

## **ENCLOSURE A**

# **Changes in California's EMFAC Vehicle Emissions Model**

EMFAC2002 represents a comprehensive review, restructuring and revision of California's on-road emissions inventory as compared to the previous emissions model approved by the U.S. Environmental Protection Agency (U.S. EPA), EMFAC7G. The most notable changes are described below. In addition, because some areas in California relied on EMFAC7F in their last State Implementation Plan (SIP) submittal, the list of EMFAC2002 changes is followed by a list of major changes from EMFAC7F to EMFAC7G.

### ***Major Changes from EMFAC7G to EMFAC2002***

#### **Rule Implementation**

- **LEV II Standards**

EMFAC2002 is updated to reflect amendments to California's Low Emission Vehicle regulation (LEV II) (formally adopted in 1998), amendments to the zero emission vehicle program, and adoption of some portions of the U.S. EPA Tier II program. These changes affect exhaust and evaporative emissions for light-duty autos, light-duty trucks, and medium-duty trucks (less than 8,500 pounds GVWR.) This change decreases future emissions from light and medium-duty vehicles.

Changes occur in Versions 2.02, 2.06 and 2.2

Reference: Technical Support Document (EMFAC2000), May 2000, Section 9.0.

Reference: EMFAC2001 Documentation, 2001, pp. 5-10 and 35.

Reference: Technical Memo, Revised Implementation Schedule for LEV II Evaporative Emissions: Evap Tech Fractions for MY2003+ PC and LDT1, August 2002.

- **Inspection and Maintenance**

California's Inspection and Maintenance (I/M or Smog Check) program requires periodic emissions tests of on-road vehicles as a condition of registration renewal. In 1990, the program was improved to include more comprehensive inspections, higher repair cost limits, and more stringent standards. In 1998, an Enhanced I/M Program was implemented in most urban areas using more stringent emission test procedures called acceleration simulation mode (ASM) tests. EMFAC7G assumed substantial emission reductions for the 1984 and 1990 programs, as well as additional reductions based on the Enhanced Program envisioned when that model was created. EMFAC2002 claims more modest emission reductions from Smog Check based on the Enhanced Program as currently implemented. The changes affect all pollutants, particularly ROG and NOx.

Change occurs in Version 2.02

Reference: ARB Staff Report, Public Meeting to Consider Approval of Revisions to the State's On-Road Motor Vehicle Emissions Inventory, May 2000, p. 22.

Reference: Technical Support Document (EMFAC2000), May 2000, Section 13.10.

- **Heavy-Duty Truck Standards**

EMFAC2002 reflects several new regulations for heavy-duty trucks. (1) U.S. EPA (1997) and ARB (1998) adopted a 2 g/bhp-hr NO<sub>x</sub> standard for heavy-duty diesel engines effective in 2004. The model also accounts for the early introduction of these engines resulting from a settlement (Consent Decree) between U.S. EPA and engine manufacturers. (2) ARB adopted a 1.0 g/bhp-hr HC+NO<sub>x</sub> standard for medium and heavy heavy-duty gasoline trucks affecting model year 2005. (3) In 2001, ARB adopted new emission standards identical to those promulgated by U.S. EPA (December 2000) for 2007 heavy-duty diesel engines. U.S. EPA also adopted 2008 heavy-duty gasoline engine standards. The regulations and resulting model adjustments also affect school buses and motor homes. The model changes from these regulations decrease future emissions from heavy-duty trucks for all pollutants.

Changes occur in Versions 2.02, 2.07 (HC, CO, NO<sub>x</sub>) and 2.2 (PM)

Reference: Technical Support Document (EMFAC2000), May 2000, Sections 10.3 through 10.6.

Reference: EMFAC2001 Documentation, 2001, pp. 36-43.

Reference: Technical Memo, Correction to 2007+ HDD PM Emission Rates:

Update to Heavy and Medium Heavy-Duty Diesel Truck Emission Rates, 2002.

- **Transit Bus Standards**

EMFAC2002 reflects ARB's transit fleet rule and urban bus emission standards adopted in 2000 and updated in 2001. The rule has a graduated implementation schedule affecting model years 2000 through 2007 and includes provision for a portion of new purchases in 2008 and beyond to be zero emission buses. This change decreases future emissions from transit buses for all pollutants, particularly NO<sub>x</sub>.

