehicle Class/Body-Type/SmartWay Category (2011 Partner Data)

Body Type by Class	Avg Payload (tons)	Std Dev
Class 2b		
Flatbed	1.19	0.69
Step Van	1.14	0.48
Walk-In Van	1.05	0.48
Conventional Van	0.77	0.41
Other	0.58	0.49
Class 3		
Step Van	1.65	0.53
Walk-In Van	1.64	0.57
Conventional Van	1.50	0.83
Other	1.08	0.90
Class 4		
Flatbed	2.68	1.53
Step Van	2.24	1.19
Walk-In Van	1.70	0.80
Conventional Van	2.27	0.90
Other	1.16	0.76
Class 5		
Walk-In Van	1.99	1.08
Conventional Van	3.39	0.99
Other	2.91	1.19
Class 6		
Flatbed	4.67	1.71
Reefer	4.84	1.80
Walk-In Van	4.01	1.68
Single-Axle Van	3.78	1.19
Other	4.17	1.48
Class 7		
Beverage	6.10	2.22
Flatbed	7.05	0.85
Reefer	6.03	1.27
Tanker	7.45	0.92
Single-Axle Van	5.53	1.83
Other - straight truck	8.30	4.63
Combination Flatbed	5.22	0.41
Combination Reefer	3.58	1.01
Dry Van - Single	5.44	2.57
Other - combo	5.90	1.15
Class 8a		

Body Type by Class	Avg Payload (tons)	Std Dev
Flatbed	10.04	5.88
Tanker	12.12	5.43
Single-Axle Van	8.09	3.80
Other - straight truck	9.76	4.08
Beverage	12.30	4.40
Combination Flatbed	12.51	1.41
Dry Van - Single (other than LTL)	12.42	4.66
Other - combo	12.68	4.56
Class 8b		
Dry Van - Single (Heavy-Bulk)	24.1	2.98
Dry Van - Single (Tanker)	24.06	2.96
Dry Van - Single (other bins)	18.46	3.97
Dry Van - Double (Mixed-TL-Reefer)	27.74	13.33
Dry Van - Double (Other bins)	19.39	3.82
Dry Van – Triple	27.10	3.20
Combination Reefer	20.10	2.82
Combination Flatbed	22.50	4.23
Combination Tanker	24.90	2.89
Chassis	21.80	5.28
Specialty (Other bins)	25.62	2.72
Other (Other bins)	21.50	8.41
Specialty (Auto bin)*	18.20	5.29
Specialty (Heavy-bulk bin)*	29.20	7.15
Specialty (Moving bin)*	14.60	2.70
Specialty (Flatbed bin)	21.56	2.58
Other (Heavy-Flatbed-Mixed bins)	27.41	6.36

* Calculated using 2014 calendar year data, for new body type additions to the payload calculator.

The values above serve as the basis for the default payload ranges provided in the Truck Tool payload calculator. For most vehicle class/body-type/SmartWay Category combinations,[37] seven default ranges are offered for Partner selection:

- Range 1: from 0 tons to (Average payload – 2 x standard deviation);
- Range 2: from (Average payload – 2 x standard deviation) to (Average payload – 1 x standard deviation);
- Ranges 3-5: evenly split in three sections, from (Average payload – 1 x standard deviation) to (Average payload + 1 x standard deviation);

[37] In a few instances, the calculated lower bound value for Range 2 was less than zero. In these cases the lower bound value for Range 2 was set to zero and the Payload Calculator indicates Range 1 as "N/A".

- Range 6: from (Average payload + 1 x standard deviation) to (Average payload + 2 x standard deviation); and,
- Range 7: from (Average payload + 2 x standard deviation) to (Average payload + 3 x standard deviation).

Once a particular range is selected, the payload calculator determines the midpoint of the range in order to estimate class level average payloads. The midpoint payload values for each body type are weighted by one of the four allocation methods specified by the user in the payload calculator: # miles, # trips, % operation, and # vehicles by body type. The weighted sum is then used as the class level average payload, which in turn is used directly in determining grams per ton-mile performance metrics for the fleet.

Payload data based on bills of lading and entered directly into the payload calculator are validated using the same data described above (see Section 3.4).

LTL and Package Fleet Payloads

For most payload validations in the Tool, ranges are calculated by class and by body type as described above. LTL and package delivery payload validation ranges were updated using data from the 2015 tools, and are calculated on a simple truck class basis, as there was not enough LTL and Package Delivery Partner information to break payload out by body type. Therefore, each body type in a class is validated using the same range, as shown in Table 6.

Table 6. Payload Validation Ranges (Short Tons) for LTL and Package Delivery Fleets

Truck Class	Avg Payload	# Obs	Standard Dev	R1 Min	R2 Min	R3 Min	R4 Min	R5 Min	R6 Min	R7 Min
2B	0.93	86	0.172	>0	0.30	0.761	0.875	0.990	1.104	1.190
3	1.52	61	0.269	>0	1.10	1.250	1.430	1.609	1.789	1.924
4	2.04	33	0.379	>0	1.50	1.666	1.918	2.171	2.423	2.613
5	2.62	21	0.475	>0	1.60	2.146	2.462	2.779	3.095	3.333
6	3.45	102	0.561	>0	2.70	2.892	3.266	3.640	4.015	4.296
7	5.31	84	0.754	>0	4.00	4.560	5.063	5.566	6.069	6.446
8A	9.64	67	2.357	>0	6.50	7.287	8.859	10.431	12.002	13.181
8B	15.28	144	2.903	>0	10.70	12.381	14.316	16.252	18.187	19.639

The lower payload ranges (for "R1" and "R2") were set so as to identify less than 20% of the observed LTL/package fleets during validation. The middle R3-R5 ranges extend from one standard deviation less than the average payload to one standard deviation greater than the average. The upper payload values for "R6" range from the payload average plus one standard deviation to the average plus 1.5 standard deviations. The

range for "R7" extends above the "R6" maximum value. The maximum R7 range values are taken directly from the original R7 maximum values described above by class and by body type.[38]

3.4 DATA VALIDATION

The SmartWay Truck Tool has a number of standard logical, range and value checks that must be passed before Partners can submit their data to EPA. Many of these checks simply confirm the presence of required data (e.g., total miles for each truck class selected), or the accuracy of logical relationships (e.g., revenue miles less than or equal to total miles). The list of these basic checks is provided below. Partners will not be able to finalize their fleet files until all associated errors have been resolved. Also note that there is an implicit validation check on all numeric fields because the system will not accept any non-numeric characters (including minus signs) within these fields.

Table 7. Basic Range and Logical Checks

Contact Information	User must enter at least two distinct contacts
Fleet Description	User must include a Partner Name.
Fleet Description	If entered, SCACs must be between 2 and 4 characters in length, and at least one character must be a letter. Multiple SCACs must be separated by commas.
Fleet Description	If entered, MCNs must be between 6 and 7 digits.
Fleet Description	If entered, DOT numbers must be 7 digits or less.
Fleet Description	User must select a Fleet Type.
Fleet Description	User must indicate operational control over at least 95% of the fleet. (If Partner does not have at least 95% operational control, Truck Tool may not be used for the fleet.)
Fleet Description	The Operation Category totals must add up to 100%.
Fleet Description	The Body Type totals must add up to 100%.
Fleet Description	If a value for the Special Hauler body type is entered, a description must be provided.
Fleet Description	Warnings are issued for any of the following Operation Type/Body Type combinations. NOTE: This validation will only be invoked if there is a single selection made for either Operation or Body Type - otherwise combinations can't be determined with certainty. LTL/Chassis; LTL/Moving; LTL/Heavy; LTL/Specialized; Dray/Flatbed; Dray/Moving; Dray/Utility; Package/Flatbed; Package/Chassis; Package/Heavy; Package/Auto; Package/Moving; Package/Utility; Package/Specialized.
General Information	User must designate the operations split between U.S. and Canadian operations.
General Information	User must select at least one fuel type.
General Information	User must indicate what percent of the company's total freight volume they broker-out. If no freight volume is brokered-out, a zero can be entered.
Activity Information	All fields are required, so no field can be left blank. (If appropriate, a zero can be placed in certain fields.)

[38] For two body types under Class 7 trucks (Combination Flatbed and Combination Reefer), the original Range 7 max value is less than the new Range 6 max value. (R7 max is 6.45 and 6.61 respectively, while the new R6 max value for all class 7 body types is 6.914). Therefore, for just these two body types within Class 7, instead of using the original Range 7 max, we use the Range 7 max that would be calculated from the new table values. This is calculated as Avg + 2.5 x standard deviation, based on the table above (7.896 in this case). [Note it is Avg + 2.5 x standard deviation instead of Avg + 3 x standard deviation because of the 1.5 sigma rule for Range 6. Therefore, the Range 7 max value is simply 1 standard deviation larger than the Range 6 max.]

Contact Information	User must enter at least two distinct contacts
Activity Information	For all numeric fields except Empty Miles, Biofuel gallons, and Idle Hours, the value must be greater than zero. (An explanation must be provided for zero Empty Miles and idle hours).
Activity Information	For mileage and gallons fields, enter exact rather than rounded values. (warning)
Activity Information	For Revenue Miles, the amount cannot exceed the number of Total Miles Driven.
Activity Information	Revenue Miles that are significantly outside the expected range for percent of total miles for the given truck class (based on a lookup table) must be explained.
Activity Information	For Empty Miles, the amount must be less than the number of Total Miles.
Activity Information	Empty Miles that are significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	Distance per truck that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	On the Biofuel Blend Worksheet, the total gallons of biofuel cannot exceed the amount entered for Total Fuel on the Activity Information screen.
Activity Information	For Idle Hours, the value cannot exceed 8,760 per year per truck.
Activity Information	For Idle Hours, values significantly outside the expected range for daily short duration idle hours, daily long duration idle hours, and average number of days on the road must be explained.
Activity Information	MPG must be greater than zero.
Activity Information	MPG that is significantly outside the expected range for the given truck class (based on a lookup table) must be explained.
Activity Information	Reefer fuel inputs for each fuel type must be less than 50% of the total fuel volume used for reefer truck engine power.
Activity Information	Reefer fuel as a percent of fuel used for reefer truck engine power that is significantly outside the expected range (based on lookup table) must be explained.
Model Year & Class	Total truck count for each fleet cannot be zero.
Model Year & Class	Total truck counts for each selected truck class (those with a check mark) cannot be zero.
PM Reduction	The number of trucks using any particular PM reduction strategy cannot be greater than the number of trucks for the given class and model year.
PM Reduction	The sum of the trucks using either DOC or Particulate Matter Traps cannot be greater than the number of trucks for the given class and model year.
PM Reduction	If user indicates that the company uses PM reduction equipment, there must be at least one truck included on the PM Reduction sub-tab.
Payload Calculator	User must provide a preferred allocation method for the information entered.
Payload Calculator	The sum of the total miles or total trucks entered in the calculator must equal the number entered on the Activity Information screen.
Payload Calculator	The calculated average cannot be equal to zero.
Payload Calculator	For percentages, the total must equal 100%.
Payload Calculator	For each body type for which some information has been entered, all of the visible field must be completed (including the explanation field if shown).
Payload Calculator	Zero is not a valid value for any payload (absolute minimum payload = 0.001 tons).
Payload Calculator	Values that are significantly outside the expected range for the truck class must be explained.

Contact Information	User must enter at least two distinct contacts
Payload Calculator	Ensure consistency between body-type selections in the Fleet Description section with those from the Payload Calculator. For example, if 100% is specified for Dry Van under Fleet Description, only Dry Vans (single, double, triple) may be selected within the calculator. See Table 9.
Payload Calculator	If "# of Vehicles in this class" is selected, the number of body-types selected cannot exceed the number of vehicles specified.
Data Sources	Data sources for Total Miles Driven, Gallons of Fuel Used, Average Payload, and Other Data must be specified.

As noted in Table 7, a warning is issued if an inconsistency is identified between body-types specified within the Fleet Description Section and those within the payload calculator. Warning conditions (associated with 100% body-type entries under Fleet Description) are presented in Table 8 below. Warnings are also issued if a body type is specified in the Fleet Description section that does not appear in the payload calculator.

Table 8. Consistent Body-Types Resulting in No Warning Messages

Acceptable selections								
Body Type (100%)	**2b**	**3**	**4**	**5**	**6**	**7**	**8a**	**8b**
Dry Van	all except flatbed	all	all except flatbed	all	walk-in, single axle van	beverage, single axle van, dry van single	single axle van, beverage, dry van single	dry van (single, double, triple)
Refrigerated	other	other	other	other	reefer, other	reefer, beverage, combination reefer, other	beverage, other	combination reefer, dry van double, dry van triple
Flatbed	flatbed	other	flatbed	other	flatbed	flatbed, combination flatbed	flatbed, combination flatbed	combination flatbed
Tanker	other	other	other	other	other	tanker	Tanker	combination tanker
Chassis	N/A	N/A	N/A	N/A	N/A	other	Other	chassis
Heavy-Bulk	N/A	N/A	N/A	N/A	N/A	other	Other	heavy-bulk
Auto Carrier	N/A	N/A	N/A	N/A	N/A	other	Other	auto carrier
Moving	all except flatbed	all	all except flatbed	all	all except reefer, flatbed	single axle van, dry van-single, other	single axle van, dry van-single, other	moving, dry van single, dry van double, dry van triple, other
Specialty Hauler	other	other	other	other	other	other	Other	Specialty, other
Utility	all	all	all	all	all except reefer	single axle van, combination flatbed, other	single axle van, combination flatbed, other	dry van single, combination flatbed, other

Additional, rigorous validation checks of key data inputs are also needed to ensure the overall quality of the performance metrics calculated by the Truck Tool. Validation checks serve three purposes to this end. First, unusually high or low values can be identified and flagged for the user's attention before finalizing inputs. For example, a user may misplace a decimal, inadvertently add an extra zero, or utilize the wrong units (e.g. reporting pounds instead of tons for payload) upon data entry. By comparing these data entries to reliable industry averages and distributions, these values can be flagged allowing users to quickly correct such errors.

Second, under certain circumstances Partners may operate their fleets under atypical conditions, resulting in extreme (outlier) data values. For example, permitted heavy-haul operations may routinely exceed industry-average payload values by 10 or more tons. By flagging such data entries Partners have the opportunity to provide additional information regarding their unique operating conditions through use of the Truck Tool comment fields.

Finally, independent criteria can be established to ensure that data inputs are never allowed to exceed certain physically-constrained absolute limits. For example, a truck cannot exceed roughly 500,000 miles per year, even with dual drivers and minimal maintenance time, simply due to the available hours per year and highway speed limits. Data values above these absolute maximum levels are not allowed by the Truck Tool, and users are required to modify the associated inputs before proceeding.

The following presents the Truck Tool validation ranges for all parameters but payload, which is discussed above. Validation flags are of three types:

- "Yellow" values indicating that the input or derived performance value is notably lower/higher than the expected value. Partners may enter an explanation backing up such entries, but this is not mandatory.
- "Red" values indicating that the input or derived performance value differs greatly from the expected value. In this case the partner must enter text explaining why this value is accurate. Once entered, the value will change from "Red" to "Yellow" on the data entry screen.
- "Absolute errors" exceed values deemed physically possible and must be changed in order to be accepted by the tool.

Reefer Fuel Validation

1,008 diesel fleets designated as "Reefer" for the 2019 calendar year were evaluated to determine the distribution of the fraction of reefer fuel consumption to total fuel consumption. Four of these observations were dropped from the analysis data set, having greater than 50% of their total fuel consumption attributed to reefer fuel.[39] As shown in Figure 4 below, the distribution for the remaining reefer fleets was highly skewed toward low fractions (reefer consumption / total consumption). For this reason, the Tool does not generate Range 1 or Range 2 warnings at the low end of the distribution. Range 4 and Range 5 warnings were set to flag upper end reefer fuel consumption percentages as shown in Table 9.

[39] EPA suspects these reefer trucks are primarily used for storage rather than transportation. An additional validation rule has been adopted to flag such entries as errors.

Figure 4. Number of Observations vs Fraction of Fuel Used by Reefers

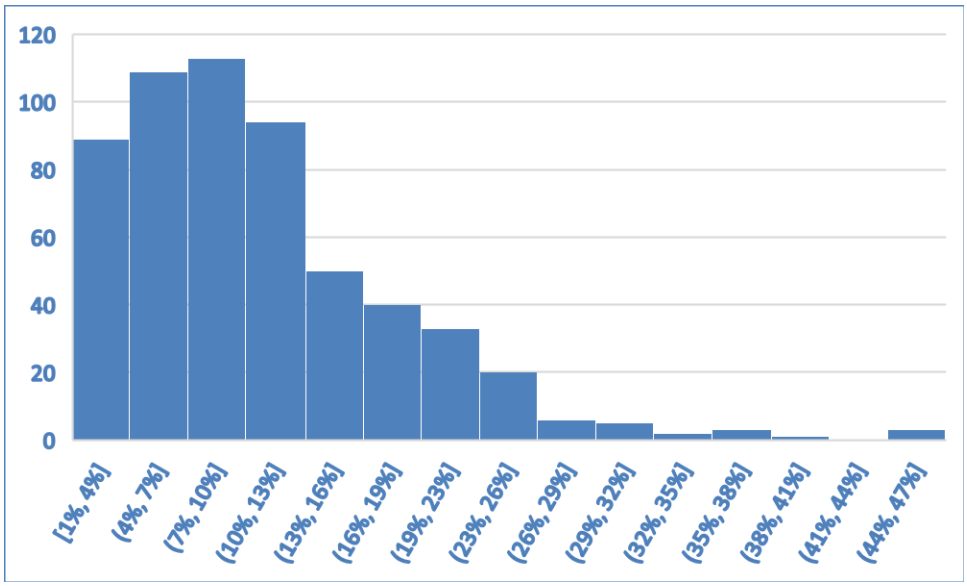


Table 9. Reefer Fuel Consumption Validation Ranges

	Min	Max	% of Obs
Range 1	**N/A**	**N/A**	**N/A**
Range 2	**N/A**	**N/A**	**N/A**
Range 3	>0	19%	92.7%
Range 4	19%	26%	5.6%
Range 5	26%	50%	1.7%

The mean of the distribution shown in Figure 4 (11%) can be used as the default percentage reefer fuel consumption if the partner lacks data for this parameter.

The percentages discussed above are multiplied by the total fuel value entered on the Activity screen (engine fuel plus reefer fuel) to determine the Reefer fuel validation ranges and default values for a given fleet. If the percentage designated as "Reefer" in the Body Types section of the Truck Tool is less than 100%, then the validation ranges and default value are scaled downward by the reported percentage.

Data Processing

Except as noted, the validation range recommendations are based upon a distributional analysis performed on the 2015 Truck Partner input and performance data.[40] Fleet level data was grouped by truck class and bin category. If a particular combination had less than 20 fleets, it was aggregated to the next "higher" level until at least 20 fleets were included. This process resulted in 29 groupings, as shown in Table 10. Note these

[40] Miles per gallon distributions were updated based on 2019 partner data to reflect recent changes in fleet fuel efficiency.

groupings are mutually exclusive – e.g. "Class 6_Mixed" (Group 6) includes all Class 6 vehicles with the exception of TL/Dry Van, LTL/Dry Van, and Package (Groups 8, 10, and 11).

Table 10. Truck Fleet Groupings Used for Distributional Analysis

Group #	Name	# Fleets
1	2B_Expedited	35
2	2B_Mixed	96
3	2B_Package	34
4	2B_TL/Dry Van	42
5	3_Mixed	85
6	4_Mixed	71
7	5_Mixed	59
8	6_LTL/Dry Van	55
9	6_Mixed	124
10	6_Package	25
11	6_TL/Dry Van	51
12	7_LTL/Dry Van	61
13	7_Mixed	144
14	7_TL/Dry Van	44
15	8A_LTL/Dry Van	54
16	8A_Mixed	106
17	8A_Refrigerated	21
18	8A_TL/Dry Van	61
19	8B_AutoCarrier	36
20	8B_Dray	109
21	8B_Expedited	26
22	8B_Flatbed	159
23	8B_Heavy/Bulk	22
24	8B_LTL/Dry Van	106
25	8B_Mixed	470
26	8B_Refrigerated	574
27	8B_Specialized	60
28	8B_TL/Dry Van	912
29	8B_Tanker	84

A distributional assessment was then performed for each of the above groupings for the following parameters.

- Miles per vehicle

- Miles per gallon
- Revenue Miles (as a percent of total miles)
- Empty Miles (as a percent of total miles)

The following parameters were not updated based on 2015 data due to one of two reasons: (1) the data set for 2015 was too thin, or (2) the majority of the data relied on default values.

- Percent Biofuel
- Percent Miles Traveled, Urban
- Percent Miles Traveled, Highway
- Average Idle Hours per Year

ERG then identified suspected outliers and erroneous data entry values for each parameter/group combination, based on the criteria presented in Table 11.

Table 11. Outlier Definition

Metric	Unreasonably Low	Unreasonably High
Miles per Vehicle	Mean – 3*Std dev	Mean + 3*std dev
MPG	0	Mean + 3*std dev
Percent Revenue Miles	<40	100
Percent Empty Miles	0	>60
Percent Biofuel	0	>20
Percent Urban Operation	0	100
Percent Highway Operation	0	100
Average Idle Hours	0	Mean + 3*std dev

Using these criteria ERG identified 132 values, which were subsequently dropped from the data set in order to develop "yellow" and "red" validation ranges for generalized distributions. The dropped values are shown below in Table 12.

Table 12. Values Flagged as Outliers

Parameter	Class/Category	Value	Mean
gallons per year	2B_Expedited	412,514	53,503
gallons per year	2B_Mixed	1,118,423	97,172
gallons per year	2B_Mixed	2,575,025	97,172
gallons per year	2B_Mixed	1,155,575	97,172
gallons per year	2B_Package	16,598,790	1,573,156

Parameter	Class/Category	Value	Mean
gallons per year	2B_Package	18,812,438	1,573,156
gallons per year	2B_TL/Dry Van	9,561,432	297,320
gallons per year	3_Mixed	7,488,083	566,721
gallons per year	3_Mixed	6,000,532	566,721
gallons per year	3_Mixed	10,025,500	566,721
gallons per year	3_Mixed	6,895,410	566,721
gallons per year	4_Mixed	32,131,244	1,287,415
gallons per year	4_Mixed	23,340,749	1,287,415
gallons per year	5_Mixed	5,886,948	526,173
gallons per year	5_Mixed	8,195,008	526,173
gallons per year	5_Mixed	5,391,967	526,173
gallons per year	6_LTL/Dry Van	3,981,088	229,194
gallons per year	6_LTL/Dry Van	2,229,735	229,194
gallons per year	6_Mixed	971,878	64,977
gallons per year	6_Mixed	434,514	64,977
gallons per year	6_Mixed	655,144	64,977
gallons per year	6_Package	42,086,822	5,063,945
gallons per year	6_TL/Dry Van	4,063,283	202,354
gallons per year	7_LTL/Dry Van	2,027,074	251,393
gallons per year	7_LTL/Dry Van	2,991,399	251,393
gallons per year	7_LTL/Dry Van	2,241,644	251,393
gallons per year	7_Mixed	6,172,258	273,971
gallons per year	7_Mixed	3,374,633	273,971
gallons per year	7_Mixed	5,989,442	273,971
gallons per year	7_Mixed	3,559,828	273,971
gallons per year	7_TL/Dry Van	4,950,320	262,592
gallons per year	8A_LTL/Dry Van	36,116,464	3,648,512
gallons per year	8A_LTL/Dry Van	53,625,048	3,648,512
gallons per year	8A_Mixed	57,351,694	986,765
gallons per year	8A_Refrigerated	5,643,067	443,374
gallons per year	8A_TL/Dry Van	70,846,629	2,760,796
gallons per year	8B_AutoCarrier	25,533,283	3,748,093
gallons per year	8B_Dray	14,150,069	1,604,817
gallons per year	8B_Dray	34,766,125	1,604,817
gallons per year	8B_Dray	13,354,331	1,604,817

Parameter	Class/Category	Value	Mean
gallons per year	8B_Expedited	1,424,076	218,990
gallons per year	8B_Flatbed	36,752,966	2,361,101
gallons per year	8B_Flatbed	34,640,701	2,361,101
gallons per year	8B_Flatbed	17,704,415	2,361,101
gallons per year	8B_Flatbed	17,023,256	2,361,101
gallons per year	8B_Heavy/Bulk	9,404,277	1,037,619
gallons per year	8B_LTL/Dry Van	92,200,872	7,616,076
gallons per year	8B_LTL/Dry Van	124,000,000	7,616,076
gallons per year	8B_LTL/Dry Van	89,849,912	7,616,076
gallons per year	8B_Mixed	66,558,332	2,535,432
gallons per year	8B_Mixed	37,456,768	2,535,432
gallons per year	8B_Mixed	59,418,064	2,535,432
gallons per year	8B_Mixed	48,225,936	2,535,432
gallons per year	8B_Mixed	180,000,000	2,535,432
gallons per year	8B_Mixed	119,000,000	2,535,432
gallons per year	8B_Refrigerated	33,225,674	1,941,435
gallons per year	8B_Refrigerated	42,919,799	1,941,435
gallons per year	8B_Refrigerated	28,773,217	1,941,435
gallons per year	8B_Refrigerated	37,152,519	1,941,435
gallons per year	8B_Refrigerated	20,502,480	1,941,435
gallons per year	8B_Refrigerated	53,869,408	1,941,435
gallons per year	8B_Refrigerated	18,295,369	1,941,435
gallons per year	8B_Refrigerated	18,899,380	1,941,435
gallons per year	8B_Refrigerated	31,452,760	1,941,435
gallons per year	8B_Refrigerated	67,708,438	1,941,435
gallons per year	8B_Specialized	109,000,000	3,815,822
gallons per year	8B_TL/Dry Van	39,566,042	3,015,269
gallons per year	8B_TL/Dry Van	86,776,622	3,015,269
gallons per year	8B_TL/Dry Van	41,147,713	3,015,269
gallons per year	8B_TL/Dry Van	40,502,655	3,015,269
gallons per year	8B_TL/Dry Van	102,000,000	3,015,269
gallons per year	8B_TL/Dry Van	47,825,507	3,015,269
gallons per year	8B_TL/Dry Van	131,000,000	3,015,269
gallons per year	8B_TL/Dry Van	55,482,608	3,015,269
gallons per year	8B_TL/Dry Van	72,226,731	3,015,269

Parameter	Class/Category	Value	Mean
gallons per year	8B_TL/Dry Van	182,000,000	3,015,269
gallons per year	8B_TL/Dry Van	61,329,730	3,015,269
gallons per year	8B_TL/Dry Van	99,023,569	3,015,269
gallons per year	8B_Tanker	63,833,642	2,691,859
annual miles/vehicle	2B_Mixed	116,299	28,854
annual miles/vehicle	3_Mixed	85,788	22,873
annual miles/vehicle	3_Mixed	81,697	22,873
annual miles/vehicle	4_Mixed	87,149	23,285
annual miles/vehicle	5_Mixed	93,600	18,865
annual miles/vehicle	5_Mixed	77,510	18,865
annual miles/vehicle	6_Mixed	343,740	34,199
annual miles/vehicle	6_Package	103,854	24,362
annual miles/vehicle	6_TL/Dry Van	116,000	36,656
annual miles/vehicle	7_Mixed	135,356	35,442
annual miles/vehicle	7_Mixed	117,865	35,442
annual miles/vehicle	7_TL/Dry Van	166,021	37,351
annual miles/vehicle	8B_Flatbed	5,000	78,258
annual miles/vehicle	8B_Flatbed	7,500	78,258
annual miles/vehicle	8B_LTL/Dry Van	271,366	69,987
annual miles/vehicle	8B_Mixed	203,275	74,314
annual miles/vehicle	8B_Mixed	175,555	74,314
annual miles/vehicle	8B_Refrigerated	215,350	101,711
annual miles/vehicle	8B_Refrigerated	211,217	101,711
annual miles/vehicle	8B_Refrigerated	248,360	101,711
annual miles/vehicle	8B_Refrigerated	221,995	101,711
annual miles/vehicle	8B_Refrigerated	225,974	101,711
annual miles/vehicle	8B_Refrigerated	262,511	101,711
annual miles/vehicle	8B_Refrigerated	208,809	101,711
annual miles/vehicle	8B_Specialized	189,507	73,838
annual miles/vehicle	8B_TL/Dry Van	195,768	90,012
annual miles/vehicle	8B_TL/Dry Van	193,195	90,012
annual miles/vehicle	8B_TL/Dry Van	189,257	90,012
annual miles/vehicle	8B_TL/Dry Van	250,391	90,012
annual miles/vehicle	8B_TL/Dry Van	194,704	90,012
annual miles/vehicle	8B_TL/Dry Van	191,012	90,012

Parameter	Class/Category	Value	Mean
annual miles/vehicle	8B_TL/Dry Van	215,143	90,012
annual miles/vehicle	8B_Tanker	148,721	79,629
% Empty Miles	3_Mixed	90.19	13.39
% Empty Miles	8B_Specialized	99.38	30.34
% Empty Miles	2B_Mixed	0.02	82.54
% Empty Miles	8B_TL/Dry Van	35.17	87.37

Once values were defined as outliers and excluded from the data set, the mean and standard deviation of the distribution for each truck fleet grouping were then re-calculated for each metric. Each fleet was treated equally in the distributional assessment, independent of the number of vehicles in the fleet. Histograms presenting the distributions for each truck fleet grouping/metric combination are available electronically from SmartWay.

