UCD-ITS RP-6-97

For Presentation at the Air & Waste Management Association's 90th Annual Meeting & Exhibition, June 8-13, 1997, Toronto, Ontario, Canada

97-RP143.08

Implications of Using MVEI 7f and MVEI 7g for Carbon Monoxide (CO) Conformity Determination

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Introduction

The California Air Resources Board (CARB) developed updated versions of their motor vehicle emissions inventory (MVEI) models to more accurately predict impacts on air quality due to motor vehicle emissions. CARB submits MVEIs to the Environmental Protection Agency (EPA) with the state implementation plan (SIP), to support air quality attainment or maintenance plans and to set emission budgets for all counties within the state of California. Air quality attainment or maintenance plans are designed to achieve and maintain primary and secondary air quality standards promulgated under the Clean Air Act (CAA). Motor vehicle emission budgets, or allowable emissions of pollutants from motor vehicles, are determined using MVEI models. As MVEI models improve, budgets in the attainment or maintenance plans set with older models must still be met unless the SIP is revised.

Metropolitan Planning Organizations and the U.S. Department of Transportation must demonstrate that proposed transportation plans and programs are consistent with the SIP by showing that emissions associated with these plans and programs do not exceed emission budgets. Further, a specific project cannot create new or worsen existing "hot spots". This requirement is known as "conformity". To comply with the conformity requirement, the California Department of Transportation (CALTRANS) uses CARB's MVEI models to estimate emissions from proposed projects, even though the models were not developed or intended for this purpose (Long, 1996, personal communication).

The changes made to CARB's MVEI models have significant impacts on modeled emissions of carbon monoxide (CO). The purpose of this paper is to describe changes made to MVEI 7f that significantly impact prediction of modeled CO emission rates and total CO emissions. Using the South Coast Air Basin (SCAB) as an example of a CO nonattainment area, MVEI programs were run for several calendar years to compare MVEI 7f CO emission rates and inventories for the SCAB with those predicted by MVEI 7g. The accuracy of CARB's MVEI models in terms of "real world" emissions is not addressed in this paper, rather, a description of the changes made to the MVEI models (particularly EMFAC) is given and the consequences of using the MVEI models for conformity is explored.

Understanding CARB's MVEI

CARB's MVEI is composed of four programs, CALIMFAC, WEIGHT, EMFAC, and BURDEN. Elements of the four MVEI programs and a schematic of their inputs and outputs are shown in Figure 1 (page 13).

Calculation of MVEI

Equation 1 (page 11) describes how a motor vehicle emissions inventory is calculated; emission rates for specific activities are multiplied by corresponding activity data. Three types of activity are used to calculate the MVEI, vehicle miles traveled (VMT), vehicle starts, and vehicle population. All motor vehicle emissions corresponding to all vehicle activities in a particular California county or air basin comprise the MVEI for that county or air basin.

EMFAC Methodology

The emission factor forms the foundation of inventory and dispersion modeling. EMFAC is CARB's motor vehicle emission factor model, used to estimate composite start and running emission factors for all vehicles in California's on-road fleet. Emission factors for specific vehicle model years are calculated in EMFAC using model year specific base emission rates (BERs) from CALIMFAC. EMFAC adjusts the emission rates to account for vehicle age and applies "correction factors" to simulate non-Federal Test Procedure (FTP), operating conditions. EMFAC calculates model year specific emission factors using Equation 2 (page 11).

The corrected emission rates are then weighted with travel fractions from WEIGHT (representing the contribution of each vehicle model year, by class and technology group/weight class, to VMT, starts, or population). Lastly, EMFAC sums weighted model year specific emission factors to obtain the composite emission factor for a particular emitting process, vehicle class and technology group/weight class. The composite emission factor is the final product of the EMFAC model, and may be used as input to regional emission inventory models (i.e. BURDEN) used by CARB, or microscale inventory models (i.e. DTIM), and dispersion models (i.e. CALINE) used by CALTRANS.

Exhaust Emission Factors

Exhaust emissions (including CO) occur during vehicle operation and include running exhaust emissions and starting exhaust emissions.

Running Exhaust Emissions

After adjusting BERs from CALIMFAC to account for vehicle aging, EMFAC applies correction factors to account for non-FTP driving conditions. The following vehicle class, technology group/weight class, and model year-specific running exhaust correction factors are used to calculate running emission factors for a variety of operating conditions. EMFAC 7g correction factors are shown in bold.

- bag correction factor (BCF), which corrects for driving mode by disaggregating the FTP time trace into bags 1, 2, and 3
- speed correction factor (SCF), to adjust the FTP speed (16 mph running speed, bag2) to non-FTP speeds or starting speeds (25.6 mph starting speeds, bags 1 and 3)
- temperature correction factor (TCF) to adjust the FTP temperature (75°F) to non-FTP temperatures
- fuel correction factor (FCF) to account for changes in fuel formulation

- **cycle correction factor** (CCF) to adjust the FTP to the Unified Cycle
- **high emitter correction factor (HECF)** to account for observed I/M emissions

EMFAC calculates running exhaust emission factors for 17 vehicle and technology/weight class groups for a range of temperatures (20-110°F) and operating speeds (3-65 mph) (CARB, 1995).

