EMFAC Modeling Change Technical Memo

**SUBJECT:** STANDARDS-RATIO FACTORS FOR TIRE WEAR AND BRAKE WEAR PM

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# Summary

The Emfac2001 model and its predecessors calculate emission factors for passenger cars. These emission factors are often scaled up, using “standards ratio” factors, to estimate emissions from light-duty and medium-duty trucks. The standards ratio factors correct for the differences in exhaust emissions standards between passenger cars, light-, and medium-duty trucks.

The model currently applies a standards ratio factor to all PM emissions, including all running emissions (PMEX), emissions from tire wear (PMTW), and emissions from brake wear (PMBW). This means that PMEX, PMTW, and PMBW emission factors for light-duty and medium-duty trucks are scaled up using the standards ratio factor for PM. This approach is correct for exhaust emissions since the exhaust PM standards vary between the light-duty vehicles but it is not correct for PMTW or PMBW emissions. In the proposed change, the calculations have been corrected so that the exhaust PM factor is not applied to PMTW and PMBW. This change will **only** reduce PMTW and PMBW emissions from **light-duty** and **medium-duty trucks**.

On a statewide basis in 2010, correcting this error will reduce summer episodic total PM10 emissions from light-, and medium-duty trucks by about 5.6 tons per day, or about 26.4%. To put this in perspective this change will reduce total PM10 emissions from all on-road vehicles in 2010 by 9.8%. Depending on the calendar year, correcting this error will decrease statewide on-road PM10 emissions from light-, and medium-duty trucks by 0.3 tons per day in 1980, and 6.6 tons per day in 2020. Relative to PM10 emissions from all on-road vehicles, this change reduces total PM emissions by 0.8% in 1980 and 10% in 2020.

This change only affects gasoline powered light-, and medium-duty trucks. It has no impact on pre-1976 non-catalyst vehicles because the standards ratio factor is 1.0 for this group of vehicles. The change affects PMTW and PMBW from catalyst equipped light-, and medium-duty trucks.

# Reason for Change

A consultant with Sonoma Technology asked why the PMBW emissions vary by vehicle class. The consultant noted that the PMBW emissions from light and medium-duty trucks were higher than those from passenger cars.

# Background

The Emfac2001 model and its predecessors calculate technology specific emission factors. These technology groups are weighted to calculate model year specific emission factors. The technology groups for light-duty vehicles reflect the emissions characteristics of vehicles that have been certified to passenger car emission standards. For light-duty vehicles, it is assumed that the type of technologies employed do not change between categories. For example, a fuel-injected technology used on passenger cars will eventually be used on light and medium-duty trucks. What changes between the light-duty vehicles is the mix of technologies by model year, and the model year emission standards. To calculate emission factors for light-duty and medium-duty trucks the technology mix is changed to represent actual sales of light and medium-duty trucks. The exhaust emission factors are then scaled up using a “standards ratio” intended to account for the differences in exhaust emissions standards between passenger cars, light-duty trucks and medium-duty trucks.

The model calculates standards ratio correction factors for HC, CO, NOx, CO2, and PM, and applies the factors to all running emissions for these species. The standards ratios are calculated from exhaust emissions factors. This approach is correct for PMEX, but not for PMTW and PMBW.

In previous model versions, the PMTW and PMBW emissions from light-duty and medium-duty trucks have been scaled by the same factor as exhaust PM. In the proposed change, the calculations will be corrected so that the exhaust PM standards ratio factor is not applied to PMTW and PMBW.

# Affected Source Code & the Version Change that was Implemented

Source files that were changed for this version: calimfac.for, e\_calc.for, and xburden.for.

In preparation for the change, code was modified in ERG’s working version of version 2.093, including changes in utilities.for and the conversion of stdratio.for to stdratio.f90.

# Revised Methodology

The Emfac2001 model calculates basic emission factors and correction factors in a nested loop of pollutant (HC, CO, PM, etc.) and “mode” or “process”. For the PM pollutant, emissions are calculated for three FTP and two UC modes, then for starting, idle, PMTW, and PMBW emission modes.

The standards ratio correction factors are calculated for all pollutants and all active technology groups, but they are calculated independent of the emissions mode.

The pollutant/mode loops were modified so that for PM emissions the standard ratio factor is set to 1.0 if the emission mode is PMTW or PMBW. The code below is adapted from subroutine BURDEN\_CALC, which calculates Burden-mode emission rates. Similar changes were made to the Emfac- and Calimfac-mode calculations. BURDEN\_CALC is called once for each combination of model year and vehicle class.