For groupings with large numbers of fleets (e.g., Class 8b diesel TL/Dry Van, Refrigerated, and Mixed), the data for miles per vehicle and miles per gallon appear normally distributed. Examples for Class 8b TL/Dry Van Diesel fleets are shown in Figures 5 and 6.

Figure 5. Annual Miles per Vehicle Distribution, Class 8b TL/Dry Van Diesel Fleets

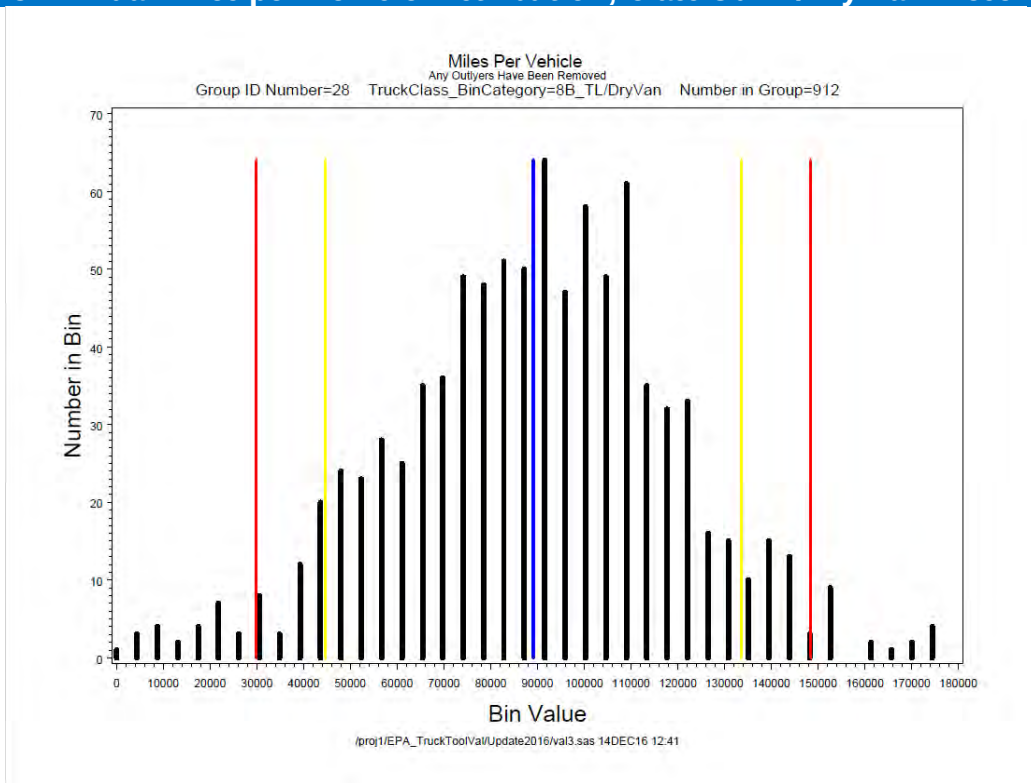
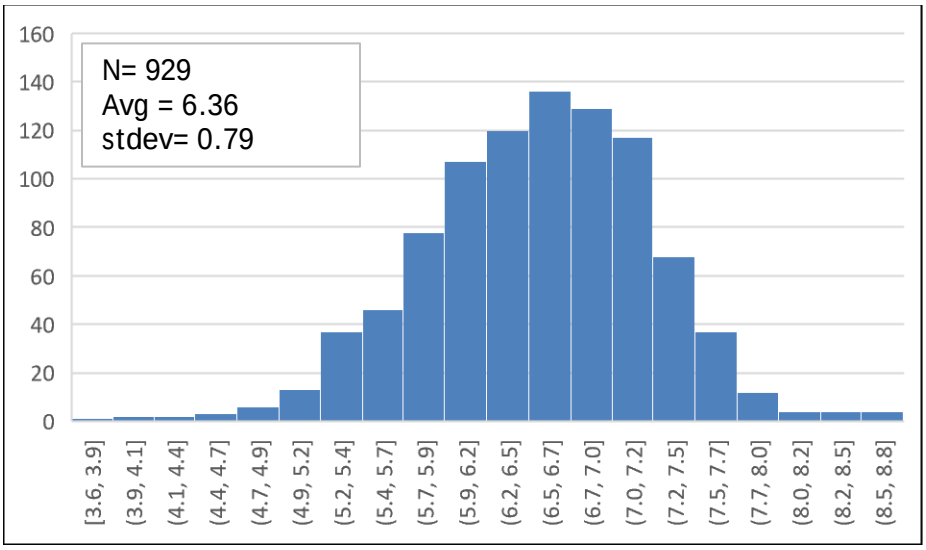


Figure 6. Miles per Gallon Distribution, Class 8b TL/Dry Van Diesel Fleets



Other fleet group/metric combinations displayed sharp drop offs at certain discrete levels. For example, % Revenue Miles were seldom less than 50% of total miles, and conversely, % Empty Miles were seldom greater than 50% of total miles. % Biofuel also displayed a discrete maximum value with no fleets using blends higher than 20% biodiesel.[41]

Based on this assessment, red and yellow flag areas were defined for each fleet group/metric combination as shown in Table 13.

Table 13. "Red" and "Yellow" Flag Criteria

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
2B_Expedited	35	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
2B_TL/Dry Van	42	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Miles Per Vehicle	NONE	5,000	Mean+1.5StD	Mean+2StD
4_Mixed	71	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_LTL/Dry Van	55	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_Mixed	124	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
6_Package	25	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%

[41] As such, a yellow warning is issued for any biodiesel blend > 20%, with no red warning.

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
6_TL/Dry Van	51	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
7_LTL/Dry Van	61	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
7_Mixed	144	Miles Per Vehicle	NONE	5,000	Mean+1.5StD	Mean+2StD
7_TL/Dry Van	44	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_LTL/Dry Van	54	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_Mixed	106	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_Refrigerated	21	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8A_TL/Dry Van	61	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_AutoCarrier	36	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Dray	109	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Expedited	26	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Heavy/Bulk	22	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_LTL/Dry Van	106	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Miles Per Vehicle	5.0%	15.0%	85.0%	95.0%
8B_TL/Dry Van	912	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Miles Per Vehicle	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B	72	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
3	45	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
4	38	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
5	38	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
6	214	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
7	234	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8A	234	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_AutoCarrier	40	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_Dray	107	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Expedited	18	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_Flatbed	166	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Heavy/Bulk	37	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_LTL/Dry Van	76	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Mixed/Moving	452	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Refrigerated	492	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_Specialized	41	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
8B_TL/Dry Van	929	Miles Per Gallon	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
8B_Tanker	80	Miles Per Gallon	5.0%	10.0%	90.0%	95.0%
2B_Expedited	35	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_Mixed	96	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_Package	34	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
2B_TL/Dry Van	42	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
3_Mixed	85	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
4_Mixed	71	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
5_Mixed	59	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_LTL/Dry Van	55	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_Mixed	124	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_Package	25	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
6_TL/Dry Van	51	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_LTL/Dry Van	61	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_Mixed	144	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
7_TL/Dry Van	44	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_LTL/Dry Van	54	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_Mixed	106	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_Refrigerated	21	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8A_TL/Dry Van	61	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_AutoCarrier	36	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Dray	109	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_Expedited	26	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_Flatbed	159	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Heavy/Bulk	22	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_LTL/Dry Van	106	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Mixed	470	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Refrigerated	574	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Specialized	60	Percent Revenue Miles	5.0%	15.0%	NONE	NONE
8B_TL/Dry Van	912	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	NONE	NONE
8B_Tanker	84	Percent Revenue Miles	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
2B_Expedited	35	Percent Empty Miles	NONE	NONE	85.0%	95.0%
2B_Mixed	96	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
2B_Package	34	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
2B_TL/Dry Van	42	Percent Empty Miles	5.0%	15.0%	Mean+1.5StD	Mean+2StD
3_Mixed	85	Percent Empty Miles	NONE	NONE	85.0%	95.0%
4_Mixed	71	Percent Empty Miles	NONE	NONE	85.0%	95.0%

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
5_Mixed	59	Percent Empty Miles	NONE	NONE	85.0%	95.0%
6_LTL/Dry Van	55	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
6_Mixed	124	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
6_Package	25	Percent Empty Miles	NONE	NONE	85.0%	95.0%
6_TL/Dry Van	51	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_LTL/Dry Van	61	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_Mixed	144	Percent Empty Miles	NONE	NONE	85.0%	95.0%
7_TL/Dry Van	44	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_LTL/Dry Van	54	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_Mixed	106	Percent Empty Miles	NONE	NONE	85.0%	95.0%
8A_Refrigerated	21	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8A_TL/Dry Van	61	Percent Empty Miles	Mean – 2StD	Mean-1.5StD	Mean+1.5StD	Mean+2StD
8B_AutoCarrier	36	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Expedited	26	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_Heavy/Bulk	22	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_LTL/Dry Van	106	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Mixed	470	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Refrigerated	574	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Specialized	60	Percent Empty Miles	5.0%	15.0%	85.0%	95.0%
8B_TL/Dry Van	912	Percent Empty Miles	NONE	NONE	Mean+1.5StD	Mean+2StD
8B_Tanker	84	Percent Empty Miles	5.0%	15.0%	NONE	50.0%
2B_Expedited	35	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Mixed	96	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_Package	34	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
2B_TL/Dry Van	42	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
3_Mixed	85	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
4_Mixed	71	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
5_Mixed	59	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_LTL/Dry Van	55	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_Mixed	124	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_Package	25	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
6_TL/Dry Van	51	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_LTL/Dry Van	61	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
7_Mixed	144	Percent Biofuel	5.0%	15.0%	85.0%	95.0%

Class Category	Count	Variable	Low Red	Low Yellow	High Yellow	High Red
7_TL/Dry Van	44	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_LTL/Dry Van	54	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_Mixed	106	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_Refrigerated	21	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8A_TL/Dry Van	61	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_AutoCarrier	36	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Dray	109	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Expedited	26	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Flatbed	159	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Heavy/Bulk	22	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_LTL/Dry Van	106	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Mixed	470	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Refrigerated	574	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Specialized	60	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_TL/Dry Van	912	Percent Biofuel	5.0%	15.0%	85.0%	95.0%
8B_Tanker	84	Percent Biofuel	5.0%	15.0%	85.0%	95.0%

For distributions that appeared to have a relatively normal distribution on the low and/or high end, yellow flag criteria were set at ± 1.5 times the standard deviation (StD), and the red flag criteria at ± 2.0 times the standard deviation of the distribution for each truck fleet grouping. In most cases these criteria result in roughly 10-20% of the values for these metrics being flagged as either red or yellow for partner attention. For several variables with a clearly skewed distribution yellow cutoffs were set to include approximately 15% of observations, and red cutoffs were selected to include approximately 5% of observations. Selecting cutoffs at these levels of stringency is intended to identify likely input errors without unduly burdening the large majority of Truck Tool users with unnecessary data checks and text explanations.

Finally, certain distributions showed common values up to and including the absolute min/max values. For example, a substantial number of truck carriers reported revenue miles equal to 100% of total miles. In these instances no yellow/red flags are assigned for that variable.

Tables 14-18 present the actual yellow and red flag values for each fleet group/metric combination, given the decision criteria presented in Table 13. Tables 19-22 present the number of observations that would be flagged with yellow and red warnings for these combinations. The complete set of histograms associated with the distributional analysis of the 2016 data is available upon request from SmartWay.

Table 14. Yellow/Red Criteria by Fleet Group/Metric Combination
Annual Miles per Vehicle

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	>0	9,698	16,183	63,029	90,800	500,000
2B-Mixed	>0	2,046	7,741	53,432	71,391	500,000
2B-PD	>0	5,247	11,565	47,936	65,500	500,000
2B-TL/Dry van	>0	6,799	18,007	52,984	58,368	500,000
3-Mixed	>0	0	5,000	45,712	53,814	500,000
4-Mixed	>0	1,402	6,556	40,071	51,362	500,000
5-Mixed	>0	306	3,470	40,000	49,485	500,000
6-LTL/Dry van	>0	9,631	11,696	49,080	60,950	500,000
6-Mixed	>0	2,036	10,931	51,916	67,014	500,000
6-Moving	>0	3,000	8,000	68,107	79,506	500,000
6-PD	>0	5,921	9,073	65,000	72,065	500,000
6-TL/Dry van	>0	8,632	14,133	56,713	68,836	500,000
7-LTL/Dry van	>0	12,488	15,654	54,122	72,666	500,000
7-Mixed	>0	0	5,000	67,560	78,694	500,000
7-TL/Dry van	>0	2,326	10,312	57,249	79,650	500,000
8A-LTL/.Dry van	>0	10,558	15,625	68,215	88,352	500,000
8A-Mixed	>0	6,271	13,039	85,890	102,000	500,000
8A-Reefer	>0	15,505	26,162	70,000	79,308	500,000
8A-TL/Dry van	>0	10,069	13,877	97,567	128,406	500,000
8B-Auto	>0	43,112	51,769	103,710	112,367	500,000
8B-Dray	>0	6,985	18,413	86,984	98,413	500,000
8B-Expedited	>0	23,226	27,112	92,857	140,232	500,000
8B-Flatbed	>0	36,935	47,495	110,856	121,416	500,000
8B-Heavy	>0	44,171	48,663	101,118	108,168	500,000
8B-LTL/Dry van	>0	13,983	27,504	108,634	122,156	500,000
8B-Mixed	>0	12,029	27,477	120,168	135,616	500,000
8B-Reefer	>0	36,939	52,743	147,566	163,370	500,000
8B-Special	>0	20,765	39,854	105,338	117,433	500,000
8B-TL/Dry van	>0	29,853	44,672	133,586	148,405	500,000
8B-Tanker	>0	36,503	47,076	110,517	121,090	500,000

Table 15. Yellow/Red Criteria by Fleet Group/Metric Combination Miles per Gallon[42]

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B	>0	5.38	7.58	20.75	22.95	37.5
3	>0	3.52	6.41	13.52	14.37	28.5
4	>0	6.45	7.10	12.22	13.20	24.4
5	>0	4.42	5.69	12.40	15.10	21.4
6	>0	5.41	6.21	10.98	11.77	16.8
7	>0	4.74	5.57	10.58	11.41	15.8
8A	>0	3.94	4.66	8.97	9.69	12.2
8B-Auto	>0	4.27	4.61	5.51	6.20	9.3
8B-Dray	>0	4.88	5.14	6.70	6.96	10.5
8B-Expedited	>0	5.76	5.82	7.14	7.20	10.2
8B-Flatbed	>0	4.38	4.75	6.97	7.34	10.8
8B-Heavy	>0	2.95	3.77	5.91	5.95	9.9
8B-LTL/Dry van	>0	5.52	5.79	7.41	7.68	11.8
8B-Mixed/Moving	>0	4.78	5.18	7.55	7.94	11.8
8B-Reefer	>0	5.09	5.57	8.42	8.89	11.9
8B-Specialized	>0	3.04	3.75	6.21	6.66	10.1
8B-TL/Dry van	>0	5.02	5.39	7.61	7.98	12.4
8B-Tanker	>0	3.74	4.34	6.75	7.10	10.8

[42] Equivalent MPG cutoffs can be found by dividing these values by 1.26 for gasoline and CNG vehicles; dividing by 1.35 for LPG vehicles; and dividing by 1.52 for LNG vehicles – see "Non-Diesel MPG" section below for details.

Table 16. Yellow/Red Criteria by Fleet Group/Metric Combination
% Revenue Miles

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	52	59	N/A	N/A	N/A
2B-Mixed	N/A	53	61	N/A	N/A	N/A
2B-PD	N/A	66	72	N/A	N/A	N/A
2B-TL/Dry van	N/A	69	74	N/A	N/A	N/A
3-Mixed	N/A	65	71	N/A	N/A	N/A
4-Mixed	N/A	65	71	N/A	N/A	N/A
5-Mixed	N/A	59	67	N/A	N/A	N/A
6-LTL/Dry van	N/A	61	68	N/A	N/A	N/A
6-Mixed	N/A	55	63	N/A	N/A	N/A
6-Moving	N/A	55	65	N/A	N/A	N/A
6-PD	N/A	75	80	N/A	N/A	N/A
6-TL/Dry van	N/A	56	64	N/A	N/A	N/A
7-LTL/Dry van	N/A	64	71	N/A	N/A	N/A
7-Mixed	N/A	57	64	N/A	N/A	N/A
7-TL/Dry van	N/A	64	70	N/A	N/A	N/A
8A-LTL/.Dry van	N/A	67	73	N/A	N/A	N/A
8A-Mixed	N/A	52	59	N/A	N/A	N/A
8A-Reefer	N/A	59	65	N/A	N/A	N/A
8A-TL/Dry van	N/A	69	74	N/A	N/A	N/A
8B-Auto	N/A	43	50	N/A	N/A	N/A
8B-Dray	N/A	46	54	N/A	N/A	N/A
8B-Expedited	N/A	57	63	N/A	N/A	N/A
8B-Flatbed	N/A	62	67	N/A	N/A	N/A
8B-Heavy	N/A	34	43	N/A	N/A	N/A
8B-LTL/Dry van	N/A	68	73	N/A	N/A	N/A
8B-Mixed	N/A	62	68	N/A	N/A	N/A
8B-Reefer	N/A	72	76	N/A	N/A	N/A
8B-Special	N/A	40	49	N/A	N/A	N/A
8B-TL/Dry van	N/A	68	73	N/A	N/A	N/A
8B-Tanker	N/A	48	50	N/A	N/A	N/A

Table 17. Yellow/Red Criteria by Fleet Group/Metric Combination
% Empty Miles

Class Category	Absolute Min	Low Red	Low Yellow	High Yellow	High Red	Absolute Max
2B-Expedited	N/A	1	5	38	44	N/A
2B-Mixed	N/A	1	5	41	48	N/A
2B-PD	N/A	1	5	31	37	N/A
2B-TL/Dry van	N/A	1	5	28	33	N/A
3-Mixed	N/A	1	5	28	34	N/A
4-Mixed	N/A	1	5	30	35	N/A
5-Mixed	N/A	1	5	33	40	N/A
6-LTL/Dry van	N/A	1	5	36	44	N/A
6-Mixed	N/A	1	5	38	45	N/A
6-Moving	N/A	1	5	40	50	N/A
6-PD	N/A	1	5	15	31	N/A
6-TL/Dry van	N/A	1	5	35	47	N/A
7-LTL/Dry van	N/A	1	5	32	35	N/A
7-Mixed	N/A	1	5	33	44	N/A
7-TL/Dry van	N/A	1	5	33	39	N/A
8A-LTL/.Dry van	N/A	1	5	30	36	N/A
8A-Mixed	N/A	1	5	36	47	N/A
8A-Reefer	N/A	1	5	35	41	N/A
8A-TL/Dry van	N/A	1	5	31	36	N/A
8B-Auto	N/A	5	15	40	49	N/A
8B-Dray	N/A	5	7	40	50	N/A
8B-Expedited	N/A	5	6	33	37	N/A
8B-Flatbed	N/A	5	7	27	37	N/A
8B-Heavy	N/A	1	5	56	64	N/A
8B-LTL/Dry van	N/A	1	5	29	34	N/A
8B-Mixed	N/A	1	5	34	40	N/A
8B-Reefer	N/A	1	5	25	29	N/A
8B-Special	N/A	1	5	49	50	N/A
8B-TL/Dry van	N/A	1	5	28	32	N/A
8B-Tanker	N/A	20	36	50	50	N/A

Table 18. Yellow/Red Criteria by Fleet Group/Metric Combination Idle Hours and Days of Use per Year

Class Category	Low Red	Low Yellow	High Yellow	High Red
Average Service Days/Year				
Non-Class 8b (less Package/Specialty)	96	171	320	--
Non-Class 8b (Package/Specialty)	142	200	315	--
Class 8b (less LTL/Package)	157	213	325	--
Class 8b (LTL/Package)	135	193	309	--
Average Hours Long Duration Idle/Day				
Non-Class 8b (less Package/Specialty)	--	1.00	1.73	2.81
Non-Class 8b (Package/Specialty)	--	1.00	24.00	--
Class 8b (less LTL/Package)	--	1.00	4.11	6.10
Class 8b (LTL/Package)	--	1.00	2.53	4.18
Average Hours Short Duration Idle/Day				
Non-Class 8b (less Package/Specialty)	--	0	1.87	2.81
Non-Class 8b (Package/Specialty)	--	0	1.42	1.99
Class 8b (less LTL/Package)	--	0	2.36	3.60
Class 8b (LTL/Package)	--	0	2.63	4.15

Table 19. Number of Values Flagged by Fleet Group/Metric Combination
Annual Miles per Vehicle

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	6,001	1	3	40,870	3	1	95,938
2B_Mixed	96	720	4	9	27,933	9	4	76,590
2B_Package	34	4,144	1	3	30,012	3	1	70,685
2B_TL/Dry Van	42	505	2	3	31,821	3	2	59,203
3_Mixed	85	581	0	6	21,406	6	4	76,320
4_Mixed	71	117	3	6	22,373	6	3	53,172
5_Mixed	59	83	2	5	16,525	5	2	54,486
6_LTL/Dry Van	55	1,429	2	5	29,919	5	2	70,391
6_Mixed	124	53	6	11	31,682	11	6	79,858
6_Package	25	814	1	1	21,050	1	1	90,196
6_TL/Dry Van	51	3,179	2	4	35,069	4	2	93,498
7_LTL/Dry Van	61	5,701	3	5	34,379	5	3	87,534
7_Mixed	144	100	0	10	34,158	7	6	106,615
7_TL/Dry Van	44	1,693	2	3	34,359	3	2	109,287
8A_LTL/Dry Van	54	3,458	2	5	45,351	5	2	108,183
8A_Mixed	106	155	5	9	47,086	9	5	124,901
8A_Refrigerated	21	1,738	1	1	45,741	1	1	79,469
8A_TL/Dry Van	61	7,460	3	5	59,438	5	3	155,136
8B_AutoCarrier	36	47,525	0	2	77,740	1	1	120,671
8B_Dray	109	3,165	1	9	52,699	4	4	102,164
8B_Expedited	26	22,697	1	1	63,362	1	1	150,415
8B_Flatbed	159	15,680	3	5	79,175	8	2	130,597
8B_Heavy/Bulk	22	40,305	1	1	73,132	1	1	116,004
8B_LTL/Dry Van	106	14,096	0	5	68,069	3	3	146,016
8B_Mixed	470	3,658	7	20	73,822	22	11	151,353
8B_Refrigerated	574	9,171	20	20	100,155	22	10	203,947
8B_Specialized	60	4,568	2	5	71,877	5	2	178,303
8B_TL/Dry Van	912	2,072	27	33	89,129	39	19	176,478
8B_Tanker	84	28,055	4	3	78,796	0	3	136,449

Table 20. Number of Values Flagged by Fleet Group/Metric Combination
Miles per Gallon

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	10.00	1	3	14.47	3	1	25.00
2B_Mixed	96	2.00	4	9	12.93	9	4	22.91
2B_Package	34	3.51	1	3	11.68	3	1	20.74
2B_TL/Dry Van	42	2.50	2	3	10.68	3	2	19.50
3_Mixed	85	1.07	2	3	9.82	6	1	18.99
4_Mixed	71	1.34	3	6	8.98	6	3	16.27
5_Mixed	59	0.96	3	1	7.77	2	1	14.25
6_LTL/Dry Van	55	0.68	2	5	8.01	5	2	11.17
6_Mixed	124	4.02	1	6	7.93	2	2	12.06
6_Package	25	0.91	1	1	7.39	1	1	11.37
6_TL/Dry Van	51	0.76	1	0	7.86	0	0	10.00
7_LTL/Dry Van	61	5.48	0	2	7.82	2	2	10.50
7_Mixed	144	3.69	4	4	7.55	3	4	11.25
7_TL/Dry Van	44	4.60	2	3	7.76	3	2	9.76
8A_LTL/Dry Van	54	4.25	1	0	6.31	1	1	8.13
8A_Mixed	106	3.38	3	3	6.57	5	3	8.97
8A_Refrigerated	21	5.19	1	2	6.38	2	1	8.34
8A_TL/Dry Van	61	1.84	1	1	6.43	0	1	8.69
8B_AutoCarrier	36	4.29	1	3	4.96	3	1	6.22
8B_Dray	109	3.35	5	2	5.83	3	0	7.00
8B_Expedited	26	4.79	1	1	6.04	1	1	6.80
8B_Flatbed	159	3.10	5	4	5.80	6	2	7.20
8B_Heavy/Bulk	22	4.11	1	1	5.32	1	1	6.63
8B_LTL/Dry Van	106	4.08	5	3	6.27	1	1	7.87
8B_Mixed	470	3.18	17	11	5.94	17	6	7.88
8B_Refrigerated	574	1.11	12	15	5.96	19	15	7.96
8B_Specialized	60	0.50	3	6	5.07	6	3	6.72
8B_TL/Dry Van	912	2.30	26	21	6.18	36	16	8.26
8B_Tanker	84	2.66	2	4	5.95	4	0	7.21

Table 21. Number of Values Flagged by Fleet Group/Metric Combination
% Revenue Miles

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	54.2	0	3	80.9	0	0	100
2B_Mixed	96	50.0	3	9	83.4	0	0	100
2B_Package	34	60.1	3	1	88.6	0	0	100
2B_TL/Dry Van	42	63.3	1	2	89.7	0	0	100
3_Mixed	85	57.0	3	7	89.7	0	0	100
4_Mixed	71	65.0	3	9	90.4	0	0	100
5_Mixed	59	50.0	2	5	88.5	0	0	100
6_LTL/Dry Van	55	50.0	3	4	88.4	0	0	100
6_Mixed	124	47.0	8	2	84.4	0	0	100
6_Package	25	64.0	2	0	94.2	0	0	100
6_TL/Dry Van	51	45.2	3	1	87.3	0	0	100
7_LTL/Dry Van	61	65.0	0	10	89.2	0	0	100
7_Mixed	144	50.0	6	2	84.4	0	0	100
7_TL/Dry Van	44	41.1	2	2	89.5	0	0	100
8A_LTL/Dry Van	54	55.0	5	2	90.5	0	0	100
8A_Mixed	106	46.1	5	4	82.3	0	0	100
8A_Refrigerated	21	60.0	0	2	85.0	0	0	100
8A_TL/Dry Van	61	49.1	3	3	91.3	0	0	100
8B_AutoCarrier	36	50.0	0	0	71.8	0	0	100
8B_Dray	109	49.5	0	7	79.2	0	0	100
8B_Expedited	26	56.2	1	2	82.8	0	0	100
8B_Flatbed	159	50.0	6	5	82.8	0	0	100
8B_Heavy/Bulk	22	46.0	0	0	70.9	0	0	100
8B_LTL/Dry Van	106	55.0	4	5	89.0	0	0	100
8B_Mixed	470	50.0	18	30	85.4	0	0	100
8B_Refrigerated	574	50.0	25	25	88.4	0	0	100
8B_Specialized	60	49.4	0	0	74.6	0	0	100
8B_TL/Dry Van	912	50.0	49	34	87.4	0	0	100
8B_Tanker	84	44.9	4	2	61.9	1	1	100

Table 22. Number of Values Flagged by Fleet Group/Metric Combination
% Empty Miles

Class/Category	N	Minimum Value	Low Red Flags	Low Yellow Flags	Mean Value	High Yellow Flags	High Red Flags	Maximum Value
2B_Expedited	35	2.96	0	0	20.65	3	1	45.75
2B_Mixed	96	0.00	0	0	18.10	8	3	50.00
2B_Package	34	0.00	0	0	12.26	1	4	39.91
2B_TL/Dry Van	42	0.00	0	3	14.00	0	2	39.60
3_Mixed	85	0.00	0	0	12.47	7	4	42.23
4_Mixed	71	0.00	0	0	12.55	6	3	40.00
5_Mixed	59	0.00	0	0	16.01	5	2	50.00
6_LTL/Dry Van	55	0.00	0	0	14.99	3	2	50.00
6_Mixed	124	0.00	0	0	16.57	2	9	52.99
6_Package	25	0.00	0	0	6.27	1	1	35.98
6_TL/Dry Van	51	0.00	0	0	17.42	4	2	54.76
7_LTL/Dry Van	61	0.00	0	0	13.09	5	3	40.00
7_Mixed	144	0.00	0	0	17.54	13	7	50.00
7_TL/Dry Van	44	0.00	0	0	15.42	4	1	45.00
8A_LTL/Dry Van	54	0.00	0	0	11.35	5	2	45.00
8A_Mixed	106	0.00	0	0	19.51	9	5	53.91
8A_Refrigerated	21	0.00	0	0	14.93	2	0	40.00
8A_TL/Dry Van	61	0.00	0	0	13.44	3	2	50.94
8B_AutoCarrier	36	0.00	0	3	29.68	3	1	50.00
8B_Dray	109	0.00	3	10	25.36	10	5	50.45
8B_Expedited	26	5.00	1	1	18.12	1	1	43.83
8B_Flatbed	159	0.00	3	15	18.12	15	7	50.00
8B_Heavy/Bulk	22	0.00	0	0	31.51	0	0	50.81
8B_LTL/Dry Van	106	0.00	0	0	12.65	4	6	50.00
8B_Mixed	470	0.00	0	0	16.49	28	22	50.00
8B_Refrigerated	574	0.00	0	0	12.91	20	25	50.00
8B_Specialized	60	0.00	0	4	29.17	4	2	50.61
8B_TL/Dry Van	912	0.00	0	0	13.71	39	51	50.00
8B_Tanker	84	3.00	4	7	43.51	0	9	55.12

Absolute errors were also developed for each fleet category/metric combination. Cutoffs for absolute errors are intended to prevent users from inadvertently entering data with incorrect units and typos. For this reason we have defined absolute errors to ensure an adequate "safety" interval between the highest values observed in the cleaned (no outlier) dataset. The recommended values for absolute errors and their associated justifications are discussed below for each metric.

