

Frequently Asked Questions In-Use Off-Road Diesel Vehicle Regulation

Emission Factors for Off-road Diesel, On-road Diesel, Alternative Fuel, and Gasoline-powered Vehicles FAQ Revised May 2011

Q – What emission factors do I use for off-road engines when calculating my fleet average?

A – Emission factors are based on the new engine NOx emission standards off-road engines met when they were manufactured (see Appendix A of the regulation for the emission factors table). The DOORS system and fleet average calculator looks up each engine’s emission factor and calculates fleet averages based on the individual engines in a fleet. To illustrate what factors these tools are using, the following table shows the emission factors from Appendix A of the regulation. The emission factor for an engine is determined by locating the row with the proper engine model year and column with the specified horsepower (See below for examples).

Emission Factors by Horsepower and Year (g/bhp-hr)								
Engine Model Year	Horsepower Group							
	25-49	50-74	75-99	100-174	175-299	300-599	600-750	Over 750
1900 – 1969	7.2	14.8	14.8	15.9	15.9	15.2	15.2	15.2
1970 – 1971	7.2	14.8	14.8	14.8	14.8	14.1	14.1	14.1
1972 – 1979	7.2	14.8	14.8	13.6	13.6	13.0	13.0	13.0
1980 – 1987	7.2	14.8	14.8	12.5	12.5	11.9	11.9	11.9
1988	7.1	9.9	9.9	9.3	9.3	8.9	8.9	8.9
1989 – 1995	7.1	9.9	9.9	9.3	9.3	8.9	8.9	8.9
1996	7.1	9.9	9.9	9.3	6.9	6.9	6.9	8.9
1997	7.1	9.9	9.9	6.9	6.9	6.9	6.9	8.9
1998	7.1	6.9	6.9	6.9	6.9	6.9	6.9	8.9
1999	6.2	6.9	6.9	6.9	6.9	6.9	6.9	8.9
2000	6.2	6.9	6.9	6.9	6.9	6.9	6.9	6.9
2001	6.2	6.9	6.9	6.9	6.9	4.2	6.9	6.9
2002	6.2	6.9	6.9	6.9	6.9	4.2	4.2	6.9
2003	6.2	6.9	6.9	4.3	4.3	4.2	4.2	6.9
2004	4.9	4.9	4.9	4.3	4.3	4.2	4.2	6.9
2005	4.9	4.9	4.9	4.3	4.3	4.2	4.2	6.9
2006	4.9	4.9	4.9	4.3	2.6	2.6	2.6	4.2
2007	4.9	4.9	4.9	2.6	2.6	2.6	2.6	4.2
2008	4.9	3.0	3.0	2.6	2.6	2.6	2.6	4.2
2009	4.9	3.0	3.0	2.6	2.6	2.6	2.6	4.2
2010	4.9	3.0	3.0	2.6	2.6	2.6	2.6	4.2
2011	4.9	3.0	3.0	2.6	1.5	1.5	1.5	2.6
2012	4.9	3.0	2.5	2.5	1.5	1.5	1.5	2.6
2013	3.0	3.0	2.5	2.5	1.5	1.5	1.5	2.6
2014	3.0	3.0	2.5	2.5	0.3	0.3	0.3	2.6
2015 and later	3.0	3.0	0.3	0.3	0.3	0.3	0.3	2.6

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The table below illustrates the emission factors for a few different model years and horsepower ratings. Each one is circled with a different color on the tables above.

Engine Model Year	Horsepower (Hp)	Emission Factor (g/bhp-hr)
1996 (Red)	150	9.3
2001 (Blue)	300	4.2
2003 (Green)	150	4.3

For more information on determining engine horsepower, please see the Engine Horsepower FAQ which is available in the off-road Knowledge Center at: www.arb.ca.gov/msprog/ordiesel/knowcenter.htm

Q - What are pre- and post-2007 flexibility (flex) engines, and what emission factor should I use for those engines?

A - Flexibility (flex) engines are engines that were produced by engine manufacturers to a less stringent emission standard after a new tier of emission standards goes into effect. The purpose was to provide equipment manufacturers with some lead time to redesign their equipment for the newer, more stringent, engines.

