South Coast
Air Quality Management District
21865 Copley Drive, Diamond Bar, CA 91765-4178
(909) 396-2000 • www.aqmd.gov

Rule 2202 – On-Road Motor Vehicle Mitigation Options
Emission Factor Methodology

Rule 2202 – On-Road Motor Vehicle Mitigation Options has been designed to reduce emissions from mobile sources. Rule 2202 provides employers with a menu of options that they can choose from to implement and meet the emission reduction target (ERT) for their worksites.

The Emission Reduction Target (ERT) which is the annual ROG, NOx, and CO emissions required to be reduced by each worksite based on the number of employees reporting to work during the peak window and the appropriate Performance Zone. The ERT for each pollutant, for each worksite may be calculated by using the appropriate emission factors based on an EPA approved CARB on-road mobile source emission factors (EMFAC) model.

The EMFAC based emission factors are to be revised using the most recent version that has EPA's final approval for use of the California Air Resources Board (CARB) approved EMFAC model in accordance with subdivision (m) of the Rule.

This document describes the formulas and methodologies used to develop the emission reduction factors used and defined by Rule 2202 – On-Road Motor Vehicle Mitigation Options. This document is an update of the technical appendix found in the February 2004 Staff Report as part of amendments to Rule 2202 and associated guidelines (SCAQMD Governing Board Meeting, February 2, 2004, Agenda No. 26).

Annual Emission Factors for Daily Commute Vehicles

Emission Generation

Motor vehicles are responsible for the generation of reactive organic gases (ROG), oxides of nitrogen (NOx), and carbon monoxide (CO) emissions. These pollutants are linked to either the combustion process of the engine or to the evaporation of the motor fuel from the storage and delivery system. These processes can be further categorized into different operating modes of the vehicle. Combustion emissions are usually higher during start-up, and are even higher during "cold" starts, since the vehicle's emission control device operates more efficiently at elevated temperatures. In addition, since the rate of evaporation increases at higher temperatures, more emissions result during the "hot soak" period following a trip. Table 1 below lists the vehicle trip generated emission sources.

Table 1. Vehicle Trip Generated Emission Sources by Pollutant

ROG	NOx	CO
Start Ignition	Start Ignition	Start Ignition
Running Exhaust	Running Exhaust	Running Exhaust
Hot Soak Evaporation		
Running Losses		
Resting Losses		
Diurnal Evaporation		

EMFAC Model

SCAQMD relies on the most recent EPA approved California Air Resources Board (CARB) EMFAC computer model to produce emission factors which are then used as input to generate regional emissions inventories. The emissions inventories can then be categorized, for reduction quantification purposes, into a trip component, and a vehicle miles traveled (VMT) component.

- *Trip Component* - includes the start ignition emissions, and the hot soak evaporation emissions. Emissions from these sources are represented as pounds per trip.
- *VMT* Component - is the vehicle miles traveled (VMT) components include the running exhaust, and running loss emissions. Emissions from these sources are represented as pounds per VMT.
- *Resting and Diurnal Evaporation* – the remaining emissions attributed to trip reduction programs; resting and diurnal evaporation occur at a rate independent from the vehicle's trip VMT rate.

Daily Commute Vehicle Emission Factor

The calculation of daily commute vehicle emission factors rely on the following:

- The most recent EPA approved CARB EMFAC emission inventory model is used to determine the daily commute vehicle emission factors.
- The trip generation rate assigned to daily commute vehicles, for the purposes of Rule 2202, is 2.0 trips per daily commute vehicle.
- The regional emission generation rates, daily trip, daily VMT, and other parameters, as determined by the EMFAC model, is assumed to be accurate and representative for the years represented in the emission factor tables.
- The average one-way work-trip length in the South Coast Air Basin (SCAB) is 16 miles.
- ROG emissions from diurnal and resting loss evaporation are constant and independent from the vehicle trip VMT rate.
- Volatile organic compounds (VOC) as used in the Rule and Guidelines is equivalent to ROG for purposes of these emission factor tables.

- Commuting vehicles operate primarily in cold start mode and is measured as start ignition.
- The number of annual operating days for commutes vehicles is equal to 260 days per year.
- Commute vehicles include passenger cars (LDA), light duty trucks (LDT1 and LDT2), and motorcycles (MCY) as defined by EMFAC.
- Trip end emissions are based on SCAB inventories.
- Annual average inventory output was used to develop the Rule emission factors.