Change occurs in Versions 2.02 and 2.06

Reference: Technical Support Document (EMFAC2000), May 2000, Sections 10.13 and 10.14.

- **Gasoline Fuel Volatility**

State regulation requires that gasoline sold in California during summer ozone months have low volatility or less than 7.0 Reid Vapor Pressure (RVP). EMFAC2002 has been adjusted to more accurately reflect implementation of this regulation. The model also reflects a change in the methodology used to estimate winter average RVP, thereby reducing evaporative ROG emissions included in winter inventories.

Change occurs in Versions 2.2

Reference: Technical Memo, Correct Monthly Average Gasoline RVP:

Gasoline Sales Volatility (RVP), August 2002.

- **Reformulated Gasoline Phase 3**

California reformulated gasoline regulations for Phase 3 gasoline were approved in 1999 (and modified in 2002) to eliminate the additive MTBE. EMFAC2002 assumes that 50% of gasoline sold will be Phase 3 in 2003 and that full benefits will be realized in 2004. The Phase 3 regulation also "locked in" the in-use benefits from Phase 2 gasoline by requiring the cleaner formulas already being produced. EMFAC7G did not

include Phase 3 gasoline. These changes decrease NOx emissions. In addition, ARB modified its gasoline deposit control additive regulation in 1998 to add a standard for combustion chamber deposits. Control of combustion chamber deposits reduces NOx emissions.

Changes occurs in Versions 2.02 and 2.2

Reference: Technical Memo, Revise Implementation Dates for Phase 3 Gasoline, August 2002.

Reference: Technical Support Document (EMFAC2000), May 2000, Section 6.3

- **Low Sulfur Diesel Fuel**

In 2001, U.S. EPA adopted a low sulfur diesel fuel regulation (15 ppm) for on-road vehicles. ARB anticipates adopting low sulfur limits that would become effective in 2006. EMFAC2002 includes adjustments to fuel correction factors to account for the use of low sulfur diesel fuel in calendar year 2007 and beyond. This change reduces SOx emissions.

Change occurs in Version 2.07

Reference: EMFAC2001 Documentation, 2001, p. 44.

- **Motorcycles**

In 1998, ARB adopted lower exhaust emission standards for motorcycles starting with model year 2004. EMFAC2002 reflects this regulation. The change reduces future emissions of ROG and NOx.

Change occurs in Version 2.02

Reference: Technical Support Document (EMFAC2000), May 2000, Sections 9.0 and 4.11.

## **Base Emission Rates**

ARB conducts annual vehicle emissions surveillance programs and compiles emissions test data from manufacturers and other agencies. ARB has adjusted the base emission rates used in the EMFAC model to reflect emissions test data and improve model accuracy.

- **Unified Cycle Emission Rates**

In the early 1990's, ARB created a new driving cycle, the Unified Cycle (UC), for emission inventory assessment that reflects the speeds and accelerations common in contemporary driving behavior. In EMFAC7G, basic emission rates were based on the federal FTP driving cycle and adjusted to a UC basis using cycle correction factors. In EMFAC2002 base emission rates are based directly on UC emissions test data. This change increases emissions from passenger cars for all pollutants.

Change occurs in Version 2.02

Reference: ARB Staff Report, Public Meeting to Consider Approval of Revisions to the State's On-Road Motor Vehicle Emissions Inventory, May 2000, p. 11.

- **Evaporative Emissions for ZEVs**

Zero emission vehicles (ZEVs) have a finite amount of evaporative emissions from upholstery, tires, etc. EMFAC2002 is modified to include these emissions which had been previously unaccounted for in EMFAC7G. The adjustment was made on ZEV hot soak and diurnal emission rates. This change increases evaporative ROG emissions for light-duty vehicles.

Change occurs in Version 2.06

Reference: EMFAC2001 Documentation, 2001, p. 11.

- **Light-Duty Diesel Trucks**

Base emission rates for light-duty diesel vehicles are updated to reflect analysis of vehicle emissions test data. The changes in emission rates vary by model year groups.

Change occurs in Version 2.06

Reference: EMFAC2001 Documentation, 2001, pp. 26-34.

- **Liquid Leakers**

Liquid leakers are vehicles that drip fuel while running or parked. EMFAC7G did not include an estimate of evaporative emissions from liquid leakers; the revised model includes specific estimates of liquid leakers as a function of vehicle age and technology. This change significantly increases evaporative ROG emissions.