Pre-2007 flex engines are engines that were subject to the 2000 Plus Limited Test Procedures for new off-road diesel engines and have been certified to either Tier 1 or Tier 2 emission standards. Post-2007 flex engines are engines that are subject to the 2008 and Later Test procedures for new off-road diesel engines and are certified to Tier 2, Tier 3, or Tier 4 interim emission standards (depending on the year and engine power rating)..

All fleets must report whether or not an engine is flexed in DOORS. However, a fleet is not required to use the emission factor to which the engine is certified. Instead, a fleet should use the emission factor from Appendix A, as shown above, like it would for any other non-flexed vehicle in its fleet.

Q – What emission factor do I use if I have an on-road engine in my vehicle?

A – The regulation allows credit for repowering off-road vehicles with on-road engines. For on-road engines, the NOx standard to which the engine is certified is used as the emission factor. The on-road engine emission factors are shown in the table below.

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On-Road Heavy-Duty Diesel Emission Factors (g/bhp-hr)

Engine Model Year	Emission Factor (g/bhp-hr)
Pre-1979	-- ¹
1979	7.5
1980-1984	5.2
1985-1986	5.1
1987-1990	6.0
1991-1993	5.0
1994-1997	5.0
1998-2003	4.0
2004-2006	Use actual certification standard ²
2007+	Use actual certification standard ²

¹ For these model years, use the off-road emission factor for the purposes of compliance with the off-road regulation.

² Actual engine emission standards will vary. Phased in sales averaging 1.2 to 0.2 g/bhp-hr between 2007 and 2010 model years.

For an explanation of the benefits of on-road engines in off-road equipment, please see the On-road Engines in Off-road Vehicles FAQ, which is available in the off-road Knowledge Center at:

www.arb.ca.gov/msprog/ordiesel/knowcenter.htm

Q – What emission factor do I use if I have an alternative fuel or gasoline-powered vehicle operating in my fleet, or have repowered a diesel vehicle with an alternative fuel or gasoline-powered engine?


A – A fleet may include an alternative fuel or gasoline-powered vehicle that is 25 horsepower or greater (or that replaced a diesel vehicle 25 horsepower or greater) in the fleet average calculations, as specified in Section 2449(d)(1)(A), as long as its owner can demonstrate the following:

- (1) The vehicle serves a function and performs the work equivalent to that of a diesel vehicle and is used for a purpose for which diesel vehicles are predominantly used;
- (2) The vehicle is used predominantly outdoors;
- (3) The vehicle is not already included in the fleet average emission level requirements for large spark ignition engine fleets in title 13, Section 2775.1;

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- (4) Its engine is certified to a NOx standard less than or equal to the Tier 1 NOx standard for the same horsepower, and is less than or equal to the NOx emissions of a diesel engine of the same model year and horsepower; and
- (5) For a gasoline-powered vehicle, the owner must identify the diesel vehicle that the gasoline-powered vehicle replaced and maintain records documenting the function of the diesel vehicle replaced and the gasoline-powered replacement vehicle, and the dates of sale and purchase for both vehicles

For an alternative fuel or gasoline-powered vehicle, or a diesel vehicle that has been repowered with an alternative fuel or gasoline-powered engine, the emission factor must be obtained from the emission standard on the certification executive order. If the executive order lists an emission standard in terms of HC + NOx, the HC + NOx standard must be multiplied by 0.95 to get the emission factor. For example, in the executive order below, the HC + NOx standard of 3.0 g/bhp-hr (circled in the document) must be multiplied by 0.95 to get the emission factor.

