



SURFACE VEHICLE STANDARD

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(R) Diesel Fuels

RATIONALE

Diesel fuel accounts for approximately 20% of all crude oil consumed in the U.S. The oil, automobile, and fuel additive industries have worked together for many decades to determine the composition and properties of diesel fuels required to provide satisfactory vehicle operation. This work is ongoing. Since the late 1960s, environmental concerns have led to federal and state regulations to reduce emissions from vehicles and from petroleum storage and transportation facilities.

This SAE Surface Vehicle Standard discusses the characteristics of diesel fuels, common Standard Test Methods, specifications developed by ASTM International and others, government regulations, and the effects of diesel fuel composition and properties on vehicle performance, fuel economy, emissions, and durability. This historical document provides useful information for the proper and safe use of diesel fuel and is not intended to be a product specification.

1. SCOPE

Automotive and locomotive diesel fuels, in general, are derived from petroleum refinery products which are commonly referred to as middle distillates. Middle distillates represent products which have a higher boiling range than gasoline and are obtained from fractional distillation of the crude oil or from streams from other refining processes. Finished diesel fuels represent blends of middle distillates and may contain other blending components of substantially non-petroleum origin, such as biodiesel fuel blend stock, and/or middle distillates from non-traditional refining processes, such as gas-to-liquid processes.

The properties of commercial distillate diesel fuels depend on the refinery practices employed and the nature of the crude oils from which they are derived. Thus, they may differ both with and within the region in which they are manufactured. Such fuels generally boil, at atmospheric pressure, over a range between 130 °C and 400 °C (approximately 270 °F to 750 °F). Their makeup can represent various combinations of volatility, ignition quality, viscosity, sulfur level, density, and other characteristics. Additives may be used to impart specific properties to the finished diesel fuel.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this surface vehicle standard to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

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2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J183 Engine Oil Performance and Engine Service Classification (Other than “Energy Conserving”)

SAE J304 Engine Oil Tests

SAE J1498 Heating Value of Fuels

SAE J3050 Biodiesel in Automotive Application; Lessons Learned

2.1.2 ASTM International Publications¹

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D86 Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

ASTM D93 Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

ASTM D97 Standard Test Method for Pour Point of Petroleum Products

ASTM D129 Standard Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)

ASTM D130 Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

ASTM D240 Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter

ASTM D287 Standard Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

ASTM D445 Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

ASTM D482 Standard Test Method for Ash from Petroleum Products

ASTM D524 Standard Test Method for Ramsbottom Carbon Residue of Petroleum Products

ASTM D611 Standard Test Methods for Aniline Point and Mixed Aniline Point of Petroleum Products and Hydrocarbon Solvents

ASTM D613 Standard Test Method for Cetane Number of Diesel Fuel Oil

ASTM D665 Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water

ASTM D975 Standard Specification for Diesel Fuel Oils

ASTM D976 Standard Test Method for Calculated Cetane Index of Distillate Fuels

ASTM D1266 Standard Test Method for Sulfur in Petroleum Products (Lamp Method)

ASTM D1298 Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

¹ References to ASTM standards in this report are all to be construed as to the most recent ASTM publications.

ASTM D1319	Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
ASTM D1405	Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
ASTM D1552	Standard Test Method for Sulfur in Petroleum Products by High Temperature Combustion and IR Detection
ASTM D1796	Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
ASTM D2068	Standard Test Method for Determining Filter Blocking Tendency
ASTM D2274	Standard Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)
ASTM D2500	Standard Test Method for Cloud Point of Petroleum and Liquid Fuels
ASTM D2622	Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
ASTM D2624	Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
ASTM D2709	Standard Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge
ASTM D2887	Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
ASTM D3120	Standard Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
ASTM D3338	Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
ASTM D3828	Standard Test Methods for Flash Point by Small Scale Closed Cup Tester
ASTM D4052	Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
ASTM D4057	Standard Practice for Manual Sampling of Petroleum and Petroleum Products
ASTM D4177	Standard Practice for Automatic Sampling of Petroleum and Petroleum Products
ASTM D4294	Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
ASTM D4306	Standard Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
ASTM D4308	Standard Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter
ASTM D4530	Standard Test Method for Determination of Carbon Residue (Micro Method)
ASTM D4539	Standard Test Method for Filterability of Diesel Fuels by Low Temperature Flow Test (LTFT)
ASTM D4629	Standard Test Method for Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection
ASTM D4737	Standard Test Method for Calculated Cetane Index by Four Variable Equation
ASTM D4809	Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
ASTM D4865	Standard Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems

ASTM D5186	Standard Test Method for Determination of the Aromatic Content and Polynuclear Aromatic Content of Diesel Fuels and Aviation Turbine Fuels By Supercritical Fluid Chromatography
ASTM D5304	Standard Test Method for Assessing Middle Distillate Fuel Storage Stability by Oxygen Overpressure
ASTM D5453	Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
ASTM D5771	Standard Test Method for Cloud Point of Petroleum Products (Optical Detection Stepped Cooling Method)
ASTM D5772	Standard Test Method for Cloud Point of Petroleum Products (Linear Cooling Rate Method)
ASTM D5773	Standard Test Method for Cloud Point of Petroleum Products (Constant Cooling Rate Method)
ASTM D5842	Standard Practice for Sampling and Handling of Fuels for Volatility Measurement
ASTM D5854	Standard Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
ASTM D5950	Standard Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)
ASTM D5985	Standard Test Method for Pour Point of Petroleum Products (Rotational Method)
ASTM D6078	Standard Test Method for Evaluating Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator (SLBOCLE)
ASTM D6079	Standard Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR)
ASTM D6217	Standard Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration
ASTM D6258	Standard Test Method for Determination of Solvent Red 164 Dye Concentration in Diesel Fuels
ASTM D6304	Standard Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
ASTM D6371	Standard Test Method for Cold Filter Plugging Point of Diesel and Heating Fuels
ASTM D6426	Standard Test Method for Determining Filterability of Distillate Fuel Oils
ASTM D6468	Standard Test Method for High Temperature Stability of Distillate Fuels
ASTM D6469	Standard Guide for Microbial Contamination in Fuels and Fuel Systems
ASTM D6749	Standard Test Method for Pour Point of Petroleum Products (Automatic Air Pressure Method)
ASTM D6751	Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels
ASTM D6756	Standard Test Method for Determination of the Red Dye Concentration and Estimation of the ASTM Color of Diesel Fuel and Heating Oil Using a Portable Visible Spectrophotometer
ASTM D6890	Standard Test Method for the Determination of Ignition Delay and Derived Cetane Number (DCN) of Diesel Fuel Oils by Combustion in a Constant Volume Chamber
ASTM D6892	Standard Test Method for Pour Point of Petroleum Products (Robotic Tilt Method)
ASTM D6898	Standard Test Method for Evaluating Diesel Fuel Lubricity by an Injection Pump Rig

