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Standard Specification for Performance of Active API Service Category Engine Oils[1]

This standard is issued under the fixed designation D4485; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This specification covers all the currently active American Petroleum Institute (API) engine oil performance categories that have been defined in accordance with the ASTM consensus process. There are organizations with specifications not subject to the ASTM consensus process, such as the International Lubricant Standardization and Approval Committee (ILSAC), American Petroleum Institute (API – SM, SN SP Specifications), and the Association des Constructeurs Europeans d'Automobiles (ACEA). Certain of these specifications, which have been defined primarily by the use of current ASTM test methods, have also been included in the Appendixes for information.

In the ASTM system, a specific API designation is assigned to each category. The system is open-ended, that is, new designations are assigned for use with new categories as each new set of oil performance characteristics are defined. Oil categories may be referenced by engine builders in making lubricant recommendations, and used by lubricant suppliers and customers in identifying products for specific applications. Where applicable, candidate oil programs are conducted in accordance with the American Chemistry Council (ACC) Petroleum Additives Product Approval Code of Practice.

Other service categories not shown in this document have historically been used to describe engine oil performance (SA, SB, SC, SD, SE, SF, SG, SH and CA, CB, CC, CD, CD-II, CE, CF, CF-2, CF-4, CG-4) (see 3.1.2). SA is not included because it does not have specified engine performance requirements. SH is not included because it was a category that could not be licensed for gasoline engine oil use in the API Service Symbol after Dec. 2, 2010. ~~(Note—The SH category has been included in Appendix X10 as relevant information in combination with "C" categories.)~~ The others are not included because they are based on test methods for which engine parts, test fuel, or reference oils, or a combination thereof, are no longer available. Also, the ASTM 5-Car and Sequence VI Procedures are obsolete and have been deleted from the category Energy Conserving and Energy Conserving II (defined by Sequence VI). Information on excluded older categories and obsolete test requirements can be found in SAE J183.

1. Scope*

1.1 This specification covers engine oils for light-duty and heavy-duty internal combustion engines used under a variety of operating conditions in automobiles, trucks, vans, buses, and off-highway farm, industrial, and construction equipment.[2]

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.B0 on Automotive Lubricants.

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[2] Until the next revision of this specification, the ASTM Test Monitoring Center will update changes in specification by means of information letters. Information letters may be obtained from the ASTM Test Monitoring Center, ~~6555 Penn Avenue, Pittsburgh, PA 15206-4489, www.astmtmc.cmu.edu.~~203 Armstrong Drive, Freeport, PA 16229, www.astmtmc.org. This edition incorporates revisions in all information letters through No. ~~20-7.~~22-1.

***A Summary of Changes section appears at the end of this standard**

1.2 This specification is not intended to cover engine oil applications such as outboard motors, snowmobiles, lawn mowers, motorcycles, railroad locomotives, or oceangoing vessels.

1.3 This specification is based on engine test results that generally have been correlated with results obtained on reference oils in actual service engines operating with gasoline or diesel fuel. As it pertains to the API SL engine oil category, it is based on engine test results that generally have been correlated with results obtained on reference oils run in gasoline engine Sequence Tests that defined engine oil categories prior to 2000. It should be recognized that not all aspects of engine oil performance are evaluated by the engine tests in this specification. In addition, when assessing oil performance, it is desirable that the oil be evaluated under actual operating conditions.

1.4 This specification includes bench and chemical tests that help evaluate some aspects of engine oil performance not covered by the engine tests in this specification.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5.1 *Exceptions:*

1.5.1.1 The roller follower shaft wear in Test Method D5966 is in mils.

1.5.1.2 The oil consumption in Test Method D6750 is in grams per kilowatthour.

NOTE 1—The kWh unit is deprecated. The preferred SI unit is the joule (J); 1 kWh = 3.6 MJ.

