



Emission Control Technology Distribution Used in MOBILE6

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M6.FLT.008a

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Abstract

The “Emission Control Technology Distribution” report (M6.FLT.008) submitted by Pechan and Associates lists percentages of vehicles which have been equipped with emission control devices and fuel delivery systems for model years of 1990 and beyond. This report, M6.FLT.008a, summarizes the vehicles fractions from the report, M6.FLT.008, which are used in MOBILE6.

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INTRODUCTION

The “Emission Control Technology Distribution” report (M6.FLT.008) prepared by Energy and Environmental Analysis, Inc. and submitted by E.H. Pechan and Associates, Inc. lists the percentages of vehicles which have been equipped with emission control devices and fuel delivery systems for model years of 1990 and beyond. These vehicle fractions are indexed by vehicle type and model year and have been gathered from meetings with automobile and heavy duty truck engine manufacturers. MOBILE6 estimates the effects that these pollution control devices and fuel delivery systems which are placed on light duty gasoline vehicles, light duty gasoline trucks, and heavy duty gasoline vehicles have on exhaust and evaporative emissions. Percentages listed in Tables 3-1 and 3-2 (from M6.FLT.008) were used to update the fraction of light duty cars and trucks, respectively, which have the different types of pollution control devices and fuel delivery systems installed. Also, the percentages listed in Tables 4-2 and 4-4 (from M6.FLT.008) were used for heavy duty gasoline vehicles and buses. However, some of the results from the Pechan report for exhaust gas recirculation (EGR) equipped light heavy duty vehicles have typographical errors and inconsistencies between what is reported in the text and the numbers which are in the tables. (For example, note the model year ranges 1996-1999, 2000-2004, and 2005-2009 in Table 4 on page 5; Tables 4-2 and 4-4 on pages 4-6 and 4-13, respectively, of M6.FLT.008.) These numbers are under review and may be changed if found inconsistent with an EPA maintained database of vehicles, Certification and Fuel Economy Information System (CFEIS)¹.

In MOBILE6 these vehicle fractions are used in determining correction factors for fuel sulfur content, temperature, and different fuel effects on emissions. Furthermore, effects on emissions due to emission controls which have been tampered and/or disabled are determined using these vehicle fractions. The fuel delivery system fractions are also used in the evaporative emissions determination.

The emissions estimations in MOBILE6 do not, however, use the fractions as they are listed in the aforementioned tables. The Pechan report has the fractions divided according to the type of fuel delivery system, catalytic converter type, and whether the vehicle is equipped with EGR and/or a secondary air supply to the exhaust. Whereas in MOBILE6 the fractions have been subdivided according to the fuel delivery system type and according to the type of pollution control technology. In particular, the pollution control technologies are divided into two categories each with three subcategories. The first category distinguishes between vehicles with and without secondary air supplies (air pumps) and catalysts, i.e., air pump only, air pump with a catalyst, and catalyst equipped without an air pump. The second category distinguishes between vehicles with and without EGR and catalysts, i.e., EGR only, EGR with a catalyst, and catalyst

¹e.g., “Certification and Fuel Economy Information System Manufacturers’ User Guide”, United States Environmental Protection Agency, Sep. 1999

equipped without EGR. The fuel delivery systems have three categories, i.e., multi-port fuel injection (MPFI; ported fuel injection or PFI in MOBILE6 documentation), single-port fuel injection (SPFI; throttle body fuel injection or TBI in MOBILE6 documentation), and carburetion.

Below are equations for each of the gasoline fueled vehicles which explicitly illustrate how the fractions are determined for use in MOBILE6. In the tables that are directly below each set of equations the fractions which are used in MOBILE6 are listed according to the above fuel delivery, pollution control categories, and the vehicle model year. (Although the fractions have been determined for a particular model year, model year ranges are used in MOBILE6. So, the vehicle fractions reported here have model year ranges associated with them.)

LIGHT DUTY GASOLINE CARS WITH SPECIFIC EMISSION CONTROL TECHNOLOGY

Table 3-1 on page 3-6 of M6.FLT.008 lists emission control technology vehicle fractions for light duty vehicles which are categorized by fuel delivery system and pollution control technology. These fractions are distinguished according to whether the vehicle has a secondary air supply to the catalyst and whether the vehicle is equipped with an EGR system. Using the notation from Table 3-1, the following sums are used to determine the fraction of light duty vehicles which are used in MOBILE6. The resulting vehicle fractions are displayed in Table 1.