Annual Miles per Vehicle

The maximum number of miles a vehicle can accumulate in a year are constrained by truck highway speed limits (typically 65 mph or less) and the number of hours in a year.[43] Excluding engine down-time associated with maintenance and repairs, the absolute maximum annual mileage possible for a truck is estimated to be ~500,000 miles per year. This estimate is more than twice the highest observed value of 228,151 miles per year (for Class 8b TL/Dry Van diesels). Therefore 500,000 miles per year value is set as the absolute maximum for all vehicle classes. Values greater than 0 and less than 500,000 are permissible.

Miles per Gallon

The maximum and minimum miles per gallon from the diesel dataset are presented in Table 23.

Table 23. Maximum and Minimum Observed Miles per Gallon

Class/Category	N	Minimum Value	Maximum Value
2B	72	2.37	24.48
3	45	0.68	16.90
4	38	5.75	15.60
5	38	1.83	16.93
6	214	2.35	14.59
7	234	2.45	12.23
8A	234	0.84	10.98
8B_AutoCarrier	48	4.27	6.38
8B_Dray	107	3.95	7.33
8B_Expedited	18	5.76	7.30
8B_Flatbed	166	3.15	7.99
8B_Heavy/Bulk	37	2.95	6.15
8B_LTL/Dry Van	75	5.10	7.69
8B_Mixed/Moving	452	1.42	8.40
8B_Refrigerated	492	4.85	10.46
8B_Specialized	41	3.00	7.17
8B_TL/Dry Van	929	2.10	8.76
8B_Tanker	80	1.49	7.36

[43] While DOT regulations limit drivers' daily hours, some companies utilize driver teams to maximize on-road time.

[Note: Unlike the other parameters discussed above, miles per gallon values are derived from other inputs (total miles and gallons). Therefore, any changes to address absolute limits on MPG (as well as red and yellow warnings) must be handled through updates to one or both of these primary inputs.]

As seen from the above table, fuel efficiency estimates can be very low (<1.0 mpg) and for this reason the absolute lower bound is set to 0.001 for miles per gallon. To establish absolute upper bounds for miles per gallon estimates the results from the PERE modeling analysis previously developed for the 2010 Truck Tool were used. Background on the PERE modeling exercise is provided in Appendix D.

Absolute maximum miles per gallon estimates were developed for conventional diesel trucks using the PERE model, and are shown in Table 24 by truck class.

Table 24. Maximum Diesel Miles per Gallon Estimates (PERE Model Basis)

Class	Maximum MPG
2b	25.0
3	23.3
4	20.2
5	18.7
6	18.0
7	14.5
8a	11.2
8b	11.2

Note that the maximum MPG estimates obtained from the PERE model are substantially higher than almost all of the maximum value observed for diesel trucks in the 2018 Truck Tool data.

Non-Diesel MPG

The 2018 data submissions from SmartWay Truck partners did not include enough information on non-diesel trucks in order to develop a robust distribution of mpg values specific to non-diesels for validation purposes. Accordingly, engineering judgment was used to adjust the diesel mpg values for other fuel types, accounting for general, relative vehicle and/or fuel efficiency differences. First, a ratio was developed for adjusting diesel mpg values to comparable gasoline mpg values, based upon simulated modeling performed by Argonne National Laboratory.[44] The Argonne data for gas and diesel trucks was based on PSAT simulations of a typical pickup in the Class 2b or Class 3 range. The fuel consumption was reported for the same truck equipped with both gasoline and diesel engines over the various EPA emissions and fuel economy driving cycles. Using this data, a combined fuel economy was calculated using the method from EPA's pre-2008 combined 2-cycle fuel

[44] Delorme, A. et. al., *Impact of Advanced Technologies on Medium-Duty Trucks Fuel Efficiency*, Argonne National Laboratory, 2010-01-1929. https://www.autonomie.net/docs/6%20-%20Papers/Heavy%20duty/impact_of_advancedtechnologies.pdf, Accessed 11-29-2020.

economy using the FTP and Highway cycles as given in 40 CFR Part 600. This method uses a weighted harmonic average of the two values, with the FTP weighted at 55% and the Highway weighted at 45%.

The difference in the calculated combined fuel economies for the gas- and diesel-powered model results showed that the diesel had a 25.9% greater fuel economy than gasoline. These results are a direct volumetric comparison rather than in terms of gasoline-equivalent gallons. As such, the diesel mpg values shown in Table 28 above can be divided by 1.259 to obtain comparable mpg ranges for gasoline vehicles. Since CNG vehicle fuel consumption is reported in terms of gasoline-equivalent gallons, the mpg validation ranges for CNG vehicles can be set equal to those for comparable gasoline vehicles.

Validation ranges for LPG and LNG vehicles can be developed from the gasoline ranges, dividing the gasoline values by the appropriate gasoline gallon-equivalent factor for these fuels (1.35 for LPG and 1.52 for LNG),[45] thereby adjusting mpg values for volumetric energy density. Table 25 presents the corresponding upper bound MPG values for non-diesel vehicles by truck class.

Table 25. Maximum Miles per Gallon Estimates – Non-Diesel Vehicles

Class	Gasoline/CNG	LPG	LNG
2b	19.9	18.5	16.4
3	18.5	17.3	15.3
4	16.0	15.0	13.3
5	14.9	13.9	12.3
6	14.3	13.3	11.8
7	11.5	10.7	9.5
8a	8.9	8.3	7.4
8b	8.9	8.3	7.4

Hybrid MPG

EPA's Physical Emission Rate Estimator (PERE) model was used in order to establish estimates of the fuel economy benefit of hybridization of medium- and heavy-duty trucks. The details of the modeling are presented in Appendix D.

However, the in-use fuel economy of hybrid vehicles is highly dependent upon drive cycle. Specifically the expected hybrid truck fuel economy will vary depending upon the relative fraction of highway versus urban driving. Therefore the MPG ranges used for validation of hybrid fuel economy are calculated using the following steps.

Step 1 – Weight the following GALLON PER MILE (Not MPG) values based on the Highway/Urban split

[45] See https://afdc.energy.gov/fuels/equivalency_methodology.html, Accessed 11-29-2020.

Gallons/Mile - Urban

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
	2B_Mixed	0.2641	0.1813	0.0942	0.0636	0.0576
	3_Mixed	0.2340	0.1857	0.1147	0.0830	0.0760
	4_Mixed	0.2090	0.1763	0.1213	0.0925	0.0861
	5_Mixed	0.2599	0.2127	0.1392	0.1026	0.0943
	6_LTL/Dry Van_Diesel	0.1951	0.1765	0.1390	0.1147	0.1080
	6_Mixed	0.2200	0.1972	0.1467	0.1179	0.1111
	6_Moving	0.1906	0.1783	0.1514	0.1301	0.1242
	6_Package_Diesel	0.1788	0.1628	0.1254	0.1029	0.0965
	6_TL/Dry Van_Diesel	0.2350	0.2056	0.1495	0.1175	0.1097
10	7_LTL/Dry Van_Diesel	0.1968	0.1806	0.1450	0.1211	0.1148
11	7_Mixed	0.2506	0.2169	0.1545	0.1200	0.1117
12	7_TL/Dry Van_Diesel	0.2131	0.1915	0.1467	0.1202	0.1130
13	8A_LTL/Dry Van_Diesel	0.2184	0.2104	0.1837	0.1653	0.1607
14	8A_Mixed	0.2747	0.2519	0.1950	0.1591	0.1492
15	8A_Refrigerated_Diesel	0.2502	0.2402	0.2036	0.1793	0.1716
16	8A_TL/Dry Van_Diesel	0.2477	0.2337	0.1966	0.1697	0.1630
17	8B_AutoCarrier_Diesel	0.2980	0.2781	0.2407	0.2158	0.2052
18	8B_Dray_Diesel	0.2434	0.2338	0.2056	0.1835	0.1780
19	8B_Flatbed_Diesel	0.2912	0.2727	0.2248	0.1942	0.1857
20	8B_Heavy/Bulk_Diesel	0.3768	0.3371	0.2562	0.2033	0.1912
21	8B_LTL/Dry Van_Diesel	0.2383	0.2250	0.2025	0.1814	0.1761
22	8B_Mixed	0.2597	0.2493	0.2149	0.1889	0.1807
23	8B_Refrigerated_Diesel	0.2656	0.2500	0.2236	0.1992	0.1931
24	8B_Specialized_Diesel	0.3389	0.2995	0.2342	0.1894	0.1789
25	8B_TL/Dry Van_Diesel	0.2534	0.2436	0.2147	0.1891	0.1836
26	8B_Tanker_Diesel	0.2596	0.2492	0.2149	0.1888	0.1806

Gallons/Mile – Highway

Group #	Name	Low Red	Low Yellow	Mean	High Yellow	High Red
1	2B_Mixed	0.1759	0.1208	0.0627	0.0424	0.0383
2	3_Mixed	0.1594	0.1265	0.0781	0.0565	0.0518
3	4_Mixed	0.1482	0.1250	0.0860	0.0656	0.0611
4	5_Mixed	0.1805	0.1477	0.0967	0.0713	0.0655
	6_LTL/Dry Van_Diesel	0.1470	0.1330	0.1047	0.0864	0.0813
6	6_Mixed	0.1657	0.1486	0.1105	0.0889	0.0837
7	6_Moving	0.1436	0.1343	0.1141	0.0980	0.0936
8	6_Package_Diesel	0.1347	0.1226	0.0944	0.0775	0.0727
9	6_TL/Dry Van_Diesel	0.1770	0.1549	0.1127	0.0885	0.0826
10	7_LTL/Dry Van_Diesel	0.1513	0.1389	0.1115	0.0931	0.0883
11	7_Mixed	0.1928	0.1668	0.1188	0.0923	0.0859
12	7_TL/Dry Van_Diesel	0.1640	0.1473	0.1128	0.0924	0.0869
13	8A_LTL/Dry Van_Diesel	0.1558	0.1501	0.1310	0.1179	0.1147
14	8A_Mixed	0.1960	0.1796	0.1391	0.1135	0.1065
15	8A_Refrigerated_Diesel	0.1785	0.1714	0.1452	0.1279	0.1224
16	8A_TL/Dry Van_Diesel	0.1767	0.1667	0.1402	0.1210	0.1163
17	8B_AutoCarrier_Diesel	0.2126	0.1984	0.1717	0.1539	0.1464
18	8B_Dray_Diesel	0.1736	0.1668	0.1467	0.1309	0.1270
19	8B_Flatbed_Diesel	0.2078	0.1945	0.1604	0.1385	0.1325
20	8B_Heavy/Bulk_Diesel	0.2688	0.2405	0.1828	0.1450	0.1364
21	8B_LTL/Dry Van_Diesel	0.1700	0.1605	0.1445	0.1294	0.1256
22	8B_Mixed	0.1853	0.1779	0.1533	0.1347	0.1289
23	8B_Refrigerated_Diesel	0.1894	0.1783	0.1595	0.1421	0.1378
24	8B_Specialized_Diesel	0.2418	0.2137	0.1670	0.1351	0.1276
25	8B_TL/Dry Van_Diesel	0.1807	0.1738	0.1532	0.1349	0.1310
26	8B_Tanker_Diesel	0.1852	0.1778	0.1533	0.1347	0.1288

Example:

Truck Class 2b has 40% urban, 60% highway.
The Low Red Gallon/Mile value is therefore 0.2641 x 0.40 + 0.1759 x 0.60 = 0.2112

Step 2: Convert the weighted gallon per mile values back to MPG

Example:

0.2112 gal/mi = 4.74 MPG

Step 3: Use these final, weighted, converted MPG values for validation

Electric Truck Efficiency

Mi/kWhr estimates for battery electric trucks were developed based on available data sources and engineering judgment. The average value for Class 2b, Class 6, and Class 8b trucks was assumed to equal the mi/kWhr value estimates for light commercial, single unit long-haul, and combination long-haul truck categories respectively in the 2019 AFLEET model.[46] Estimates for Class 3-5, 7 and 8a trucks were estimated from these values, scaling by the relative values used in the prior version of the Truck Tool. Once average mi/kWhr estimates were derived, "red" and "yellow" validation ranges were established based on simple multiplicative factors applied to the averages – Low red from 0 to 0.5 x average; low yellow from 0.5 x average to 0.75 x average; high yellow from 1.25 x average to 1.5 x average; and high red from 1.5 x average to 10 x average (absolute max). The prior and updated mi/kWhr estimates are presented by truck class in Table 26.

Table 26. Electric Truck Average mi/kWhr and Validation Ranges

Truck Class	Prior Avg	Updated Avg	Low Red	Low Yellow	High Yellow	High Red	Max
2a	3.01	1.14	0.57	0.86	1.43	1.72	11.44
3	2.22	0.94	0.47	0.70	1.17	1.41	9.38
4	1.43	0.73	0.37	0.55	0.92	1.10	7.32
5	1.22	0.68	0.34	0.51	0.85	1.01	6.76
6	1.00	0.62	0.31	0.47	0.78	0.93	6.20
7	0.75	0.48	0.24	0.36	0.60	0.72	4.81
8a	0.50	0.34	0.17	0.26	0.43	0.51	3.41
8b	0.40	0.29	0.14	0.21	0.36	0.43	2.85

Percent Revenue Miles

Revenue miles were frequently equal to total miles in the dataset. Accordingly, no absolute upper (or lower) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

[46] Argonne National Laboratory, Welcome to AFLEET. https://afleet-web.es.anl.gov/home/. Accessed 11-30-2020.

Percent Empty Miles

Empty miles were occasionally equal to 0 in the dataset. Accordingly, no absolute lower (or upper) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Percent Biodiesel

While the maximum observed blend level for biodiesel was 20 percent, B100 use is possible. Therefore no absolute upper (or lower) bound was set for this field, beyond requiring all values to be ≥ 0 and ≤ 100.

Average Payload

The maximum and minimum payloads from the 2011 dataset (prior to cleaning) are presented in Table 27.[47]

Table 27. Maximum and Minimum Observed Payloads (Short Tons)

Group #	Name	Min	Mean	Max
1	2B_Mixed	0.1	1.0	1.9[48]
2	3_Mixed	0.1	1.7	3.0
3	4_Mixed	0.5	2.4	4.0
4	5_Mixed	1.3	3.1	5.3
5	6_LTL/Dry Van_Diesel	0.9	4.6	6.3
6	6_Mixed	0.9	4.5	6.5
7	6_Moving	2.5	3.6	4.9
8	6_Package_Diesel	2.0	4.2	6.0
9	6_TL/Dry Van_Diesel	0.9	4.1	6.9
10	7_LTL/Dry Van_Diesel	1.8	6.0	8.7
11	7_Mixed	1.1	6.0	20.0
12	7_TL/Dry Van_Diesel	4.5	6.4	12.7
13	8A_LTL/Dry Van_Diesel	6.0	10.6	15.0
14	8A_Mixed	1.9	11.3	24.0
15	8A_Refrigerated_Diesel	6.3	13.3	21.0
16	8A_TL/Dry Van_Diesel	3.8	11.4	20.0
17	8B_AutoCarrier_Diesel	9.3	19.6	24.5
18	8B_Dray_Diesel	15.0	20.5	24.5
19	8B_Flatbed_Diesel	14.8	23.2	33.3
20	8B_Heavy/Bulk_Diesel	20.0	27.6	40.0
21	8B_LTL/Dry Van_Diesel	7.8	18.2	27.9

[47] As noted above, the 2016 dataset did not have an adequate number of exact payload estimates to allow for a robust distributional analysis. Accordingly, the 2011 payload analysis results are retained in the current Truck Tool.

[48] Three extreme outliers for Class 2b trucks were dropped for the purposes of establishing maximum upper bounds: 16.0, 13.0 and 5.0 tons.

Group #	Name	Min	Mean	Max
22	8B_Mixed	7.5	20.3	33.1
23	8B_Refrigerated_Diesel	13.2	20.9	27.5
24	8B_Specialized_Diesel	7.3	24.4	37.0
25	8B_TL/Dry Van_Diesel	6.5	18.9	50.0
26	8B_Tanker_Diesel	17.5	24.6	34.6

Based on a review of previous out of range values, unit conversion problems are the most common source of data entry errors for payload. One type of error results from data being entered in pounds instead of short tons, resulting in overestimates by a factor of 2,000. Such errors should be easy to prevent using a reasonable upper bound ton level. Another possible source of error could be reporting metric or long tons instead of short tons, although detecting these errors will be extremely difficult, due to the small difference in units (roughly 10 percent difference). Finally, note that standard payload limitations can be waived by obtaining permits for heavy loads, or by avoiding over-the-road operation.[49] Accordingly, the absolute upper bound payload levels were set equal to 3 times the maximum observed values shown in Table 26.

The absolute lower-bound payload value was set at 0.001 tons, to allow for light package and specialty deliveries.

Percent Urban/Highway Miles

There is no clear distributional pattern associated with these data fields, with values frequently ranging from 0 to 100. Therefore, no lower or upper bound values are set.

Idle Hours per Day and Days of Use per Year

Absolute limits are placed on the number of hours per day (short plus long duration idle hours less than or equal to 24) and days of use per year (less than or equal to 365). In addition, since extended idling is defined as sustained idling events an hour or more in duration, warnings are issued for extended idle hour per day entries less than an hour.

[49] One SmartWay Truck Partner indicated unusually high payloads for their Class 2b truck fleet, but noted they only use their trucks in terminal operations.

4.0 Performance Metrics

The Truck Tool allows the user to calculate their emissions performance using a number of different metrics, at different levels of aggregation. Available performance metrics include:

- Grams per mile
- Grams per Payload Ton-Mile

The Internal Metrics report within the Truck Tool presents the results of 30 calculations (2 x 5 x 3 = 30), which represent the following two calculations for each of the five pollutants (CO_2, NOx, PM_{10} $PM_{2.5}$ and BC) and for each of three different mileage types (total, loaded, and revenue). Note that all capitalized fields represent fields in the user interface:

$$g/mile: \sum E / M$$

where

E = Emissions,

M = Miles Driven

$$g/avg\ payload\ ton\text{-}mile: \sum E / (M \times AP)$$

where

E = Emissions,

M = Miles Driven,

AP = Average Payload

For each of the two calculations:

Emissions = grams of pollutant (as specified above)

Miles Driven = Total Miles, Revenue Miles, or Loaded Miles (Total Miles minus Empty Miles)

As shown in the equations above, summations are performed for the different metrics. Each of the metrics is automatically aggregated across model years (for NOx and PM) for all reporting purposes. Additional aggregation may be reported across truck classes, fuel types, fleets, and at the company level, as specified by the user.

Appendix A: MOVES2014b NO_x, PM & BC Emission Factors (g/mi) 2020 Calendar Year

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
		10.714	0.25833	0.3879	1.323	0.01760	0.0310	17.791	0.32724	0.6700	21.918	0.36776	0.7197	11.523	0.31684	0.6096
		12.136	0.28448	0.4378	1.456	0.01176	0.0245	21.009	0.39276	0.8163	27.018	0.41984	0.8642	12.997	0.32288	0.6666
		20.386	0.54563	0.6886	1.355	0.01029	0.0187	24.308	0.53993	0.8616	35.567	0.96188	1.4270	24.914	0.63174	0.9563
		12.852	0.27998	0.4183	1.469	0.01538	0.0302	20.488	0.37169	0.7935	26.139	0.37596	0.7790	13.497	0.31986	0.6611
		17.011	0.43890	0.5858	1.407	0.01105	0.0217	22.780	0.47156	0.8411	31.635	0.71122	1.1654	19.411	0.48868	0.8221
		20.566	0.54688	0.6885	1.360	0.01043	0.0191	24.270	0.53631	0.8629	35.584	0.94897	1.4101	24.920	0.62571	0.9515
		25.100	0.69735	0.8339	1.273	0.00902	0.0134	26.704	0.64964	0.8954	42.396	1.39471	1.8745	34.277	0.87645	1.1851
		26.627	0.75138	0.8863	1.232	0.00842	0.0112	27.681	0.69126	0.9075	44.900	1.57330	2.0569	37.858	0.97619	1.2775
		10.714	0.25833	0.3879	1.323	0.01760	0.0310	17.791	0.32724	0.6700	21.918	0.36776	0.7197	11.523	0.31684	0.6096
		12.136	0.28448	0.4378	1.456	0.01176	0.0245	21.009	0.39276	0.8163	27.018	0.41984	0.8642	12.997	0.32288	0.6666
		20.386	0.54563	0.6886	1.355	0.01029	0.0187	24.308	0.53993	0.8616	35.567	0.96188	1.4270	24.914	0.63174	0.9563
		12.852	0.27998	0.4183	1.469	0.01538	0.0302	20.488	0.37169	0.7935	26.139	0.37596	0.7790	13.497	0.31986	0.6611
		17.011	0.43890	0.5858	1.407	0.01105	0.0217	22.780	0.47156	0.8411	31.635	0.71122	1.1654	19.411	0.48868	0.8221
		20.566	0.54688	0.6885	1.360	0.01043	0.0191	24.270	0.53631	0.8629	35.584	0.94897	1.4101	24.920	0.62571	0.9515
		25.100	0.69735	0.8339	1.273	0.00902	0.0134	26.704	0.64964	0.8954	42.396	1.39471	1.8745	34.277	0.87645	1.1851
		26.627	0.75138	0.8863	1.232	0.00842	0.0112	27.681	0.69126	0.9075	44.900	1.57330	2.0569	37.858	0.97619	1.2775
	HDV2b	9.5407	0.22922	0.3375	1.192	0.01791	0.0301	14.996	0.26763	0.5342	18.192	0.31541	0.5959	10.383	0.29040	0.5363
	HDV3	11.943	0.28173	0.4324	1.391	0.01144	0.0234	20.416	0.38158	0.7842	26.086	0.41034	0.8389	12.776	0.31774	0.6504
	HDV4	12.122	0.28785	0.4433	1.456	0.01172	0.0241	21.045	0.39498	0.8135	27.055	0.42622	0.8765	12.999	0.32784	0.6748
	HDV5	13.203	0.28653	0.4328	1.461	0.01217	0.0260	21.255	0.38800	0.8261	27.545	0.38746	0.8156	13.896	0.31466	0.6662