Methodology

Applying the above, calculating the annual emissions per daily commute vehicle for each pollutant and year can be determine by the following equation:

$$\text{Emission Factor} = 2.0 \text{ tpv } x \left[\left[\begin{array}{c} \text{Emissions per} \\ \text{Vehicle Trip} \end{array} \right] + \left[\begin{array}{c} \text{Emissions} \\ \text{per VMT} \end{array} \right] x \, 16 \text{ miles/trip} \right] x \, 260 \text{ dpy}$$

Where:

tpv = trips per daily vehicle

dpy = days per year

Emission Factor Data

Tables 2, 3, and 4 were developed based on the EMFAC model output. These values were used to derive the daily commute vehicle emission factor. The calculated emission factor represents emissions from light-duty vehicles that were used for the home-to-work commute trip, which includes passenger cars (LDA), light duty trucks (LDT1 and LDT2), and motorcycles (MCY).

Table 2. ROG Mobile Source Emission Factors

Year	**Start Exhaust** pounds/trip	**Hot Soak** pounds/trip	**Running Exhaust** pounds/mile	**Running Loss** pounds/mile
2014	0.000604	0.000396	0.000142	0.000197
2015	0.000530	0.000371	0.000125	0.000182
2016	0.000467	0.000348	0.000110	0.000169
2017	0.000413	0.000324	0.000097	0.000157
2018	0.000368	0.000302	0.000085	0.000146

Table 3. NOx Mobile Source Emission Factors

Year	**Start Exhaust** pounds/trip	**Running Exhaust** pounds/mile
2014	0.000526	0.000379
2015	0.000465	0.000340
2016	0.000412	0.000307
2017	0.000365	0.000278
2018	0.000324	0.000253

Table 4. CO Mobile Source Emission Factors

Year	**Start Exhaust** pounds/trip	**Running Exhaust** pounds/mile
2014	0.007162	0.003995
2015	0.006421	0.003599
2016	0.005775	0.003262
2017	0.005203	0.002953
2018	0.004709	0.002689

For example, to calculate the ROG Annual Emission Factor for calendar year 2015:

Trip End Component:
= (Start Exhaust Emissions) + (Hot Soak Emissions)
= 0.000530 lbs/trip + 0.000371 lbs/trip
= 0.000901 lbs/trip

VMT Component:
= [(Running Exhaust) + (Running Loss)] X trip length
= (0.000125 lbs/mile + 0.000182 lbs/mile) X 16 miles
= 0.00491 lbs/trip

ROG Annual Emission Factor:
= 2.0 trips/vehicle/day x (Trip End Component + VMT Component) X 260 days per year
= 2.0 trips/vehicle/day x (0.000901 lbs/mile + 0.00491 lbs/trip) X 260 days/year
= 3.02 pounds/year/daily commute vehicle

Table 5 lists the remaining daily commute vehicle emission factors.

Table 5. Annual Emission Factors (pounds/year/daily commute vehicle)

Year	ROG	NOx	CO
2014	3.34	3.43	36.96
2015	3.02	3.07	33.29
2016	2.75	2.77	30.14
2017	2.49	2.50	27.28
2018	2.27	2.27	24.82
2019	2.11	2.09	22.86
2020	2.00	1.95	21.47

Employee Emission Reduction Factors

The emission calculations in Rule 2202 were developed such that employers would determine the annual emissions resulting from work related commute trips and reductions that would be necessary to meet the region's pollutant attainment goals. In other words, based on the number of employees reporting in the peak commute window, an employer would calculate the equivalent amount of ROG, NOx, and CO that would be needed to be reduced to meet the SCAB's AVR target. The approach would give the regulated community an easy method to calculate this amount and realistically represents the emissions from commute vehicle trips.

A calculation method was derived where the employer would first determine the amount of emissions that are caused by the employees commuting in the peak window (emission reduction target). Then the employer would obtain emission credits, through the application of various mobile source reduction options (vehicle trip emission credits or rideshare), that would be at least equal to the calculated emission reduction target. The calculations were developed to simplify and make consistent the methods for determining both the emission reduction targets and the vehicle trip emission credits.

Annual Emission Factors

The initial data points for the annual emission factor table as found in Table 5 is derived from the EMFAC model. The emission factors typically decrease over time which is the result of several EMFAC model inputs which may include replacement vehicles that have decreasing tailpipe emissions, changes in demographics, fuel formulations, or vehicle population size.

Employee Emission Reduction Factors

The Performance Zones for regions 1, 2, and 3 are assigned AVRs 1.75, 1.5, and 1.3 respectively (a Performance Zone map can be found in Attachment I of Rule 2202). These were determined to be the most effective approach in achieving the emission reduction goals for the region.

Employers determine their worksite (AVR) from the number of employees reporting in the peak commute window divided by the number of vehicles driven to the worksite. Typically employers would also determine how many additional vehicles would need to be reduced to actually meet the worksite's AVR target.