EMFAC 7g treats running exhaust emissions for light and medium duty gasoline powered vehicles (LDGs and MDGs) as FTP bag 2 emissions with various correction factors applied. All other vehicle classes and technology types use the EMFAC 7f methodology of applying bag correction factors to disaggregate the FTP composite base rate emissions into running emissions and start emissions (CARB, 1995).

Starting Exhaust Emissions

Starting emissions are "extra" or incremental emissions, in excess of running exhaust emissions. Start emissions result from cold operating conditions, leading to incomplete fuel combustion and inefficient emissions control by cold catalysts. Cold starts usually have the highest emissions, followed by hot starts, with running emissions being lowest (CARB, 1993, 1995). Start emissions are calculated for light and medium duty vehicles (LDVs and MDVs), and are not estimated for heavy duty vehicles (HDVs) and motorcycles (MCYs).

EMFAC 7f modeled two start conditions based on two soak periods, hot starts and cold starts; EMFAC 7f starts are also based on the FTP drive cycle. The same basic equation is used to calculate both cold and hot starts for a particular model year, vehicle class and technology group, the difference being in the specific bag, temperature, and fuel correction factors used (Equation 3, page 11). Incremental starts, or emissions exceeding stabilized running emissions, for a particular model year, vehicle class and technology group/weight class are calculated using Equation 4 (page 11). EMFAC 7f start emissions are associated with an event, or "trip" of 3.59 miles, the length of bags 1 and 3 of the FTP (CARB, 1993).

Because catalyst temperature is dependent on soak time, or engine-off time, EMFAC 7g models start emissions based on a wide range of soak times; EMFAC 7g starts are also assumed to last only 100 seconds and are based on the Unified Cycle (CARB, 1995). EMFAC 7g methodology is applied to LDGs and MDGs. EMFAC 7f methodology is still used for diesel vehicles.

<u>Composite Emission Factors</u>

To obtain a particular model year's contribution to the total composite emission factor, the model year emission factor is weighted by its travel fraction. All model years are then summed to obtain the composite emission factor for a particular emitting process, vehicle class, technology group, and calendar year. Emission factors are not county specific, unlike activity, and are applicable to all on-road motor vehicles in California.

Changes from EMFAC 7f to 7g

A summary of the changes specific to MVEI subprograms are shown in Table 1 (page 12).

The changes made to EMFAC will have the most significant effects on microscale modeling/conformity requirements, since output from EMFAC is used by CALTRANS in conjunction with DTIM (used for microscale emissions inventories) or CALINE (used for "hot spot" analysis) to predict whether proposed transportation plans meet the conformity requirement or exceed a particular county's emissions budget.

A preliminary analysis performed by CARB suggested the changes having the greatest impact on modeled CO emissions are the following: 1) EMFAC 7g continuous start methodology, which tends to predict decreased CO emissions 2) EMFAC 7g cycle correction factor (CCF), and 3) EMFAC 7g high emitter correction factor (HECF), both of which tend to predict increased CO emissions (CARB, 1995). Continuous starts, CCFs, and HECFs are applied to LDGs and MDGs, which comprise the majority of on-road vehicles. Changes in base emission rates (BERs) to account for enhanced inspection and maintenance (I/M) and the new classification of medium duty trucks (MDTs) will tend to predict decreased CO emissions, but changes in BERs due to revised light duty truck (LDT) weight class splits will tend to predict increased CO emissions. Overall, changes in BERs will not be as significant as continuous starts, CCFs, and HECFs.

New Start Methodology for LDGs and MDGs

Start emissions testing was carried out using 29 LDAs. Analysis of the modal emissions data used in the continuous starts study indicated that all of the emissions attributable to the starts of the test vehicles occurred within the first 100 seconds after start up, regardless of vehicle technology type (Sabate, 1995). For this reason the start interval was defined as 100 seconds for all pollutants and vehicles.

As with running emissions, the basic start emission rate (SER) for the bag 1 portion of the FTP cycle after an overnight soak is calculated based on the cumulative mileage according to Equation 5 (page 11). The SERs are then multiplied by correction factors to adjust FTP bag 1 emissions to the first 100 seconds of the Unified Cycle after an overnight soak and to correct for non-FTP conditions (Equation 6, page 11).

An additional correction factor is used to adjust start emissions to soak times shorter than an overnight soak. The 100 second start emissions for all soak times were measured by subtracting cumulative running emissions produced during the start interval from the cumulative emissions produced during the start interval for a particular soak time (Sabate, 1995). After start emissions for all soak times and vehicles were measured, they were normalized to an overnight soak, allowing all other soak times to be expressed as functions of start emissions following an overnight soak. Curves were fit to the normalized emissions data to describe the soak functions (SOAKCFs). The SOAKCF is calculated for each model year as a function of soak time according to Equation 7 (page 11).