ASTM D6974	Standard Practice for Enumeration of Viable Bacteria and Fungi in Liquid Fuels—Filtration and Culture Procedures
ASTM D7039	Standard Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry
ASTM D7042	Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
ASTM D7094	Standard Test Method for Flash Point by Modified Continuously Closed Cup (MCCCFP) Tester
ASTM D7170	Standard Test Method for Determination of Derived Cetane Number (DCN) of Diesel Fuel Oils—Fixed Range Injection Period, Constant Volume Combustion Chamber Method
ASTMD7220	Standard Test Method for Sulfur in Automotive, Heating, and Jet Fuels by Monochromatic Energy Dispersive X-ray Fluorescence Spectrometry
ASTM D7261	Standard Test Method for Determining Water Separation Characteristics of Diesel Fuels by Portable Separometer
ASTM D7321	Standard Test Method for Particulate Contamination of Biodiesel B100 Blend Stock Biodiesel Esters and Biodiesel Blends by Laboratory Filtration
ASTM D7345	Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)
ASTM D7371	Standard Test Method for Determination of Biodiesel (Fatty Acid Methyl Esters) Content in Diesel Fuel Oil Using Mid Infrared Spectroscopy (FTIR-ATR-PLS Method)
ASTM D7451	Standard Test Method for Water Separation Properties of Light and Middle Distillate, and Compression and Spark Ignition Fuels
ASTM D7463	Standard Test Method for Adenosine Triphosphate (ATP) Content of Microorganisms in Fuel, Fuel/Water Mixtures, and Fuel Associated Water
ASTM D7464	Standard Practice for Manual Sampling of Liquid Fuels, Associated Materials and Fuel System Components for Microbiological Testing
ASTM D7467	Standard Specification for Diesel Fuel Oil, Biodiesel Blend (B6 to B20)
ASTM D7545	Standard Test Method for Oxidation Stability of Middle Distillate Fuels—Rapid Small Scale Oxidation Test (RSSOT)
ASTM D7548	Standard Test Method for Determination of Accelerated Iron Corrosion in Petroleum Products
ASTM D7619	Standard Test Method for Sizing and Counting Particles in Light and Middle Distillate Fuels, by Automatic Particle Counter
ASTMD7668	Standard Test Method for Determination of Derived Cetane Number (DCN) of Diesel Fuel Oils—Ignition Delay and Combustion Delay Using a Constant Volume Combustion Chamber Method
ASTM D7687	Standard Test Method for Measurement of Cellular Adenosine Triphosphate in Fuel, Fuel/Water Mixtures, and Fuel-Associated Water with Sample Concentration by Filtration
ASTMD7688	Standard Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR) by Visual Observation
ASTM D7777	Standard Test Method for Density, Relative Density, or API Gravity of Liquid Petroleum by Portable Digital Density Meter

- ASTM D7806 Standard Test Method for Determination of the Fatty Acid Methyl Ester (FAME) Content of a Blend of Biodiesel and Petroleum-Based Diesel Fuel Oil Using Mid-Infrared Spectroscopy
Status: Review for Ballot
- ASTM D7861 Standard Test Method for Determination of Fatty Acid Methyl Esters (FAME) in Diesel Fuel by Linear Variable Filter (LVF) Array Based Mid-Infrared Spectroscopy
- ASTM D7963 Standard Test Method for Determination of Contamination Level of Fatty Acid Methyl Esters in Middle Distillate and Residual Fuels Using Flow Analysis by Fourier Transform Infrared Spectroscopy—Rapid Screening Method
- ASTM D7978 Standard Test Method for Determination of the Viable Aerobic Microbial Content of Fuels and Associated Water—Thixotropic Gel Culture Method

2.1.3 American Petroleum Institute (API) Publications

Available from API Publishing Services, 1220 L Street, NW, Washington, DC 20005; Tel; www.api.com.

- RP 2003 Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents

2.1.4 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

- ISO 12156-1 Diesel fuel — Assessment of lubricity using the high-frequency reciprocating rig (HFRR) — Part 1: Test method

- ISO 12156-2 Diesel fuel — Assessment of lubricity using the high-frequency reciprocating rig (HFRR) — Part 2: Limit

2.1.5 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

Miscellaneous Publication No. 97, 1929 Thermal Properties of Petroleum Products

2.1.6 U.S. Department of Defense Publications

Available from ASSIST Quick Search <http://quicksearch.dla.mil/>.