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1992	HDV6	16.484	0.41965	0.5683	1.413	0.01111	0.0217	22.589	0.46442	0.8377	31.177	0.67194	1.1310	18.703	0.46923	0.8075
1992	HDV7	18.440	0.47105	0.6146	1.398	0.01103	0.0213	23.250	0.48846	0.8508	32.927	0.75703	1.2113	21.202	0.52068	0.8567
1992	HDV8a	24.713	0.68377	0.8204	1.289	0.00925	0.0142	26.433	0.63796	0.8940	41.759	1.34525	1.8234	33.338	0.84977	1.1615
1992	HDV8b	26.689	0.74795	0.8821	1.234	0.00849	0.0113	27.709	0.69238	0.9117	45.007	1.56032	2.0443	37.995	0.97234	1.2755
1993	HDV2b	11.020	0.26736	0.4041	1.396	0.01685	0.0303	18.615	0.34321	0.7033	22.980	0.38392	0.7598	11.755	0.32408	0.6328
1993	HDV3	11.862	0.28168	0.4325	1.435	0.01270	0.0255	20.468	0.38105	0.7890	26.037	0.41158	0.8409	12.663	0.32301	0.6598
1993	HDV4	13.586	0.33380	0.4866	1.441	0.01153	0.0236	21.522	0.41541	0.8205	28.257	0.50587	0.9548	14.769	0.37293	0.7156
1993	HDV5	12.472	0.28674	0.4385	1.457	0.01190	0.0250	21.077	0.39020	0.8178	27.161	0.40992	0.8487	13.284	0.32149	0.6691
1993	HDV6	15.805	0.39650	0.5446	1.423	0.01136	0.0229	22.257	0.44511	0.8333	30.250	0.61345	1.0617	17.541	0.43572	0.7752
1993	HDV7	16.892	0.43556	0.5829	1.412	0.01112	0.0219	22.656	0.46646	0.8382	31.492	0.69996	1.1535	19.174	0.48293	0.8186
1993	HDV8a	24.590	0.68444	0.8215	1.294	0.00927	0.0144	26.330	0.63473	0.8906	41.612	1.34922	1.8259	33.093	0.84886	1.1591
1993	HDV8b	26.720	0.75359	0.8880	1.235	0.00846	0.0113	27.718	0.69317	0.9099	45.055	1.57854	2.0616	38.056	0.98002	1.2814
1994	HDV2b	10.853	0.30937	0.4797	1.157	0.01534	0.0321	17.647	0.47979	1.0233	21.916	0.45284	0.9582	11.580	0.31711	0.6722
1994	HDV3	11.721	0.34889	0.5368	1.377	0.01891	0.0394	19.621	0.54574	1.1593	24.813	0.54475	1.1421	12.521	0.37323	0.7859
1994	HDV4	12.153	0.36142	0.5633	1.457	0.01960	0.0423	21.062	0.57053	1.2318	27.105	0.57024	1.2301	13.043	0.38934	0.8404
1994	HDV5	13.034	0.38636	0.5928	1.459	0.02023	0.0440	21.224	0.59455	1.2928	27.621	0.58421	1.2516	13.862	0.42349	0.9165
1994	HDV6	15.423	0.44818	0.6364	1.434	0.01920	0.0403	22.054	0.60972	1.2308	29.958	0.75584	1.4109	16.986	0.46859	0.9159
1994	HDV7	18.732	0.53506	0.7012	1.394	0.01778	0.0351	23.392	0.63784	1.1557	33.589	1.02553	1.6603	21.957	0.54778	0.9401
1994	HDV8a	25.156	0.70471	0.8323	1.286	0.01430	0.0219	26.630	0.71723	1.0144	42.614	1.68351	2.2730	34.386	0.75847	1.0440
1994	HDV8b	26.660	0.74479	0.8633	1.238	0.01306	0.0177	27.674	0.73521	0.9708	44.953	1.87727	2.4466	37.900	0.81761	1.0714
1995	HDV2b	10.199	0.31975	0.4801	1.318	0.02029	0.0385	16.377	0.52311	1.0606	19.879	0.50369	0.9979	10.986	0.36059	0.7157
1995	HDV3	12.278	0.36555	0.5666	1.448	0.01977	0.0423	20.880	0.57977	1.2463	26.951	0.57944	1.2344	13.206	0.39671	0.8488
1995	HDV4	13.102	0.38746	0.5835	1.442	0.01965	0.0416	21.173	0.58752	1.2337	27.581	0.63110	1.2819	14.194	0.41447	0.8580
1995	HDV5	14.568	0.42599	0.6220	1.442	0.01968	0.0420	21.789	0.61001	1.2673	29.057	0.69149	1.3532	15.810	0.45362	0.9216
1995	HDV6	16.088	0.46489	0.6473	1.422	0.01876	0.0387	22.388	0.61722	1.2091	30.802	0.82392	1.4744	18.100	0.48270	0.9078
1995	HDV7	18.203	0.52068	0.6905	1.400	0.01803	0.0359	23.191	0.63692	1.1736	33.063	0.98648	1.6259	21.198	0.53570	0.9357

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1995	HDV8a	25.050	0.70221	0.8296	1.292	0.01443	0.0224	26.549	0.71077	1.0115	42.440	1.68278	2.2676	34.120	0.75275	1.0377
1995	HDV8b	26.638	0.74432	0.8619	1.242	0.01309	0.0179	27.645	0.72834	0.9619	44.909	1.88656	2.4498	37.823	0.81395	1.0642
1996	HDV2b	10.424	0.33240	0.4996	1.325	0.02066	0.0397	17.190	0.53327	1.0867	20.686	0.52818	1.0550	11.125	0.37104	0.7418
1996	HDV3	12.353	0.36750	0.5663	1.458	0.01956	0.0418	21.081	0.56977	1.2192	27.064	0.58688	1.2426	13.313	0.39348	0.8379
1996	HDV4	14.489	0.42263	0.6109	1.440	0.01890	0.0396	21.964	0.59054	1.1956	29.085	0.71967	1.3714	15.990	0.43916	0.8659
1996	HDV5	15.792	0.45862	0.6470	1.435	0.01944	0.0408	22.178	0.61630	1.2452	29.825	0.76064	1.4141	17.268	0.48017	0.9405
1996	HDV6	17.281	0.49752	0.6708	1.419	0.01827	0.0370	22.889	0.61708	1.1692	31.808	0.91754	1.5557	19.718	0.50685	0.9129
1996	HDV7	19.843	0.56360	0.7225	1.385	0.01726	0.0331	23.950	0.64727	1.1288	34.805	1.12221	1.7501	23.832	0.57721	0.9522
1996	HDV8a	25.383	0.71150	0.8364	1.291	0.01415	0.0214	26.847	0.71304	0.9980	42.795	1.72599	2.3061	34.920	0.76388	1.0401
1996	HDV8b	26.821	0.74989	0.8670	1.243	0.01299	0.0174	27.869	0.73453	0.9632	45.038	1.90758	2.4718	38.330	0.82347	1.0722
1997	HDV2b	8.9760	0.29674	0.4414	1.198	0.01946	0.0361	14.332	0.49283	0.9813	16.732	0.46536	0.9033	9.5320	0.33926	0.6594
1997	HDV3	13.209	0.39125	0.5837	1.425	0.01960	0.0410	20.979	0.58828	1.2259	27.125	0.64252	1.2800	14.318	0.41777	0.8536
1997	HDV4	12.215	0.36372	0.5690	1.463	0.01988	0.0430	21.175	0.58746	1.2714	27.083	0.57250	1.2391	13.149	0.39772	0.8608
1997	HDV5	13.624	0.40215	0.6084	1.460	0.02034	0.0442	21.515	0.61022	1.3152	27.949	0.61377	1.2832	14.532	0.44038	0.9404
1997	HDV6	14.496	0.42302	0.6152	1.444	0.01932	0.0408	21.915	0.60438	1.2403	29.094	0.71558	1.3715	15.954	0.44622	0.8908
1997	HDV7	16.255	0.46936	0.6504	1.429	0.01878	0.0387	22.492	0.61668	1.2093	30.851	0.84366	1.4894	18.323	0.48541	0.9092
1997	HDV8a	24.346	0.68342	0.8129	1.313	0.01483	0.0242	26.254	0.68970	1.0127	41.070	1.61835	2.1972	32.547	0.71981	1.0105
1997	HDV8b	26.505	0.74055	0.8570	1.254	0.01315	0.0183	27.660	0.71554	0.9486	44.467	1.88663	2.4406	37.524	0.80347	1.0496
1998	HDV2b	7.1680	0.14777	0.2189	1.039	0.01827	0.0313	10.186	0.15179	0.2848	11.794	0.20084	0.3674	8.1994	0.22110	0.3952
1998	HDV3	11.359	0.19596	0.3211	1.688	0.01985	0.0406	18.173	0.22826	0.4692	22.926	0.32502	0.6676	13.778	0.27950	0.5737
1998	HDV4	11.490	0.19754	0.3243	1.720	0.01994	0.0410	18.434	0.23083	0.4753	23.386	0.33038	0.6802	13.998	0.28192	0.5807
1998	HDV5	11.883	0.19699	0.3227	1.722	0.02068	0.0430	18.507	0.22211	0.4607	23.505	0.31282	0.6485	14.331	0.28847	0.5995
1998	HDV6	11.751	0.20060	0.3266	1.721	0.02009	0.0414	18.475	0.23041	0.4729	23.571	0.33320	0.6800	14.295	0.28616	0.5874
1998	HDV7	13.669	0.23619	0.3570	1.698	0.01970	0.0400	19.057	0.25538	0.4899	25.028	0.40327	0.7511	16.706	0.31570	0.6115
1998	HDV8a	22.591	0.42374	0.5198	1.538	0.01444	0.0234	22.675	0.45126	0.6470	35.133	0.96121	1.3519	32.706	0.51254	0.7394
1998	HDV8b	24.783	0.47083	0.5614	1.456	0.01241	0.0173	24.029	0.51551	0.6978	38.288	1.14305	1.5426	38.048	0.58093	0.7873

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1999	HDV2b	5.2393	0.15885	0.2341	0.927	0.02223	0.0376	7.8235	0.16324	0.3048	8.7036	0.21455	0.3899	6.6671	0.25553	0.4531
1999	HDV3	7.0375	0.19028	0.3148	0.930	0.02098	0.0431	11.431	0.21782	0.4521	12.503	0.30081	0.6229	8.9385	0.28421	0.5882
1999	HDV4	7.1179	0.19157	0.3184	0.928	0.02083	0.0434	11.605	0.22035	0.4591	12.729	0.30579	0.6367	9.0655	0.28546	0.5953
1999	HDV5	7.2235	0.19411	0.3205	0.929	0.02079	0.0433	11.640	0.22187	0.4603	12.845	0.31178	0.6433	9.1917	0.28741	0.5966
1999	HDV6	7.5085	0.20078	0.3258	0.922	0.02098	0.0437	11.647	0.22316	0.4580	12.939	0.31780	0.6450	9.4666	0.29514	0.6081
1999	HDV7	8.4876	0.22458	0.3463	0.927	0.02044	0.0420	12.178	0.24202	0.4742	13.989	0.37406	0.7085	10.650	0.31242	0.6166
1999	HDV8a	16.770	0.43100	0.5263	0.942	0.01447	0.0234	18.321	0.45897	0.6520	24.889	0.98702	1.3761	23.923	0.52340	0.7502
1999	HDV8b	18.615	0.47894	0.5693	0.930	0.01223	0.0169	20.288	0.52529	0.7068	27.954	1.17212	1.5731	27.936	0.59007	0.7952
2000	HDV2b	5.6349	0.16036	0.2475	0.874	0.02016	0.0358	8.5350	0.17012	0.3310	9.2726	0.22168	0.4224	7.0131	0.24568	0.4579
2000	HDV3	7.0863	0.19098	0.3162	0.927	0.02077	0.0428	11.515	0.21929	0.4552	12.624	0.30401	0.6304	9.0048	0.28394	0.5883
2000	HDV4	7.2508	0.19465	0.3209	0.930	0.02075	0.0431	11.672	0.22277	0.4614	12.905	0.31387	0.6470	9.2265	0.2876	0.5955
2000	HDV5	7.3904	0.19792	0.3236	0.931	0.02070	0.0429	11.717	0.22473	0.4629	13.058	0.32158	0.6556	9.3951	0.29021	0.5972
2000	HDV6	7.4225	0.19859	0.3238	0.924	0.02095	0.0436	11.627	0.22225	0.4581	12.918	0.31528	0.6441	9.3818	0.29305	0.6049
2000	HDV7	9.4972	0.25027	0.3690	0.928	0.01987	0.0403	12.849	0.26474	0.4940	14.995	0.43183	0.7727	11.865	0.33134	0.6268
2000	HDV8a	16.023	0.41211	0.5099	0.933	0.01518	0.0256	17.687	0.43480	0.6324	23.564	0.91274	1.2953	22.365	0.49846	0.7334
2000	HDV8b	18.603	0.47908	0.5696	0.931	0.01229	0.0171	20.271	0.52493	0.7068	27.906	1.17092	1.5715	27.879	0.58955	0.7952
2001	HDV2b	4.3573	0.14868	0.2017	0.924	0.02343	0.0375	6.3407	0.14557	0.2520	7.4040	0.19424	0.3279	5.7547	0.25352	0.4194
2001	HDV3	7.0949	0.19224	0.3156	0.934	0.02105	0.0428	11.430	0.21914	0.4520	12.541	0.30558	0.6267	8.9921	0.28545	0.5857
2001	HDV4	7.1452	0.19220	0.3189	0.930	0.02075	0.0432	11.650	0.22146	0.4606	12.793	0.30840	0.6412	9.0994	0.28523	0.5937
2001	HDV5	7.2426	0.19458	0.3209	0.931	0.02071	0.0430	11.683	0.22289	0.4618	12.900	0.31402	0.6475	9.2158	0.28704	0.5949
2001	HDV6	8.4679	0.22489	0.3468	0.922	0.02058	0.0424	12.163	0.24113	0.4727	13.793	0.36641	0.6978	10.525	0.31234	0.6194
2001	HDV7	8.3064	0.22027	0.3427	0.925	0.02051	0.0422	12.115	0.23905	0.4719	13.770	0.36252	0.6962	10.406	0.30867	0.6143
2001	HDV8a	17.266	0.44383	0.5379	0.935	0.01390	0.0218	18.845	0.47583	0.6659	25.610	1.03155	1.4229	24.922	0.54010	0.7613
2001	HDV8b	18.553	0.47653	0.5668	0.927	0.01229	0.0170	20.218	0.52253	0.7039	27.870	1.16421	1.5645	27.844	0.58816	0.7934
2002	HDV2b	4.2422	0.14697	0.1984	0.905	0.02340	0.0375	6.1522	0.14273	0.2465	7.2059	0.18987	0.3187	5.6411	0.25473	0.4210
2002	HDV3	6.7539	0.18452	0.3054	0.903	0.02188	0.0444	10.750	0.20664	0.4289	11.735	0.27682	0.5711	8.5565	0.28715	0.5912

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2002	HDV4	6.9152	0.18671	0.3131	0.904	0.02173	0.0456	11.136	0.21176	0.4444	12.226	0.28513	0.5983	8.8299	0.29037	0.6094
2002	HDV5	6.9152	0.18671	0.3131	0.904	0.02173	0.0456	11.136	0.21176	0.4444	12.226	0.28513	0.5983	8.8299	0.29037	0.6094
2002	HDV6	7.1550	0.19206	0.3171	0.899	0.02193	0.0461	11.099	0.21081	0.4402	12.283	0.28758	0.5969	9.0470	0.29713	0.6215
2002	HDV7	9.1056	0.24068	0.3599	0.903	0.02087	0.0429	12.281	0.25096	0.4750	14.183	0.39419	0.7156	11.305	0.33105	0.6389
2002	HDV8a	16.243	0.41734	0.5139	0.927	0.01530	0.0257	17.710	0.43908	0.6328	23.854	0.92990	1.3077	22.850	0.50913	0.7443
2002	HDV8b	18.459	0.47309	0.5632	0.921	0.01246	0.0173	20.079	0.51797	0.6987	27.715	1.15157	1.5489	27.711	0.58638	0.7926
2003	HDV2b	3.2514	0.12592	0.1714	0.423	0.01962	0.0315	4.2244	0.12251	0.2129	5.7631	0.16228	0.2742	4.6060	0.21531	0.3574
2003	HDV3	5.2617	0.16744	0.2764	1.288	0.01935	0.0392	9.2785	0.18831	0.3900	9.4566	0.25443	0.5239	7.1968	0.25675	0.5276
2003	HDV4	5.4072	0.16989	0.2840	1.414	0.01937	0.0405	9.7150	0.19359	0.4051	9.8746	0.26329	0.5509	7.4626	0.26088	0.5459
2003	HDV5	5.4072	0.16989	0.2840	1.414	0.01937	0.0405	9.7150	0.19359	0.4051	9.8746	0.26329	0.5509	7.4626	0.26088	0.5459
2003	HDV6	5.5465	0.17497	0.2878	1.410	0.01955	0.0409	9.7633	0.19308	0.4016	9.9806	0.26641	0.5502	7.6112	0.26719	0.5567
2003	HDV7	6.2110	0.22496	0.3318	1.391	0.01849	0.0378	10.169	0.23443	0.4372	10.662	0.37662	0.6724	8.3183	0.30287	0.5762
2003	HDV8a	8.4157	0.38568	0.4723	1.305	0.01344	0.0222	11.887	0.40793	0.5822	13.945	0.87227	1.2180	11.692	0.46913	0.6777
2003	HDV8b	9.0490	0.4315	0.5129	1.243	0.01113	0.0154	12.599	0.47316	0.6364	15.059	1.05530	1.4160	12.942	0.53375	0.7191
2004	HDV2b	3.0413	0.12613	0.1719	0.411	0.01974	0.0318	4.1000	0.12270	0.2137	5.4045	0.16216	0.2743	4.2760	0.21648	0.3604
2004	HDV3	5.2595	0.16615	0.2752	1.285	0.01955	0.0398	9.2719	0.18618	0.3866	9.4235	0.24936	0.5149	7.1974	0.25777	0.5313
2004	HDV4	5.4200	0.16854	0.2825	1.411	0.01958	0.0410	9.7116	0.19123	0.4011	9.8736	0.25769	0.5405	7.4955	0.26187	0.5494
2004	HDV5	5.4200	0.16854	0.2825	1.411	0.01958	0.0410	9.7116	0.19123	0.4011	9.8736	0.25769	0.5405	7.4955	0.26187	0.5494
2004	HDV6	5.5480	0.17333	0.2862	1.407	0.01972	0.0414	9.7575	0.19107	0.3985	9.9725	0.26127	0.5414	7.6287	0.26751	0.5587
2004	HDV7	6.1505	0.21804	0.3255	1.390	0.01877	0.0385	10.123	0.22785	0.4301	10.586	0.35906	0.6500	8.2665	0.29917	0.5757
2004	HDV8a	8.3511	0.37641	0.4636	1.306	0.01382	0.0232	11.812	0.39614	0.5710	13.810	0.83875	1.1799	11.576	0.45979	0.6720
2004	HDV8b	9.0430	0.42626	0.5076	1.240	0.01130	0.0157	12.581	0.4666	0.6298	15.032	1.03626	1.3948	12.932	0.52895	0.7154
2005	HDV2b	2.7896	0.13001	0.1678	0.359	0.02151	0.0337	3.5573	0.12380	0.2052	5.2326	0.16754	0.2720	4.1083	0.23003	0.3686
2005	HDV3	5.1245	0.16718	0.2729	1.210	0.01957	0.0387	8.9725	0.18706	0.3836	9.1415	0.25324	0.5147	6.9543	0.25569	0.5169
2005	HDV4	5.3979	0.17090	0.2850	1.417	0.01919	0.0400	9.7176	0.19537	0.4080	9.8755	0.26757	0.5587	7.4386	0.25998	0.5429
2005	HDV5	5.3979	0.17090	0.2850	1.417	0.01919	0.0400	9.7176	0.19537	0.4080	9.8755	0.26757	0.5587	7.4386	0.25998	0.5429

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2005	HDV6	5.5287	0.17634	0.2892	1.413	0.01931	0.0403	9.7658	0.19604	0.4061	9.9844	0.27330	0.5617	7.5817	0.26608	0.5520
2005	HDV7	6.2753	0.23091	0.3372	1.391	0.01818	0.0369	10.221	0.24109	0.4442	10.750	0.39393	0.6944	8.3874	0.30628	0.5753
2005	HDV8a	8.4708	0.38800	0.4740	1.302	0.01326	0.0216	11.939	0.41174	0.5852	14.051	0.88331	1.2308	11.802	0.47294	0.6792
2005	HDV8b	9.0572	0.42998	0.5113	1.241	0.01115	0.0153	12.604	0.47152	0.6346	15.071	1.05057	1.4108	12.962	0.53280	0.7181
2006	HDV2b	2.9035	0.13908	0.1784	0.378	0.02328	0.0364	3.7248	0.13237	0.2184	5.5063	0.17986	0.2907	4.3076	0.24781	0.3956
2006	HDV3	5.1466	0.16771	0.2738	1.218	0.01998	0.0394	9.0094	0.18745	0.3845	9.2011	0.25353	0.5152	7.0047	0.25876	0.5228
2006	HDV4	5.4027	0.17039	0.2845	1.416	0.01928	0.0403	9.7164	0.19446	0.4065	9.8752	0.26536	0.5547	7.4511	0.26046	0.5445
2006	HDV5	5.4027	0.17039	0.2845	1.416	0.01928	0.0403	9.7164	0.19446	0.4065	9.8752	0.26536	0.5547	7.4511	0.26046	0.5445
2006	HDV6	5.5191	0.17573	0.2887	1.413	0.01935	0.0404	9.7618	0.19586	0.4058	9.9765	0.27237	0.5600	7.5775	0.26592	0.5519
2006	HDV7	6.2067	0.22603	0.3329	1.392	0.01832	0.0373	10.179	0.2371	0.4406	10.677	0.38286	0.6815	8.3154	0.30285	0.5735
2006	HDV8a	8.4054	0.38408	0.4707	1.306	0.01345	0.0222	11.877	0.40629	0.5808	13.931	0.86758	1.2134	11.675	0.46741	0.6760
2006	HDV8b	9.0439	0.43006	0.5115	1.242	0.01116	0.0154	12.592	0.47139	0.6347	15.047	1.05009	1.4105	12.931	0.53221	0.7178
2007	HDV2b	1.5916	0.00101	0.0105	0.624	0.00049	0.0051	2.4499	0.00126	0.0133	2.9291	0.00161	0.0170	2.1551	0.00165	0.0173
2007	HDV3	2.9589	0.00095	0.0106	0.589	0.00023	0.0025	5.1967	0.00154	0.0171	5.2818	0.00181	0.0201	4.0801	0.00146	0.0162
2007	HDV4	3.0714	0.00094	0.0105	0.585	0.00019	0.0020	5.4723	0.00157	0.0175	5.5923	0.00183	0.0204	4.3128	0.00143	0.0160
2007	HDV5	3.0714	0.00094	0.0105	0.585	0.00019	0.0020	5.4723	0.00157	0.0175	5.5923	0.00183	0.0204	4.3128	0.00143	0.0160
2007	HDV6	3.1485	0.00096	0.0107	0.587	0.00019	0.0020	5.4927	0.00157	0.0176	5.6588	0.00185	0.0207	4.3735	0.00145	0.0162
2007	HDV7	3.8691	0.00116	0.0129	0.537	0.00018	0.0020	6.1841	0.00177	0.0198	6.5767	0.00230	0.0257	5.1131	0.00158	0.0177
2007	HDV8a	5.7522	0.00166	0.0186	0.330	0.00016	0.0017	8.5217	0.00244	0.0272	10.050	0.00398	0.0445	7.8814	0.00208	0.0232
2007	HDV8b	6.2239	0.0018	0.0201	0.249	0.00014	0.0016	9.3303	0.00267	0.0298	11.071	0.00449	0.0502	8.7327	0.00224	0.0250
2008	HDV2b	1.4665	0.00102	0.0105	0.658	0.00052	0.0055	2.2325	0.00125	0.0133	2.8346	0.00159	0.0168	2.0511	0.00168	0.0178
2008	HDV3	2.7142	0.00091	0.0101	0.646	0.00026	0.0028	4.7187	0.00144	0.0160	4.7894	0.00162	0.0179	3.7181	0.00148	0.0164
2008	HDV4	2.8751	0.00090	0.0100	0.646	0.00019	0.0021	5.0905	0.00147	0.0164	5.1923	0.00162	0.0181	4.0308	0.00145	0.0162
2008	HDV5	2.8751	0.00090	0.0100	0.646	0.00019	0.0021	5.0905	0.00147	0.0164	5.1923	0.00162	0.0181	4.0308	0.00145	0.0162
2008	HDV6	2.9230	0.00091	0.0102	0.646	0.00019	0.0021	5.1111	0.00147	0.0165	5.2354	0.00164	0.0183	4.0707	0.00146	0.0163
2008	HDV7	3.2851	0.00101	0.0112	0.620	0.00019	0.0020	5.4500	0.00157	0.0175	5.6769	0.00185	0.0207	4.4245	0.00151	0.0169

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2008	HDV8a	5.1836	0.00151	0.0169	0.428	0.00017	0.0018	7.6210	0.00218	0.0244	8.7943	0.00336	0.0375	6.9050	0.00192	0.0215
2008	HDV8b	6.1025	0.00176	0.0196	0.274	0.00015	0.0016	9.1047	0.00260	0.0291	10.769	0.00433	0.0484	8.5125	0.00219	0.0245
2009	HDV2b	1.3740	0.00100	0.0100	0.516	0.00043	0.0043	2.0617	0.00115	0.0118	2.4637	0.00158	0.0162	1.8326	0.00157	0.0161
2009	HDV3	2.9584	0.00096	0.0106	0.557	0.00023	0.0024	5.1836	0.00154	0.0171	5.2331	0.00184	0.0204	4.0483	0.00145	0.0160
2009	HDV4	3.1234	0.00095	0.0107	0.569	0.00019	0.0020	5.5733	0.00159	0.0178	5.6981	0.00188	0.0210	4.3875	0.00143	0.0160
2009	HDV5	3.1234	0.00095	0.0107	0.569	0.00019	0.0020	5.5733	0.00159	0.0178	5.6981	0.00188	0.0210	4.3875	0.00143	0.0160
2009	HDV6	3.1996	0.00097	0.0109	0.576	0.00019	0.0020	5.5687	0.00159	0.0178	5.7418	0.00189	0.0212	4.4344	0.00145	0.0162
2009	HDV7	3.9294	0.00117	0.0131	0.524	0.00018	0.0020	6.2777	0.00179	0.0200	6.6810	0.00236	0.0263	5.1869	0.00159	0.0177
2009	HDV8a	5.8086	0.00168	0.0188	0.317	0.00016	0.0017	8.6281	0.00247	0.0276	10.181	0.00405	0.0453	7.9661	0.0021	0.0234
2009	HDV8b	6.2604	0.00181	0.0202	0.241	0.00014	0.0016	9.4032	0.00269	0.0301	11.155	0.00454	0.0508	8.7800	0.00225	0.0252
2010	HDV2b	0.5493	0.00091	0.0089	0.217	0.00036	0.0035	0.7408	0.00098	0.0099	0.9887	0.00143	0.0143	0.7515	0.00141	0.0141
2010	HDV3	0.8805	0.00088	0.0096	0.238	0.00021	0.0022	1.5481	0.00138	0.0153	1.5745	0.00165	0.0182	1.1835	0.00133	0.0146
2010	HDV4	0.9238	0.00087	0.0097	0.245	0.00017	0.0019	1.6735	0.00145	0.0162	1.6994	0.00169	0.0189	1.2665	0.00132	0.0147
2010	HDV5	0.9238	0.00087	0.0097	0.245	0.00017	0.0019	1.6735	0.00145	0.0162	1.6994	0.00169	0.0189	1.2665	0.00132	0.0147
2010	HDV6	0.9519	0.00088	0.0099	0.244	0.00017	0.0019	1.6835	0.00144	0.0161	1.7217	0.00169	0.0189	1.2978	0.00134	0.0149
2010	HDV7	1.0830	0.00106	0.0118	0.241	0.00017	0.0018	1.7673	0.00162	0.0181	1.8575	0.00209	0.0233	1.4389	0.00145	0.0162
2010	HDV8a	1.4869	0.00156	0.0175	0.228	0.00015	0.0016	2.0962	0.00228	0.0255	2.4653	0.00372	0.0416	2.0649	0.00195	0.0218
2010	HDV8b	1.5955	0.00170	0.0190	0.219	0.00014	0.0015	2.2224	0.00253	0.0283	2.6552	0.00426	0.0476	2.2795	0.00212	0.0237
2011	HDV2b	0.6105	0.00091	0.0092	0.276	0.00044	0.0045	0.8800	0.00108	0.0113	1.1777	0.00142	0.0148	0.8619	0.00147	0.0153
2011	HDV3	0.8855	0.00085	0.0094	0.248	0.00023	0.0024	1.5533	0.00135	0.0150	1.5953	0.00157	0.0173	1.2043	0.00134	0.0148
2011	HDV4	0.9219	0.00084	0.0094	0.241	0.00017	0.0019	1.6583	0.00139	0.0156	1.6851	0.00159	0.0178	1.2707	0.00131	0.0147
2011	HDV5	0.9219	0.00084	0.0094	0.241	0.00017	0.0019	1.6583	0.00139	0.0156	1.6851	0.00159	0.0178	1.2707	0.00131	0.0147
2011	HDV6	0.9431	0.00086	0.0096	0.241	0.00017	0.0019	1.6680	0.00140	0.0156	1.7043	0.00161	0.0180	1.2938	0.00133	0.0148
2011	HDV7	1.0495	0.00100	0.0111	0.239	0.00017	0.0018	1.7356	0.00154	0.0172	1.8130	0.00192	0.0215	1.4063	0.00141	0.0158
2011	HDV8a	1.4555	0.00151	0.0169	0.228	0.00015	0.0016	2.0601	0.00219	0.0245	2.4029	0.00350	0.0392	2.0071	0.00189	0.0211
2011	HDV8b	1.5911	0.00168	0.0188	0.219	0.00014	0.0015	2.2157	0.00250	0.0279	2.6438	0.00419	0.0468	2.2702	0.00210	0.0234