A potential problem exists with using the cumulative emissions from the first 100 seconds of Unified Cycle to develop the start correction factor (Sierra, 1993). During cycle development, special care was taken to start the Unified Cycle with a micro-trip that closely matched the speed-acceleration distribution associated with the first 120 seconds of trip origins in the LA-92 database (Sierra, 1993). The first 100 seconds of the Unified Cycle should be a good approximation of trip origins, but after the cycle was developed, Sierra added 30 seconds of idle and 30 seconds of low speed operation to the beginning of the cycle to account for the trip (Sierra, 1993).

The SOAKCFs, or functional relationships of the normalized incremental start emissions were developed from a small database. For modeling purposes in EMFAC 7g, the CATs tested represent all CATs in the LDV and MDT fleet, including TLEVs. The soak factors produced by the EHC (a 1992 Ford Tempo) represent all LEVs and ULEVs, which will make up 27 percent of new light-duty vehicle sales in 1997, and 98 percent in 2000. The coefficients of the soak curves for the CATs and the EHC vehicle were weighted with the sales fractions for the different vehicle types of the respective model years to reflect LEV regulations.

Potential problems with the implementation of the EMFAC7g start emissions methodology include the following:

- The first 100s of the Unified Cycle may not accurately represent trip origins in the SCAB after 60 seconds of idle and low speed operation were added to the cycle. The impact on CO emissions is unknown.
- The functional relationship of the normalized incremental start emissions was developed from a small database. The impact on CO start emission rates is unknown.

Cycle Correction Factor for LDGs, MDGs, and MCYs

The Unified Cycle is based on data gathered using an instrumented chase car in the greater metropolitan Los Angeles area in 1992. Data were collected from vehicles driven over 700 miles on 100 different routes (CARB, 1995). Target vehicles were followed over pre-selected routes , such that the routes selected would estimate the operation during peak a.m., peak p.m., and off-peak periods (Gammariello and Long, 1993). The chase car recorded the speed-time profile of randomly selected vehicles. Analysis of the LA-92 (chase car) data led to the development of the Unified Cycle, a single cycle incorporating observed driving patterns in the same proportions that occurred on the road (Long, 1995). CARB believes the Unified Cycle to be more representative of contemporary driving patterns in the SCAB than the speed-corrected FTP cycle. The FTP and the Unified Cycle are of similar overall durations and distances, however, the bag specific times and distances are significantly different. Unified Cycle running emissions are considerably higher than FTP running emissions (Gammariello and Long, 1993).

Unified Cycle emissions were collected from 249 multipoint fuel injected (MFI), throttle body injected (TBI), carbureted, and NCAT vehicles of various model years (Long, 1995). The CCF is calculated by comparing measured emissions of the SCAB fleet, as characterized by the Unified Cycle, to the modeled emissions of the same vehicles (characterized by the FTP cycle) using BURDEN 7f assumed activity data for the SCAB in 1992 (Carlock, 1996). The ratio between this measured inventory and the BURDEN inventory represents the off-cycle emissions that have not captured in the past. The functional representation is given in Equation 8 (page 11).

The Unified Cycle inventory was VMT multiplied by a composite Unified Cycle emission factor. Because the BURDEN inventory is a function of the activity data used (total VMT, speed distribution, etc.), the observed ratio is the assumed error in emissions and activity data. CARB's goal is to have modeled BURDEN 7g emissions from the SCAB in 1992 exactly match their Unified Cycle inventory, so CCFs were modified to minimize the difference between the two inventories (Carlock, 1996).

Potential problems with use of the CCF for conformity include the following:

- The CCFs are only as accurate as the Unified Cycle. Although the Unified Cycle may represent SCAB driving behavior more accurately than the FTP, urban driving behavior in the SCAB may not be representative of all areas in California. In particular, hard accelerations associated with aggressive driving and low speed operation associated with traffic congestion may be more typical of SCAB than of other regions, and SCAB CCFs may overestimate emissions elsewhere.
- The CCF is only applicable for regional level modeling because it incorporates all driving modes observed during all periods of the day. CCFs are included in EMFAC7g emission rates and will be applied at the link level if DTIM and CALINE are used in conjunction with EMFAC 7g.
- The CCF neglects the impacts of diesel and heavy-duty vehicles.
- Since the Unified Cycle emissions database was developed in 1992, adjustments are needed to account for future changes in fleet makeup and activity (Long, 1996).

High Emitter Correction Factor for LDGs, MDGs, and MCYs

The HECF is defined as the ratio between two stepwise regression lines. The numerator is a regression though the emissions data from CARB's 616 vehicle I/M Pilot Project data base, the denominator is a regression through CALIMFAC output. The functional form is depicted in Figure 2 (page 14). The HECF will not force the distribution of CALIMFAC's predicted emissions by model year to match the emissions of the 616 car data base, however, aggregate emissions from the entire fleet are better predicted (Carlock, 1996).

The HECF will be a short lived correction, lasting only until 1997; incorporation of new test data into CALIMFAC the models will eliminate the need for the HECF (CARB, 1995).