Change occurs in Version 2.02

Reference: ARB Staff Report, Public Meeting to Consider Approval of Revisions to the State's On-Road Motor Vehicle Emissions Inventory, May 2000, p. 15.

- **Particulate Matter**

Particulate emission rates were updated for both gasoline and diesel powered vehicles based on additional vehicle emissions testing and research. Smoking vehicles account for most of the increase resulting from this adjustment. The data for gasoline vehicles in EMFAC7G were taken from the U.S. EPA PART5 model.

Change occurs in Version 2.02

Reference: ARB Staff Report, Public Meeting to Consider Approval of Revisions to the State's On-Road Motor Vehicle Emissions Inventory, May 2000, p. 21.

Reference: Technical Support Document (EMFAC2000), May 2000, Section 4.12.

- **Chassis Dynamometer Data for Heavy-Duty Trucks**

In EMFAC7G, heavy-duty diesel truck emissions were based on engine tests. In EMFAC2002 heavy-duty diesel emission rates are based on chassis dynamometer tests. This change in test procedure showed increases in NOx and decreases in PM emissions, which are reflected in the model. In addition, chassis dynamometer tests data collected by ARB and U.S. EPA led to revisions in the emission factors for gasoline-powered heavy-duty trucks. The new emission factors for gasoline vehicles are lower than before.

Change occurs in Versions 2.02 and 2.06

Reference: Technical Support Document (EMFAC2000), May 2000, Section 10.1.

- **Cycle Based (UDDS) Data for Heavy-Duty Diesel Trucks**

In EMFAC7G, heavy-duty vehicle emission rates were based on engine tests. EMFAC2002 relies on data from chassis dynamometer tests using the Urban Dynamometer Driving Schedule (UDDS). The UDDS better represents typical vehicle operations and includes some of the “off-cycle” NOx emissions associated with extended cruises of diesel trucks. This change increases emissions, particularly NOx.

Change occurs in Version 2.02

Reference: ARB Staff Report, Public Meeting to Consider Approval of Revisions to the State’s On-Road Motor Vehicle Emissions Inventory, May 2000, pp. 20-21.

- **Heavy-Duty Truck Idle Emission Rates**

EMFAC7G did not account for emissions from heavy-duty truck idling. EMFAC2002 uses heavy-duty truck idling emission rates based on U.S.EPA emissions testing. This change increases emissions from heavy-duty trucks for all pollutants. Revisions made to heavy-duty idling time are discussed in the activity section of this document.

Change occurs in Version 2.02

Reference: Technical Support Document (EMFAC2000), May 2000, Section 10.10.

- **Air Conditioning**

EMFAC2002 updated model algorithms to better estimate emissions associated with the running of vehicle air conditioners. Low emitting vehicles are affected more than other current in-use vehicles. This change increases TOG, NOx, and CO.

Change occurs in Version 2.06

Reference: EMFAC2001 Documentation, 2001, pp. 18-19.

## **Vehicle Activity**

- **COG-Submitted Estimates**

Local councils of government (COGs) or regional transportation planning agencies (RTPAs) submit vehicle activity estimates to ARB. The information is based on locally maintained travel demand models. This information includes vehicle miles traveled and speed distributions for a base year and for forecasted years. The estimates are entered into the EMFAC model and are updated as new information is submitted. Recent changes in speed distributions tend to decrease forecasted emissions of ROG, CO, and PM10 while increasing NOx. Recent VMT changes typically increase emissions but may cause a decrease in forecasted emissions for some areas of the state. ARB is excluding the default travel activity estimates in EMFAC2002 from this package for U.S. EPA approval. These travel activity estimates are updated and approved through alternate processes.

Changes occur on an ongoing basis.

Reference: EMFAC2001 Documentation, 2001, pp. 45-48.

Technical memos, Updated Vehicle Miles Traveled: Updating Vehicle Miles Traveled, July 2002 and Updated Speed Distribution: Updating Estimates of Speed Distribution, September 2002.

- **County Specific Fleet Characterization**

Unlike EMFAC7G, the new model includes vehicle model year age distributions resolved to the county level. The distributions are based on the Department of Motor Vehicles registration records and also reflect fuel type such as gasoline, diesel, or electric vehicles.

Change occurs in Version 2.02

Reference: Technical Support Document (EMFAC2000), May 2000, Section 7.2.