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2012	HDV2b	0.6102	0.00086	0.0089	0.273	0.00042	0.0043	0.8958	0.00105	0.0112	1.1782	0.00137	0.0145	0.8637	0.00141	0.0149
2012	HDV3	0.8900	0.00085	0.0094	0.247	0.00022	0.0023	1.5701	0.00135	0.0151	1.6074	0.00156	0.0174	1.2130	0.00133	0.0147
2012	HDV4	0.9205	0.00084	0.0094	0.241	0.00017	0.0019	1.6573	0.00139	0.0156	1.6830	0.00159	0.0178	1.2686	0.00131	0.0147
2012	HDV5	0.9205	0.00084	0.0094	0.241	0.00017	0.0019	1.6573	0.00139	0.0156	1.6830	0.00159	0.0178	1.2686	0.00131	0.0147
2012	HDV6	0.9413	0.00086	0.0096	0.241	0.00017	0.0019	1.6673	0.00140	0.0157	1.7027	0.00162	0.0181	1.2911	0.00133	0.0148
2012	HDV7	1.0082	0.00095	0.0106	0.240	0.00017	0.0018	1.7097	0.00149	0.0166	1.7695	0.00181	0.0202	1.3605	0.00138	0.0154
2012	HDV8a	1.3978	0.00142	0.0159	0.231	0.00015	0.0017	2.0011	0.00207	0.0231	2.3124	0.00323	0.0361	1.9092	0.00180	0.0201
2012	HDV8b	1.5740	0.00164	0.0184	0.219	0.00014	0.0015	2.1957	0.00244	0.0273	2.6085	0.00405	0.0452	2.2338	0.00205	0.0229
2013	HDV2b	0.6002	0.00085	0.0087	0.271	0.00041	0.0043	0.8815	0.00103	0.0110	1.1658	0.00135	0.0143	0.8538	0.00139	0.0147
2013	HDV3	0.8259	0.00078	0.0086	0.230	0.00020	0.0022	1.4570	0.00125	0.0139	1.4963	0.00144	0.0160	1.1295	0.00123	0.0136
2013	HDV4	0.8494	0.00077	0.0086	0.222	0.00016	0.0017	1.5282	0.00127	0.0142	1.5520	0.00145	0.0162	1.1714	0.00120	0.0134
2013	HDV5	0.8494	0.00077	0.0086	0.222	0.00016	0.0017	1.5282	0.00127	0.0142	1.5520	0.00145	0.0162	1.1714	0.00120	0.0134
2013	HDV6	0.8662	0.00078	0.0088	0.222	0.00016	0.0017	1.5356	0.00128	0.0143	1.5676	0.00147	0.0165	1.1895	0.00121	0.0136
2013	HDV7	0.9195	0.00085	0.0095	0.220	0.00016	0.0017	1.5676	0.00135	0.0151	1.6200	0.00163	0.0182	1.2449	0.00125	0.0140
2013	HDV8a	1.2467	0.00126	0.0140	0.210	0.00014	0.0015	1.7956	0.00183	0.0204	2.0692	0.00283	0.0317	1.7044	0.00160	0.0179
2013	HDV8b	1.4029	0.00145	0.0162	0.196	0.00012	0.0013	1.9587	0.00215	0.0241	2.3254	0.00357	0.0399	1.9904	0.00181	0.0203
2014	HDV2b	0.5890	0.00082	0.0086	0.267	0.00040	0.0042	0.8782	0.00102	0.0109	1.1526	0.00133	0.0141	0.8450	0.00136	0.0145
2014	HDV3	0.8224	0.00078	0.0086	0.229	0.00020	0.0021	1.4560	0.00124	0.0138	1.4932	0.00144	0.0159	1.1274	0.00122	0.0135
2014	HDV4	0.8454	0.00077	0.0086	0.222	0.00016	0.0017	1.5234	0.00127	0.0142	1.5471	0.00145	0.0162	1.1677	0.00120	0.0134
2014	HDV5	0.8454	0.00077	0.0086	0.222	0.00016	0.0017	1.5234	0.00127	0.0142	1.5471	0.00145	0.0162	1.1677	0.00120	0.0134
2014	HDV6	0.8610	0.00078	0.0087	0.221	0.00016	0.0017	1.5296	0.00128	0.0143	1.5614	0.00147	0.0164	1.1846	0.00121	0.0135
2014	HDV7	0.9068	0.00084	0.0094	0.219	0.00015	0.0017	1.5572	0.00134	0.0150	1.6085	0.00161	0.0181	1.2354	0.00125	0.0139
2014	HDV8a	1.1982	0.00122	0.0136	0.206	0.00014	0.0015	1.7563	0.00179	0.0200	2.0227	0.00278	0.0310	1.6646	0.00157	0.0175
2014	HDV8b	1.3269	0.00139	0.0156	0.190	0.00012	0.0013	1.8929	0.00209	0.0234	2.2468	0.00347	0.0388	1.9226	0.00176	0.0197
2015	HDV2b	0.5915	0.00082	0.0086	0.266	0.00040	0.0042	0.8838	0.00102	0.0109	1.1550	0.00133	0.0141	0.8471	0.00136	0.0145
2015	HDV3	0.8235	0.00077	0.0086	0.228	0.00020	0.0021	1.4590	0.00124	0.0139	1.4956	0.00144	0.0160	1.1292	0.00122	0.0135

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2015	HDV4	0.8454	0.00077	0.0086	0.222	0.00016	0.0017	1.5234	0.00127	0.0142	1.5471	0.00145	0.0162	1.1676	0.00120	0.0134
2015	HDV5	0.8454	0.00077	0.0086	0.222	0.00016	0.0017	1.5234	0.00127	0.0142	1.5471	0.00145	0.0162	1.1676	0.00120	0.0134
2015	HDV6	0.8608	0.00078	0.0087	0.221	0.00016	0.0017	1.5296	0.00128	0.0143	1.5613	0.00147	0.0165	1.1844	0.00121	0.0135
2015	HDV7	0.9068	0.00084	0.0094	0.219	0.00015	0.0017	1.5573	0.00134	0.0150	1.6087	0.00162	0.0181	1.2355	0.00125	0.0139
2015	HDV8a	1.1983	0.00122	0.0136	0.206	0.00014	0.0015	1.7565	0.00179	0.0200	2.0227	0.00278	0.0310	1.6647	0.00157	0.0175
2015	HDV8b	1.3269	0.00139	0.0156	0.190	0.00012	0.0013	1.8929	0.00209	0.0234	2.2467	0.00347	0.0388	1.9226	0.00176	0.0197
2016	HDV2b	0.5788	0.00080	0.0084	0.262	0.00039	0.0041	0.8743	0.00100	0.0107	1.1399	0.00130	0.0139	0.8363	0.00133	0.0142
2016	HDV3	0.8116	0.00076	0.0085	0.225	0.00019	0.0021	1.4396	0.00123	0.0137	1.4753	0.00142	0.0157	1.1139	0.00120	0.0133
2016	HDV4	0.8331	0.00076	0.0085	0.219	0.00015	0.0017	1.5015	0.00125	0.0140	1.5249	0.00143	0.0160	1.1509	0.00118	0.0132
2016	HDV5	0.8331	0.00076	0.0085	0.219	0.00015	0.0017	1.5015	0.00125	0.0140	1.5249	0.00143	0.0160	1.1509	0.00118	0.0132
2016	HDV6	0.8480	0.00077	0.0086	0.218	0.00015	0.0017	1.5074	0.00126	0.0141	1.5386	0.00145	0.0162	1.1669	0.00119	0.0133
2016	HDV7	0.8938	0.00083	0.0093	0.216	0.00015	0.0017	1.5354	0.00132	0.0148	1.5859	0.00159	0.0178	1.2177	0.00123	0.0138
2016	HDV8a	1.1867	0.00121	0.0135	0.204	0.00014	0.0015	1.7385	0.00177	0.0198	2.0021	0.00275	0.0307	1.6473	0.00155	0.0174
2016	HDV8b	1.3179	0.00138	0.0155	0.188	0.00012	0.0013	1.8799	0.00208	0.0233	2.2311	0.00345	0.0385	1.9092	0.00175	0.0196
2017	HDV2b	0.5694	0.00080	0.0084	0.262	0.00039	0.0041	0.8743	0.00100	0.0108	1.1274	0.00130	0.0139	0.8194	0.00133	0.0142
2017	HDV3	0.8112	0.00076	0.0085	0.225	0.00019	0.0020	1.4410	0.00123	0.0137	1.4748	0.00142	0.0157	1.1127	0.00120	0.0133
2017	HDV4	0.8331	0.00076	0.0085	0.219	0.00015	0.0017	1.5015	0.00125	0.0140	1.5248	0.00143	0.0160	1.1508	0.00118	0.0132
2017	HDV5	0.8331	0.00076	0.0085	0.219	0.00015	0.0017	1.5015	0.00125	0.0140	1.5248	0.00143	0.0160	1.1508	0.00118	0.0132
2017	HDV6	0.8478	0.00077	0.0086	0.218	0.00015	0.0017	1.5073	0.00126	0.0141	1.5385	0.00145	0.0162	1.1668	0.00119	0.0133
2017	HDV7	0.8934	0.00083	0.0093	0.216	0.00015	0.0017	1.5353	0.00132	0.0148	1.5855	0.00159	0.0178	1.2173	0.00123	0.0138
2017	HDV8a	1.1860	0.00121	0.0135	0.204	0.00014	0.0015	1.7379	0.00177	0.0198	2.0008	0.00275	0.0307	1.6461	0.00155	0.0174
2017	HDV8b	1.3177	0.00138	0.0155	0.188	0.00012	0.0013	1.8797	0.00208	0.0233	2.2306	0.00345	0.0385	1.9086	0.00175	0.0196
2018	HDV2b	0.2853	0.00048	0.0051	0.121	0.00024	0.0025	0.4414	0.00061	0.0066	0.5427	0.00078	0.0083	0.3986	0.00080	0.0085
2018	HDV3	0.4866	0.00048	0.0054	0.131	0.00012	0.0013	0.8681	0.00078	0.0087	0.8796	0.00090	0.0100	0.6627	0.00076	0.0085
2018	HDV4	0.5039	0.00048	0.0054	0.133	0.00010	0.0011	0.9115	0.00080	0.0090	0.9254	0.00091	0.0102	0.6953	0.00076	0.0085
2018	HDV5	0.5039	0.00048	0.0054	0.133	0.00010	0.0011	0.9115	0.00080	0.0090	0.9254	0.00091	0.0102	0.6953	0.00076	0.0085

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2018	HDV6	0.5165	0.00049	0.0055	0.133	0.00010	0.0011	0.9184	0.00081	0.0090	0.9381	0.00093	0.0104	0.7088	0.00076	0.0085
2018	HDV7	0.5600	0.00054	0.0061	0.133	0.00010	0.0010	0.9514	0.00086	0.0096	0.9849	0.00104	0.0116	0.7556	0.00080	0.0089
2018	HDV8a	0.8288	0.00083	0.0093	0.136	0.00009	0.0010	1.1899	0.00122	0.0136	1.3793	0.00190	0.0212	1.1390	0.00106	0.0119
2018	HDV8b	0.9477	0.00097	0.0108	0.134	0.00008	0.0009	1.3471	0.00145	0.0163	1.6003	0.00241	0.0270	1.3705	0.00122	0.0137
2019	HDV2b	0.2616	0.00047	0.0050	0.109	0.00024	0.0025	0.4045	0.00061	0.0065	0.4915	0.00076	0.0082	0.3625	0.00078	0.0084
2019	HDV3	0.4722	0.00048	0.0054	0.126	0.00012	0.0013	0.8428	0.00078	0.0087	0.8518	0.00090	0.0100	0.6414	0.00076	0.0085
2019	HDV4	0.4905	0.00048	0.0054	0.129	0.00010	0.0011	0.8881	0.00080	0.0090	0.9015	0.00091	0.0102	0.6764	0.00076	0.0085
2019	HDV5	0.4905	0.00048	0.0054	0.129	0.00010	0.0011	0.8881	0.00080	0.0090	0.9015	0.00091	0.0102	0.6764	0.00076	0.0085
2019	HDV6	0.5036	0.00049	0.0055	0.129	0.00010	0.0011	0.8956	0.00081	0.0090	0.9148	0.00093	0.0104	0.6904	0.00076	0.0085
2019	HDV7	0.5495	0.00054	0.0061	0.130	0.00010	0.0010	0.9310	0.00086	0.0096	0.9644	0.00104	0.0117	0.7398	0.00080	0.0089
2019	HDV8a	0.8270	0.00084	0.0093	0.135	0.00009	0.0010	1.1835	0.00122	0.0136	1.3738	0.00191	0.0213	1.1355	0.00106	0.0119
2019	HDV8b	0.9477	0.00097	0.0108	0.134	0.00008	0.0009	1.3466	0.00146	0.0163	1.6002	0.00241	0.0270	1.3707	0.00122	0.0137
2020	HDV2b	0.2381	0.00046	0.0049	0.096	0.00024	0.0025	0.3679	0.00060	0.0065	0.4404	0.00074	0.0079	0.3265	0.00077	0.0083
2020	HDV3	0.4579	0.00048	0.0054	0.121	0.00012	0.0013	0.8176	0.00078	0.0087	0.8240	0.00089	0.0100	0.6202	0.00076	0.0084
2020	HDV4	0.4772	0.00048	0.0054	0.126	0.00010	0.0011	0.8646	0.00080	0.0090	0.8776	0.00091	0.0102	0.6575	0.00076	0.0085
2020	HDV5	0.4772	0.00048	0.0054	0.126	0.00010	0.0011	0.8646	0.00080	0.0090	0.8776	0.00091	0.0102	0.6575	0.00076	0.0085
2020	HDV6	0.4907	0.00049	0.0055	0.126	0.00010	0.0011	0.8727	0.00081	0.0090	0.8915	0.00093	0.0104	0.6720	0.00076	0.0085
2020	HDV7	0.5389	0.00054	0.0061	0.127	0.00010	0.0010	0.9105	0.00086	0.0096	0.9439	0.00105	0.0117	0.7237	0.00080	0.0089
2020	HDV8a	0.8250	0.00084	0.0094	0.133	0.00009	0.0010	1.1769	0.00122	0.0137	1.3679	0.00191	0.0214	1.1315	0.00107	0.0119
2020	HDV8b	0.9476	0.00097	0.0108	0.133	0.00008	0.0009	1.3459	0.00146	0.0163	1.5999	0.00242	0.0270	1.3707	0.00123	0.0137
2021	HDV2b	0.2156	0.00044	0.0048	0.084	0.00023	0.0025	0.3328	0.00059	0.0064	0.3922	0.00071	0.0077	0.2927	0.00075	0.0081
2021	HDV3	0.4444	0.00048	0.0054	0.117	0.00012	0.0013	0.7938	0.00078	0.0087	0.7976	0.00089	0.0099	0.6002	0.00076	0.0084
2021	HDV4	0.4649	0.00048	0.0054	0.123	0.00010	0.0011	0.8430	0.00080	0.0090	0.8556	0.00091	0.0102	0.6401	0.00076	0.0085
2021	HDV5	0.4649	0.00048	0.0054	0.123	0.00010	0.0011	0.8430	0.00080	0.0090	0.8556	0.00091	0.0102	0.6401	0.00076	0.0085
2021	HDV6	0.4788	0.00049	0.0055	0.123	0.00010	0.0011	0.8515	0.00081	0.0090	0.8699	0.00093	0.0104	0.6549	0.00076	0.0085
2021	HDV7	0.5288	0.00055	0.0061	0.124	0.00010	0.0010	0.8914	0.00086	0.0096	0.9245	0.00105	0.0117	0.7085	0.00080	0.0089

		DIESEL														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2021	HDV8a	0.8224	0.00084	0.0094	0.132	0.00009	0.0010	1.1701	0.00123	0.0137	1.3614	0.00192	0.0215	1.1268	0.00107	0.0119
2021	HDV8b	0.9474	0.00097	0.0108	0.133	0.00008	0.0009	1.3451	0.00146	0.0163	1.5994	0.00242	0.0271	1.3704	0.00123	0.0137
2022	HDV2b	0.2156	0.00044	0.0048	0.084	0.00023	0.0025	0.3328	0.00059	0.0064	0.3922	0.00071	0.0077	0.2927	0.00075	0.0081
2022	HDV3	0.4444	0.00048	0.0054	0.117	0.00012	0.0013	0.7938	0.00078	0.0087	0.7976	0.00089	0.0099	0.6002	0.00076	0.0084
2022	HDV4	0.4649	0.00048	0.0054	0.123	0.00010	0.0011	0.8430	0.00080	0.0090	0.8556	0.00091	0.0102	0.6401	0.00076	0.0085
2022	HDV5	0.4649	0.00048	0.0054	0.123	0.00010	0.0011	0.8430	0.00080	0.0090	0.8556	0.00091	0.0102	0.6401	0.00076	0.0085
2022	HDV6	0.4788	0.00049	0.0055	0.123	0.00010	0.0011	0.8515	0.00081	0.0090	0.8699	0.00093	0.0104	0.6549	0.00076	0.0085
2022	HDV7	0.5288	0.00055	0.0061	0.124	0.00010	0.0010	0.8914	0.00086	0.0096	0.9245	0.00105	0.0117	0.7085	0.00080	0.0089
2022	HDV8a	0.8224	0.00084	0.0094	0.132	0.00009	0.0010	1.1701	0.00123	0.0137	1.3614	0.00192	0.0215	1.1268	0.00107	0.0119
2022	HDV8b	0.9474	0.00097	0.0108	0.133	0.00008	0.0009	1.3451	0.00146	0.0163	1.5994	0.00242	0.0271	1.3704	0.00123	0.0137

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
Pre 1991	HDV2b	4.8270	0.00832	0.0568	0.142	0.00057	0.0039	4.6848	0.01089	0.0743	8.0065	0.00462	0.0315	6.8087	0.00435	0.0296
Pre 1991	HDV3	5.7544	0.01474	0.1006	0.137	0.00062	0.0042	6.4833	0.01623	0.1107	9.1494	0.00518	0.0353	7.3830	0.00441	0.0301
Pre 1991	HDV4	5.8345	0.01498	0.1022	0.137	0.00062	0.0042	6.5035	0.01628	0.1111	9.2184	0.00548	0.0374	7.4501	0.00457	0.0312
Pre 1991	HDV5	5.6351	0.01445	0.0986	0.137	0.00062	0.0042	6.5055	0.01633	0.1114	9.0934	0.00510	0.0348	7.2920	0.00428	0.0292
Pre 1991	HDV6	5.4553	0.01402	0.0957	0.137	0.00062	0.0042	6.5736	0.01661	0.1134	9.0219	0.00518	0.0353	7.1378	0.00412	0.0281
Pre 1991	HDV7	5.4553	0.01402	0.0957	0.137	0.00062	0.0042	6.5736	0.01661	0.1134	9.0219	0.00518	0.0353	7.1378	0.00412	0.0281
Pre 1991	HDV8a	5.7576	0.01502	0.1025	0.136	0.00062	0.0042	6.7632	0.01719	0.1173	9.4243	0.00727	0.0496	7.4636	0.00503	0.0343
Pre 1991	HDV8b	5.7576	0.01502	0.1025	0.136	0.00062	0.0042	6.7632	0.01719	0.1173	9.4243	0.00727	0.0496	7.4636	0.00503	0.0343
1991	HDV2b	4.8270	0.00832	0.0568	0.142	0.00057	0.0039	4.6848	0.01089	0.0743	8.0065	0.00462	0.0315	6.8087	0.00435	0.0296
1991	HDV3	5.7544	0.01474	0.1006	0.137	0.00062	0.0042	6.4833	0.01623	0.1107	9.1494	0.00518	0.0353	7.3830	0.00441	0.0301
1991	HDV4	5.8345	0.01498	0.1022	0.137	0.00062	0.0042	6.5035	0.01628	0.1111	9.2184	0.00548	0.0374	7.4501	0.00457	0.0312
1991	HDV5	5.6351	0.01445	0.0986	0.137	0.00062	0.0042	6.5055	0.01633	0.1114	9.0934	0.00510	0.0348	7.2920	0.00428	0.0292
1991	HDV6	5.4553	0.01402	0.0957	0.137	0.00062	0.0042	6.5736	0.01661	0.1134	9.0219	0.00518	0.0353	7.1378	0.00412	0.0281
1991	HDV7	5.4553	0.01402	0.0957	0.137	0.00062	0.0042	6.5736	0.01661	0.1134	9.0219	0.00518	0.0353	7.1378	0.00412	0.0281
1991	HDV8a	5.7576	0.01502	0.1025	0.136	0.00062	0.0042	6.7632	0.01719	0.1173	9.4243	0.00727	0.0496	7.4636	0.00503	0.0343
1991	HDV8b	5.7576	0.01502	0.1025	0.136	0.00062	0.0042	6.7632	0.01719	0.1173	9.4243	0.00727	0.0496	7.4636	0.00503	0.0343
1992	HDV2b	4.8833	0.00863	0.0588	0.139	0.00056	0.0038	4.7966	0.01113	0.0760	8.0890	0.00459	0.0313	6.8590	0.00427	0.0292
1992	HDV3	5.8104	0.01491	0.1017	0.137	0.00062	0.0042	6.4927	0.01625	0.1109	9.1931	0.00535	0.0365	7.4284	0.00451	0.0308
1992	HDV4	5.9418	0.01531	0.1045	0.137	0.00062	0.0042	6.5332	0.01636	0.1116	9.3122	0.00591	0.0403	7.5391	0.00478	0.0326
1992	HDV5	5.6628	0.01451	0.0990	0.137	0.00062	0.0042	6.4976	0.01630	0.1112	9.1051	0.00509	0.0347	7.3131	0.00431	0.0294
1992	HDV6	5.4568	0.01403	0.0957	0.137	0.00062	0.0042	6.5764	0.01662	0.1134	9.0269	0.00518	0.0353	7.1391	0.00412	0.0281
1992	HDV7	5.4568	0.01403	0.0957	0.137	0.00062	0.0042	6.5764	0.01662	0.1134	9.0269	0.00518	0.0353	7.1391	0.00412	0.0281
1992	HDV8a	6.0508	0.01599	0.1091	0.136	0.00062	0.0042	6.9617	0.01779	0.1214	9.8355	0.00939	0.0640	7.7946	0.00596	0.0407
1992	HDV8b	6.0508	0.01599	0.1091	0.136	0.00062	0.0042	6.9617	0.01779	0.1214	9.8355	0.00939	0.0640	7.7946	0.00596	0.0407
1993	HDV2b	4.9683	0.00971	0.0662	0.137	0.00057	0.0038	5.0797	0.01198	0.0817	8.1477	0.00454	0.0310	6.8961	0.00411	0.0281
1993	HDV3	5.6602	0.01455	0.0993	0.138	0.00062	0.0042	6.4391	0.01613	0.1101	9.0258	0.00505	0.0344	7.3126	0.00428	0.0292

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1993	HDV4	5.7658	0.01480	0.1010	0.138	0.00062	0.0042	6.4527	0.01614	0.1101	9.1150	0.00518	0.0353	7.3923	0.00441	0.0301
1993	HDV5	5.6624	0.01454	0.0992	0.138	0.00062	0.0042	6.4351	0.01612	0.1100	9.0245	0.00500	0.0341	7.3127	0.00427	0.0291
1993	HDV6	5.3720	0.01392	0.0950	0.138	0.00062	0.0042	6.4271	0.01623	0.1107	8.7611	0.00496	0.0338	7.0670	0.00394	0.0269
1993	HDV7	5.3720	0.01392	0.0950	0.138	0.00062	0.0042	6.4271	0.01623	0.1107	8.7611	0.00496	0.0338	7.0670	0.00394	0.0269
1993	HDV8a	5.4701	0.01424	0.0971	0.137	0.00062	0.0042	6.4880	0.01641	0.1120	8.8915	0.00561	0.0383	7.1701	0.00423	0.0288
1993	HDV8b	5.4701	0.01424	0.0971	0.137	0.00062	0.0042	6.4880	0.01641	0.1120	8.8915	0.00561	0.0383	7.1701	0.00423	0.0288
1994	HDV2b	4.7143	0.01014	0.0692	0.111	0.00031	0.0021	4.5531	0.00227	0.0154	7.6386	0.00706	0.0482	6.7764	0.01790	0.1221
1994	HDV3	5.6210	0.01697	0.1158	0.135	0.00038	0.0025	6.4191	0.00322	0.0220	9.0144	0.01225	0.0836	7.2433	0.02731	0.1864
1994	HDV4	5.8554	0.01833	0.1251	0.135	0.00038	0.0025	6.4637	0.00324	0.0221	9.2050	0.01277	0.0871	7.4383	0.02869	0.1958
1994	HDV5	5.6819	0.01736	0.1184	0.135	0.00038	0.0026	6.3547	0.00313	0.0214	8.9901	0.01211	0.0826	7.2727	0.02759	0.1882
1994	HDV6	5.3630	0.01543	0.1053	0.135	0.00037	0.0025	6.4605	0.00332	0.0226	8.8640	0.01194	0.0815	7.0188	0.02565	0.1750
1994	HDV7	5.3630	0.01543	0.1053	0.135	0.00037	0.0025	6.4605	0.00332	0.0226	8.8640	0.01194	0.0815	7.0188	0.02565	0.1750
1994	HDV8a	9.2534	0.03741	0.2553	0.123	0.00033	0.0023	10.694	0.00737	0.0502	16.097	0.03383	0.2308	12.949	0.06555	0.4473
1994	HDV8b	9.2534	0.03741	0.2553	0.123	0.00033	0.0023	10.694	0.00737	0.0502	16.097	0.03383	0.2308	12.949	0.06555	0.4473
1995	HDV2b	4.7140	0.01011	0.0689	0.116	0.00034	0.0023	4.6047	0.00320	0.0218	7.6279	0.00443	0.0302	6.7365	0.00540	0.0369
1995	HDV3	5.5089	0.01634	0.1115	0.135	0.00039	0.0026	6.4041	0.00451	0.0308	8.9213	0.00410	0.0280	7.1474	0.00528	0.0360
1995	HDV4	5.6726	0.01682	0.1148	0.135	0.00039	0.0026	6.3954	0.00449	0.0306	9.0231	0.00438	0.0299	7.2787	0.00557	0.0380
1995	HDV5	5.5887	0.01654	0.1129	0.135	0.00039	0.0026	6.3765	0.00447	0.0305	8.9508	0.00403	0.0275	7.2075	0.00536	0.0366
1995	HDV6	5.3561	0.01593	0.1087	0.135	0.00038	0.0026	6.4483	0.00458	0.0312	8.8424	0.00412	0.0281	7.0129	0.00505	0.0345
1995	HDV7	5.3561	0.01593	0.1087	0.135	0.00038	0.0026	6.4483	0.00458	0.0312	8.8424	0.00412	0.0281	7.0129	0.00505	0.0345
1995	HDV8a	9.2534	0.03095	0.2112	0.123	0.00036	0.0024	10.694	0.00818	0.0558	16.097	0.04854	0.3313	12.949	0.02565	0.1750
1995	HDV8b	9.2534	0.03095	0.2112	0.123	0.00036	0.0024	10.694	0.00818	0.0558	16.097	0.04854	0.3313	12.949	0.02565	0.1750
1996	HDV2b	3.5270	0.00885	0.0604	0.099	0.00043	0.0029	3.4401	0.00255	0.0174	5.1974	0.00672	0.0459	5.0014	0.00291	0.0198
1996	HDV3	5.5901	0.0162	0.1105	0.135	0.00046	0.0031	6.3991	0.00366	0.0250	8.9769	0.00605	0.0413	7.2116	0.00276	0.0188
1996	HDV4	5.7167	0.01651	0.1127	0.135	0.00046	0.0031	6.3920	0.00367	0.0250	9.0492	0.00636	0.0434	7.3096	0.00287	0.0196
1996	HDV5	5.6673	0.01638	0.1118	0.135	0.00046	0.0031	6.3614	0.00365	0.0249	8.9886	0.00588	0.0401	7.2630	0.00279	0.0190