(AP.1)air pump without catalyst	= 0.0
(AP.2)air pump with catalyst	= MPFI/3CL/AIR/EGR + MPFI/3CL&OXD/AIR/EGR + SPFI/3CL/AIR/EGR + SPFI/3CL&OXD/AIR/EGR + CARB/3CL&OXD/AIR/EGR
(AP.3)catalyst without air pump	= MPFI/3CL + MPFI/3CL/EGR + SPFI/3CL + SPFI/3CL/EGR + OTHER
(EGR.1)EGR without catalyst	= OTHER
(EGR.2)EGR with 3-way catalyst	= MPFI/3CL/EGR + MPFI/3CL/AIR/EGR + MPFI/3CL&OXD/AIR/EGR + SPFI/3CL/EGR + SPFI/3CL/AIR/EGR + SPFI/3CL&OXD/AIR/EGR + CARB/3CL&OXD/AIR/EGR
(EGR.3)3-way catalyst without EGR	= MPFI/3CL + SPFI/3CL

vehicle model year range (light duty cars)	1990	1991	1992	1993	1994	post 1995
(AP.1)air pump only	0.0	0.0	0.0	0.0	0.0	0.0
(AP.2)air pump with catalyst	0.2720	0.2272	0.1786	0.092	0.0752	0.0586
(AP.3)catalyst with no air pump	0.278	0.7728	0.8214	0.908	0.9248	0.9414
(EGR.1)EGR without 3-way catalyst	0.0041	0.0021	0.0029	0.0	0.0	0.0
(EGR.2)EGR with 3-way catalyst	0.7538	0.7494	0.6344	0.7825	0.8152	0.9082
(EGR.3)3-way catalyst with no EGR	0.2421	0.2485	0.3627	0.2175	0.1848	0.0918

Table 1. Fractions of light duty gasoline cars equipped with pollution control devices used in MOBILE6

LIGHT DUTY GASOLINE TRUCKS WITH SPECIFIC EMISSION CONTROL TECHNOLOGY

Table 3-2 from the report M6.FLT.008 lists the vehicle fractions for light duty trucks. The fractions used in MOBILE6 are determined from the following list of six equations, AP.4, AP.5, AP.6, EGR.4, EGR.5, and EGR.6, and are displayed numerically in Table 2. The notation follows the notation of the report.

$$\begin{aligned}
 \text{(AP.4)air pump without catalyst} &= 0.0 \\
 \text{(AP.5)air pump/catalyst} &= \text{MPFI/3CL/AIR/EGR} + \text{MPFI/3CL\&OXD/AIR/EGR} + \\
 &\quad \text{SPFI/3CL/AIR/EGR} + \text{SPFI/3CL\&OXD/AIR/EGR} + \\
 &\quad \text{CARB/3CL\&OXD/AIR/EGR} \\
 \text{(AP.6)no air pump/catalyst} &= \text{MPFI/3CL} + \text{MPFI/3CL/EGR} + \text{SPFI/3CL} + \\
 &\quad \text{SPFI/3CL/EGR} + \text{CARB/OPLP} + \text{OTHER} \\
 \text{(EGR.4)EGR without 3-way catalyst} &= \text{CARB/OPLP} + \text{OTHER} \\
 \text{(EGR.5)EGR with 3-way catalyst} &= \text{MPFI/3CL/EGR} + \text{MPFI/3CL/AIR/EGR} + \\
 &\quad \text{MPFI/3CL\&OXD/AIR/EGR} + \text{SPFI/3CL/EGR} + \\
 &\quad \text{SPFI/3CL/AIR/EGR} + \text{SPFI/3CL\&OXD/AIR/EGR} +
 \end{aligned}$$

CARB/3CL&OXD/AIR/EGR

(EGR.6)3-way catalyst without EGR = MPFI/3CL + SPFI/3CL

vehicle model year range (light duty trucks)	1990	1991	1992	1993	1994	post 1995
(AP.4)air pump only	0.0	0.0	0.0	0.0	0.0	0.0
(AP.5)air pump with catalyst	0.5317	0.336	0.2461	0.2394	0.1841	0.1587
(AP.6)catalyst with no air pump	0.4683	0.6640	0.7539	0.7606	0.8159	0.8413
(EGR.4)EGR without 3-way catalyst	0.0314	0.0105	0.0135	0.0	0.0	0.0
(EGR.5)EGR with 3-way catalyst	0.6947	0.7022	0.6437	0.7630	0.9167	0.8904
(EGR.6)3-way catalyst with no EGR	0.2739	0.2873	0.3428	0.2370	0.0833	0.1096