In BURDEN\_CALC, the STDRATIO array is initialized with standards ratio values for the model year and vehicle class:

 CALL GET\_STDRATIO (IVEH, MYR, STDRATIO)

Following this, nested loops iterate over all of the technology groups present in the model year for the vehicle class, all pollutants in use, and all modes in use:

 TECH\_LOOP: DO TECHIDX=1, TECHIDX$

 POL\_LOOP: DO IPOL = 1, POL$

 IF (.NOT. USE\_POL$(IPOL) ) CYCLE

 MODE\_LOOP: DO IMODE = 1, MODE$

 IF (.NOT. USE\_MODE$(IMODE,IPOL) ) CYCLE

 BMODE = GET\_BMODE(IPOL,IMODE)

For each TECHIDX/IPOL/IMODE combination, the standards ratio value is retrieved from the array:

 STD\_RATIO = STDRATIO(IPOL, TECHIDX)

In the proposed change, if the mode is PMBW/PMTW, the factor is reset to 1.0:

 **IF(BMODE==PMBW$ .OR. BMODE==PMTW$) STD\_RATIO=1.0**

Following this, the BER (either FACTOR\_NO\_IM or FACTOR\_IM) is corrected by adding the composite correction factor (ACFTEMP), multiplying by the combined correction factors (CFAC) and then multiplying by the standards ratio.

 BER\_X\_CFAC=(FACTOR\_NO\_IM+ACFTEMP)\*CFAC\*STD\_RATIO

 IMBER\_X\_CFAC=(FACTOR\_IM+ACFTEMP)\*CFAC\*STD\_RATIO

The corrected BERs are combined with activity for tons of emissions for this specific vehicle class, model year, technology group, pollutant, and mode:

 T = BER\_X\_CFAC \* ACTIVITY \*

 & (TECHFRAC/SUMFRAC) / GRAMS\_PER\_TON$

For PMTW/PMBW, the activity used is VMT. The SUMFRAC correction is the fraction of vehicles in the class that are in the technology group. GRAMS\_PER\_TON$ is a units correction.

The contribution from the technology group is added to the totals for the vehicle class:

 TONS\_NO\_IM(IPOL,BMODE,IVEH,BTECH,IPERIOD)

 & = T + TONS\_NO\_IM(IPOL,BMODE,IVEH,BTECH,IPERIOD)

# Emissions Impact

To facilitate an incremental analysis, the change to the standards ratio factor for PM was applied to ERG’s current working model version (Emfac2001 version 2.093) that contained changes to school bus activity, LEVII evaporative technology groups, and fuel RVP. The subsequent model was titled “proposed PMTW/BW” since the intent was to only quantify the effect on emissions, and then seek approval for inclusion into CARB’s working model.

Table 1 shows the **statewide** summer episodic emissions from Emfac2001 ver. 2.093 for PMTW, PMBW, and total PM, for the vehicle classes affected and for all vehicles. The PMTW and PMBW values include gasoline and diesel emissions, and the Total-PM values also include exhaust PM.

Table 2 shows the statewide emissions with the “proposed PMTW/BW” revisions. Table 3 shows the net decrease in emissions.

In comparison to Emfac2001 ver 2.093, the change in standard ratio for PM will reduce statewide on-road PM emissions by 0.8% in 1980 to 10% in 2020. The 1980 case shows the least reduction, because the change did not affect pre-1976 gasoline vehicles. The change affects PMTW and PMBW emissions from catalyst equipped light-, and medium-duty trucks. The effect of this change becomes more significant in future calendar years because the proportion of catalyst equipped trucks increases in the light-, and medium-duty truck fleets.

For light-duty trucks[[1]](#footnote-1) (LDT1) vehicles, the PMTW and PMBW reductions range from 0.5% to 7.5%, with the greatest reduction in 1990. For light-duty trucks (LDT2) and medium-duty trucks (MDV), PMTW and PMBW decrease by 14% to 53%, with the percentage reduction increasing each year.