 AIR RESOURCES BOARD	FORD MOTOR COMPANY	EXECUTIVE ORDER U-L-005-0021 New Off-Road Large Spark-Ignition Engines At & Above 25 Horsepower
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Pursuant to the authority vested in the Air Resources Board by the Health and Safety Code, Division 26, Part 5, Chapters 1 and 2; and

Pursuant to the authority vested in the undersigned by Health and Safety Code Sections 39515 and 39516 and Executive Order G-02-003;

IT IS ORDERED AND RESOLVED: That the following new large spark-ignition engines and emission control systems produced by the manufacturer are certified for use in off-road equipment as described below. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY NAME	ENGINE DISPLACEMENT (liters)	FUEL TYPE
2006	6FMXB04.2GAA	4.2	Gasoline, LPG, CNG, Gasoline-LPG Dual Fuel, Gasoline-CNG Dual Fuel, or LPG-CNG Dual Fuel
DURABILITY HOURS	SPECIAL FEATURES & EMISSION CONTROL SYSTEMS		TYPICAL EQUIPMENT USAGE
3500	Three-Way Catalytic Converters, Heated Oxygen Sensors, Sequential Multiport Fuel Injection		Forklift, Tractor/Tug, Generator, Sweeper, Aerial Lift, Other Industrial Equipment
ENGINE MODELS (rated power in horsepower, hp)	ESG642 [(Gasoline (143 hp), LPG (137 hp), NG (127 hp), CNG (127 hp)]		

The following are the hydrocarbon plus oxides of nitrogen (HC+NOx) and carbon monoxide (CO) exhaust certification emission standards (Title 13, California Code of Regulations, (13 CCR) Section 2433(b)(1)) and certification emission levels for this engine family in grams per brake horsepower-hour (g/bhp-hr). Engines within this engine family shall have closed crankcases in conformance with 13 CCR Section 2433(b)(2).

(g/bhp-hr)	HC+NOx	CO
Standards	3.0	37.0
Certification Levels	2.2	8.4

BE IT FURTHER RESOLVED: That for the listed engines for the aforementioned model-year, the manufacturer has submitted, and the Executive Officer hereby approves, the information and materials to demonstrate certification compliance with 13 CCR Section 2433(c) (certification and test

Emission factor = 3.0 x 0.95 = 2.85 g/bhp-hr.

If the alternative fuel vehicle or engine is not certified to a NOx emission standard, the owner may apply to the Executive Officer to use an appropriate

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emission factor. In the application, the owner must demonstrate that the chosen emission factor is appropriate and not exceeded by the alternative fuel vehicle.

Q – What emission factor do I use for a diesel fueled vehicle that has been converted to an alternative fueled or gasoline-powered vehicle?

A – The emission factor is the same as the emission factor for the diesel vehicle, as specified in section 2449(d)(1)(A)4..

Q - What emission factor and horsepower do I use if I have an electric vehicle?

A – A fleet may include an electric vehicle 25 horsepower or greater in the fleet average calculations, as specified in section 2449(d)(1)(B), as long as its owner can demonstrate the following:

- (1) The electric vehicle perform the work of a diesel vehicle and must be used for a purpose for which diesel vehicles are predominately used;
- (2) The electric vehicle must be used predominately outdoors; and
- (3) The electric vehicle cannot already be included in the fleet average requirements for large spark ignition engine fleets.

Electric vehicles should not be included when determining fleet size, or when calculating the required horsepower for the BACT requirements in section 2449.1(b)

For GSE electric vehicles purchased before January 1, 2007: For an electric vehicle that replaced a diesel vehicle in the owner's fleet, the maximum power of the diesel vehicle replaced may be used as the electric vehicle's horsepower. Otherwise, the electric vehicle's own maximum power rating should be used. When calculating the fleet average index and target rate, the fleet owner must multiply the vehicle's horsepower by 0.2, along with an emission factor of zero.

For non-GSE electric vehicles purchased before January 1, 2007: For an electric vehicle that replaced a diesel vehicle in the owner's fleet, the maximum power of the diesel vehicle replaced may be used as the electric vehicle's horsepower. Otherwise, the electric vehicle's own maximum power rating should be used. An emission factor of zero should be used for the electric vehicle.

For all electric vehicles purchased on after January 1, 2007: For an electric vehicle that replaced a diesel vehicle in the owner's fleet, the horsepower of the diesel vehicle replaced may be used as the electric vehicle's horsepower. For an electric vehicle added to the fleet that did not replace a diesel vehicle, the fleet owner may apply to the Executive Officer to use the horsepower of a diesel vehicle that serves the same function and performs equivalent work to that of the electric vehicle. If no request to the Executive Officer is received, the electric

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vehicle's own maximum power rating shall be used. An emission factor of zero should be used for the electric vehicle.