1.5.1.3 The bearing wear in Test Method D6709 is in grams and is described as weight loss, a non-SI term.

1.5.1.4 Some of the appendixes are verbatim from other sources, and non-SI units are included.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
D412 Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
D471 Test Method for Rubber Property—Effect of Liquids
D874 Test Method for Sulfated Ash from Lubricating Oils and Additives
D892 Test Method for Foaming Characteristics of Lubricating Oils
D2240 Test Method for Rubber Property—Durometer Hardness
D2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D3244 Practice for Utilization of Test Data to Determine Conformance with Specifications
D4171 Specification for Fuel System Icing Inhibitors
D4683 Test Method for Measuring Viscosity of New and Used Engine Oils at High Shear Rate and High Temperature by Tapered Bearing Simulator Viscometer at 150 °C
D4684 Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature
D4741 Test Method for Measuring Viscosity at High Temperature and High Shear Rate by Tapered-Plug Viscometer
D4951 Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D5119 Test Method for Evaluation of Automotive Engine Oils in the CRC L-38 Spark-Ignition Engine (Withdrawn 2003)[4]
D5133 Test Method for Low Temperature, Low Shear Rate, Viscosity/Temperature Dependence of Lubricating Oils Using a Temperature-Scanning Technique
D5185 Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
D5293 Test Method for Apparent Viscosity of Engine Oils and Base Stocks Between –10 °C and –35 °C Using Cold-Cranking Simulator
D5302 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation and Wear in a Spark-Ignition Internal Combustion Engine Fueled with Gasoline and Operated Under Low-Temperature, Light-Duty Conditions (Withdrawn 2003)[4]
D5480 Test Method for Engine Oil Volatility by Gas Chromatography (Withdrawn 2003)[4]
D5481 Test Method for Measuring Apparent Viscosity at High-Temperature and High-Shear Rate by Multicell Capillary Viscometer
D5533 Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIE, Spark-Ignition Engine (Withdrawn 2003)[4]
D5800 Test Method for Evaporation Loss of Lubricating Oils by the Noack Method
D5844 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID) (Withdrawn 2003)[4]
D5966 Test Method for Evaluation of Engine Oils for Roller Follower Wear in Light-Duty Diesel Engine
D5967 Test Method for Evaluation of Diesel Engine Oils in T-8 Diesel Engine
D6082 Test Method for High Temperature Foaming Characteristics of Lubricating Oils
D6202 Test Method for Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light-Duty Trucks in the Sequence VIA Spark Ignition Engine (Withdrawn 2009)[4]
D6278 Test Method for Shear Stability of Polymer Containing Fluids Using a European Diesel Injector Apparatus
D6335 Test Method for Determination of High Temperature Deposits by Thermo-Oxidation Engine Oil Simulation Test
D6417 Test Method for Estimation of Engine Oil Volatility by Capillary Gas Chromatography
D6483 Test Method for Evaluation of Diesel Engine Oils in T-9 Diesel Engine (Withdrawn 2009)[4]
D6557 Test Method for Evaluation of Rust Preventive Characteristics of Automotive Engine Oils
D6593 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation in a Spark-Ignition Internal Combustion Engine Fueled with Gasoline and Operated Under Low-Temperature, Light-Duty Conditions
D6594 Test Method for Evaluation of Corrosiveness of Diesel Engine Oil at 135 °C
D6681 Test Method for Evaluation of Engine Oils in a High Speed, Single-Cylinder Diesel Engine—Caterpillar 1P Test Procedure
D6709 Test Method for Evaluation of Automotive Engine Oils in the Sequence VIII Spark-Ignition Engine (CLR Oil Test Engine)
D6750 Test Methods for Evaluation of Engine Oils in a High-Speed, Single-Cylinder Diesel Engine—1K Procedure (0.4 % Fuel Sulfur) and 1N Procedure (0.04 % Fuel Sulfur)
D6794 Test Method for Measuring the Effect on Filterability of Engine Oils After Treatment with Various Amounts of Water and a Long (6 h) Heating Time
D6795 Test Method for Measuring the Effect on Filterability of Engine Oils After Treatment with Water and Dry Ice and a Short (30 min) Heating Time
D6837 Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIB Spark Ignition Engine (Withdrawn 2022)[4]
D6838 Test Method for Cummins M11 High Soot Test (Withdrawn 2019)[4]
D6891 Test Method for Evaluation of Automotive Engine Oils in the Sequence IVA Spark-Ignition Engine
D6894 Test Method for Evaluation of Aeration Resistance of Engine Oils in Direct-Injected Turbocharged Automotive Diesel Engine (Withdrawn 2022)[4]
D6896 Test Method for Determination of Yield Stress and Apparent Viscosity of Used Engine Oils at Low Temperature
D6922 Test Method for Determination of Homogeneity and Miscibility in Automotive Engine Oils
D6923 Test Method for Evaluation of Engine Oils in a High Speed, Single-Cylinder Diesel Engine—Caterpillar 1R Test Procedure
D6975 Test Method for Cummins M11 EGR Test (Withdrawn 2019)[4]
D6984 Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIF, Spark-Ignition Engine
D6987/D6987M Test Method for Evaluation of Diesel Engine Oils in T-10 Exhaust Gas Recirculation Diesel Engine (Withdrawn 2022)[4]
D7094 Test Method for Flash Point by Modified Continuously Closed Cup (MCCCFP) Tester
D7097 Test Method for Determination of Moderately High Temperature Piston Deposits by Thermo-Oxidation Engine Oil Simulation Test—TEOST MHT

[4] The last approved version of this historical standard is referenced on www.astm.org.