Potential problems with the HECF include the following:

- Prediction errors associated with CALIMFAC are assumed to be a function of vehicle technology, and not vehicle age. CALIMFAC may inadequately account for deterioration, thus as newer vehicles age, the model will again tend to under predict emissions (Carlock, 1996).
- Because of the relatively large errors associated with individual model years, the HECF could produce erroneous emission factors if the vehicle age distribution is altered.

Impacts of Changes from MVEI 7f to MVEI 7g

EMFAC and BURDEN Simulations

Modeled emission rates from EMFAC affect air quality planning on both the local and regional levels, as they are used as input to both local and regional inventory and dispersion models. To assess the impacts of the changes made to EMFAC on CO emissions, EMFAC 7f and the Beta release of EMFAC 7g were run for several calendar years; the results are shown in Figures 3-6, pages 14-15. SCAB travel fractions from BURDEN 7g were used to obtain CO emission factors depicted in Figures 3-6. All vehicle classes were represented by summing emission factors from each technology group of each vehicle class and multiplying by their respective activity fraction for a given calendar year. To assess the impacts of the changes made to MVEI on emission budgets, BURDEN 7f and the Beta release of BURDEN 7g were run for several calendar years; the results are shown in Figure 7 (page 15) for SCAB, a CO non-attainment area.

Local Impacts

The changes from EMFAC 7f to 7g that are expected to have the most significant impacts on microscale emissions include the CCF and the HECF. The new definition of a 100 second continuous start should not have significant impacts at the local level unless a given link is within 100 seconds of a service area where cars are parked for long periods of time (i.e. a parking garage or shopping mall).

Total CO emission factors (start and running) predicted by EMFAC 7f, and running CO emission factors predicted by EMFAC 7g are shown in Figures 3-4 for calendar years 1990 and 2010. To obtain total EMFAC 7f emission rates, the distribution of vehicles in the various modes of operation were assumed to be the following: fraction of vehicles in cold start mode = 20.6%, fraction of vehicles in stabilized or running mode = 52.1%, fraction of vehicles in hot start mode = 27.3%.

Emission factors predicted by EMFAC 7g are shown with and without the CCF to show the impact of the regional correction factor on emission rates (Figures 3-4). The running emission factors predicted by 7g without the CCF are very similar to total emission factors predicted by 7f, especially at low speeds. The CCF increases CO emission rates by a factor of approximately two, and contributes significantly to predicted CO emissions in both 1990 and 2010. Although off-cycle events are still predicted to cause an increase in CO emission rates in 2010 (possibly accounting for vehicles with computer controlled throttle body fuel injection), vehicles will have lower overall running emissions. CO emission factors are predicted to decrease by about 71 percent from 1990 to 2010.

The HECF was not removed from EMFAC 7g because it is a short-lived correction and is of smaller magnitude than the CCF. The HECF will hopefully be more appropriate for link level modeling than the CCF, although it may produce erroneous results for microscale modeling if the distribution of vehicle ages on a given link is not the same as that assumed by CARB during the development of the HECF.

Regional Impacts

The changes from EMFAC 7f to 7g that are expected to have the most significant impacts on regional emissions include the following: CCFs, HECFs, continuous starts, and possibly changes in BERs to account for I/M programs, LDT population splits, and low emitting vehicle (LEV) benefits.

Start methodologies are compared in Figures 5-6 (page 15). Starts defined as continuous functions of soak time in MVEI 7g should predict decreased CO start emissions relative to the MVEI 7f definition of only cold or hot starts. The magnitudes of continuous start emissions (Figure 6) are generally smaller than those predicted by 7f because 7g start emissions take long soak times to reach the same magnitude as the 7f emissions after one hour. Modeled cold start emissions are seen to drop significantly with increasing calendar year due to improvements in catalyst technology.

Implications for the Conformity Requirement

BURDEN 7f and 7g CO emissions inventories for several calendar years are shown with corresponding emission budgets for the SCAB in Figure 7 (page 15). The use of MVEI 7g in SIPs and maintenance plans will raise emission budgets for CO; however, since California county budgets were set with MVEI 7f, conformity will be difficult to achieve using MVEI 7g until a new SIP is approved. Regional emissions predicted by BURDEN 7g are much higher than those predicted by MVEI 7f, and many counties will exceed their current budgets until approximately 2000.

Ten areas in California are currently designated as non-attainment areas for the national carbon monoxide (CO) air quality standard (CARB, 1996b). CARB submitted a SIP revision to the Environmental Protection Agency (EPA) to request that all areas of California (except SCAB) be redesignated as CO attainment areas; emission inventories were submitted to support the redesignation request (CARB, 1996b). Transportation planners using MVEI 7f for conformity purposes were granted a "grace period" to accommodate them during the adjustment to MVEI 7g (Federal Register, 1996). If the grace period expires before the request for redesignation is approved, transportation planners may experience a period of having to conform to current MVEI 7f budgets using the new MVEI 7g models (Federal Register, 1996).