Double Credit for Electric in 2014-2016 - For compliance dates in 2014 through 2016, the horsepower of all electric vehicles purchased on or after January 1, 2007 may be doubled in determining the horsepower that is used in calculating the fleet average index. The horsepower of each electric vehicle is included but not doubled in the calculation of fleet average target rate.

Single Credit for Electric in 2017 and Later - For compliance dates in year 2017 and later, the horsepower of all electric vehicles purchased on or after January 1, 2007 is used in determining the horsepower that is used in calculating the fleet average index and target

Q - What emission factor and horsepower do I use if I replaced diesel vehicles with an electric portable or electric stationary system?

A - A fleet may apply to the Executive Officer to include electric portable or electric stationary systems that replace mobile diesel vehicles, such as an electric conveyor system used to replace diesel haul trucks at a mine, in the fleet average calculations as long as the owner can demonstrate:

- (1) That the system replaced an off-road diesel fueled vehicle subject to this regulation on or after January 1, 2007; and
- (2) The system is not already counted toward the fleet average emission level requirements for large spark ignition engine fleets in title 13, CCR, section 2775.1 or for portable diesel engine fleets in title 17, CCR, section 93116.3.

The system may be considered in the fleet average calculations by including the horsepower of the diesel vehicles replaced in the calculations of the fleet average index and target rate, along with an emission factor of 0.

Q - What emission factor and horsepower do I use if I have a hybrid off-road vehicle?

A - Fleets may include a hybrid off-road diesel vehicle 25 horsepower or greater in their fleet average index and target rate calculation. The emission factor for the hybrid vehicle is equal to the NOx emission standard to which its engine is certified in g/bhp-hr. If a fleet owner wishes to use different emission factor, other than the standard to which the engine is certified, the owner may apply to the Executive Officer to use an alternative emission factor. The Executive Officer shall approve the alternative emission factor if, in the fleet owner's application, the owner demonstrates that the chosen emission factor is appropriate and not exceeded by the hybrid vehicle.

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Emission factors – How to reflect exhaust retrofits

Q – How do I determine what my new emission factors are if I have retrofitted my vehicle with a VDECS (i.e., an exhaust retrofit)?

A – The emission factor is adjusted down to reflect the emission reductions achieved by the VDECS.

The equation to determine the adjusted emission reduction is:

Emission Factor (Post VDECS) = Emission Factor (Pre VDECS) x VDECS Factor

The VDECS factor is calculated based on the type of VDECS placed on the vehicle. The VDECS factor table is located in section 2449.1(a) of the regulation, and is also shown below.

VDECS Factors

VDECS	VDECS Factor
No VDECS Installed or Level 1 VDECS	1
Level 2 PM VDECS, not highest level	0.82
Level 2 PM VDECS, not highest level, with NOx Reduction	1 Minus (0.18 + (Verified Percent NOx Reduction Divided by 170))
Highest Level PM VDECS	0.7
Highest Level PM VDECS with NOx Reduction	1 Minus (0.3 + (Verified Percent NOx Reduction Divided by 170))
NOx Reduction only	1 Minus (Verified Percent NOx Reduction Divided by 170)

For example, a 1998 engine with 200 hp has an emission factor of 6.9 g/bhp-hr. The equation below shows how the emission factor would be reduced with a Level 3 VDECS that achieves 60 percent NOx reductions:

Adjusted Emission Factor = [6.9] x [1 – (0.3 + 60/170)] = 2.39 g/bhp-hr

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The table below is an example fleet that has been retrofitted with VDECS. The before and after emission factors are listed for quick comparison.

Engine Model Year	Horsepower	PM VDECS?	NOx VDECS?	Emission Factor Before VDECS	Emission Factor After VDECS
1996	175	Yes, level 3	Yes, 65% reduction	6.9	2.19
1998	200	No	Yes, 60% reduction	6.9	4.46
2000	250	Yes, level 3	No	6.9	4.83
2003	300	Yes, level 2 (not highest level)	Yes, 50% reduction	4.2	2.21

Fleet Average Calculations

Q – How are fleet averages and fleet average targets calculated?