The various worksite AVRs, determined through employee surveys, are the result of employer implemented trip reduction programs. The ratio of the worksite's computed AVR and the AVR target is termed the shortfall and can be used to illustrate the level of effort that would be required to achieve the worksite's AVR target. The shortfall is determined by the following equation:

$$\text{Shortfall} = 1 - \frac{\text{AVR Worksite}}{\text{AVR Target}}$$

Thus, an employer's shortfall or level of effort will vary directly with the effectiveness of a trip reduction program or employee use of alternative modes of transportation. The shortfall number can be used to determine the number of vehicles that the employer would need to reduce to achieve the worksite's AVR target. If an employer chooses not to implement a trip reduction program then it is assumed that the AVR is equal to 1.0. This effectively means that all employees are driving solo to work.

An employer, complying with Rule 2202, is not required to implement a trip reduction program. Therefore, the assumption is that employers would be starting at a worksite AVR of 1.0. From the equation above, each worksite's shortfall can then be determined. For worksites with an AVR target of 1.5 (Zone 2) the shortfall would be calculated as follows:

$$\text{Shortfall} = 1 - \frac{1.0}{1.5}$$

$$\text{Shortfall} = 0.333$$

Performing a similar calculation for AVR targets 1.75 (Zone 1) and 1.3 (Zone 3) result in shortfall values of 0.429 and 0.231, respectively. The shortfall number directly relates to the total number of commute vehicles that would need to be reduced to achieve the worksite's AVR target. It is assumed that this value remains relatively constant over the year between the required reporting times.

If we assume that each employee drives alone to work then multiplying the number of employees by the shortfall value will give a value that represents the number of vehicles driven to work that need to be reduced or the number of employees that would need to seek alternatives means of transportation in order to achieve the AVR target.

$$\begin{matrix}\text{Reductions Needed} \\ \text{to Achieve AVR Target}\end{matrix} = \text{Shortfall} \times \begin{matrix}\text{Number of} \\ \text{Employees}\end{matrix}$$

From the annual emission factors listed in Table 5 above, each commute trip is defined as resulting in annual emissions for ROG, NOx, and CO expressed in pounds per year per daily commute vehicle. Since we assumed that each employee drives alone there is a one-to-one relationship between a commute vehicle and employee therefore, each employee is responsible for the corresponding annual emissions. From the above equation we then calculate the amount of emissions for each pollutant that would need to be reduced per employee to reach the AVR target as follows:

Employee Emission Reductions (pounds/year/employee) = Shortfall X Annual Emissions (pounds/year/daily commute vehicles)

The employee emission reductions are the pounds of emissions per employee that would be required to be reduced in order to achieve the worksite's AVR target. Applying the resulting number to the total number of employees that report to work in the peak commute window would result in the following equation:

Emission Reduction Target (pounds/year) = Total Number of Employees in the Peak Window X Employee Emission Reduction Factor (pounds/year/employee)

The Emission Reduction Target (ERT) is the total number pounds of emissions per year that the employer would need to reduce to achieve the worksite's AVR target.

Since each AVR zone results in different shortfall values employee emission reduction factors are calculated specifically for each AVR zone and each pollutant. In order to accommodate the terms in which the AVR targets are to be achieved (i.e., pounds of emissions per employee), the AVR target zones are redefined as Performance Target Zones. Performance Target Zones 1, 2 and 3 correspond to the AVR targets of 1.75, 1.5, and 1.3, respectively. The annual emission factors are then multiplied by the corresponding shortfall for each AVR target to develop the employee emission reduction factors. The employee emission reduction factors for Performance Target Zones 1, 2 and 3 are shown below.

Table 6. Performance Zone 1 – pounds/yr/employee

Year	ROG	NOx	CO
2014	1.43	1.47	15.84
2015	1.30	1.32	14.27
2016	1.18	1.19	12.92
2017	1.07	1.07	11.69
2018	0.97	0.97	10.64
2019	0.90	0.90	9.80
2020	0.86	0.84	9.20

Table 7. Performance Zone 2 – pounds/yr/employee

Year	ROG	NOx	CO
2014	1.11	1.14	12.32
2015	1.01	1.02	11.10
2016	0.92	0.92	10.05
2017	0.83	0.83	9.09
2018	0.76	0.76	8.27
2019	0.70	0.70	7.62
2020	0.67	0.65	7.16

Table 8. Performance Zone 3 – pounds/yr/employee

Year	VOC	NOx	CO
2014	0.77	0.79	8.53
2015	0.70	0.71	7.68
2016	0.63	0.64	6.96
2017	0.58	0.58	6.29
2018	0.52	0.52	5.73
2019	0.49	0.48	5.27
2020	0.46	0.45	4.95