Because EMFAC 7g predicts increased CO emissions from motor vehicles, transportation planners may be adversely affected for the following reasons: 1) transportation planners using EMFAC 7g for conformity purposes may not be able to obtain approval for a particular microscale project if modeled violations of air quality standards occur, and 2) counties with predicted CO emissions in excess of their budgets may face restricted development of transportation facilities and/or driving activity.

MVEI models were developed from the perspective of air quality; their intended use is for regional level air quality attainment. Using EMFAC in conjunction with microscale inventory and dispersion models may lead to incorrect prediction of vehicular emissions if correction factors are not modified for microscale projects and corridor analyses.

Conclusions

General Considerations

- CARB uses a multiplicative approach to model emissions factors. Because the equations for start and running emissions are non-linear, errors present in the BERs, correction factors, travel fractions may also grow non-linearly.
- Although regional travel demand models (TDMs) are often used for activity estimates, the SCAB is heavily relied on for derivation of base emission rates and correction factors, used to represent all vehicle characteristics and driving behavior in California.

Implications for Transportation Planners

- The new definition of a start should have little impact on many transportation projects; unless a proposed facility is within 100s of a service area. Most vehicles will be in a stabilized operating mode by the time they reach a link on a regionally significant facility.
- The HECF contributes significantly to CO emissions in earlier calendar years and disappears by 1998.
- The Unified Cycle (reflected in CCFs) increases predicted CO emission rates by a factor of approximately two. Modeled off-cycle driving (most apparent at low running speeds) results in increased CO emissions for all calendar years.
- The Unified Cycle is a "self-weighted" cycle, incorporating a wide range of driving modes observed in the SCAB throughout the day, and describes the average "trip" in the SCAB. CCFs are regional correction factors, intended to represent emissions in the SCAB not captured by the FTP drive cycle, and may or may not be applicable on a given link.
- Use of a cycle correction factor may be necessary for large regions to grossly approximate motor vehicle emissions, but modal analysis of emissions and modal emissions modeling may be more accurate and appropriate at the link level.
- Correction factors based on SCAB vehicles (HECFs) and driving behavior (CCFs) are applied throughout the state. In particular, the CCF may not accurately represent off-cycle driving events and their associated emissions in all California counties because SCAB driving behavior may not be representative of the entire state.
- MVEI models were developed from the perspective of air quality; their intended use is for regional level air quality attainment/maintenance plans and budgets. Transportation planners should exercise caution or avoid using EMFAC in conjunction with DTIM or CALINE for microscale design purposes. If EMFAC must be used, regional correction factors should be adjusted or eliminated to customize the model for a particular project.

Acknowledgments

The authors wish to thank the California Department of Transportation (CALTRANS) for the research funding that led to this paper. The authors would also like to thank professors Dan Chang, Debbie Niemeier, and Dan Sperling of UC Davis, and the California Air Resources Board for their cooperation and assistance.

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Equation 1. emissions = emission factor × vehicle activity

where

emissions are given in grams (converted to tons), emission factors are given in grams/mile, grams/start, or grams/vehicle corresponding to VMT, start, or vehicle population activities.

Equation 2. $\textit{emission factor} = \textit{base emission rate} \times CF_1 \times CF_2 \times CF_3 \times CF_4 \times \ldots$

where

CFs are correction factors that depend on vehicle class and technology group/weight class, pollutant type, and emission process.

Equation 3. $STARTEF = BER \times BCF_N \times TCF_N \times FCF_N$

where

STARTEF is the model year start emission factor (in grams/mile) for "bag N", where N equals one for the cold start calculation, or three for the hot start calculation, and the correction factors are the same as previously defined.

Equation 4. $STARTINC = (STARTEF - STABEF_{25.6}) \times 3.59$

where

STARTINC is the incremental start emission factor in grams/trip, $STABEF_{25.6}$ is the stabilized running emission factor at 25.6 mph, the average speed of bags 1 and 3, and 3.59 miles is the trip length of bags 1 and 3.

Equation 5. $SER_{MY} = ONS + (DR_1 \times CM_1) + (DR_2 \times CM_2)$

where

SER_{MY} = model year specific basic start emission rate in g/mile after an overnight soak, ONS = overnight soak emission rate (bag 1 zero mile rate), in grams per mile, DR_1 = deterioration rate up to the flex point in g/10,000 miles, DR_2 = deterioration rate after the flex point in g/10,000 miles, CM_1 = cumulative miles less than or equal to the flex point, in 10,000 miles, CM_2 = cumulative miles greater than the flex point, in 10,000 miles.

Equation 6. $MYSEF_{MY} = SER_{MY} \times SCCF \times S100CF \times SOAKCF_{MY} \times TCF_{MY} \times FCF_{MY}$

where

$MYSEF_{MY}$ = model year start emission factor in g/trip, SCCF = cycle correction factor for starts (to correct the bag 1 portion of the FTP to the Unified Cycle), S100CF = 100 second start correction factor, in miles/100 seconds (to correct the FTP start cycle (bag 1) in g/mile to an overnight soak in g/trip), SOAKCF = soak time correction factor (to correct the overnight soak start emission rates to rates at various soak times), TCF_{MY} = the model year specific bag 3 temperature correction factor if the soak time is less than 120 minutes (otherwise the bag 1 temperature correction factor is used), FCF_{MY} = the model year specific bag 3 fuel correction factor if the soak time is less than 120 minutes (otherwise the bag 1 correction fuel factor is used).