A – The DOORS system and fleet average calculator calculate fleet averages and fleet average targets for fleets that use these tools. However, if you wish to understand how fleet averages are calculated, the discussion below provides an explanation.

Fleet averages and fleet average targets are calculated using a series of equations and tables based on the size of the fleet. Large and Medium fleets will use the Large and Medium Fleet Targets tables in section 2449.1(a)(1), and small fleets will use the Small Fleet PM Targets table in section 2449.1(a)(2).

The equation below is for calculating a fleet’s average targets.

$$\text{Fleet Average Target} = \frac{\sum_{i=1}^n \text{MaxHp}_i \times \text{Target}_i}{\sum_{i=1}^n \text{MaxHp}_i}$$

Where *i* is the first engine and *n* is the number of engines in the fleet.

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Large and Medium Fleet Targets								
For Use in Calculating Fleet Average Target Rates [g/bhp-hr]								
	Targets for each Max Hp Group							
Compliance Date: January 1 of the Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-750 hp	>750 hp
2014 (Large Fleets Only)	5.8	6.5	7.1	6.4	6.2	5.9	6.1	7.2
2015 (Large Fleets Only)	5.6	6.2	6.7	6.0	5.8	5.5	5.6	6.8
2016 (Large Fleets Only)	5.3	5.8	6.2	5.5	5.3	5.1	5.2	6.5
2017	5.0	5.4	5.5	4.9	4.7	4.5	4.6	6.0
2018	4.7	5.0	4.8	4.3	4.1	4.0	4.0	5.5
2019	4.4	4.6	4.1	3.7	3.5	3.4	3.4	5.0
2020	4.1	4.2	3.4	3.1	2.9	2.8	2.9	4.5
2021	3.8	3.8	2.7	2.5	2.3	2.2	2.3	4.0
2022	3.5	3.4	2.0	1.9	1.7	1.7	1.7	3.5
2023	3.3	3.0	1.4	1.3	1.5	1.5	1.5	3.4

Small Fleet Targets								
For Use in Calculating Fleet Average Target Rates [g/bhp-hr]								
	Targets for each Max Hp Group							
Compliance Date: January 1 of the Year	25-49 hp	50-74 hp	75-99 hp	100-174 hp	175-299 hp	300-599 hp	600-750 hp	>750 hp
2019	5.8	6.5	7.1	6.4	6.2	5.9	6.1	7.2
2020	5.6	6.2	6.7	6.0	5.8	5.5	5.6	6.8
2021	5.3	5.8	6.2	5.5	5.3	5.1	5.2	6.5
2022	5.0	5.4	5.5	4.9	4.7	4.5	4.6	6.0
2023	4.7	5.0	4.8	4.3	4.1	4.0	4.0	5.5
2024	4.4	4.6	4.1	3.7	3.5	3.4	3.4	5.0
2025	4.1	4.2	3.4	3.1	2.9	2.8	2.9	4.5
2026	3.8	3.8	2.7	2.5	2.3	2.2	2.3	4.0
2027	3.5	3.4	2.0	1.9	1.7	1.7	1.7	3.5
2028	3.3	3.0	1.4	1.3	1.5	1.5	1.5	3.5

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The equation below is for calculating a fleet's Fleet Average Index.

$$\text{Fleet Average Index} = \frac{\sum_{i=1}^n \text{MaxHp}_i \times \text{EmissionFactor}_i}{\sum_{i=1}^n \text{MaxHp}_i}$$

The emission factors are shown in the tables below.

If the fleet's Fleet Average Index is less than or equal to the Fleet Average Target for a compliance date (i.e., January 1 of any compliance year), the fleet meets the fleet average requirements.

In cases where numerical rounding is necessary to determine compliance with the regulation, conventional (also known as standard) rounding procedures will be used. In such cases, the Fleet Average Index will be rounded to the same decimal place as the Fleet Average Target. The procedure for rounding will adhere to the standard mathematical method. The number will be rounded up if the first digit that is not included is a five or greater, and will be rounded down if the first digit that is not included is less than five. For example, given a fleet average target of 6.2 g/bhp-hr, a fleet's index of 6.2499 will be rounded down to 6.2, and the fleet would meet the requirements for that compliance date.