Table 2. Fractions of light duty gasoline trucks equipped with pollution control devices used in MOBILE6

LIGHT DUTY GASOLINE CARS AND TRUCKS WITH SPECIFIC FUEL DELIVERY SYSTEMS

Similarly, the percentage of light duty gas cars and light duty gas trucks with the two different types of fuel injection systems used in MOBILE6 were determined from Tables 3-1 and 3-2, respectively. Equations FI.1 and FI.2 explicate the sums and they are listed numerically in Table 3.

MOBILE6 documentation typically uses a different notation for the multi-port fuel injection (MPFI) and the single-port fuel injection (SPFI). The single-port fuel injection acronym more commonly used in MOBILE6 documentation is TBI. Likewise, the MOBILE6 documentation multi-port acronym is PFI rather than MPFI.

$$(FI.1) \% \text{ MPFI} = \text{MPFI/3CL} + \text{MPFI/3CL/EGR} + \text{MPFI/3CL/AIR/EGR} + \text{MPFI/3CL\&OXD/AIR/EGR}$$

$$(FL.2) \% SPFI = SPFI/3CL + SPFI/3CL/EGR + SPFI/3CL/AIR/EGR + SPFI/3CL\&OXD/AIR/EGR$$

vehicle model year range (light duty cars and trucks)	1990	1991	1992	1993	1994	1995-2003	post 2003
light duty cars MPFI (or PFI)	0.7933	0.7898	0.9007	0.8906	0.9612	0.988	1.0
light duty cars SPFI (or TBI)	0.1882	0.2078	0.0956	0.1094	0.0388	0.012	0.0
light duty trucks MPFI (or PFI)	0.552	0.4837	0.6601	0.6882	0.7279	0.7463	1.0
light duty trucks SPFI (or TBI)	0.3944	0.4945	0.3188	0.3008	0.2721	0.2536	0.0

Table 3. Fractions of light duty gasoline cars and trucks equipped with different fuel delivery systems which are used in MOBILE6. Note that most MOBILE6 documentation refers to MPFI as PFI and SPFI as TBI (throttle body fuel injection).

LIGHT HEAVY DUTY GASOLINE TRUCKS (GROSS VEHICLE WEIGHT BETWEEN 8501 POUNDS AND 14000 POUNDS)

From Tables 4-2 and 4-4 the fractions of vehicles with particular types of emission control devices used in MOBILE6 for light heavy duty gasoline vehicles with gross vehicle weight (GVW) between 8501 pounds and 14000 pounds were determined from the following sums (equations AP.7, AP.8, AP.9, EGR.7, EGR.8, and EGR.9). The notation is from M6.FLT.008 and the fractions are listed in Table 4.

$$\begin{aligned} (AP.7)\text{air pump without catalyst} &= 0.0 \\ (AP.8)\text{air pump with catalyst} &= MPFI/3CL\&OXD/AIR/EGR + MPFI/OXD/AIR/EGR + MPFI/3CL/AIR \\ (AP.9)\text{catalyst without air pump} &= MPFI/OXD/EGR \\ (EGR.7)\text{EGR without 3-way catalyst} &= 100\%(1990 \text{ ONLY}) \\ &= 63\% (* 1996-1999, \text{ see below and pages 4-5 and 4-6}) \\ &= 100\% - [(EGR.2) + (EGR.3)] \\ (EGR.8)\text{EGR with 3-way catalyst} &= 0\%(1990 \text{ ONLY}) \end{aligned}$$

= 27%(* 1996-1999, see below and pages 4-5 and 4-6)
 = MPFI/3CL&OXD/AIR/EGR

(EGR.9)3-way catalyst without EGR = MPFI/3CL/AIR

vehicle model year range (light heavy duty trucks)	1990- 1995	1996- 1999	2000- 2004	2005- 2009	post 2009
(AP.7)air pump only	0.0	0.0	0.0	0.0	0.0
(AP.8)air pump with catalyst	0.5	0.55	0.65	1.0	1.0
(AP.9)catalyst with no air pump	0.5	0.45	0.35	0.0	0.0
(EGR.7)EGR without 3-way catalyst	1.0	0.73*	0.7	0.0	0.0
(EGR.8)EGR with 3-way catalyst	0.0	0.27*	0.0	0.75	0.75
(EGR.9)3-way catalyst with no EGR	0.0	0.0	0.3	0.25	0.25

Table 4. Fractions of light heavy duty gasoline trucks (GVW between 8500 lbs. and 14000lbs.) equipped with pollution control devices used in MOBILE6.