Equation 7. $SOAKCF_{MY} = A_o + (A_1 \times t) + (A_2 \times t^2) + (A_3 \times t^3) + (A_4 \times t^4)$

where

A_o, A_1, A_2, A_3, A_4, = pollutant specific coefficients for each model year, and t = soak time in minutes.

Equation 8. $CCF = \dfrac{\text{Unified Cycle inventory}_{\text{SCAB 1992}}}{\text{BURDEN 7f inventory}_{\text{SCAB 1992}}}$

where

Unified Cycle inventory = emissions from the 1992 SCAB fleet, characterized by the Unified Cycle, and BURDEN 7f inventory = the modeled emissions of the same vehicles using BURDEN's assumed activity data for the SCAB in 1992.

Table 1. Summary of Changes Specific to MVEI Subprograms

Major Changes Impacting Carbon Monoxide (CO) Emissions

Changes to WEIGHT

New Start Rates and Starts Travel Fractions by Model Year for LDVs and MDTs

Changes to EMFAC

Modified Start Emission Methodology for LDGs and MDGs

- Cold Start Correction Factor Adjusts the FTP Bag 1 to the First 100 Seconds of the Unified Cycle Bag 1
- Variable Starts Soak Correction Factor Adjusts the Start Emission Rate for Any Soak Time from 0 to 12 Hours

Running Emissions

- CCF Added
- HECF Added
- BERs Revised for Emissions Benefits
    - Basic and Enhanced I/M- no I/M, I/M 84, I/M 90, and I/M 96
    - Vehicle Population Splits
    - LEV and ZEV Benefits
- SCFs for NCATs

Changes to BURDEN

New Fleet Start Rates

Vehicle Soak Distributions for Variable Starts

HDT Weight Class Split for LHG, MHG, LHD, MHD, and HHD

Updated Activity

- Total Vehicle Population
- Total VMT
- VMT by Speed Distribution

Changes to WEIGHT, EMFAC, and BURDEN

HDT Weight Class Splits and Travel Fractions

- Light Duty Truck (LDT) up to 6,000 lbs
- Reclassification of Medium Duty Truck (MDT)
    - MDTs from 6,000-14,000 lbs, previously 6,000-8,500 lbs
    - now include Light Heavy Duty Trucks (LHDTs)
        - ⇒ In 1995, 50% of LHDTs to meet MDT vehicle standards
        - ⇒ In 1996, 100% of LHDTs to meet MDT vehicle standards
- Heavy Duty Trucks (HDTs) Split by Weight Class
    - LHDT from 8,501-14,000 lbs
    - MHDT from 14,001-33,000 lbs
    - HHDT over 33,000 lbs
- Includes Gasoline (G) and Diesel (D) Powered Vehicles- LHG, MHG, LHD, MHD, HHD