D7109 Test Method for Shear Stability of Polymer-Containing Fluids Using a European Diesel Injector Apparatus at 30 Cycles and 90 Cycles
D7156 Test Method for Evaluation of Diesel Engine Oils in the T-11 Exhaust Gas Recirculation Diesel Engine
D7216 Test Method for Determining Automotive Engine Oil Compatibility with Typical Seal Elastomers
D7320 Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIG, Spark-Ignition Engine
D7422 Test Method for Evaluation of Diesel Engine Oils in T-12 Exhaust Gas Recirculation Diesel Engine
D7468 Test Method for Cummins ISM Test
D7484 Test Method for Evaluation of Automotive Engine Oils for Valve-Train Wear Performance in Cummins ISB Medium-Duty Diesel Engine
D7528 Test Method for Bench Oxidation of Engine Oils by ROBO Apparatus
D7549 Test Method for Evaluation of Heavy-Duty Engine Oils under High Output Conditions—Caterpillar C13 Test Procedure
D7563 Test Method for Evaluation of the Ability of Engine Oil to Emulsify Water and Simulated Ed85 Fuel
D7589 Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VID Spark Ignition Engine
D8047 Test Method for Evaluation of Engine Oil Aeration Resistance in a Caterpillar C13 Direct-Injected Turbocharged Automotive Diesel Engine
D8048 Test Method for Evaluation of Diesel Engine Oils in T-13 Diesel Engine
D8111 Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIH, Spark-Ignition Engine
D8114 Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIE Spark Ignition
~~D8047 Test Method for Evaluation of Engine Oil Aeration Resistance in a Caterpillar C13 Direct-Injected Turbocharged Automotive Diesel Engine~~
~~D8048 Test Method for Evaluation of Diesel Engine Oils in T-13 Diesel Engine~~
D8226 Test Method for Measurement of Effects of Automotive Engine Oils on Fuel Economy of Passenger Cars and Light-Duty Trucks in Sequence VIF Spark Ignition Engine
D8256 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Deposit Formation in the Sequence VH Spark-Ignition Engine Fueled with Gasoline and Operated Under Low-Temperature, Light-Duty Conditions
D8279 Test Method for Determination of Timing-Chain Wear in a Turbocharged, Direct-Injection, Spark-Ignition, Four-Cylinder Engine
D8291 Test Method for Evaluation of Performance of Automotive Engine Oils in the Mitigation of Low-Speed, Preignition in the Sequence IX Gasoline Turbocharged Direct-Injection, Spark-Ignition Engine
D8350 Test Method for Evaluation of Automotive Engine Oils in the Sequence IVB Spark-Ignition Engine
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E178 Practice for Dealing With Outlying Observations

2.2 *Society of Automotive Engineers Standards:*[5]
SAE J183 Engine Oil Performance and Engine Service Classification
SAE J300 Engine Oil Classification
SAE J1423 Passenger Car and Light-Duty Truck Energy-Conserving Engine Oil Classification
SAE J2643 Standard Reference Elastomers (SRE) for Characterizing the Effects on Vulcanized Rubber

2.3 *American Petroleum Institute Publication:*[6]
API 1509 Engine Oil Licensing and Certification System (EOLCS)

2.4 *Government Standard:*[7]
DOD CID A-A-52039A (SAE 5W-30, 10W-30, and 15W-40)

2.5 *American Chemical Council Code:*[8]
ACC Petroleum Additives Product Approval Code of Practice

3. Terminology

3.1 *Definitions:*

3.1.1 *automotive, adj*—descriptive of equipment associated with self-propelled machinery, usually vehicles driven by internal combustion engines.

3.1.2 *category, n—in engine oils*, a designation such as SJ, SL, SM, SN, SP, CH-4, CI-4, CJ-4, CK-4, FA-4, Energy Conserving, Resource Conserving, and so forth, for a given level of performance in specified engine and bench tests.

