

# US: FUELS: DIESEL AND GASOLINE

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## History

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In the United States, fuel quality as it relates to emissions is regulated by EPA under the authority of the Clean Air Act Amendments of 1990. Sulfur levels have been slowly ratcheted down to near-zero levels in diesel fuels for a variety of applications as well as gasoline. EPA Fuel Programs page contains up-to date, useful information on US fuels programs. Other technical parameters of automotive fuels are specified by ASTM standards. Diesel fuels are covered by the ASTM D975 standard.

EPA manages a comprehensive fuel compliance program that combines fuel registration, extensive fuel inspections, fuel quality testing and reporting system, as well as stiff noncompliance penalties. EPA's fuel compliance program targets all parties in the distribution system, including refiners, importers, distributors, carriers, oxygenate blenders, retailers, and wholesale-purchaser-consumers (fleet operators with their own dispensing pumps). Since 1998, domestic and international refineries, as well as refined product importers, must use the complex model<sup>[1]</sup> to certify that combustion and evaporative emissions generated by their fuel comply with the reformulated gasoline (RFG) requirements or the anti-dumping requirements.

# Technical Standards

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## Sulfur Content

Environmental regulations limiting sulfur levels in diesel fuels can be summarized as follows:

### **Highway Diesel Fuel**

- *500 ppm* - Sulfur limit of 500 ppm = 0.05% (wt.) became effective in October 1993. This fuel, commonly referred to as "low sulfur" diesel fuel, was introduced to facilitate sulfate particulate emission reductions, which were necessary for meeting the 1994 emission standards for heavy-duty highway engines.
- *15 ppm* - Diesel fuel of maximum sulfur level of 15 ppm was available for highway use beginning in June 2006. This fuel, referred to as "ultra low sulfur diesel" (ULSD), was legislated by EPA to enable catalyst-based emission control devices, such as diesel particulate filters and NO<sub>x</sub> absorbers necessary for meeting the 2007-2010 emission standards for heavy-duty engines and the Tier 2 light-duty standards. For additional information, see the US Heavy-duty Emissions page.

## **Nonroad Diesel Fuel**

The following sulfur requirements are applicable to Nonroad, Locomotive and Marine (NRLM) fuels, with the exception of heavy fuel oils (HFO) used in Category 2 and Category 3 marine diesel engines.

- *500 ppm* - Sulfur limit of 500 ppm became effective in June 2007 for nonroad, locomotive and marine fuels.
- *15 ppm* - Sulfur limit of 15 ppm (ULSD) becomes effective in June 2010 for nonroad fuel, and in June 2012 for locomotive and marine fuels. ULSD has been legislated for nonroad engines to enable advanced emission control systems for meeting the Tier 4 nonroad emission standards.
- For additional information, see the US Nonroad Emissions page.

## **Category 3 Marine Engine Fuel**

The International Maritime Organization (IMO) passed an amendment to the 1997 protocol of the International Convention for the Prevention of Pollution from Ships for the establishment the North American Emission Control Area (ECA) along the US and Canadian shorelines. The ECA triggered international and EPA sulfur limits in marine fuels:

- *IMO limits* - 1% (10,000 ppm) sulfur in 2010, and 0.1% (1,000 ppm) sulfur from 2015. SO<sub>x</sub> after treatment, such as SO<sub>x</sub> scrubbers, are allowed in lieu of

low sulfur fuel. Additional information can be found in IMO Resolution MEPC.190(60).

- *EPA limits* - 2009 EPA Category 3 marine engine rule established a sulfur limit of *1,000 ppm* for marine fuels produced and/or sold for use within an ECA. SO<sub>x</sub> aftertreatment can be used in lieu of low sulfur fuel. Additional flexibilities apply to vessels operated on the Great Lakes and Saint Lawrence Seaway. Low sulfur requirements can be deferred, subject to fuel availability and economic hardship provisions, and are not applicable to steamships. The marine fuel standards are located in section IV of the Final Rule.
- For additional information, see the US Nonroad Emissions page, the US Marine Emissions page, and EPA's ECA application to the IMO.