Figure 1. CARB's MVEI

** Adapted from Reference 19. Changes from MVEI 7f to MVEI 7g in bold.

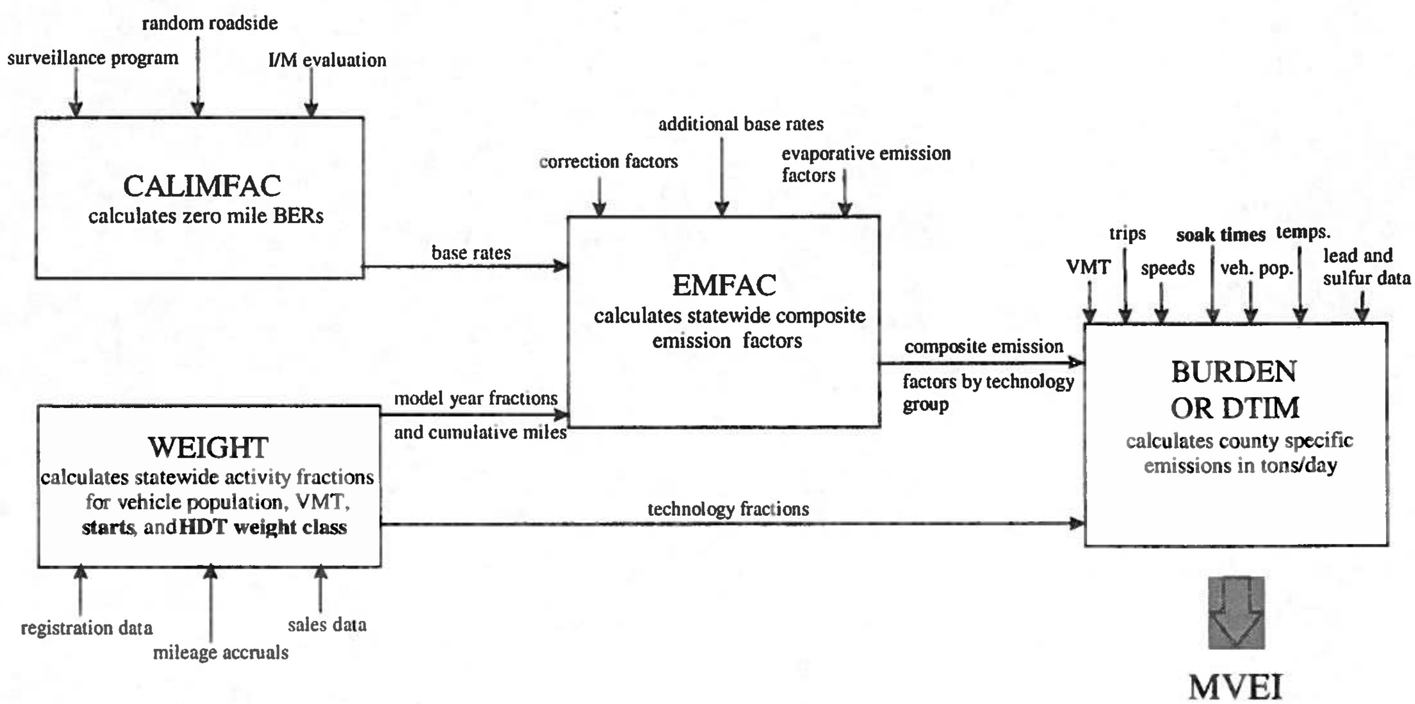
Temporal Characteristics
- calendar year (1970-**2010**)
- season (summer and winter)
- time of day (divided into six periods)
- ambient temperature (**20**-110°F)

Emitting Process
- exhaust
  * hot running
- starts
  * cold start
  * hot start
  * **starts as continuous functions of soak time (0-720 minutes)**

Fleet Activity
- vehicle population
- vehicle miles traveled (VMT)
- vehicle trips (7f) or **starts** (7g)
- cumulative miles
- vehicle speed distribution (for speeds 3 to 65 mph)
- **vehicle start distribution**

Fleet Characteristics
- vehicle class
  * light duty autos (LDA)
  * light duty trucks (LDT)
  * medium duty trucks (MDT)
  * heavy duty trucks (HDT)- gas and diesel
  * **light heavy duty trucks (LHDT)**
  * **medium heavy duty trucks (MHDT)**
  * **heavy heavy duty trucks (HHDT)**
  * urban buses (UB)
  * motorcycles (MCY)
- vehicle technology
  * gasoline catalyst-equipped (CAT)
  * gasoline non-catalyst-equipped (NCAT)
  * diesel (DSL)
- vehicle model year
- zero mile base emission rates (BERs)
- state inspection and maintenance programs (I/M)
- **enhanced I/M (I/M 96)**