## Table 1. Current (2.093) Statewide On-Road PMTW and PMBW Emissions from LDT1, LDT2, MDV

|  |  |
| --- | --- |
|   | Particulate Matter (PM10) (tons per day) for LDT1, LDT2, MDV, and Total |
| Calendar | LDT1 | LDT2 | MDV | All-Vehicle |
| Year | PMTW | PMBW | Tot-PM | PMTW | PMBW | Tot-PM | PMTW | PMBW | Tot-PM | Tot-PM |
| 1970 | 0.30 | 0.47 | 2.09 | 0.46 | 0.72 | 3.19 | 0.06 | 0.10 | 0.45 | 29.26 |
| 1980 | 0.30 | 0.47 | 1.78 | 0.56 | 0.87 | 2.96 | 0.07 | 0.11 | 0.41 | 40.56 |
| 1990 | 0.60 | 0.94 | 2.75 | 1.96 | 3.07 | 6.85 | 0.35 | 0.55 | 1.83 | 67.05 |
| 2000 | 0.62 | 0.97 | 2.88 | 2.64 | 4.14 | 9.83 | 0.95 | 1.48 | 4.07 | 53.47 |
| 2010 | 0.76 | 1.19 | 3.36 | 2.92 | 4.57 | 12.45 | 1.23 | 1.92 | 5.33 | 57.10 |
| 2020 | 0.90 | 1.42 | 3.93 | 3.37 | 5.29 | 14.86 | 1.50 | 2.36 | 6.60 | 65.50 |

## Table 2. Proposed Statewide On-Road PMTW and PMBW Emissions From LDT1, LDT2, and MDV

|  |  |
| --- | --- |
|   | Particulate Matter (PM10) (tons per day) for LDT1, LDT2, MDV, and Total |
| Calendar | LDT1 | LDT2 | MDV | All-Vehicle |
| Year | PMTW | PMBW | Tot-PM | PMTW | PMBW | Tot-PM | PMTW | PMBW | Tot-PM | Tot-PM |
| 1970 | 0.30 | 0.47 | 2.09 | 0.46 | 0.72 | 3.19 | 0.06 | 0.10 | 0.45 | 29.26 |
| 1980 | 0.29 | 0.45 | 1.76 | 0.44 | 0.69 | 2.66 | 0.06 | 0.09 | 0.38 | 40.22 |
| 1990 | 0.55 | 0.87 | 2.63 | 0.95 | 1.49 | 4.26 | 0.22 | 0.35 | 1.49 | 64.01 |
| 2000 | 0.59 | 0.93 | 2.81 | 1.25 | 1.95 | 6.25 | 0.50 | 0.78 | 2.92 | 48.67 |
| 2010 | 0.75 | 1.18 | 3.33 | 1.37 | 2.16 | 8.50 | 0.60 | 0.94 | 3.73 | 51.51 |
| 2020 | 0.90 | 1.41 | 3.92 | 1.59 | 2.49 | 10.26 | 0.72 | 1.12 | 4.58 | 58.87 |

## Table 3. Proposed Difference In Statewide On-Road Emissions

|  |  |
| --- | --- |
|   | Particulate Matter (PM10) (tons per day) for LDT1, LDT2, MDV, and Total |
| Calendar | LDT1 | LDT2 | MDV | All-Vehicle |
| Year | PMTW | PMBW | Tot-PM | PMTW | PMBW | Tot-PM | PMTW | PMBW | Tot-PM | Tot-PM |
| 1970 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1980 | -0.01 | -0.01 | -0.02 | -0.12 | -0.18 | -0.30 | -0.01 | -0.02 | -0.03 | -0.34 |
| 1990 | -0.04 | -0.07 | -0.12 | -1.01 | -1.58 | -2.59 | -0.13 | -0.20 | -0.33 | -3.04 |
| 2000 | -0.03 | -0.04 | -0.07 | -1.39 | -2.19 | -3.58 | -0.45 | -0.70 | -1.15 | -4.80 |
| 2010 | -0.01 | -0.02 | -0.03 | -1.54 | -2.42 | -3.96 | -0.62 | -0.98 | -1.60 | -5.59 |
| 2020 | 0.00 | -0.01 | -0.01 | -1.79 | -2.80 | -4.59 | -0.79 | -1.24 | -2.03 | -6.63 |

# Remaining Issues

The proposed revisions should completely address this problem. There are no other combinations of pollutant and mode that require the same special considerations for the standards ratio.

1. Light-duty trucks consist of LDT1 and LDT2 trucks. The LDT1 represent trucks with less than 3750 lbs inertia weight. Whereas, LDT2 represent trucks in the 3751-5750 lbs range. [↑](#footnote-ref-1)