### **California (CARB Diesel)**

Effective October 1, 1993, the California Air Resources Board (CARB) adopted a diesel fuel specification limiting the sulfur and aromatics in commercially available diesel fuel. Starting in January 2005, California diesel fuel was required to meet a minimum lubricity specification as well. This fuel, commonly referred to as the CARB diesel, is mandatory for use in a variety of applications including both highway and off-road vehicles. The limits and applicability have evolved as follows:

- 1993.10—Sulfur limited to a maximum of 500 ppm and aromatics to 10% or equivalent. Applicable to on- and off-road vehicles but not stationary engines, locomotives and marine vessels.
- 2004.12—CARB diesel requirement extended to stationary sources (applies to on- and off-road motor vehicles and nonvehicular sources other than locomotives and marine vessels).
- 2005.01—CARB diesel required to meet a lubricity requirement of a maximum wear scar diameter of 520 microns by ASTM D6079, the High Frequency Reciprocating Rig (HFRR).
- 2006.06—Sulfur in CARB diesel limited to 15 ppm.
- 2007.01—CARB diesel requirement extended to intrastate locomotives and marine engines (within the SCAQMD, CARB diesel must be sold to harborcraft operators beginning 2006.01).

### **Sulfur Levels in Gasoline**

The *LDV Emissions program* required that most refiners and importers meet a corporate average gasoline sulfur standard of 120 ppm and a cap of 300 ppm beginning in 2004. Since 2006, the average standard was reduced to 30 ppm with an 80 ppm sulfur cap. Temporary, less stringent standards applied to some small refiners through 2007. In addition, temporary, less stringent standards applied to a limited geographic area in the western USA for the 2004-2006 period.

## Diesel

Since 2004, the ASTM D975 standard has covered seven grades of diesel. Heavier fuel oils Grade 5 and 6 (residual), which are used primarily for heating purposes, are described by ASTM D396.

Diesel Fuel Grades		
Grade	Description	Sulfur Content (max, ppm)
No. 1-D S15	A special-purpose, light middle distillate fuel for use in diesel engine applications with frequent and widely varying speeds and loads or when abnormally low operating temperatures are encountered. Higher volatility than that provided by No. 2-D fuels.	15
No. 1-D S500		500
No. 1-D S5000		5000
No. 2-D S15	A general-purpose, middle distillate fuel for use in diesel engines, especially in applications with relatively high loads and uniform speeds, or in diesel engines not requiring fuels having higher volatility or other properties specified in Grade No. 1-D fuels.	15
No. 2-D S500		500
No. 2-D S5000		5000
No. 4-D	A heavy distillate fuel, or a blend of distillate and residual oil, for low- and medium-speed diesel engines in applications involving predominantly constant speed and load.	

The Sxxx designation was first adopted in the D975-04 edition of the standard to distinguish grades by sulfur content. The S5000 grades correspond to the "regular" sulfur grades, the previous No. 1-D and No. 2-D. S500 grades correspond to the

previous "Low Sulfur Diesel" grades (D975-03). S15 grades are commonly referred to as "Ultra-Low Sulfur Diesel" grades or ULSD.

An ASTM standard (D2069) once existed for marine diesel fuels, but it has been withdrawn. It was technically equivalent to ISO 8217. While some marine diesel engines use No. 2 distillate, D2069 covered four kinds of marine distillate fuels: DMX, DMA, DMB, and DMC and residual fuels (see also International: Fuels: ISO Petroleum Marine Fuels):

- *DMX* is a special light distillate intended mainly for use in emergency engines.
- *DMA* (also called marine gas oil, MGO) is a general purpose marine distillate that must be free from traces of residual fuel. DMX and DMA fuels are primarily used in Category 1 marine engines (< 5 liters per cylinder).
- *DMB* (marine diesel oil, MDO) is allowed to have traces of residual fuel, which can be high in sulfur. This contamination with residual fuel usually occurs in the distribution process, when using the same supply means (e.g., pipelines, supply vessels) that are used for residual fuel. DMB is produced when fuels such as DMA are brought on board the vessel in this manner. DMB is typically used for Category 2 (5-30 liters per cylinder) and Category 3 ( $\geq 30$  liters per cylinder) engines.