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1996	HDV6	5.3694	0.01565	0.1068	0.135	0.00046	0.0031	6.4717	0.00368	0.0251	8.8840	0.00604	0.0412	7.0242	0.00261	0.0178
1996	HDV7	5.3694	0.01565	0.1068	0.135	0.00046	0.0031	6.4717	0.00368	0.0251	8.8840	0.00604	0.0412	7.0242	0.00261	0.0178
1996	HDV8a	9.2534	0.02547	0.1738	0.123	0.00042	0.0028	10.694	0.00609	0.0416	16.097	0.06136	0.4187	12.949	0.01220	0.0832
1996	HDV8b	9.2534	0.02547	0.1738	0.123	0.00042	0.0028	10.694	0.00609	0.0416	16.097	0.06136	0.4187	12.949	0.01220	0.0832
1997	HDV2b	3.2924	0.00712	0.0486	0.106	0.00020	0.0013	3.0882	0.00181	0.0123	4.8652	0.00546	0.0372	4.5122	0.00731	0.0498
1997	HDV3	5.4964	0.01228	0.0837	0.135	0.00022	0.0015	6.4354	0.00247	0.0168	8.9478	0.00503	0.0343	7.1385	0.00848	0.0578
1997	HDV4	5.6981	0.01292	0.0882	0.135	0.00022	0.0015	6.3805	0.00245	0.0167	9.0266	0.00497	0.0339	7.2919	0.00893	0.0609
1997	HDV5	5.6009	0.01259	0.0859	0.135	0.00022	0.0015	6.3840	0.00245	0.0167	8.9697	0.00482	0.0328	7.2165	0.0087	0.0593
1997	HDV6	5.3709	0.01187	0.0810	0.135	0.00022	0.0015	6.4743	0.00248	0.0169	8.8886	0.00507	0.0345	7.0254	0.00814	0.0555
1997	HDV7	5.3709	0.01187	0.0810	0.135	0.00022	0.0015	6.4743	0.00248	0.0169	8.8886	0.00507	0.0345	7.0254	0.00814	0.0555
1997	HDV8a	9.2535	0.02655	0.1811	0.123	0.00019	0.0013	10.694	0.00520	0.0355	16.097	0.04479	0.3057	12.949	0.02848	0.1943
1997	HDV8b	9.2535	0.02655	0.1811	0.123	0.00019	0.0013	10.694	0.00520	0.0355	16.097	0.04479	0.3057	12.949	0.02848	0.1943
1998	HDV2b	2.4447	0.00589	0.0402	0.117	0.00025	0.0017	1.7766	0.00196	0.0133	3.6797	0.00496	0.0338	3.9945	0.00535	0.0365
1998	HDV3	4.1691	0.01517	0.1035	0.258	0.00030	0.0020	4.0058	0.00380	0.0259	6.1410	0.00830	0.0566	6.4996	0.01155	0.0788
1998	HDV4	4.4189	0.01662	0.1134	0.255	0.00030	0.0020	4.1254	0.00408	0.0278	6.5632	0.01121	0.0765	6.7277	0.01266	0.0864
1998	HDV5	3.8504	0.01345	0.0918	0.263	0.00031	0.0021	3.7760	0.00335	0.0228	5.5121	0.00381	0.0260	6.2082	0.01011	0.0690
1998	HDV6	3.8161	0.01315	0.0897	0.263	0.00030	0.0021	3.8258	0.00339	0.0231	5.5113	0.00393	0.0268	6.1688	0.00993	0.0677
1998	HDV7	3.8161	0.01315	0.0897	0.263	0.00030	0.0021	3.8258	0.00339	0.0231	5.5113	0.00393	0.0268	6.1688	0.00993	0.0677
1998	HDV8a	5.3507	0.02158	0.1472	0.226	0.00025	0.0017	5.6535	0.00701	0.0479	9.7495	0.03400	0.2320	8.2019	0.01994	0.1360
1998	HDV8b	5.3507	0.02158	0.1472	0.226	0.00025	0.0017	5.6535	0.00701	0.0479	9.7495	0.03400	0.2320	8.2019	0.01994	0.1360
1999	HDV2b	2.6278	0.00826	0.0564	0.138	0.00008	0.0005	2.0219	0.00111	0.0075	3.8700	0.00435	0.0296	4.2326	0.00282	0.0192
1999	HDV3	3.8484	0.01761	0.1201	0.263	0.00009	0.0006	3.8132	0.00183	0.0125	5.5462	0.00238	0.0162	6.2090	0.00347	0.0237
1999	HDV4	3.9317	0.01816	0.1239	0.262	0.00009	0.0006	3.8408	0.00187	0.0127	5.6787	0.00356	0.0243	6.2848	0.00381	0.0260
1999	HDV5	3.8373	0.01774	0.1210	0.263	0.00009	0.0006	3.7642	0.00181	0.0123	5.4871	0.00169	0.0115	6.2022	0.00347	0.0237
1999	HDV6	3.8379	0.01774	0.1211	0.263	0.00009	0.0006	3.7636	0.00181	0.0123	5.4873	0.00169	0.0115	6.2027	0.00348	0.0237
1999	HDV7	3.8057	0.01734	0.1183	0.263	0.00009	0.0006	3.7952	0.00181	0.0123	5.4729	0.00172	0.0117	6.1692	0.00329	0.0225

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
1999	HDV8a	3.9784	0.01824	0.1245	0.261	0.00009	0.0006	3.9169	0.00192	0.0131	5.8192	0.00502	0.0342	6.3316	0.00398	0.0271
1999	HDV8b	3.9784	0.01824	0.1245	0.261	0.00009	0.0006	3.9169	0.00192	0.0131	5.8192	0.00502	0.0342	6.3316	0.00398	0.0271
2000	HDV2b	2.5785	0.00699	0.0477	0.139	0.00008	0.0005	1.9532	0.00083	0.0056	3.8319	0.00405	0.0276	4.1812	0.00368	0.0251
2000	HDV3	3.8061	0.01431	0.0976	0.264	0.00009	0.0006	3.7739	0.00108	0.0074	5.4563	0.00169	0.0115	6.1758	0.00402	0.0274
2000	HDV4	3.8232	0.01444	0.0985	0.264	0.00009	0.0006	3.7618	0.00108	0.0073	5.4682	0.00168	0.0115	6.1927	0.00407	0.0278
2000	HDV5	3.8302	0.01450	0.0989	0.264	0.00009	0.0006	3.7554	0.00108	0.0073	5.4714	0.00166	0.0113	6.1994	0.00409	0.0279
2000	HDV6	3.8308	0.01450	0.0989	0.264	0.00009	0.0006	3.7550	0.00108	0.0073	5.4718	0.00166	0.0113	6.2000	0.00409	0.0279
2000	HDV7	3.8000	0.01426	0.0973	0.264	0.00009	0.0006	3.7784	0.00108	0.0074	5.4517	0.00169	0.0115	6.1695	0.00400	0.0273
2000	HDV8a	3.8016	0.01427	0.0974	0.264	0.00009	0.0006	3.7795	0.00108	0.0074	5.4548	0.00171	0.0117	6.1709	0.00401	0.0274
2000	HDV8b	3.8016	0.01427	0.0974	0.264	0.00009	0.0006	3.7795	0.00108	0.0074	5.4548	0.00171	0.0117	6.1709	0.00401	0.0274
2001	HDV2b	1.0912	0.00538	0.0367	0.059	0.00003	0.0002	0.7199	0.00081	0.0055	1.5855	0.00428	0.0292	1.7364	0.00353	0.0241
2001	HDV3	1.7612	0.01775	0.1211	0.121	0.00004	0.0003	1.7539	0.00075	0.0051	2.5369	0.00194	0.0132	2.8459	0.01188	0.0810
2001	HDV4	1.7723	0.01792	0.1222	0.121	0.00004	0.0003	1.7409	0.00075	0.0051	2.5395	0.00192	0.0131	2.8580	0.01188	0.0810
2001	HDV5	1.7747	0.01798	0.1226	0.121	0.00004	0.0003	1.7346	0.00074	0.0051	2.5368	0.00185	0.0126	2.8608	0.01188	0.0810
2001	HDV6	1.7750	0.01798	0.1227	0.121	0.00004	0.0003	1.7343	0.00074	0.0051	2.5368	0.00185	0.0126	2.8611	0.01188	0.0810
2001	HDV7	1.7564	0.01768	0.1206	0.121	0.00004	0.0003	1.7597	0.00076	0.0051	2.5353	0.00193	0.0132	2.8403	0.01188	0.0811
2001	HDV8a	1.7598	0.01770	0.1207	0.121	0.00004	0.0003	1.7620	0.00076	0.0052	2.5419	0.00206	0.0140	2.8434	0.01188	0.0811
2001	HDV8b	1.7598	0.01770	0.1207	0.121	0.00004	0.0003	1.7620	0.00076	0.0052	2.5419	0.00206	0.0140	2.8434	0.01188	0.0811
2002	HDV2b	1.0129	0.00257	0.0175	0.050	0.00012	0.0008	0.6778	0.00131	0.0089	1.4498	0.00270	0.0184	1.5924	0.00222	0.0151
2002	HDV3	1.7616	0.00627	0.0427	0.121	0.00014	0.0009	1.7595	0.00212	0.0144	2.5419	0.00221	0.0151	2.8446	0.00336	0.0229
2002	HDV4	1.7706	0.00635	0.0433	0.121	0.00014	0.0009	1.7469	0.00210	0.0143	2.5424	0.00220	0.0150	2.8549	0.00339	0.0231
2002	HDV5	1.7731	0.00637	0.0434	0.121	0.00014	0.0009	1.7409	0.00209	0.0143	2.5402	0.00218	0.0149	2.8580	0.00340	0.0232
2002	HDV6	1.7734	0.00637	0.0435	0.121	0.00014	0.0009	1.7405	0.00209	0.0143	2.5402	0.00218	0.0149	2.8583	0.00340	0.0232
2002	HDV7	1.7581	0.00624	0.0425	0.121	0.00014	0.0009	1.7646	0.00212	0.0145	2.5415	0.00222	0.0151	2.8402	0.00334	0.0228
2002	HDV8a	1.7600	0.00625	0.0426	0.121	0.00014	0.0009	1.7659	0.00213	0.0145	2.5453	0.00225	0.0153	2.8421	0.00335	0.0228
2002	HDV8b	1.7600	0.00625	0.0426	0.121	0.00014	0.0009	1.7659	0.00213	0.0145	2.5453	0.00225	0.0153	2.8421	0.00335	0.0228

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2003	HDV2b	1.0463	0.00305	0.0208	0.053	0.00006	0.0004	0.6962	0.00081	0.0055	1.5209	0.00297	0.0202	1.6594	0.00212	0.0145
2003	HDV3	1.7616	0.00888	0.0606	0.121	0.00007	0.0005	1.7596	0.00140	0.0095	2.5420	0.00129	0.0088	2.8446	0.00403	0.0275
2003	HDV4	1.7706	0.00900	0.0614	0.121	0.00007	0.0005	1.7472	0.00138	0.0094	2.5427	0.00128	0.0087	2.8549	0.00409	0.0279
2003	HDV5	1.7729	0.00905	0.0617	0.121	0.00007	0.0005	1.7412	0.00138	0.0094	2.5402	0.00124	0.0084	2.8578	0.00410	0.0280
2003	HDV6	1.7732	0.00905	0.0617	0.121	0.00007	0.0005	1.7408	0.00138	0.0094	2.5402	0.00124	0.0084	2.8581	0.00410	0.0280
2003	HDV7	1.7581	0.00883	0.0602	0.121	0.00007	0.0005	1.7646	0.00140	0.0095	2.5415	0.00129	0.0088	2.8402	0.00401	0.0274
2003	HDV8a	1.7603	0.00885	0.0603	0.121	0.00007	0.0005	1.7661	0.00140	0.0096	2.5458	0.00134	0.0091	2.8423	0.00402	0.0274
2003	HDV8b	1.7603	0.00885	0.0603	0.121	0.00007	0.0005	1.7661	0.00140	0.0096	2.5458	0.00134	0.0091	2.8423	0.00402	0.0274
2004	HDV2b	0.6911	0.00180	0.0123	0.039	0.00012	0.0008	0.4943	0.00090	0.0061	0.9469	0.00202	0.0137	1.0465	0.00203	0.0139
2004	HDV3	1.7612	0.00468	0.0319	0.121	0.00014	0.0009	1.7603	0.00186	0.0127	2.5421	0.00165	0.0112	2.8441	0.00435	0.0297
2004	HDV4	1.7694	0.00476	0.0324	0.121	0.00014	0.0009	1.7492	0.00186	0.0127	2.5430	0.00164	0.0112	2.8535	0.00441	0.0301
2004	HDV5	1.7715	0.00478	0.0326	0.121	0.00014	0.0009	1.7433	0.00186	0.0127	2.5404	0.00162	0.0111	2.8562	0.00443	0.0302
2004	HDV6	1.7717	0.00479	0.0326	0.121	0.00014	0.0009	1.7429	0.00186	0.0127	2.5403	0.00162	0.0110	2.8565	0.00443	0.0302
2004	HDV7	1.7581	0.00465	0.0317	0.121	0.00014	0.0009	1.7646	0.00186	0.0127	2.5415	0.00165	0.0112	2.8402	0.00433	0.0295
2004	HDV8a	1.7604	0.00466	0.0318	0.121	0.00014	0.0009	1.7661	0.00187	0.0127	2.5459	0.00167	0.0114	2.8423	0.00434	0.0296
2004	HDV8b	1.7604	0.00466	0.0318	0.121	0.00014	0.0009	1.7661	0.00187	0.0127	2.5459	0.00167	0.0114	2.8423	0.00434	0.0296
2005	HDV2b	0.4735	0.00148	0.0101	0.029	0.00012	0.0008	0.3042	0.00080	0.0055	0.6657	0.00203	0.0139	0.7387	0.00186	0.0126
2005	HDV3	1.7617	0.00468	0.0319	0.121	0.00014	0.0009	1.7596	0.00186	0.0127	2.5421	0.00165	0.0112	2.8447	0.00436	0.0297
2005	HDV4	1.7709	0.00477	0.0325	0.121	0.00014	0.0009	1.7472	0.00186	0.0127	2.5431	0.00164	0.0112	2.8552	0.00442	0.0302
2005	HDV5	1.7731	0.00480	0.0327	0.121	0.00014	0.0009	1.7409	0.00186	0.0127	2.5402	0.00162	0.0110	2.8580	0.00444	0.0303
2005	HDV6	1.7734	0.00480	0.0327	0.121	0.00014	0.0009	1.7406	0.00186	0.0127	2.5402	0.00162	0.0110	2.8583	0.00445	0.0303
2005	HDV7	1.7581	0.00465	0.0317	0.121	0.00014	0.0009	1.7646	0.00186	0.0127	2.5415	0.00165	0.0112	2.8402	0.00433	0.0295
2005	HDV8a	1.7607	0.00466	0.0318	0.121	0.00014	0.0009	1.7663	0.00187	0.0127	2.5465	0.00167	0.0114	2.8426	0.00434	0.0296
2005	HDV8b	1.7607	0.00466	0.0318	0.121	0.00014	0.0009	1.7663	0.00187	0.0127	2.5465	0.00167	0.0114	2.8426	0.00434	0.0296
2006	HDV2b	0.4581	0.00157	0.0107	0.030	0.00012	0.0008	0.3030	0.00083	0.0057	0.6105	0.00204	0.0139	0.6935	0.00191	0.0130
2006	HDV3	1.7605	0.00467	0.0319	0.121	0.00014	0.0009	1.7615	0.00186	0.0127	2.5421	0.00165	0.0112	2.8432	0.00435	0.0296

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2006	HDV4	1.7672	0.00473	0.0323	0.121	0.00014	0.0009	1.7526	0.00186	0.0127	2.5433	0.00165	0.0112	2.8510	0.0044	0.0300
2006	HDV5	1.7688	0.00476	0.0324	0.121	0.00014	0.0009	1.7473	0.00186	0.0127	2.5406	0.00163	0.0111	2.8532	0.00441	0.0301
2006	HDV6	1.7690	0.00476	0.0324	0.121	0.00014	0.0009	1.7470	0.00186	0.0127	2.5406	0.00163	0.0111	2.8534	0.00441	0.0301
2006	HDV7	1.7581	0.00465	0.0317	0.121	0.00014	0.0009	1.7646	0.00186	0.0127	2.5415	0.00165	0.0112	2.8402	0.00433	0.0295
2006	HDV8a	1.7603	0.00466	0.0318	0.121	0.00014	0.0009	1.7661	0.00187	0.0127	2.5457	0.00167	0.0114	2.8423	0.00434	0.0296
2006	HDV8b	1.7603	0.00466	0.0318	0.121	0.00014	0.0009	1.7661	0.00187	0.0127	2.5457	0.00167	0.0114	2.8423	0.00434	0.0296
2007	HDV2b	0.3671	0.00114	0.0077	0.021	0.00009	0.0006	0.2344	0.00061	0.0041	0.4715	0.00153	0.0104	0.5482	0.00141	0.0096
2007	HDV3	1.7608	0.00354	0.0241	0.121	0.00010	0.0007	1.7609	0.00141	0.0096	2.5420	0.00125	0.0085	2.8435	0.00329	0.0224
2007	HDV4	1.7681	0.00359	0.0245	0.121	0.00010	0.0007	1.7509	0.00141	0.0096	2.5427	0.00124	0.0085	2.8520	0.00333	0.0227
2007	HDV5	1.7701	0.00361	0.0246	0.121	0.00010	0.0007	1.7454	0.00141	0.0096	2.5405	0.00123	0.0084	2.8546	0.00335	0.0228
2007	HDV6	1.7703	0.00361	0.0246	0.121	0.00010	0.0007	1.7451	0.00141	0.0096	2.5404	0.00123	0.0084	2.8549	0.00335	0.0228
2007	HDV7	1.7581	0.00352	0.0240	0.121	0.00010	0.0007	1.7646	0.00141	0.0096	2.5415	0.00125	0.0085	2.8402	0.00328	0.0223
2007	HDV8a	1.7600	0.00353	0.0240	0.121	0.00010	0.0007	1.7659	0.00141	0.0096	2.5451	0.00126	0.0086	2.8420	0.00328	0.0224
2007	HDV8b	1.7600	0.00353	0.0240	0.121	0.00010	0.0007	1.7659	0.00141	0.0096	2.5451	0.00126	0.0086	2.8420	0.00328	0.0224
2008	HDV2b	0.2485	0.00117	0.0080	0.013	0.00009	0.0006	0.1317	0.00062	0.0042	0.3327	0.00154	0.0105	0.3944	0.00143	0.0097
2008	HDV3	0.5279	0.00353	0.0241	0.036	0.00010	0.0007	0.5287	0.00141	0.0096	0.7626	0.00125	0.0085	0.8527	0.00329	0.0224
2008	HDV4	0.5295	0.00357	0.0243	0.036	0.00010	0.0007	0.5267	0.00141	0.0096	0.7629	0.00125	0.0085	0.8545	0.00332	0.0226
2008	HDV5	0.5298	0.00358	0.0244	0.036	0.00010	0.0007	0.5254	0.00141	0.0096	0.7622	0.00123	0.0084	0.8550	0.00333	0.0227
2008	HDV6	0.5299	0.00358	0.0244	0.036	0.00010	0.0007	0.5253	0.00141	0.0096	0.7622	0.00123	0.0084	0.8551	0.00333	0.0227
2008	HDV7	0.5274	0.00352	0.0240	0.036	0.00010	0.0007	0.5293	0.00141	0.0096	0.7624	0.00125	0.0085	0.8520	0.00328	0.0223
2008	HDV8a	0.5280	0.00353	0.0240	0.036	0.00010	0.0007	0.5297	0.00141	0.0096	0.7635	0.00126	0.0086	0.8526	0.00328	0.0224
2008	HDV8b	0.5280	0.00353	0.0240	0.036	0.00010	0.0007	0.5297	0.00141	0.0096	0.7635	0.00126	0.0086	0.8526	0.00328	0.0224
2009	HDV2b	0.2061	0.00116	0.0079	0.005	0.00009	0.0006	0.0957	0.00062	0.0042	0.2473	0.00152	0.0103	0.3141	0.00141	0.0096
2009	HDV3	0.5280	0.00354	0.0241	0.036	0.00010	0.0007	0.5285	0.00141	0.0096	0.7625	0.00125	0.0085	0.8528	0.00329	0.0224
2009	HDV4	0.5298	0.00358	0.0244	0.036	0.00010	0.0007	0.5259	0.00141	0.0096	0.7627	0.00124	0.0085	0.8549	0.00332	0.0226
2009	HDV5	0.5304	0.0036	0.0245	0.036	0.00010	0.0007	0.5245	0.00141	0.0096	0.7622	0.00123	0.0084	0.8557	0.00334	0.0227

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2009	HDV6	0.5304	0.00360	0.0245	0.036	0.00010	0.0007	0.5244	0.00141	0.0096	0.7621	0.00123	0.0084	0.8557	0.00334	0.0227
2009	HDV7	0.5274	0.00352	0.0240	0.036	0.00010	0.0007	0.5293	0.00141	0.0096	0.7624	0.00125	0.0085	0.8520	0.00328	0.0223
2009	HDV8a	0.5278	0.00352	0.0240	0.036	0.00010	0.0007	0.5296	0.00141	0.0096	0.7632	0.00126	0.0086	0.8524	0.00328	0.0224
2009	HDV8b	0.5278	0.00352	0.0240	0.036	0.00010	0.0007	0.5296	0.00141	0.0096	0.7632	0.00126	0.0086	0.8524	0.00328	0.0224
2010	HDV2b	0.1931	0.00113	0.0077	0.004	0.00009	0.0006	0.0845	0.00060	0.0041	0.2266	0.00151	0.0103	0.2934	0.00139	0.0095
2010	HDV3	0.5280	0.00353	0.0241	0.036	0.00010	0.0007	0.5285	0.00141	0.0096	0.7625	0.00125	0.0085	0.8528	0.00329	0.0224
2010	HDV4	0.5297	0.00358	0.0244	0.036	0.00010	0.0007	0.5260	0.00141	0.0096	0.7626	0.00124	0.0085	0.8548	0.00332	0.0226
2010	HDV5	0.5303	0.00359	0.0245	0.036	0.00010	0.0007	0.5246	0.00141	0.0096	0.7622	0.00123	0.0084	0.8556	0.00333	0.0227
2010	HDV6	0.5304	0.0036	0.0245	0.036	0.00010	0.0007	0.5245	0.00141	0.0096	0.7622	0.00123	0.0084	0.8556	0.00334	0.0227
2010	HDV7	0.5274	0.00352	0.0240	0.036	0.00010	0.0007	0.5293	0.00141	0.0096	0.7624	0.00125	0.0085	0.8520	0.00328	0.0223
2010	HDV8a	0.5277	0.00352	0.0240	0.036	0.00010	0.0007	0.5296	0.00141	0.0096	0.7631	0.00126	0.0085	0.8524	0.00328	0.0224
2010	HDV8b	0.5277	0.00352	0.0240	0.036	0.00010	0.0007	0.5296	0.00141	0.0096	0.7631	0.00126	0.0085	0.8524	0.00328	0.0224
2011	HDV2b	0.2122	0.00122	0.0083	0.005	0.00009	0.0006	0.1030	0.00064	0.0043	0.2512	0.00153	0.0104	0.3209	0.00146	0.0099
2011	HDV3	0.5278	0.00353	0.0241	0.036	0.00010	0.0007	0.5288	0.00141	0.0096	0.7625	0.00125	0.0085	0.8526	0.00328	0.0224
2011	HDV4	0.5292	0.00356	0.0243	0.036	0.00010	0.0007	0.5270	0.00141	0.0096	0.7628	0.00125	0.0085	0.8542	0.00331	0.0226
2011	HDV5	0.5295	0.00357	0.0244	0.036	0.00010	0.0007	0.5258	0.00141	0.0096	0.7622	0.00124	0.0084	0.8547	0.00332	0.0226
2011	HDV6	0.5296	0.00358	0.0244	0.036	0.00010	0.0007	0.5257	0.00141	0.0096	0.7622	0.00124	0.0084	0.8548	0.00332	0.0226
2011	HDV7	0.5274	0.00352	0.0240	0.036	0.00010	0.0007	0.5293	0.00141	0.0096	0.7624	0.00125	0.0085	0.8520	0.00328	0.0223
2011	HDV8a	0.5278	0.00353	0.0240	0.036	0.00010	0.0007	0.5296	0.00141	0.0096	0.7632	0.00126	0.0086	0.8524	0.00328	0.0224
2011	HDV8b	0.5278	0.00353	0.0240	0.036	0.00010	0.0007	0.5296	0.00141	0.0096	0.7632	0.00126	0.0086	0.8524	0.00328	0.0224
2012	HDV2b	0.1997	0.00106	0.0072	0.005	0.00007	0.0005	0.1059	0.00054	0.0037	0.2325	0.00126	0.0086	0.2958	0.00123	0.0084
2012	HDV3	0.5277	0.00290	0.0198	0.036	0.00008	0.0006	0.5290	0.00116	0.0079	0.7625	0.00103	0.0070	0.8524	0.00270	0.0184
2012	HDV4	0.5288	0.00292	0.0199	0.036	0.00008	0.0006	0.5277	0.00116	0.0079	0.7629	0.00103	0.0070	0.8537	0.00272	0.0185
2012	HDV5	0.5290	0.00293	0.0200	0.036	0.00008	0.0006	0.5267	0.00116	0.0079	0.7623	0.00102	0.0069	0.8540	0.00272	0.0186
2012	HDV6	0.5290	0.00293	0.0200	0.036	0.00008	0.0006	0.5266	0.00116	0.0079	0.7623	0.00102	0.0069	0.8541	0.00272	0.0186
2012	HDV7	0.5274	0.00290	0.0197	0.036	0.00008	0.0006	0.5293	0.00116	0.0079	0.7624	0.00102	0.0070	0.8520	0.0027	0.0184