Elements of CARB's MVEI



Organization of CARB's MVEI

Figure 2. High Emitter Correction Factor for CO

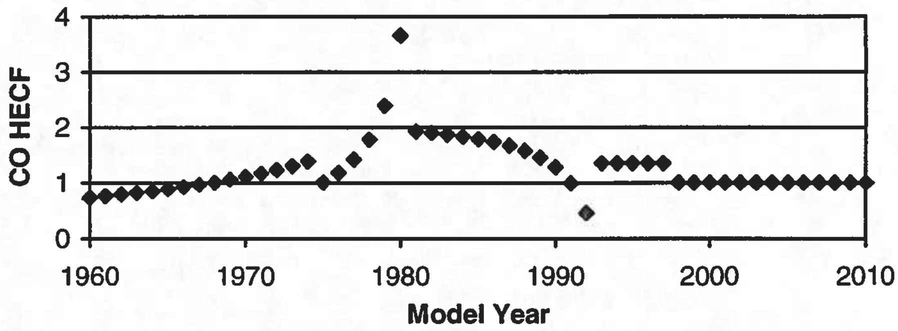


Figure 3. Comparison of EMFAC 7f and EMFAC 7g Running Emissions, 1990

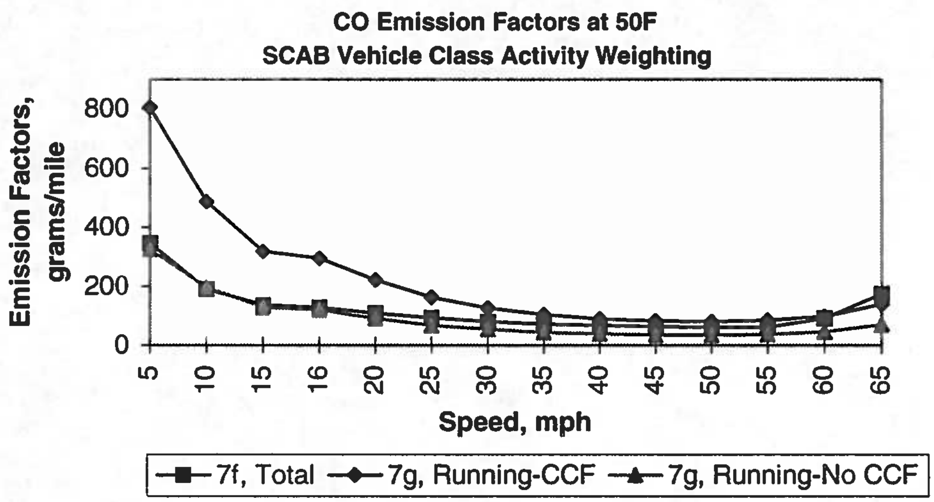


Figure 4. Comparison of EMFAC 7f and EMFAC 7g Running Emissions, 2010

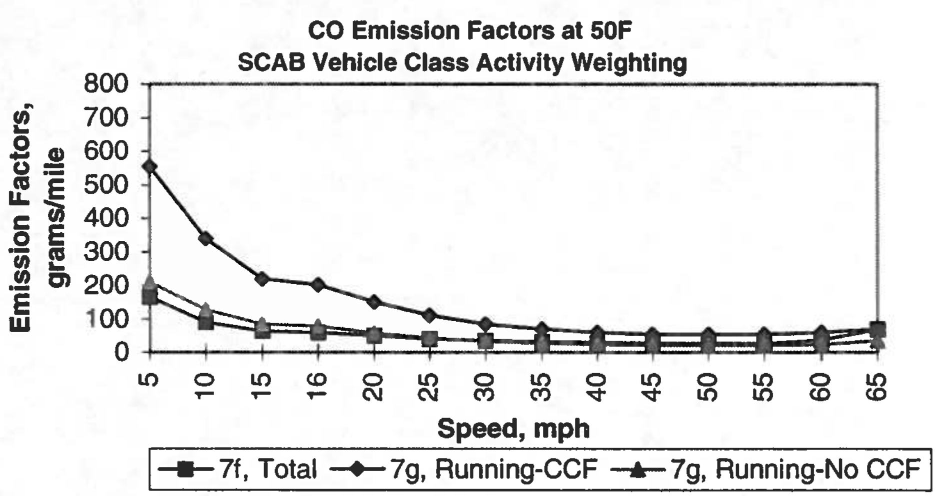


Figure 5. EMFAC 7f Start Methodology- CO Start Emissions for All Vehicle Classes

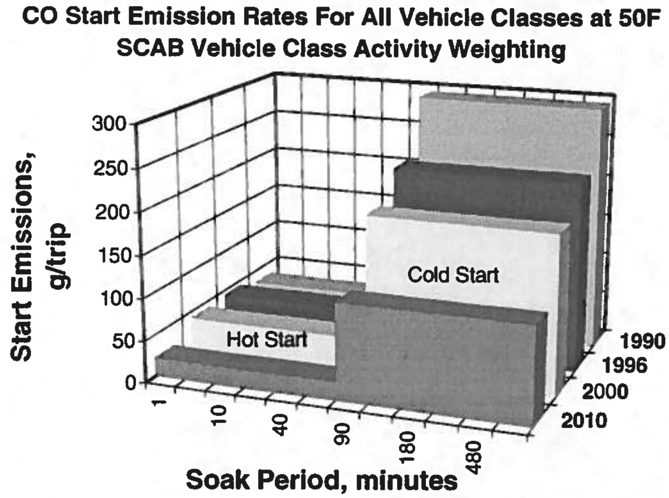


Figure 6. EMFAC 7g Start Methodology

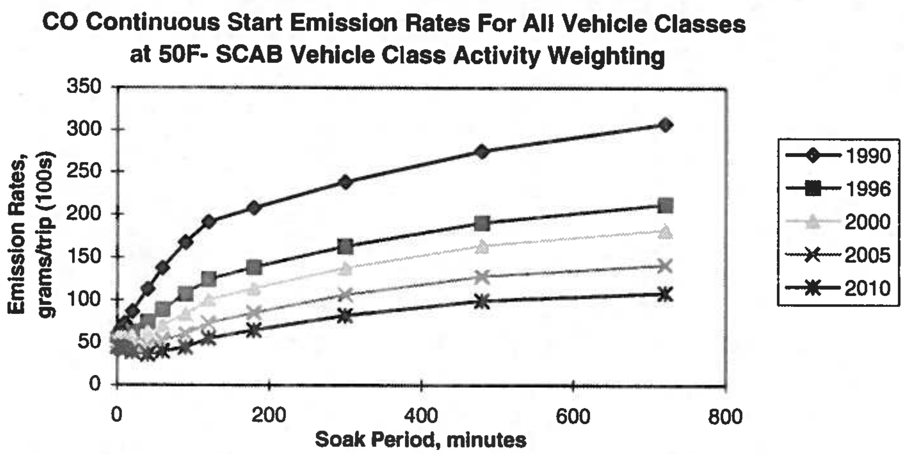


Figure 7. CO Emissions and Budgets for SCAB

** transitional period began April, 1996