- *DMC* is a grade that may contain residual fuel, and is often a residual fuel blend. It is similar to No. 4-D, and can be used in Category 2 and Category 3 marine diesel engines.
- Residual (non-distillate) fuels are designated by the prefix RM (e.g., RMA, RMB, etc.). These fuels are also identified by their nominal viscosity (e.g., RMA10, RMG35, etc.).

With the growing importance of alternative diesel fuels, standards have also been developed for biodiesel fuels and their blends.

## **Gasoline**

There are multiple programs that set gasoline standards:

- Tier 3 Gasoline Sulfur
- Tier 2 Gasoline Sulfur
  - The Tier 2 program regulations were set in 2000 and are located in 40 CFR 80 subpart H
  - Final rule
- Mobile Source Air Toxics (MSAT)
- Reformulated gasoline (RFG)
- Volatility/Reid Vapor Pressure (RVP)
- Winter Oxygenated Fuel Program

Some selected current gasoline parameter are presented as follows:

<b>Per gallon and average requirements for gasoline</b>				
<b>Property or Performance Requirement</b>	<b>Reformulated Gasoline (RFG)<sup>1</sup></b>		<b>Other Gasoline</b>	
	<i>Per Gallon</i>	<i>Average</i>	<i>Per Gallon</i>	<i>Average</i>
Lead	Non-detectable	-	Non-detectable	-
Sulfur, ppm, max	80 max	30	80	30
Volatility (summer RVP)	Approximately 7.0 psi (48 kPa)	-	7.8-9 psi (54-62 kPa)	-
Aromatics	25%	-	25%	-
Benzene	1.3 vol.%	0.95 vol.%	-	-
Other heavy metals (e.f., manganese)	Non-detectable	-	-	-
RFG and anti-dumping <sup>2</sup>	Reduce VOCs and air toxics by 25-30% (compared with 1990 gasoline quality)	Reduce VOCs and air toxics by 25-30% (compared with 1990 gasoline quality)	-	Fuel not dirtier than 1990 gasoline quality
Mobile Source Air Toxics (MSAT 1)	-	Reduce air toxics by 330,000 tons by 2030	-	Reduce air toxics by 330,000 tons by 2030
MSAT 2	Benzene: 1.3 vol.%	0.62 vol.% on average	No cap but refinery/importer annual average cannot exceed 1.3 vol.% before use of credits	0.62 vol.% average

1. RFG is a cleaner burning gasoline blend required in certain regions that do not meet air quality standards for ozone.

2. Sec. 211 of the Clean Air Act specifies a backstop limit on NO<sub>x</sub>, requiring that NO<sub>x</sub> emissions from a baseline vehicle using non-RFG shall not exceed the level from the baseline vehicle using the baseline gasoline in 1990. EPA no longer enforces the NO<sub>x</sub> standard, since compliance with the low sulfur levels in gasoline (30 ppm average and 80 ppm per-gallon cap) assures compliance with the old NO<sub>x</sub> standards. Starting in 2011, EPA will begin to phase out the toxics standards as well. These will be replaced by a benzene standard (annual average of 0.62 volume percent).

The Tier 3 light-duty vehicle emissions rule requires a reduction in sulfur content in gasoline, from the current 30-ppm average to 10-ppm average, effective January 1, 2017.

The sulfur limits at the refinery gate and downstream are unchanged from Tier 2, with maximum of:

- 80 ppm for the refinery gate
- 95 ppm for downstream

The rule also requires that oxygenates, such as denatured fuel ethanol, are compatible with the Tier 3 sulfur requirements.

### Tier 2 and Tier 3 Gasoline Sulfur Standards

Standard	Refinery annual average standard	Refinery gate per gallon cap	Downstream per gallon cap
Tier 2	30 ppm	80 ppm	95 ppm
Tier 3	10 ppm <sup>a</sup>	80 ppm	95 ppm

<sup>a</sup> Effective Jan 1<sup>st</sup>, 2017 for most refiners and January 1<sup>st</sup>, 2020 for eligible small refiners and small volume refineries

Source:

[http://transportpolicy.net/index.php?title=US:\\_Fuels:\\_Diesel\\_and\\_Gasoline](http://transportpolicy.net/index.php?title=US:_Fuels:_Diesel_and_Gasoline)