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2012	HDV8a	0.5278	0.00290	0.0198	0.036	0.00008	0.0006	0.5296	0.00116	0.0079	0.7633	0.00103	0.0070	0.8524	0.00270	0.0184
2012	HDV8b	0.5278	0.00290	0.0198	0.036	0.00008	0.0006	0.5296	0.00116	0.0079	0.7633	0.00103	0.0070	0.8524	0.00270	0.0184
2013	HDV2b	0.1972	0.00105	0.0071	0.005	0.00007	0.0005	0.1035	0.00054	0.0036	0.2291	0.00125	0.0085	0.2920	0.00122	0.0083
2013	HDV3	0.5277	0.00290	0.0198	0.036	0.00008	0.0006	0.5290	0.00116	0.0079	0.7625	0.00103	0.0070	0.8524	0.00270	0.0184
2013	HDV4	0.5287	0.00292	0.0199	0.036	0.00008	0.0006	0.5278	0.00116	0.0079	0.7629	0.00103	0.0070	0.8536	0.00272	0.0185
2013	HDV5	0.5289	0.00293	0.0200	0.036	0.00008	0.0006	0.5269	0.00116	0.0079	0.7623	0.00102	0.0069	0.8539	0.00272	0.0185
2013	HDV6	0.5289	0.00293	0.0200	0.036	0.00008	0.0006	0.5268	0.00116	0.0079	0.7623	0.00102	0.0069	0.8539	0.00272	0.0185
2013	HDV7	0.5274	0.00290	0.0197	0.036	0.00008	0.0006	0.5293	0.00116	0.0079	0.7624	0.00102	0.0070	0.8520	0.0027	0.0184
2013	HDV8a	0.5278	0.00290	0.0198	0.036	0.00008	0.0006	0.5296	0.00116	0.0079	0.7632	0.00103	0.0070	0.8524	0.00270	0.0184
2013	HDV8b	0.5278	0.00290	0.0198	0.036	0.00008	0.0006	0.5296	0.00116	0.0079	0.7632	0.00103	0.0070	0.8524	0.00270	0.0184
2014	HDV2b	0.1737	0.00095	0.0065	0.004	0.00006	0.0004	0.0978	0.00048	0.0033	0.1980	0.00112	0.0076	0.2514	0.00110	0.0075
2014	HDV3	0.5268	0.00259	0.0176	0.036	0.00007	0.0005	0.5283	0.00103	0.0070	0.7615	0.00091	0.0062	0.8512	0.00241	0.0164
2014	HDV4	0.5277	0.00260	0.0177	0.036	0.00007	0.0005	0.5271	0.00103	0.0070	0.7617	0.00092	0.0062	0.8522	0.00242	0.0165
2014	HDV5	0.5279	0.00261	0.0178	0.036	0.00007	0.0005	0.5261	0.00103	0.0070	0.7610	0.00091	0.0062	0.8523	0.00242	0.0165
2014	HDV6	0.5279	0.00261	0.0178	0.036	0.00007	0.0005	0.5261	0.00103	0.0070	0.7610	0.00091	0.0062	0.8524	0.00242	0.0165
2014	HDV7	0.5265	0.00258	0.0176	0.036	0.00007	0.0005	0.5286	0.00103	0.0070	0.7614	0.00091	0.0062	0.8509	0.00240	0.0164
2014	HDV8a	0.5270	0.00259	0.0176	0.036	0.00007	0.0005	0.5289	0.00104	0.0070	0.7622	0.00092	0.0063	0.8513	0.00241	0.0164
2014	HDV8b	0.5270	0.00259	0.0176	0.036	0.00007	0.0005	0.5289	0.00104	0.0070	0.7622	0.00092	0.0063	0.8513	0.00241	0.0164
2015	HDV2b	0.1753	0.00096	0.0065	0.004	0.00006	0.0004	0.0995	0.00048	0.0033	0.1995	0.00112	0.0076	0.2533	0.00110	0.0075
2015	HDV3	0.5268	0.00259	0.0176	0.036	0.00007	0.0005	0.5283	0.00103	0.0070	0.7615	0.00091	0.0062	0.8512	0.00241	0.0164
2015	HDV4	0.5277	0.00260	0.0177	0.036	0.00007	0.0005	0.5272	0.00103	0.0070	0.7617	0.00092	0.0062	0.8521	0.00242	0.0165
2015	HDV5	0.5278	0.00261	0.0178	0.036	0.00007	0.0005	0.5263	0.00103	0.0070	0.7610	0.00091	0.0062	0.8522	0.00242	0.0165
2015	HDV6	0.5278	0.00261	0.0178	0.036	0.00007	0.0005	0.5262	0.00103	0.0070	0.7610	0.00091	0.0062	0.8523	0.00242	0.0165
2015	HDV7	0.5265	0.00258	0.0176	0.036	0.00007	0.0005	0.5286	0.00103	0.0070	0.7614	0.00091	0.0062	0.8509	0.00240	0.0164
2015	HDV8a	0.5270	0.00259	0.0176	0.036	0.00007	0.0005	0.5289	0.00104	0.0070	0.7622	0.00092	0.0063	0.8513	0.00241	0.0164
2015	HDV8b	0.5270	0.00259	0.0176	0.036	0.00007	0.0005	0.5289	0.00104	0.0070	0.7622	0.00092	0.0063	0.8513	0.00241	0.0164

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2016	HDV2b	0.1403	0.00086	0.0059	0.003	0.00006	0.0004	0.0807	0.00043	0.0029	0.1602	0.00100	0.0068	0.2032	0.00099	0.0067
2016	HDV3	0.4190	0.00231	0.0158	0.029	0.00007	0.0004	0.4247	0.00092	0.0063	0.6122	0.00082	0.0056	0.6843	0.00215	0.0147
2016	HDV4	0.4198	0.00233	0.0158	0.029	0.00007	0.0004	0.4239	0.00092	0.0063	0.6124	0.00082	0.0056	0.6850	0.00216	0.0147
2016	HDV5	0.4200	0.00233	0.0159	0.029	0.00007	0.0004	0.4232	0.00092	0.0063	0.6118	0.00081	0.0055	0.6851	0.00216	0.0148
2016	HDV6	0.4200	0.00233	0.0159	0.029	0.00007	0.0004	0.4231	0.00092	0.0063	0.6118	0.00081	0.0055	0.6851	0.00217	0.0148
2016	HDV7	0.4187	0.00231	0.0157	0.029	0.00007	0.0004	0.4250	0.00092	0.0063	0.6121	0.00082	0.0056	0.6840	0.00215	0.0146
2016	HDV8a	0.4191	0.00231	0.0158	0.029	0.00007	0.0004	0.4252	0.00093	0.0063	0.6128	0.00082	0.0056	0.6844	0.00215	0.0147
2016	HDV8b	0.4191	0.00231	0.0158	0.029	0.00007	0.0004	0.4252	0.00093	0.0063	0.6128	0.00082	0.0056	0.6844	0.00215	0.0147
2017	HDV2b	0.1713	0.00087	0.0059	0.004	0.00006	0.0004	0.0929	0.00044	0.0030	0.2013	0.00100	0.0068	0.2552	0.00099	0.0067
2017	HDV3	0.4190	0.00231	0.0158	0.029	0.00007	0.0004	0.4247	0.00092	0.0063	0.6122	0.00082	0.0056	0.6843	0.00215	0.0147
2017	HDV4	0.4198	0.00232	0.0158	0.029	0.00007	0.0004	0.4240	0.00092	0.0063	0.6124	0.00082	0.0056	0.6850	0.00216	0.0147
2017	HDV5	0.4199	0.00233	0.0159	0.029	0.00007	0.0004	0.4233	0.00092	0.0063	0.6118	0.00081	0.0055	0.6850	0.00216	0.0147
2017	HDV6	0.4199	0.00233	0.0159	0.029	0.00007	0.0004	0.4232	0.00092	0.0063	0.6118	0.00081	0.0055	0.6850	0.00216	0.0147
2017	HDV7	0.4187	0.00231	0.0157	0.029	0.00007	0.0004	0.4250	0.00092	0.0063	0.6121	0.00082	0.0056	0.6840	0.00215	0.0146
2017	HDV8a	0.4191	0.00231	0.0158	0.029	0.00007	0.0004	0.4252	0.00093	0.0063	0.6128	0.00082	0.0056	0.6844	0.00215	0.0147
2017	HDV8b	0.4191	0.00231	0.0158	0.029	0.00007	0.0004	0.4252	0.00093	0.0063	0.6128	0.00082	0.0056	0.6844	0.00215	0.0147
2018	HDV2b	0.0986	0.00053	0.0036	0.002	0.00003	0.0002	0.0606	0.00026	0.0018	0.1054	0.00059	0.0040	0.1363	0.00060	0.0041
2018	HDV3	0.3500	0.00147	0.0100	0.024	0.00004	0.0003	0.3527	0.00059	0.0040	0.5084	0.00052	0.0035	0.5685	0.00137	0.0093
2018	HDV4	0.3517	0.00148	0.0101	0.024	0.00004	0.0003	0.3534	0.00059	0.0040	0.5105	0.00052	0.0035	0.5713	0.00138	0.0094
2018	HDV5	0.3526	0.00148	0.0101	0.024	0.00004	0.0003	0.3538	0.00059	0.0040	0.5114	0.00052	0.0035	0.5728	0.00138	0.0094
2018	HDV6	0.3527	0.00148	0.0101	0.024	0.00004	0.0003	0.3538	0.00059	0.0040	0.5115	0.00052	0.0035	0.5729	0.00138	0.0094
2018	HDV7	0.3495	0.00147	0.0100	0.024	0.00004	0.0003	0.3525	0.00059	0.0040	0.5078	0.00052	0.0035	0.5677	0.00137	0.0093
2018	HDV8a	0.3495	0.00147	0.0100	0.024	0.00004	0.0003	0.3526	0.00059	0.0040	0.5080	0.00052	0.0036	0.5677	0.00137	0.0093
2018	HDV8b	0.3495	0.00147	0.0100	0.024	0.00004	0.0003	0.3526	0.00059	0.0040	0.5080	0.00052	0.0036	0.5677	0.00137	0.0093
2019	HDV2b	0.0909	0.00050	0.0034	0.002	0.00003	0.0002	0.0556	0.00025	0.0017	0.0960	0.00055	0.0037	0.1249	0.00056	0.0038
2019	HDV3	0.3317	0.00147	0.0100	0.022	0.00004	0.0003	0.3336	0.00059	0.0040	0.4809	0.00052	0.0035	0.5378	0.00137	0.0093

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2019	HDV4	0.3336	0.00148	0.0101	0.023	0.00004	0.0003	0.3347	0.00059	0.0040	0.4834	0.00052	0.0035	0.5411	0.00138	0.0094
2019	HDV5	0.3348	0.00148	0.0101	0.023	0.00004	0.0003	0.3353	0.00059	0.0040	0.4848	0.00052	0.0035	0.5431	0.00138	0.0094
2019	HDV6	0.3349	0.00148	0.0101	0.023	0.00004	0.0003	0.3354	0.00059	0.0040	0.4849	0.00052	0.0035	0.5432	0.00138	0.0094
2019	HDV7	0.3311	0.00147	0.0100	0.022	0.00004	0.0003	0.3333	0.00059	0.0040	0.4801	0.00052	0.0035	0.5368	0.00137	0.0093
2019	HDV8a	0.3311	0.00147	0.0100	0.022	0.00004	0.0003	0.3333	0.00059	0.0040	0.4802	0.00052	0.0036	0.5367	0.00137	0.0093
2019	HDV8b	0.3311	0.00147	0.0100	0.022	0.00004	0.0003	0.3333	0.00059	0.0040	0.4802	0.00052	0.0036	0.5367	0.00137	0.0093
2020	HDV2b	0.0827	0.00046	0.0031	0.002	0.00002	0.0002	0.0504	0.00022	0.0015	0.0861	0.00048	0.0032	0.1129	0.00050	0.0034
2020	HDV3	0.3134	0.00147	0.0100	0.021	0.00004	0.0003	0.3145	0.00059	0.0040	0.4533	0.00052	0.0035	0.5071	0.00137	0.0093
2020	HDV4	0.3156	0.00148	0.0101	0.021	0.00004	0.0003	0.3160	0.00059	0.0040	0.4564	0.00052	0.0035	0.5110	0.00138	0.0094
2020	HDV5	0.3169	0.00148	0.0101	0.021	0.00004	0.0003	0.3169	0.00059	0.0040	0.4581	0.00052	0.0035	0.5133	0.00138	0.0094
2020	HDV6	0.3170	0.00148	0.0101	0.021	0.00004	0.0003	0.3169	0.00059	0.0040	0.4583	0.00052	0.0035	0.5135	0.00138	0.0094
2020	HDV7	0.3128	0.00147	0.0100	0.021	0.00004	0.0003	0.3141	0.00059	0.0040	0.4524	0.00052	0.0035	0.5060	0.00137	0.0093
2020	HDV8a	0.3126	0.00147	0.0100	0.021	0.00004	0.0003	0.3140	0.00059	0.0040	0.4524	0.00052	0.0036	0.5058	0.00137	0.0093
2020	HDV8b	0.3126	0.00147	0.0100	0.021	0.00004	0.0003	0.3140	0.00059	0.0040	0.4524	0.00052	0.0036	0.5058	0.00137	0.0093
2021	HDV2b	0.0748	0.00042	0.0028	0.001	0.00002	0.0001	0.0454	0.00020	0.0013	0.0764	0.00041	0.0028	0.1012	0.00044	0.0030
2021	HDV3	0.2965	0.00147	0.0100	0.020	0.00004	0.0003	0.2969	0.00059	0.0040	0.4279	0.00052	0.0035	0.4788	0.00137	0.0093
2021	HDV4	0.2989	0.00148	0.0101	0.020	0.00004	0.0003	0.2987	0.00059	0.0040	0.4314	0.00052	0.0035	0.4831	0.00138	0.0094
2021	HDV5	0.3005	0.00148	0.0101	0.020	0.00004	0.0003	0.2998	0.00059	0.0040	0.4335	0.00052	0.0035	0.4859	0.00138	0.0094
2021	HDV6	0.3006	0.00148	0.0101	0.020	0.00004	0.0003	0.2999	0.00059	0.0040	0.4337	0.00052	0.0035	0.4861	0.00138	0.0094
2021	HDV7	0.2958	0.00147	0.0100	0.020	0.00004	0.0003	0.2963	0.00059	0.0040	0.4269	0.00052	0.0035	0.4775	0.00137	0.0093
2021	HDV8a	0.2956	0.00147	0.0100	0.020	0.00004	0.0003	0.2962	0.00059	0.0040	0.4267	0.00052	0.0036	0.4772	0.00137	0.0093
2021	HDV8b	0.2956	0.00147	0.0100	0.020	0.00004	0.0003	0.2962	0.00059	0.0040	0.4267	0.00052	0.0036	0.4772	0.00137	0.0093
2022	HDV2b	0.0748	0.00042	0.0028	0.001	0.00002	0.0001	0.0454	0.00020	0.0013	0.0764	0.00041	0.0028	0.1012	0.00044	0.0030
2022	HDV3	0.2965	0.00147	0.0100	0.020	0.00004	0.0003	0.2969	0.00059	0.0040	0.4279	0.00052	0.0035	0.4788	0.00137	0.0093
2022	HDV4	0.2989	0.00148	0.0101	0.020	0.00004	0.0003	0.2987	0.00059	0.0040	0.4314	0.00052	0.0035	0.4831	0.00138	0.0094
2022	HDV5	0.3005	0.00148	0.0101	0.020	0.00004	0.0003	0.2998	0.00059	0.0040	0.4335	0.00052	0.0035	0.4859	0.00138	0.0094

		GASOLINE														
		Highway			Urban											
					Deceleration			0 25 mph			25 50 mph			>50 mph		
Model Yr	Vehicle Class	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM	NO_x	BC	PM
2022	HDV6	0.3006	0.00148	0.0101	0.020	0.00004	0.0003	0.2999	0.00059	0.0040	0.4337	0.00052	0.0035	0.4861	0.00138	0.0094
2022	HDV7	0.2958	0.00147	0.0100	0.020	0.00004	0.0003	0.2963	0.00059	0.0040	0.4269	0.00052	0.0035	0.4775	0.00137	0.0093
2022	HDV8a	0.2956	0.00147	0.0100	0.020	0.00004	0.0003	0.2962	0.00059	0.0040	0.4267	0.00052	0.0036	0.4772	0.00137	0.0093
2022	HDV8b	0.2956	0.00147	0.0100	0.020	0.00004	0.0003	0.2962	0.00059	0.0040	0.4267	0.00052	0.0036	0.4772	0.00137	0.0093

Note – MOVES does not provide consistent outputs for Class 8b gasoline vehicles; therefore gasoline 8bs are set equal to 8as.

Appendix B: NOx, PM & BC Idle Factors – g/hr

(MOVES2014b, 2019 Calendar Year, ULSD)

Table B-1. Short Duration Idle Emission Factors (< 60 minutes per idle event) (g/hr)

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
NO_x	Gasoline	1990	12.92726	7.274804	7.27478	7.27477	7.27478
NO_x	Gasoline	1991	12.92726	7.274804	7.27478	7.27477	7.27478
NO_x	Gasoline	1992	13.2205	7.274779	7.274758	7.274772	7.274782
NO_x	Gasoline	1993	13.41114	7.274784	7.274771	7.274771	7.274762
NO_x	Gasoline	1994	13.27161	7.156092	7.156034	7.156071	7.156044
NO_x	Gasoline	1995	13.5168	7.156035	7.156048	7.15604	7.156059
NO_x	Gasoline	1996	13.68704	7.156056	7.156049	7.156075	7.156079
NO_x	Gasoline	1997	13.85722	7.156059	7.156055	7.156052	7.156067
NO_x	Gasoline	1998	29.02486	14.82833	14.8283	14.82833	14.82833
NO_x	Gasoline	1999	29.02474	14.82838	14.82837	14.82832	14.82833
NO_x	Gasoline	2000	29.02489	14.82827	14.82829	14.82831	14.82832
NO_x	Gasoline	2001	17.14999	6.8954	6.895417	6.895414	6.895404
NO_x	Gasoline	2002	17.14994	6.895416	6.895402	6.895381	6.895413
NO_x	Gasoline	2003	17.14998	6.895371	6.89541	6.895416	6.895413
NO_x	Gasoline	2004	17.23979	6.895411	6.895392	6.895425	6.895413
NO_x	Gasoline	2005	17.23982	6.895381	6.895395	6.895403	6.895407
NO_x	Gasoline	2006	17.23977	6.895376	6.895435	6.895407	6.895417
NO_x	Gasoline	2007	17.23981	6.895448	6.895403	6.895407	6.895393

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
NO_x	Gasoline	2008	8.746104	2.068621	2.068627	2.068623	2.06862
NO_x	Gasoline	2009	0.255073	2.068622	2.068621	2.068624	2.068617
NO_x	Gasoline	2010	0.255072	2.06862	2.068619	2.068625	2.068624
NO_x	Gasoline	2011	0.255072	2.06862	2.068621	2.06862	2.068622
NO_x	Gasoline	2012	0.220072	2.068623	2.068622	2.068625	2.06862
NO_x	Gasoline	2013	0.220072	2.068623	2.06862	2.068621	2.068621
NO_x	Gasoline	2014	0.176638	2.068621	2.068617	2.06863	2.068626
NO_x	Gasoline	2015	0.176638	2.068623	2.06862	2.068623	2.068617
NO_x	Gasoline	2016	0.138643	1.118552	1.11855	1.118548	1.118547
NO_x	Gasoline	2017	0.243936	1.118547	1.118547	1.11855	1.118549
NO_x	Gasoline	2018	0.082914	0.655377	1.118548	1.118556	1.118548
NO_x	Gasoline	2019	0.067368	0.532494	1.118549	1.11855	1.118545
NO_x	Gasoline	2020	0.051822	0.409611	1.118548	1.118544	1.118546
NO_x	Gasoline	2021	0.037471	0.296181	1.11855	1.118546	1.118548
NO_x	Gasoline	2022	0.037471	0.296181	1.11855	1.118546	1.118548
NO_x	Diesel	1990	220.4358	139.7535	139.7533	139.753	139.7538
NO_x	Diesel	1991	220.4358	139.7535	139.7533	139.753	139.7538
NO_x	Diesel	1992	225.6123	139.7534	139.7535	139.7536	139.753
NO_x	Diesel	1993	228.9769	139.7535	139.7533	139.7533	139.7535
NO_x	Diesel	1994	230.4006	139.753	139.7537	139.7534	139.7534
NO_x	Diesel	1995	234.8	139.7535	139.7529	139.7536	139.7534
NO_x	Diesel	1996	237.8541	139.7529	139.7533	139.7542	139.7536
NO_x	Diesel	1997	240.9077	139.7535	139.7533	139.7533	139.7529
NO_x	Diesel	1998	194.8783	117.3488	117.3492	117.349	117.3489
NO_x	Diesel	1999	194.8789	96.53466	96.53499	96.53498	154.804

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
NO_x	Diesel	2000	194.8784	96.53519	96.53474	96.53482	154.8042
NO_x	Diesel	2001	194.8786	96.53452	96.53542	96.53523	154.8041
NO_x	Diesel	2002	194.8784	96.53505	96.53503	96.53472	154.8038
NO_x	Diesel	2003	44.29877	45.81106	45.81099	45.81104	56.9449
NO_x	Diesel	2004	44.53385	45.8111	45.81113	45.81102	56.94479
NO_x	Diesel	2005	44.53387	45.81099	45.81099	45.81103	56.94487
NO_x	Diesel	2006	44.53388	45.81091	45.81094	45.81094	56.94491
NO_x	Diesel	2007	41.18445	22.78015	22.78021	22.78014	53.19029
NO_x	Diesel	2008	41.18437	22.78013	22.78016	22.78016	53.19037
NO_x	Diesel	2009	41.61956	22.78023	22.78012	22.78013	53.19023
NO_x	Diesel	2010	17.67254	7.211741	8.088111	8.08814	10.05388
NO_x	Diesel	2011	17.67253	7.211763	8.088145	8.088143	10.05387
NO_x	Diesel	2012	17.67253	7.211781	8.088145	8.088141	10.05389
NO_x	Diesel	2013	17.67252	7.211769	7.211739	7.211754	8.964484
NO_x	Diesel	2014	17.7649	7.211738	7.211731	7.211762	8.964494
NO_x	Diesel	2015	17.76494	7.211759	7.211733	7.211741	8.96449
NO_x	Diesel	2016	17.76492	7.21176	7.211749	6.76824	8.964499
NO_x	Diesel	2017	17.76496	7.211757	7.211745	6.768251	8.964497
NO_x	Diesel	2018	8.083527	3.189981	4.564302	4.777262	6.488624
NO_x	Diesel	2019	7.159541	2.825361	4.564319	4.777257	6.488628
NO_x	Diesel	2020	6.235605	2.460729	4.56432	4.777258	6.48863
NO_x	Diesel	2021	5.382705	2.124166	4.564324	4.777266	6.488623
NO_x	Diesel	2022	5.382705	2.124166	4.564324	4.777266	6.488623
PM_{10}	Gasoline	1990	0.39005	0.39005	0.39005	0.390049	0.39005
PM_{10}	Gasoline	1991	0.39005	0.39005	0.39005	0.390049	0.39005

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
PM_{10}	Gasoline	1992	0.390051	0.39005	0.39005	0.39005	0.39005
PM_{10}	Gasoline	1993	0.39005	0.39005	0.39005	0.390049	0.390051
PM_{10}	Gasoline	1994	0.127497	0.127497	0.127497	0.127497	0.127497
PM_{10}	Gasoline	1995	0.151966	0.151966	0.151967	0.151966	0.151966
PM_{10}	Gasoline	1996	0.353582	0.353582	0.353582	0.353582	0.353583
PM_{10}	Gasoline	1997	0.371945	0.371944	0.371944	0.371943	0.371943
PM_{10}	Gasoline	1998	0.222096	0.222096	0.222096	0.222097	0.222096
PM_{10}	Gasoline	1999	0.107731	0.107732	0.107732	0.107732	0.107732
PM_{10}	Gasoline	2000	0.047852	0.047851	0.047851	0.047851	0.047851
PM_{10}	Gasoline	2001	0.044353	0.044353	0.044353	0.044353	0.044353
PM_{10}	Gasoline	2002	0.142283	0.142284	0.142284	0.142283	0.142284
PM_{10}	Gasoline	2003	0.084014	0.084013	0.084013	0.084014	0.084014
PM_{10}	Gasoline	2004	0.079558	0.079557	0.079557	0.079557	0.079557
PM_{10}	Gasoline	2005	0.079558	0.079557	0.079557	0.079557	0.079557
PM_{10}	Gasoline	2006	0.079557	0.079557	0.079557	0.079557	0.079557
PM_{10}	Gasoline	2007	0.060251	0.060251	0.060251	0.060251	0.060251
PM_{10}	Gasoline	2008	0.060251	0.060251	0.060251	0.060251	0.060251
PM_{10}	Gasoline	2009	0.060251	0.060251	0.060251	0.060251	0.060251
PM_{10}	Gasoline	2010	0.060251	0.060251	0.060251	0.060251	0.060251
PM_{10}	Gasoline	2011	0.060251	0.060251	0.060251	0.060251	0.060251
PM_{10}	Gasoline	2012	0.049598	0.049598	0.049598	0.049598	0.049598
PM_{10}	Gasoline	2013	0.049598	0.049598	0.049598	0.049598	0.049598
PM_{10}	Gasoline	2014	0.044379	0.044379	0.044379	0.044379	0.044379
PM_{10}	Gasoline	2015	0.044379	0.044379	0.044379	0.044379	0.044379
PM_{10}	Gasoline	2016	0.039709	0.039709	0.039709	0.039709	0.039709

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
PM_{10}	Gasoline	2017	0.039709	0.039709	0.039709	0.039709	0.039709
PM_{10}	Gasoline	2018	0.025343	0.025343	0.025343	0.025343	0.025343
PM_{10}	Gasoline	2019	0.025343	0.025343	0.025343	0.025343	0.025343
PM_{10}	Gasoline	2020	0.025343	0.025343	0.025343	0.025343	0.025343
PM_{10}	Gasoline	2021	0.025343	0.025343	0.025343	0.025343	0.025343
PM_{10}	Gasoline	2022	0.025343	0.025343	0.025343	0.025343	0.025343
PM_{10}	Diesel	1990	3.80142	4.314075	4.314074	4.314054	4.290527
PM_{10}	Diesel	1991	3.80142	4.314075	4.314074	4.314054	4.290527
PM_{10}	Diesel	1992	3.801412	4.314074	4.314081	4.31408	4.290519
PM_{10}	Diesel	1993	3.801402	4.314076	4.314081	4.31407	4.290516
PM_{10}	Diesel	1994	7.981013	7.458908	7.458917	7.458902	6.559885
PM_{10}	Diesel	1995	7.981034	7.458907	7.458902	7.458926	6.559874
PM_{10}	Diesel	1996	7.981049	7.458894	7.458909	7.458939	6.559889
PM_{10}	Diesel	1997	7.98104	7.458913	7.458905	7.458906	6.559882
PM_{10}	Diesel	1998	7.506484	7.081586	7.081582	7.081564	6.273523
PM_{10}	Diesel	1999	7.506494	7.081595	7.081595	7.081559	6.27353
PM_{10}	Diesel	2000	7.506508	7.081608	7.081603	7.081602	6.273523
PM_{10}	Diesel	2001	7.506488	7.081585	7.081603	7.081573	6.273532
PM_{10}	Diesel	2002	7.506473	7.081624	7.081583	7.081584	6.273541
PM_{10}	Diesel	2003	6.384851	6.384831	6.384803	6.384828	5.669618
PM_{10}	Diesel	2004	6.384823	6.384827	6.384818	6.384816	5.669604
PM_{10}	Diesel	2005	6.384825	6.384823	6.384813	6.384824	5.669607
PM_{10}	Diesel	2006	6.384825	6.384802	6.384835	6.38482	5.669621
PM_{10}	Diesel	2007	0.552165	0.228639	0.22864	0.22864	0.22864
PM_{10}	Diesel	2008	0.552164	0.22864	0.22864	0.22864	0.22864