*Note that the Pechan report has inconsistencies between numbers in the text and the numbers reported in Tables 4-2 and 4-4. For the model years 1996-1999 GM and Chrysler vehicles are equipped with EGR only and their sales of heavy duty gasoline vehicles (GVW < 14000) which comprise 47% and 16% of the market, respectively. So, the fraction of 1996-1999 heavy duty gasoline vehicles (GVW < 14000) which have EGR only(no catalyst) is 0.63 rather than 0.73.

HEAVY DUTY GASOLINE TRUCKS (GROSS VEHICLE WEIGHT GREATER THAN 14000 POUNDS)

The vehicle fractions from Tables 4-2 and 4-4 of the report M6.FLT.008 were used to determine the MOBILE6 vehicle fractions from the following sums (equations AP.10, AP.11, AP.12, EGR.10, EGR.11, and EGR.12) for the remaining heavy duty gasoline vehicles. That is, those heavy duty trucks with gross vehicle weight greater than14000 pounds. Again, the notation used in the sums is from M6.FLT.008 together with the following list of four special categories :

- i. In 1990 30% of these vehicles are equipped with fuel injection.

- ii. The 1990 categories are MPFI/OX/AIR/EGR, CARB/AIR/EGR(1990 only).
- iii. In years after 1995 100% of vehicles are equipped with fuel injection.
- iv. In years after 1995 the categories are MPFI/OX/AIR/EGR, MPFI/AIR/EGR, and MPFI/3CL&OXD/AIR/EGR.

(AP.10)air pump without catalyst = CARB/EGR/AIR(1990 only) + MPFI/AIR/EGR
 (AP.11)air pump/catalyst = MPFI/OXD/AIR/EGR + MPFI/3CL&OXD/AIR/EGR
 (AP.12)no air pump/catalyst = 0.0
 (EGR.10)EGR without 3-way catalyst = CARB/EGR/AIR(1990 only) + MPFI/AIR/EGR
 (EGR.11)EGR with 3-way catalyst = MPFI/3CL&OXD/AIR/EGR
 (EGR.12)3-way catalyst without EGR = 0.0

vehicle model year (heavy heavy duty trucks)	1990- 1995	1996- 1999	2000- 2004	2005- 2009	post 2009
(AP.10)air pump without catalyst	0.70	0.60*	0.20	0.0	0.0
(AP.11)air pump with catalyst	0.30	0.40*	0.80	1.0	1.0
(AP.12)catalyst without air pump	0.0	0.0	0.0	0.0	0.0
(EGR.10)EGR without 3-way catalyst	1.0	1.0	1.0	0.0	0.0
(EGR.11)EGR with 3-way catalyst	0.0	0.0	0.0	1.0	1.0
(EGR.12)3-way catalyst without EGR	0.0	0.0	0.0	0.0	0.0

Table 5. Fractions of heavy duty gasoline trucks (GVW greater than14000lbs.) equipped with pollution control devices used in MOBILE6.

*Note that the 1996 percentages for heavy duty gasoline trucks (GVW greater than14000lbs.) in Tables 4-4 and 4-2 are different. Moreover, according to the Pechan report on pages 4-5 and 4-6 the Ford and GM engines comprise 60% and 40% of the market, respectively. The Ford engines are fuel injected, have air pumps, and EGR. The GM engines are fuel injected, have air pumps, EGR, and oxidation catalysts. So, the 1996 values in Table 4-4 are not consistent with the values in the text and the values in Table 4-2.

SUMMARY

Report M6.FLT.008 describes a set of data for the fractions of vehicles (light duty gasoline cars, light duty gasoline trucks, and heavy duty gasoline and diesel trucks) which are equipped different types of pollution controls and fuel delivery systems for model years starting in 1990 through 2020. This report summarizes the data from that report which are used in MOBILE6.