- **Vehicle Population and Age Distribution**

EMFAC2002 updates vehicle population and includes the number of vehicles in each vehicle class by age. The revised estimates are based on over 30,000,000 records from the California Department of Motor Vehicles for calendar years 1999 and 2000. This change significantly decreases future emissions of ROG and CO. The change increases NOx and PM10 to a lesser extent.

Change occurs in Version 2.2

Reference: Technical memo, Revisions to the Population and Registration Distributions in EMFAC, September 2002.

- **Vehicle Mileage Accrual Rates**

Emissions estimates are directly related to the number of miles a vehicle travels. In EMFAC7G statewide averages were used to estimate accrual rates. Based on Smog Check mileage accrual data EMFAC2002 provides county-specific accrual rates by vehicle class. This change decreases emissions from passenger cars for all pollutants.

Change occurs in Version 2.02

Reference: Technical Support Document (EMFAC2000), May 2000, Section 7.1.

- **School Bus Activity and Speed Distributions**

In EMFAC7G, school bus activity was based on typical medium heavy-duty truck travel occurring throughout the day. EMFAC2002 is updated to reflect actual school bus travel and operations based on ARB sponsored research. School bus activity is allocated to the appropriate morning and afternoon time periods of the day resulting in new speed distributions. These changes increase emissions from the school bus inventory for all pollutants.

Changes occur in Versions 2.06 and 2.2.

Technical Memo, Activity Changes for School Buses: Correct Usage Rates for School Buses, August 2002

- **Unregistered Vehicles**

ARB directed research to determine the number of vehicles in the state that are unregistered for two or more years. Unregistered vehicles are a component in estimating the total vehicle population. Based on the new research, the percentage of these chronically unregistered vehicles was changed from 0.5 to 0.03 percent. The model assumes that these vehicles do not participate in the I/M program and, therefore, have higher emissions than vehicles that do.

Change occurs in Version 2.06

Reference: EMFAC2001 Documentation, 2001, pp. 12-17.

- **Out-of-State Heavy Heavy-Duty Diesel Vehicles**

In EMFAC2002, heavy heavy-duty diesel vehicle populations are assigned to their county of registration. The model has been adjusted to reflect research results indicating that 33% of vehicle miles traveled are by out-of-state trucks traveling in California and not subject to California regulations. This change increases emissions.

Change occurs in Version 2.08.

Reference: EMFAC2001 Workshop Presentation, May 2001.

- **Mexican Vehicles**

Unlike EMFAC7G, EMFAC2002 includes emissions estimates from vehicles registered in Mexico while traveling in California. These estimates are based on extensive U.S. Customs Service statistics on vehicles entering California cities and on an analysis of vehicle technology groups represented in the Juarez light-duty fleet and in the San Diego/Imperial Counties fleet. EMFAC2002 also includes estimates for trucks built and certified in Mexico that cross the border into California. This change increases emissions.

Change occurs in Versions 2.02 and 2.08

Reference: Technical Support Document (EMFAC2000), May 2000, Section 12.

Reference: EMFAC2001 Documentation, 2001, pp. 20-25.

- **Heavy Heavy-Duty Diesel Truck Idling Time**

Heavy heavy-duty diesel truck studies indicate that not only do trucks idle during the course of a typical trip, significant idling occurs between trips at truck stops, rest areas, and distribution centers. EMFAC7G did not account for idling emissions whereas EMFAC2002 does. The model reflects a heavy heavy-duty diesel truck idling time of about 104 minutes per vehicle per day. This change significantly increases emissions from heavy heavy-duty trucks for all pollutants, particularly NOx.

Change occurs in Version 2.2

Reference: Technical memo, Extended Idle for Heavy-Duty Diesel Trucks:

Inclusion of Extended Idle for Heavy Heavy-Duty Diesels, August 2002.

- **School Bus Idling Time**

EMFAC7G did not include idle emissions for school buses. EMFAC2002 includes approximately 32 minutes of idling per bus per day based upon an analysis performed by Valley Research Corporation for the ARB. In the absence of emissions test data specific to school buses, the idle emission rate is assumed to be the same as a medium heavy-duty truck engine. This change increases emissions from school buses for all pollutants.

Change occurs in Version 2.2

Reference: Technical memo, Extended Idle for School Buses:

Inclusion of Idle Emissions for Gasoline and Diesel Powered School Buses, August 2002.