- A-A-59693 Diesel Fuel, Biodiesel Blend (B20) [cancelled in 2015] Other Publications (Previous versions may contain earlier historical diesel documents)

2.1.7 Other Publications

1. U.S. Clean Air Act (1970)
2. Federal Register, March 5, 1980
3. Federal Register, March 15, 1985
4. U.S. Clean Air Act Amendments 1990
5. Government of Canada Gazette
6. CRC Report No. E-84, REVIEW OF PRIOR STUDIES OF FUEL EFFECTS ON VEHICLE EMISSIONS, August 2008

7. Stockholm Club Emissions - Impact on European Truck Engines. H. D. Freeman - Ricardo Consulting Engineers Autotech 89
8. Worldwide Developments in Motor Vehicle Diesel Particulate Control. Michael P. Walsh, SAE 890168
9. Fuel Effects and Heavy Duty Diesel Particulate Control. J. C. Wall & S. K. Hoekman, SAE 841364
10. Recommended Federal on Highway Diesel Fuel Specifications to Assist Engine Manufacturers Meet 1991 and 1994 Particulate Standards Joint API/EMA/NPRA/NCFC Report, July 19, 1988
11. Federal Register, August 21, 1990
12. Investigation of the Effects of Fuel Composition and Injection and Combustion System Type on Heavy Duty Diesel Exhaust Emissions. Report from CRC VE-1 Project by Terry Ullman, March 1989
13. Study of Fuel Cetane Number and Aromatic Content Effects on Regulated Emissions from a Heavy-Duty Diesel Engine. Report from CRC VE-1 Project by Terry Ullman, Robert Mason and Daniel Montalvo, September 1990
14. Gasoline and Diesel Fuel Qualification—a National Need, K. J. Springer, ASME Paper 90-ICE-19
15. Letter from EMA Fuels and Lubricants Committee to SAE Technical Committee 7-Fuels dated February 25, 1991
16. World-Wide Fuel Charter, Fifth Edition, September 2013, Alliance of Automobile Manufacturers 803 7th Street, N.W., Suite 300, Washington D.C., 20001 or Truck and Engine Manufacturers Association, 333 West Wacker Drive, Suite 810, Chicago, IL 60606

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 General Properties

1. Annual Book of ASTM Standards, "Petroleum Products, Lubricants, and Fossil Fuels," Volumes 05.01, 05.02, 05.03, and 05.04.
2. "Significance of Tests for Petroleum Products," ASTM Special Technical Publication Manual MNL 1 Seventh Edition (2003).
3. "Manual on Hydrocarbon Analysis," ASTM Special Technical Publication 332-A (1977).
4. Hultkrans, H., "Role of Fuel Properties in Diesel Fleet Economy," SAE Technical Paper 650429, 1965, doi:10.4271/650429.
5. Ingham, M., Bert, J., and Painter, L., "Improved Predictive Equations for Cetane Number," SAE Technical Paper 860250, 1986, doi:10.4271/860250.
6. Mikkonen, S. and Tenhunen, E., "Deposits in Diesel Fuel-Injection Pumps Caused by Incompatibility of Fuel and Oil Additives," SAE Technical Paper 872119, 1987, doi:10.4271/872119.
7. J. Davenport, R. Caprotti, and H. D. Cochrane, "Background, Development, and Validation of a Bench Test for Compatibility Between Diesel Fuel and Lubricating Oil," Esslingen Symposium (1991).
8. P. Richards, "Automotive Fuels Reference Book," Third Edition, SAE, 2014, ISBN 978-0-7680-0638-4. Chapter 16, Diesel Engine Design and Influence of Fuel Characteristics, pp. 445 – 492.

9. G. E. Totten (ed), "Fuels and Lubricants Handbook: Technology, Properties, Performance and Testing," ASTM International, 2003, Chapter 5 – Automotive Diesel and Non-Aviation Gas Turbine Fuels, pp. 115-144.
10. K. Owen and T. Coley, "Automotive Fuels Reference Book," Second Edition, SAE, 1995, ISBN 1-56091-589-7. Chapters 14 to 18, pp. 331-527.