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
PM_{10}	Diesel	2009	0.552164	0.22864	0.22864	0.22864	0.22864
PM_{10}	Diesel	2010	0.46106	0.190914	0.216065	0.216064	0.216065
PM_{10}	Diesel	2011	0.46106	0.190914	0.216065	0.216065	0.216066
PM_{10}	Diesel	2012	0.461059	0.190915	0.216065	0.216065	0.216065
PM_{10}	Diesel	2013	0.461059	0.190914	0.190914	0.190914	0.190914
PM_{10}	Diesel	2014	0.461058	0.190914	0.190914	0.190914	0.190914
PM_{10}	Diesel	2015	0.461059	0.190915	0.190914	0.190914	0.190914
PM_{10}	Diesel	2016	0.461057	0.190914	0.190914	0.178339	0.190914
PM_{10}	Diesel	2017	0.461058	0.190914	0.190914	0.178339	0.190915
PM_{10}	Diesel	2018	0.276084	0.114549	0.114549	0.120493	0.134097
PM_{10}	Diesel	2019	0.276083	0.114549	0.114549	0.120493	0.134097
PM_{10}	Diesel	2020	0.276083	0.114549	0.114549	0.120493	0.134097
PM_{10}	Diesel	2021	0.276083	0.114549	0.114549	0.120493	0.134097
PM_{10}	Diesel	2022	0.276083	0.114549	0.114549	0.120493	0.134097
$PM_{2.5}$	Gasoline	1990	0.345044	0.345046	0.345046	0.345045	0.345046
$PM_{2.5}$	Gasoline	1991	0.345044	0.345046	0.345046	0.345045	0.345046
$PM_{2.5}$	Gasoline	1992	0.345045	0.345046	0.345046	0.345045	0.345047
$PM_{2.5}$	Gasoline	1993	0.345045	0.345046	0.345045	0.345045	0.345046
$PM_{2.5}$	Gasoline	1994	0.112786	0.112786	0.112786	0.112787	0.112787
$PM_{2.5}$	Gasoline	1995	0.134433	0.134433	0.134432	0.134432	0.134432
$PM_{2.5}$	Gasoline	1996	0.312786	0.312786	0.312785	0.312785	0.312786
$PM_{2.5}$	Gasoline	1997	0.329029	0.329029	0.329029	0.329027	0.329028
$PM_{2.5}$	Gasoline	1998	0.196471	0.196471	0.196471	0.19647	0.19647
$PM_{2.5}$	Gasoline	1999	0.095301	0.095302	0.095302	0.095301	0.095301
$PM_{2.5}$	Gasoline	2000	0.04233	0.04233	0.04233	0.04233	0.04233

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
$PM_{2.5}$	Gasoline	2001	0.039236	0.039236	0.039236	0.039236	0.039236
$PM_{2.5}$	Gasoline	2002	0.125867	0.125867	0.125867	0.125867	0.125867
$PM_{2.5}$	Gasoline	2003	0.07432	0.07432	0.07432	0.07432	0.07432
$PM_{2.5}$	Gasoline	2004	0.070378	0.070378	0.070378	0.070378	0.070378
$PM_{2.5}$	Gasoline	2005	0.070378	0.070378	0.070378	0.070378	0.070378
$PM_{2.5}$	Gasoline	2006	0.070378	0.070378	0.070378	0.070378	0.070378
$PM_{2.5}$	Gasoline	2007	0.053299	0.053299	0.053299	0.053299	0.053299
$PM_{2.5}$	Gasoline	2008	0.053299	0.053299	0.053299	0.053299	0.053299
$PM_{2.5}$	Gasoline	2009	0.053299	0.053299	0.053299	0.053299	0.053299
$PM_{2.5}$	Gasoline	2010	0.053299	0.053299	0.053299	0.053299	0.053299
$PM_{2.5}$	Gasoline	2011	0.053299	0.053299	0.053299	0.053299	0.053299
$PM_{2.5}$	Gasoline	2012	0.043875	0.043875	0.043875	0.043875	0.043875
$PM_{2.5}$	Gasoline	2013	0.043875	0.043875	0.043875	0.043875	0.043875
$PM_{2.5}$	Gasoline	2014	0.039258	0.039258	0.039258	0.039258	0.039258
$PM_{2.5}$	Gasoline	2015	0.039258	0.039258	0.039258	0.039258	0.039258
$PM_{2.5}$	Gasoline	2016	0.035127	0.035128	0.035127	0.035127	0.035127
$PM_{2.5}$	Gasoline	2017	0.035127	0.035127	0.035127	0.035127	0.035128
$PM_{2.5}$	Gasoline	2018	0.022419	0.022419	0.022419	0.022419	0.022419
$PM_{2.5}$	Gasoline	2019	0.022419	0.022419	0.022419	0.022419	0.022419
$PM_{2.5}$	Gasoline	2020	0.022419	0.022419	0.022419	0.022419	0.022419
$PM_{2.5}$	Gasoline	2021	0.022419	0.022419	0.022419	0.022419	0.022419
$PM_{2.5}$	Gasoline	2022	0.022419	0.022419	0.022419	0.022419	0.022419
$PM_{2.5}$	Diesel	1990	3.497286	3.968937	3.96893	3.968942	3.94728
$PM_{2.5}$	Diesel	1991	3.497286	3.968937	3.96893	3.968942	3.94728
$PM_{2.5}$	Diesel	1992	3.497292	3.968933	3.968921	3.96894	3.947262

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
$PM_{2.5}$	Diesel	1993	3.49728	3.968925	3.968947	3.968926	3.947264
$PM_{2.5}$	Diesel	1994	7.342525	6.86217	6.86217	6.862166	6.035049
$PM_{2.5}$	Diesel	1995	7.342527	6.862171	6.86217	6.862176	6.035041
$PM_{2.5}$	Diesel	1996	7.342536	6.862164	6.862176	6.862199	6.035076
$PM_{2.5}$	Diesel	1997	7.342533	6.862169	6.862172	6.862172	6.035033
$PM_{2.5}$	Diesel	1998	6.905959	6.515029	6.515035	6.515051	5.771645
$PM_{2.5}$	Diesel	1999	6.905954	6.515046	6.515048	6.515009	5.771623
$PM_{2.5}$	Diesel	2000	6.905952	6.515067	6.515035	6.515056	5.771632
$PM_{2.5}$	Diesel	2001	6.905939	6.515039	6.515053	6.515026	5.77162
$PM_{2.5}$	Diesel	2002	6.90594	6.515063	6.51505	6.515059	5.771638
$PM_{2.5}$	Diesel	2003	5.87404	5.874023	5.874019	5.874024	5.216024
$PM_{2.5}$	Diesel	2004	5.87402	5.874009	5.874016	5.874006	5.216033
$PM_{2.5}$	Diesel	2005	5.873999	5.874039	5.874012	5.874018	5.216019
$PM_{2.5}$	Diesel	2006	5.87402	5.874001	5.874002	5.874003	5.216037
$PM_{2.5}$	Diesel	2007	0.507991	0.210348	0.210349	0.210348	0.210348
$PM_{2.5}$	Diesel	2008	0.50799	0.210348	0.210348	0.210348	0.210348
$PM_{2.5}$	Diesel	2009	0.507993	0.210349	0.210348	0.210348	0.210349
$PM_{2.5}$	Diesel	2010	0.424174	0.17564	0.198779	0.198779	0.198779
$PM_{2.5}$	Diesel	2011	0.424173	0.175641	0.198779	0.198779	0.198779
$PM_{2.5}$	Diesel	2012	0.424173	0.175641	0.198779	0.198779	0.198779
$PM_{2.5}$	Diesel	2013	0.424173	0.175641	0.175641	0.17564	0.17564
$PM_{2.5}$	Diesel	2014	0.424172	0.175641	0.17564	0.175641	0.17564
$PM_{2.5}$	Diesel	2015	0.424172	0.17564	0.17564	0.17564	0.17564
$PM_{2.5}$	Diesel	2016	0.424174	0.175641	0.175641	0.164071	0.175641
$PM_{2.5}$	Diesel	2017	0.424172	0.175641	0.17564	0.164072	0.175641

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
$PM_{2.5}$	Diesel	2018	0.253996	0.105385	0.105385	0.110854	0.123369
$PM_{2.5}$	Diesel	2019	0.253996	0.105385	0.105385	0.110854	0.123369
$PM_{2.5}$	Diesel	2020	0.253996	0.105385	0.105385	0.110853	0.123369
$PM_{2.5}$	Diesel	2021	0.253996	0.105385	0.105385	0.110854	0.123369
$PM_{2.5}$	Diesel	2022	0.253996	0.105385	0.105385	0.110854	0.123369
Black Carbon	Gasoline	1990	0.050559	0.050559	0.050559	0.050559	0.050559
Black Carbon	Gasoline	1991	0.050559	0.050559	0.050559	0.050559	0.050559
Black Carbon	Gasoline	1992	0.050559	0.050559	0.050559	0.050559	0.050559
Black Carbon	Gasoline	1993	0.050559	0.050559	0.050559	0.050559	0.050559
Black Carbon	Gasoline	1994	0.016526	0.016526	0.016526	0.016526	0.016526
Black Carbon	Gasoline	1995	0.019698	0.019698	0.019698	0.019698	0.019698
Black Carbon	Gasoline	1996	0.045832	0.045832	0.045832	0.045832	0.045832
Black Carbon	Gasoline	1997	0.048212	0.048212	0.048212	0.048212	0.048212
Black Carbon	Gasoline	1998	0.028789	0.028789	0.028789	0.028789	0.028788
Black Carbon	Gasoline	1999	0.013964	0.013964	0.013964	0.013964	0.013964
Black Carbon	Gasoline	2000	0.006203	0.006203	0.006203	0.006203	0.006203
Black Carbon	Gasoline	2001	0.005749	0.005749	0.005749	0.005749	0.005749
Black Carbon	Gasoline	2002	0.018442	0.018442	0.018442	0.018442	0.018442
Black Carbon	Gasoline	2003	0.010889	0.010889	0.010889	0.010889	0.010889
Black Carbon	Gasoline	2004	0.010325	0.010325	0.010325	0.010325	0.010325
Black Carbon	Gasoline	2005	0.010325	0.010325	0.010325	0.010325	0.010325
Black Carbon	Gasoline	2006	0.010325	0.010325	0.010325	0.010325	0.010325
Black Carbon	Gasoline	2007	0.00782	0.00782	0.00782	0.00782	0.00782
Black Carbon	Gasoline	2008	0.00782	0.00782	0.00782	0.00782	0.00782
Black Carbon	Gasoline	2009	0.00782	0.00782	0.00782	0.00782	0.00782

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
Black Carbon	Gasoline	2010	0.00782	0.00782	0.00782	0.00782	0.00782
Black Carbon	Gasoline	2011	0.00782	0.00782	0.00782	0.00782	0.00782
Black Carbon	Gasoline	2012	0.006437	0.006437	0.006437	0.006437	0.006437
Black Carbon	Gasoline	2013	0.006437	0.006437	0.006437	0.006437	0.006437
Black Carbon	Gasoline	2014	0.00576	0.00576	0.00576	0.00576	0.00576
Black Carbon	Gasoline	2015	0.00576	0.00576	0.00576	0.00576	0.00576
Black Carbon	Gasoline	2016	0.005154	0.005154	0.005154	0.005154	0.005154
Black Carbon	Gasoline	2017	0.005154	0.005154	0.005154	0.005154	0.005154
Black Carbon	Gasoline	2018	0.003289	0.003289	0.003289	0.003289	0.003289
Black Carbon	Gasoline	2019	0.003289	0.003289	0.003289	0.003289	0.003289
Black Carbon	Gasoline	2020	0.003289	0.003289	0.003289	0.003289	0.003289
Black Carbon	Gasoline	2021	0.003289	0.003289	0.003289	0.003289	0.003289
Black Carbon	Gasoline	2022	0.003289	0.003289	0.003289	0.003289	0.003289
Black Carbon	Diesel	1990	1.502434	1.705055	1.705045	1.705051	1.041053
Black Carbon	Diesel	1991	1.502434	1.705055	1.705045	1.705051	1.041053
Black Carbon	Diesel	1992	1.502444	1.705058	1.705052	1.705057	1.041051
Black Carbon	Diesel	1993	1.502433	1.705053	1.705054	1.705054	1.041051
Black Carbon	Diesel	1994	3.154339	2.947992	2.947993	2.947991	1.591689
Black Carbon	Diesel	1995	3.154347	2.947984	2.947998	2.947994	1.591686
Black Carbon	Diesel	1996	3.15435	2.947978	2.948	2.948006	1.59169
Black Carbon	Diesel	1997	3.154353	2.947996	2.947993	2.947995	1.591685
Black Carbon	Diesel	1998	2.966801	2.79886	2.798868	2.798863	1.522208
Black Carbon	Diesel	1999	2.966797	2.798865	2.798866	2.798864	1.522205
Black Carbon	Diesel	2000	2.966805	2.79887	2.798867	2.798868	1.522203
Black Carbon	Diesel	2001	2.966795	2.798863	2.798867	2.798869	1.522204

Pollutant	Fuel	Model Year	Class 2b	Class 3	Classes 4 5	Classes 6 7	Classes 8a/b
Black Carbon	Diesel	2002	2.966799	2.798875	2.798866	2.798868	1.522205
Black Carbon	Diesel	2003	2.523485	2.523479	2.523481	2.523482	1.375673
Black Carbon	Diesel	2004	2.523482	2.523482	2.52348	2.523484	1.37567
Black Carbon	Diesel	2005	2.523481	2.523484	2.523482	2.52348	1.375669
Black Carbon	Diesel	2006	2.523479	2.523477	2.523481	2.523479	1.375674
Black Carbon	Diesel	2007	0.045436	0.018814	0.018814	0.018814	0.018814
Black Carbon	Diesel	2008	0.045436	0.018814	0.018814	0.018814	0.018814
Black Carbon	Diesel	2009	0.045436	0.018814	0.018814	0.018814	0.018814
Black Carbon	Diesel	2010	0.037939	0.01571	0.017779	0.017779	0.017779
Black Carbon	Diesel	2011	0.037939	0.01571	0.017779	0.017779	0.017779
Black Carbon	Diesel	2012	0.037939	0.01571	0.017779	0.017779	0.017779
Black Carbon	Diesel	2013	0.037939	0.01571	0.01571	0.01571	0.01571
Black Carbon	Diesel	2014	0.037939	0.01571	0.01571	0.01571	0.01571
Black Carbon	Diesel	2015	0.037939	0.01571	0.01571	0.01571	0.01571
Black Carbon	Diesel	2016	0.037939	0.01571	0.01571	0.014675	0.01571
Black Carbon	Diesel	2017	0.037939	0.01571	0.01571	0.014675	0.01571
Black Carbon	Diesel	2018	0.022718	0.009426	0.009426	0.009915	0.011035
Black Carbon	Diesel	2019	0.022718	0.009426	0.009426	0.009915	0.011035
Black Carbon	Diesel	2020	0.022718	0.009426	0.009426	0.009915	0.011035
Black Carbon	Diesel	2021	0.022718	0.009426	0.009426	0.009915	0.011034
Black Carbon	Diesel	2022	0.022718	0.009426	0.009426	0.009915	0.011034

Table B-2. Extended Idle Emission Factors – Class 8b Diesels Only (g/hr)

Model Year	NO_x	PM_{10}	$PM_{2.5}$	Black Carbon
1990	240.2429	5.012193	4.611216	1.07339
1991	240.2429	5.012193	4.611216	1.07339
1992	240.6355	5.0126	4.611584	1.071225
1993	233.7694	5.005548	4.605088	1.109056
1994	239.5414	7.696976	7.081178	1.659313
1995	239.1037	7.699779	7.083789	1.664235
1996	237.157	7.712336	7.095328	1.686137
1997	239.5059	7.697177	7.081382	1.659706
1998	237.4083	7.371036	6.781333	1.608737
1999	241.3615	7.348521	6.760617	1.56685
2000	241.988	7.344966	6.757341	1.560223
2001	239.2928	7.360294	6.771469	1.588777
2002	237.723	7.369255	6.779707	1.60542
2003	239.3402	6.650885	6.118792	1.43515
2004	237.0764	6.662218	6.12922	1.456722
2005	238.3276	6.655958	6.123462	1.4448
2006	239.0454	6.652365	6.12015	1.437956
2007	210.1205	0.418171	0.384716	0.03441
2008	208.6581	0.417737	0.384316	0.034374
2009	211.7047	0.418642	0.38515	0.034449
2010	211.2663	0.416767	0.383424	0.034295
2011	210.1316	0.41643	0.383115	0.034267
2012	210.1319	0.416429	0.383114	0.034267
2013	210.1323	0.412936	0.379899	0.033979

Model Year	NO_x	PM_{10}	$PM_{2.5}$	Black Carbon
2014	210.1332	0.412936	0.379899	0.033979
2015	210.1322	0.412935	0.379899	0.033979
2016	210.132	0.412934	0.379899	0.033979
2017	210.1325	0.412936	0.379899	0.033979
2018	210.1323	0.412934	0.379899	0.033979
2019	210.1328	0.412935	0.379899	0.033979
2020	210.1321	0.412934	0.379898	0.033979
2021	210.1326	0.412936	0.3799	0.033979
2022	210.1326	0.412936	0.3799	0.033979

Appendix C: Derivation of National Average g/kW-hr Emission Factors

FROM ARGONNE GREET MODEL Version 2019.

http://greet.es.anl.gov/

1. Electric Generation Mix (eGRID U.S. Average 2018 Data (https://www.epa.gov/egrid/emissions-generation-resource-integrated-database-egrid))

	U.S. Mix
Residual oil	0.6%
Natural gas	35.1%
Coal	27.5%
Nuclear power	19.4%
Biomass	1.6%
Hydro	6.9%
Wind	6.5%
Solar	1.5%
Geothermal	0.4%
Other	0.3%

2. Electric Transmission and Distribution Loss = 4.87%

3. Power Plant Emissions: in Grams per kWh of Electricity Available at Power Plant Gate

	GREET Calculated Emission Factors By Fuel Type Plants (Stationary and Transportation)				
	Oil Fired	NG Fired	Coal Fired	Biomass Fired	TOTAL based on US Mix
NO_x	3.97	0.21	0.36	0.92	0.21
PM_{10}	0.16	0.011	0.061	2.09	0.056
$PM_{2.5}$	0.11	0.011	0.043	0.61	0.026
BC	0.0073	0.0015	0.0018	0.0015	0.0025
CO_2	840	404	947	0	407

Assumes no emissions from nuclear power plants, hydro, wind, solar, geothermal, and "Other"

4. Power Plant Emissions: Grams per kWh of Electricity Available at User Sites (wall outlets)

Total power plant gate emissions/(1-electric transmission and distribution loss)

	Total delivered based on US electric generation mix
NO_x	0.22
PM_{10}	0.059
$PM_{2.5}$	0.028

BC	0.0026
CO_2	428

Appendix D: PERE Efficiency Modeling Methodology

The PERE model is not specifically designed for modeling heavy duty hybrid trucks, but as it is a physical model that is primarily dependent upon input values, its use was considered appropriate for the estimation of the fuel economy effects of truck hybridization. The model calculates second-by-second fuel consumption for user-defined drive cycles based on a physical model. The model takes a number of user-specified parameters, along with some of its own defaults, to perform these calculations for a variety of vehicle and powertrain types. The assumptions and data sources for the model inputs that were used are presented below. The defaults for some parameters, such as hybrid regeneration efficiency and hybrid battery efficiency, were assumed to remain unchanged when scaling from light-duty to heavy-duty vehicles.

Many vehicle parameters, such as road load and transmission data, were used from work already done with the PERE model for the SmartWay program. Many of the parameters for that previous work were taken from findings of internet searches for specifications of various trucks in new "as-delivered" condition, prior to the addition of various vocational or cargo equipment installations that would increase drag and vehicle weight. To establish the test weights for each truck class in this modeling effort, the original estimate of minimum weight was averaged with the maximum possible weight for each truck class. This was done with the intent of modeling an average or medium payload for each truck class. An important source of information was an EPA draft document discussing the use of the PERE model by Nam and Gianelli[50]. This document contained equations that could be used for estimates of some of the input parameters, along with information describing the use of the model.

The two foremost inputs to the model include the vehicle weight and engine size. Vehicle empty weights and engine sizes were taken from manufacturer supplied truck specifications where possible. For example, Ford published a .pdf file titled *F-250/F-350/F-450/F-550 Specifications*[51] that contains base curb weights and engine sizes for some of their offerings in the light and medium duty market. Another useful source of manufacturer data was in the *Kenworth T170/T270/T370 Body Builders* Manual[52]. The T170-T370 range consists of medium duty trucks that can be delivered with a cab-only chassis. The manual describes all of the dimensions relevant to the builder of a body or cargo area on the rear of the chassis. As such, it includes curb weights, length and width dimensions, and gross vehicle weight ratings that were instrumental in creating many of the inputs for the Class 5, 6, and 7 fuel economy models. Where specifications of multiple trucks in a class were found, values were taken that would result in maximum fuel economy unless they seemed noticeably atypical of in-use vehicles. Variations in weight and engine size over the ranges found in literature did not have as large an effect on fuel economy as some of the other inputs to the PERE model. For hybrid modeling, the engine size reduction due to hybridization ranged from 1 liter for the Class 2b and 3 trucks, up to 4 liters for the Class 8 trucks. This range was chosen based on the nature of hybrid trucks currently available

[50] Nam, Edward and Gianelli, Robert, Fuel Consumption Modeling of Conventional and Advanced Technology Vehicles in the Physical Emission Rate Estimator (PERE). US EPA Publication EPA420-P-05-001, February 2005.

[51] FordF150.net. F-250/F-350/F-450/F-550 Specifications. Retrieved from http://www.fordf150.net/specs/05sd_specs.pdf Accessed 11-29-2020.

[52] Kenworth. Kenworth T170/T270/T370 Body Builders Manual. Retrieved from https://www.kenworth.com/media/25008/kenworth_medium_duty_bbm_dec_2011.pdf Accessed 11-29-2020.

on the market. Class 2 hybrid trucks on the market typically have very little engine downsizing from hybridization, however larger trucks were found to have more engine downsizing.

The number of transmission gears in each truck class was also based on specifications found on manufacturers' web sites, but there is a wide range of the number of gears in the different available transmissions. While it is very likely that the most efficient setup for Class 2b through 4 would be a 6 speed manual transmission, there are a variety of options for Classes 5 through 8. It is also typical for a modern Class 8 truck to have 10 gears, so the model input for Class 6 was taken to be 8 as a representation of typical trucks in that class, and all trucks were modeled with manual transmissions. The PERE model also requires shift speeds as an input to the model, and examples of these were not found in literature or internet searches. ERG has previously logged on-road data from Class 8 trucks with 10-speed manual transmissions, and this data was analyzed briefly to create an estimate of typical upshift speeds for this type of truck. Using this speed/gear curve, two other curves were created by scaling for the 6 and 8 speed trucks modeled in the study. Unfortunately, the shift speed chart has a very strong effect on the model's predicted fuel economy but using carefully scaled shift point curves hopefully mitigated this source of error. The hybrid trucks were modeled with exactly the same transmissions as the conventional trucks. The model did not readily include a provision for changing the transmission characteristics when changing from conventional to hybrid powertrains. All transmission parameters were kept the same when making this change with the intent of ensuring the resulting fuel economy effects were only due to hybridization, not due to transmission effects.

There were three other values regarding the driveline that were input for this study. The engine efficiency was taken to be 40% over the cycle. The maximum engine speeds and highway cruise speeds were adjusted together as well, to account for the larger displacement heavy duty engines turning more slowly than typical Class 2b truck engines. The effects of the engine speed parameters on fuel economy were fairly small.

The road load estimation required assumptions and calculations as road load curves are not generally a part of manufacturers' literature. The method of road load calculation used for this PERE modeling was based on the coefficient of rolling resistance (C_R), the aerodynamic drag coefficient (C_d), and the vehicle frontal area (A_F) in a physical equation of the truck's road load, given in Equation 1 from Nam and Gianelli (2005). Coefficients of drag were based on values in literature, such as manufacturers' specifications for Class 2b and in a report publication by Argonne National Laboratory[53]. Values for C_d ranged from .45 for the Class 2b and the smaller medium duty trucks, to .5 for the class 8 long-haul trucks. The heavier medium duty trucks were assumed to have a C_d of .55 as they were assumed to be vocational trucks with less streamlined aerodynamics. Frontal area was taken from manufacturer specifications where available. As given in Nam and Gianelli, the product of truck height and width was multiplied by a factor of 0.93 to get an estimate of effective A_F. Engineering judgment was applied to the dimensions found in literature to ensure a representative increase in frontal area from the smaller to larger trucks. The rolling resistance values were estimated using the trends observed by both Nam and Gianelli (2005) along with Delorme Karbowski, and Sharer (2009), ranging from 0.01 for the light and medium duty trucks, down to 0.008 for the class 8 trucks.

[53] Delorme, A., Karbowski, D., and Sharer, P. Evaluation of Fuel Consumption Potential of Medium and Heavy-Duty Vehicles through Modeling and Simulation. Argonne National Laboratory, DEPS-BEES-001, October 2009.

The final input to the PERE model was the driving cycle. In order to get a representative range of fuel economy benefit, two drive cycles were modeled. The first was the Heavy-Duty Urban Dynamometer Driving Schedule (HDUDDS), and the second was the EPA Highway Fuel Economy Test (HwFET). The HDUDDS can be thought of as a city-type cycle with frequent stops and starts. The HwFET simulates rural driving with varying speeds but no stops. Even though the HwFET is designed only for light duty vehicles, it was still used as it was the best representation available for in-use highway driving.

The key values used as the inputs for the PERE model fuel economy calculations are given by truck class in Table D-1.

Table D-1. PERE Model Inputs for Fuel Economy Estimation

Class	Modeled Test Weight, lbs	Conventional Engine Disp., L	Hybrid Engine Disp., L	Number of Gears	Effective Gear Ratio, RPM/mph
2b	7,875	6.0	5	6	35
3	10,000	6.0	5	6	35
4	12,250	6.4	5.4	6	33
5	14,500	6.7	5.7	6	33
6	19,500	6.7	5.7	8	33
7	24,000	8.3	6.3	10	31
8	52,500	13	9	10	30

For modeling hybrid vehicles in the PERE model, the user must adjust the hybrid threshold for each different vehicle and drive cycle combination. This variable represents the amount of power demand during acceleration that is required to cause the engine to start up to assist the electric motor. The user must adjust this value such that the amount of energy taken from the battery is approximately equal to the amount of energy charged back into the battery during regenerative braking. If this is not done, the fuel economy will be misrepresented due to the battery ending up with a different state of charge at the end of the cycle compared to the beginning of the cycle.

For the HwFET cycle in the lower truck classes, there were not enough deceleration events charge the battery back to its initial charge level, even with the hybrid threshold variable at its minimum value. This meant that the battery was ending at a lower level of charge at the end of the cycle than the beginning, which has the effect of overestimating the trucks actual fuel economy. For this reason, ERG added an extra calculation to the model in order to account for the net change in battery power. This calculation used the various efficiencies of the hybrid system to estimate the fuel required to make up the change in battery charge over the cycle, and add that number to the modeled fuel consumption. This calculation was needed for the trucks in Classes 2b through 5.

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