## **Model Structure and Weighting**

- **“What If” Scenario Generator**

The new model has a user interface that includes a “what if” scenario generator (WIS). This feature allows the user to modify a number of default parameters without having to modify the model code or recompile the model. Adjustable parameters include vehicle population, VMT, starts, relative humidity, temperature, technology fractions, speed distributions, and I/M program defaults. Also, while EMFAC7G calculated emissions by county and by air basin only, EMFAC2002 provides emissions by air district as well.

Change occurs in Version 2.08

Reference: EMFAC User’s Guide, 2002.

- **Vehicle Age Range**

In EMFAC7G, the number of model years assumed to exist in any one calendar year was 35 years for passenger cars, 14 years for motorcycles, and 25 years for all other vehicle classes. EMFAC2002 extends the age distribution for all vehicle classes to 45 years. The change is based on an analysis of Department of Motor Vehicle registration data. This change increases emissions for all pollutants.

Change occurs in Version 2.02

Reference: ARB Staff Report, Public Meeting to Consider Approval of Revisions to the State’s On-Road Motor Vehicle Emissions Inventory, May 2000, p. 12.

- **Vehicle Classes and Technology Groups**

EMFAC7G provided emissions estimates for 10 vehicle classes and 19 technology groups. EMFAC2002 provides emission estimates for 13 vehicle classes and 277 technology groups. School buses (SB) and motor homes (MH) in particular have been added to other vehicle classes: light-duty auto (LDA), light-duty trucks (LDT1, LDT2), medium-duty trucks (MDT), heavy-duty trucks (LHDT1, LHDT2, MHDT, HHDT, LH), urban buses (UB), and motorcycles (MC). The vehicle classes are differentiated primarily by gross vehicle weight. This change increases emissions.

Change occurs in Version 2.02

Reference: [Technical Support Document](#) (EMFAC2000), May 2000, Sections 3.0 and 7.2.

- **Monthly Inventories**

EMFAC7G produced summer and winter seasonal inventories. Annual average inventories were estimated by weighting the two. EMFAC2002 produces month-specific inventories. Monthly adjustments include ambient temperature, humidity, and the Reid Vapor Pressure of dispensed fuel. Annual average inventories are derived by weighting each month equally for a specific area.

Change occurs in Version 2.02

Reference: [Technical Support Document](#) (EMFAC2000), May 2000, Section 3.0.

- **Twenty-Four Hourly Time Periods**

EMFAC7G assigned vehicle activity and estimated emissions for six uneven time periods in a day. In EMFAC2002 new activity estimates are disaggregated into 24 hourly time periods.

Change occurs in Version 2.02

Reference: [Technical Support Document](#) (EMFAC2000), May 2000, Section 7.6.

## ***Major Changes from EMFAC7F to EMFAC7G***

- **Rule Implementation**

- Enhanced Inspection and Maintenance and On-Board Diagnostics II
- Inspection and Maintenance benefits for evaporative emissions
- Heavy-duty trucks and buses NOx standard of 4.0 grams/bhp-hr effective 1998
- Heavy-duty gas trucks NMHC+NOx standard of 2.5 grams/bhp-hr (SIP Measure M8)
- Medium-duty trucks accelerated ULEV program (SIP Measure M3)

- **Vehicle Starts**

- Definition changed from origin-destination trips to number of engine start-ups
- Redistributed by vehicle age with increased frequency for older vehicles
- Based on variable soak times

- **Correction Factors**

- High emitting vehicles
- Diesel fuel correction for heavy-duty diesel trucks updated

- **Emission Factors**

- FTP based emission rates adjusted to represent Unified Cycle (real world driving)
- Heavy-duty trucks/Heavy-Duty Vehicle Inspection Program revised
- Particulate matter based on U.S. EPA's PART5 Model

- **Vehicle Activity**

- Vehicle population, VMT and speed distributions updated
- Activity splits/model year distributions revised for autos, light-duty trucks, and medium-duty trucks
- VMT splits by weight class for heavy-duty trucks added
- Urban buses unique VMT by speed distribution added

Reference: ARB, Methodology for Estimating Emissions from On-Road Motor Vehicles, Volumes I through VI, November 1996.

- Volume I: Introduction and Overview (provides summary of major changes)
- Volume II: EMFAC7G
- Volume III: WEIGHT7G
- Volume IV: BURDEN7G
- Volume V: Activity Development
- Volume VI: Equations Used in the EMFAC, WEIGHT and BURDEN Models