2.2.2 Cold Weather Operation

1. McMillan, M. and Barry, E., "Fuel and Vehicle Effects On Low-Temperature Operation Of Diesel Vehicles – The 1981 CRC Field Test," SAE Technical Paper 830594, 1983, doi:10.4271/830594.
2. Steere, D. and Marino, J., "Low Temperature Field Performance of Flow Improved Diesel Fuels," SAE Technical Paper 810024, 1981, doi:10.4271/810024.
3. Fenstermaker, R. and Riley, R., "Additives for Improving the Low-Temperature Filterability of Diesel Fuel Oils," SAE Technical Paper 841350, 1984, doi:10.4271/841350.
4. Reddy, S., "Increasing the Responsiveness of No. 2-D Diesel Fuels to Flow Improvers by Blending with Low Wax Diluents," SAE Technical Paper 841351, 1984, doi:10.4271/841351.
5. Zielinski, J. and Rossi, F., "Wax and Flow in Diesel Fuels," SAE Technical Paper 841352, 1984, doi:10.4271/841352.
6. Mitchell, K., "The Cold Performance of Diesel Engines," SAE Technical Paper 932768, 1993, doi:10.4271/932768.
7. P. Richards, "Automotive Fuels Reference Book," Third Edition, ISBN 978-0-7680-0638-4. Chapter 17, Diesel Fuel Low-Temperature Characteristics, pp. 493 – 534.
8. Jääskeläinen, Hannu, "Fuel Property Testing: Low Temperature Operability" located at https://www.dieselnet.com/tech/fuel_diesel_lowtemp.php
9. Jääskeläinen, Hannu, "Low Temperature Operability of Biodiesel" located at https://www.dieselnet.com/tech/fuel_biodiesel_lowtemp.php

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2. Burley, H. and Rosebrock, T., "Automotive Diesel Engines-Fuel Composition vs Particulates," SAE Technical Paper 790923, 1979, doi:10.4271/790923.
3. Ryan, T., Stormont, J., Wright, B., and Waytulonis, R., "The Effects of Fuel Properties and Composition on Diesel Engine Exhaust Emissions - A Review," SAE Technical Paper 810953, 1981, doi:10.4271/810953.
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13. Manuch Nikanjam, et al., "Diesel Fuel Lubricity," 8th Annual Fuels & Lubes Asia Conference and Exhibition, February 2002.
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15. Mozdzen, E., Wall, S., and Byfleet, W., "The No-Harm Performance of Lubricity Additives for Low Sulphur Diesel Fuels," SAE Technical Paper 982571, 1998, doi:10.4271/982571.
16. Caprotti, R., "Harm Free Use of Diesel Additives," SAE Technical Paper 982569, 1998, doi:10.4271/982569.

3. CLASSIFICATION OF DIESEL FUEL OILS, ASTM D975

ASTM D975, which includes seven grades of fuel (Grades No. 1-D S15, No. 1-D S500, No. 1-D S5000, No. 2-D S15, No. 2-D S500, No. 2-D S5000, and 4-D), is intended as a statement of permissible limits of significant fuel properties used for classifying the wide variety of commercially available diesel fuels, in accordance with their service application. The "S#" designation refers to the maximum allowable level of sulfur in that grade: 15 mg/kg (S15), 500 mg/kg (S500), or 5000 mg/kg (S5000). ASTM D975 grades No. 1-D (all sulfur contents) and No. 2-D (all sulfur contents) may contain up to 5 volume percent biodiesel. The classification chart contained in ASTM D975 is shown here as Table 1. European diesel fuel requirements containing up to 7% FAME (fatty acid methyl ester) are shown in Table 2.

National Survey of Diesel Fuels

Since the properties of diesel fuels can vary widely, surveys were conducted annually to provide data on the properties of fuels produced in the United States. In one survey, conducted annually, laboratory inspection data on diesel fuels was furnished voluntarily by the refiners. The results were tabulated per five general regions of the country where the fuels were marketed. The average values reported were arithmetic, and were not weighed per sales volume. These results have been compiled and published as Bureau of Mines reports from 1950 to 1974, U.S. Energy Research and Development Administration reports for 1975 and 1976, U.S. Department of Energy reports from 1977 to 1982, and National Institute for Petroleum and Energy Research reports from 1983 to 1992. TRW Petroleum Technologies ran the surveys from 1993-2002 and Northrup Grumman compiled and published the survey reports until 2008.