The example below demonstrates how to calculate the Fleet Average Index and Fleet Average Target. The Fleet Average Index and Fleet Average Target values are compared to determine whether or not the fleet is in compliance with the performance requirements.

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	25-49	50-74	75-99	100-174	175-299	300-599	600-750	Over 750
1900 – 1969	7.2	14.8	14.8	15.9	15.9	15.2	15.2	15.2
1970 – 1971	7.2	14.8	14.8	14.8	14.8	14.1	14.1	14.1
1972 – 1979	7.2	14.8	14.8	13.6	13.6	13.0	13.0	13.0
1980 – 1987	7.2	14.8	14.8	12.5	12.5	11.9	11.9	11.9
1988	7.1	9.9	9.9	9.3	9.3	8.9	8.9	8.9
1989 – 1995	7.1	9.9	9.9	9.3	9.3	8.9	8.9	8.9
1996	7.1	9.9	9.9	9.3	6.9	6.9	6.9	8.9
1997	7.1	9.9	9.9	6.9	6.9	6.9	6.9	8.9
1998	7.1	6.9	6.9	6.9	6.9	6.9	6.9	8.9
1999	6.2	6.9	6.9	6.9	6.9	6.9	6.9	8.9
2000	6.2	6.9	6.9	6.9	6.9	6.9	6.9	6.9
2001	6.2	6.9	6.9	6.9	6.9	4.2	6.9	6.9
2002	6.2	6.9	6.9	6.9	6.9	4.2	4.2	6.9
2003	6.2	6.9	6.9	4.3	4.3	4.2	4.2	6.9
2004	4.9	4.9	4.9	4.3	4.3	4.2	4.2	6.9
2005	4.9	4.9	4.9	4.3	4.3	4.2	4.2	6.9
2006	4.9	4.9	4.9	4.3	2.6	2.6	2.6	4.2
2007	4.9	4.9	4.9	2.6	2.6	2.6	2.6	4.2
2008	4.9	3.0	3.0	2.6	2.6	2.6	2.6	4.2
2009	4.9	3.0	3.0	2.6	2.6	2.6	2.6	4.2
2010	4.9	3.0	3.0	2.6	2.6	2.6	2.6	4.2
2011	4.9	3.0	3.0	2.6	1.5	1.5	1.5	2.6
2012	4.9	3.0	2.5	2.5	1.5	1.5	1.5	2.6
2013	3.0	3.0	2.5	2.5	1.5	1.5	1.5	2.6
2014	3.0	3.0	2.5	2.5	0.3	0.3	0.3	2.6
2015 and later	3.0	3.0	0.3	0.3	0.3	0.3	0.3	2.6

Fleet Average Calculation Example

Example fleet of 3 vehicles:

Vehicle 1: 1996, 100 hp, Emission Factor = 9.3

Vehicle 2: 2000, 200 hp, Emission Factor = 6.9

Vehicle 3: 2002, 300 hp, Emission Factor = 4.2

Fleet Average Index

$$= [(9.3 \times 100) + (6.9 \times 200) + (4.2 \times 300)] / (100 + 200 + 300)$$

$$= 6.0$$

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For 2014 compliance date:¹

Vehicle 1 (100 hp): Target = 6.4

Vehicle 2 (200 hp): Target = 6.2

Vehicle 3 (300 hp): Target = 5.9

Fleet Average Target:

= $[(6.4 \times 100) + (6.2 \times 200) + (5.9 \times 300)] / (100 + 200 + 300)$

= 6.1

Compare target with average:

Fleet Average Index = 6.0

Fleet Average 2010 Target = 6.1

6.0 < 6.1

Since the Fleet Average Index is less than the Fleet Average Target set for 2014, the fleet meets the performance requirement for 2014.

¹ The example uses the 2014 large fleet target rates, which apply only to large fleets (those with over 5,000 hp). To make the example shorter and easier to follow, we show the calculations for just three vehicles with a total horsepower of 600 hp. In reality, a fleet with total horsepower of 600 hp would be subject to the small fleet requirements.

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