Before 1957, the data were tabulated in these reports per ASTM grade. From 1957 to 1982, they were tabulated per intended service type as follows:

- Type C-B - Diesel fuel oils for city-bus and similar operations
- Type T-T - Fuels for diesel engines in trucks, tractors, and similar service
- Type R-R - Fuels for railroad diesel engines
- Type S-M - Heavy-distillate and residual fuels for large stationary and marine diesel engines

Fuels that met the requirements for ASTM D975, Grade No. 1-D or 2-D (see Table 1) were so indicated in these reports.

Since 1983, the data have been tabulated per ASTM D975 Grade No. 1-D or 2-D, and the intended service types (listed previously) have been so indicated. Beginning in 1995 the on-highway (low sulfur) Grade No. 1-D and Grade No. 2-D diesel fuels were reported separately.

The Alliance of Automobile Manufacturers conducts winter and summer surveys of diesel fuel quality in the U.S., and to a limited extent in Canada and Mexico. Fuel samples from 19 U.S. cities, five Canadian cities, and seven Mexican cities are collected and analyzed by an independent laboratory. This survey is available from the Alliance of Automobile Manufacturers (<http://www.autoalliance.org/>).

Table 1 - Detailed requirements for diesel fuel oils ^{(1),(2),(3)} (ASTM D975-15c)

	No. 1-D S15	No. 1-D S500	No. 1-D S5000	No. 2-D S15	No. 2-D S500	No. 2-D S5000	No. 4-D
Flash Point, °C, min	38	38	38	52	52	52	55
Water and Sediment, volume %, max	0.05	0.05	0.05	0.05	0.05	0.05	0.50
Carbon Residue, 10% Residuuum, % mass, max	0.15	0.15	0.15	0.35	0.35	0.35	---
Ash, % mass, max	0.01	0.01	0.01	0.01	0.01	0.01	0.10
Distillation Temperature °C, 90% vol. recovered, min	---	---	---	282	282	282	---
Distillation Temperature °C, 90% vol. recovered, max	288	288	288	338	338	338	---
Kinematic Viscosity, mm ² /s ⁽⁴⁾ , at 40 °C, min	1.3	1.3	1.3	1.9	1.9	1.9	5.5
Kinematic Viscosity, mm ² /s ⁽⁴⁾ , at 40 °C, max	2.4	2.4	2.4	4.1	4.1	4.1	24.0
Sulfur ⁽⁵⁾ , % mass, max	0.0015	0.05	0.50	0.0015	0.05	0.50	2.00
Copper Strip Corrosion, rating, max	No. 3	No. 3	No. 3	No. 3	No. 3	No. 3	---
Cetane Number ⁽⁶⁾ , min	40 ⁽⁹⁾	40 ⁽⁹⁾	40 ⁽⁹⁾	40 ⁽⁹⁾	40 ⁽⁹⁾	40 ⁽⁹⁾	30 ⁽⁸⁾
Cloud Point, °C, or LTFT/CFPP, °C, max	⁽⁷⁾	⁽⁷⁾	⁽⁷⁾	⁽⁷⁾	⁽⁷⁾	⁽⁷⁾	
Lubricity, HFRR @ 60 °C, micron, max	520	520	520	520	520	520	---
Conductivity, pS/m, min	25 ⁽¹²⁾	25 ⁽¹²⁾	25 ⁽¹²⁾	25 ⁽¹²⁾	25 ⁽¹²⁾	25 ⁽¹²⁾	---

⁽¹⁾ To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller, and manufacturer.

⁽²⁾ The values in SI units are to be regarded as the standard. The values of U.S. customary units are for information only.

⁽³⁾ Nothing in this specification shall preclude observance of federal, state, or local regulations which may be more restrictive.

⁽⁴⁾ Millimeter squared per second Note: 1 centiStokes (cSt) = 1 mm²/s).

⁽⁵⁾ In countries outside the USA, other sulfur limits may apply.

⁽⁶⁾ Where cetane number by Method D613 is not available, Method D4737 may be used as an approximation. Where there is disagreement, Method D613 shall be the referee method.

- (7) It is unrealistic to specify low-temperature properties that will ensure satisfactory operation on a broad basis. The tenth percentile minimum ambient temperatures for the months of October, November, December, January, February, and March are given in ASTM D975 in maps for the 48 contiguous states and Alaska. This guidance is of a general nature; some equipment designs, use of flow improver additives, fuel properties, and/or operations may allow higher or require lower cloud point fuels. Appropriate low temperature operability properties should be agreed on between the fuel supplier and purchaser for the intended use and expected ambient temperatures. In general, cloud point (or wax appearance point) Low Temperature Flow Test, and Cold Filter Plugging Point Test may be used as an estimate of operating temperature limits for Grades No. 1-D and No. 2-D diesel fuel oils. Test Methods D4539 and D6371 may be especially useful to estimate vehicle low temperature operability limits when flow improvers are used. Due to fuel delivery system, engine design, and test method differences, low temperature operability tests may not provide the same degree of protection in various vehicle operating classes.
- (8) Low atmospheric temperatures as well as engine operation at high altitudes may require use of fuels with higher cetane ratings.
- (9) EPA requires minimum 40 Cetane Index (ASTM D976-80) or 35% vol maximum aromatics content (ASTM D1319).
- (10) When cloud point less than -12°C (10°F) is specified, as can occur during cold months, it is permitted and normal blending practice to combine Grades No. 1-D and No. 2-D to meet the low temperature requirements. In that case, the minimum flash point shall be 38°C (100°F), the minimum viscosity shall be 1.7 cSt, and the minimum 90% recovered temperature shall be waived.
- (11) Under United States regulations, if Grades No. 1-D S500 or No. 2-D S500 are sold for tax exempt purposes then, at or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to 3.9 lb per thousand barrels of the solid dye standard Solvent Red 26, or the tax must be collected.
- (12) The electrical conductivity of the diesel fuel is measured at the time and temperature of the fuel at delivery. The 25 pS/m minimum conductivity requirement applies at all instances of high velocity transfer (7 m/s), but sometimes lower velocities into mobile transport (for example, tanker trucks, rail cars, and barges). To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller, and manufacturer.

Table 2 - European requirements – 7% fame

EN 590:2013

European specifications are often followed or used as guidance outside US and Canada:

Asia, Africa, CIS countries, parts of Latin America, Australia

Property	Unit	Min	Max
Cetane number		51.0	
Cetane Index		46.0	
Density @ 15°C	kg/m ³	820.0	845.0
Polycyclic aromatic hydrocarbons	%m/m	-	8.0
Sulfur content	mg/kg		10.0
Flash point	°C	Above 55	-
Carbon residue (on 10 % distillation residue)	% (m/m)	-	0,30
Ash content	% (m/m)	-	0.010
Water content	mg/kg	-	200
Total contamination	mg/kg	-	24
Copper strip corrosion (3 h at 50 °C)	Rating	Class 1	
Fatty acid methyl ester (FAME) content	% (V/V)	-	7.0
Oxidation stability EN ISO 12205 (ASTM D2274) EN 15751 Rancimat	g/m ³ h	- 20	25 -
Lubricity, corrected wear scar diameter (wsd 1,4)at 60 °C	Mm	-	460
Viscosity at 40 °C	mm ² /s	2.00	4.50
Distillation % (V/V) recovered at 250 °C % (V/V) recovered at 350 °C 95 % (V/V) recovered at	% (V/V) % (V/V) °C	85	< 65 360