[5] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096–0001.
[6] Available from American Petroleum Institute (API), 1220 L. St., NW, Washington, DC 20005-4070, http://www.api.org.
[7] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.
[8] Available from American Chemical Council, 1300 Wilson Blvd., Arlington, VA 22209.

3.1.3 *classification, n—in engine oils*, the systematic arrangement into categories in accordance with different levels of performance in specified engine and bench tests.

3.1.4 *heavy duty, adj—in internal combustion engine operation*, characterized by average speeds, power output, and internal temperatures that are generally close to the potential maximums.

3.1.5 *heavy-duty engine, n—in internal combustion engine types*, one that is designed to allow operation continuous at or close to its peak output.

3.1.6 *light-duty, adj—in internal combustion engine operation*, characterized by average speeds, power output, and internal temperatures that are generally much lower than the potential maximums.

3.1.7 *light-duty engine, n—in internal combustion engine types*, one that is designed to be normally operated at substantially less than its peak output.

3.1.7.1 *Discussion—*
This type of engine is typically installed in automobiles and small trucks, vans, and buses.

3.1.8 *lugging, adj—in internal combustion engine operation*, characterized by a combined mode of relatively low-speed and high-power output.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *C category, n*—the group of engine oils that are intended primarily for use in diesel and certain gasoline-powered vehicles.

3.2.2 *Energy Conserving category, n*—the group of engine oils that have demonstrated fuel economy benefits and are intended primarily for use in automotive gasoline engine applications, such as passenger cars, light-duty trucks, and vans.

3.2.3 *engine oil, n*—a lubricating liquid with additives that reduces friction or wear, or both, between the moving parts within an engine; removes heat, serves as a combustion-gas sealant for piston rings; and reduces potentially harmful effects such as rusting, deposit formation, oil oxidation, and foaming resulting from engine operation.

3.2.4 *F category, n*—a group of heavy duty engine oils specified to help meet greenhouse gas (GHG) emission legislation, for example, legislation first introduced on 2017 model year engines.

3.2.5 *S category, n*—the group of engine oils that are intended primarily for use in automotive gasoline engine applications, such as passenger cars, light-duty trucks, and vans.

4. Performance Classification

4.1 Automotive engine oils are classified in three general arrangements, as defined in 3.2; that is, S, C, and Energy Conserving. These arrangements are further divided into categories with performance measured as follows:

4.1.1 *SJ*—Oil meeting the performance requirements measured in the following gasoline engine tests and bench tests:

4.1.1.1 Test Method D5844, the Sequence IID, gasoline engine test has been correlated with vehicles used in short-trip service prior to 1978,[6,9] particularly with regard to rusting. (An alternative is Test Method D6557, the Ball Rust Test.)

4.1.1.2 Test Method D5533, the Sequence IIIE gasoline engine test, has been correlated with vehicles used in high-temperature service prior to 1988,[10] particularly with regard to oil thickening and valve train wear. (Alternatives are Test Method D6984, the Sequence IIIF test, or Test Method D7320, the Sequence IIIG ~~test.)~~test, or Test Method D8111, the Sequence IIIH test using Appendix X5 IIIH70 hour guidelines.)

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1473. Contact ASTM Customer Service at service@astm.org.

[10] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1471. Contact ASTM Customer Service at service@astm.org.

4.1.1.3 Test Method D5302, the Sequence VE gasoline engine test, has been correlated with vehicles used in stop-and-go service prior to 1988,[11] particularly with regard to sludge and valve train wear. (An alternative is the combination of Test Method D6593, the Sequence VG test, and Test Method D6891, the Sequence IVA ~~test.)~~test or the combination of Test Method D8256, the Sequence VH Test and Test Method D6891, the Sequence IVA Test.)

4.1.1.4 Test Method D5119, the L-38 gasoline engine test, is used to measure copper-lead bearing weight loss under high-temperature operating conditions. (An alternative is Test Method D6709, the Sequence VIII test.)

(*1*) Test Method D5119 (or Test Method D6709) is also used to determine the ability of an oil to resist permanent viscosity loss due to shearing in an engine.

4.1.1.5 In addition to passing performance in the engine tests, specific viscosity grades shall also meet bench test requirements (see Table 1), which are discussed in the following subsections:

(1) The volatility of engine oils is one of several factors that relates to engine oil consumption.

(2) Test Method D6795, the EOFT screens for the formation of precipitates and gels that form in the presence of water and can cause oil filter plugging.

(3) Phosphorus compounds in excessive amounts can cause glazing of automotive catalysts and exhaust gas oxygen sensors and, thereby, deactivate them. Control of the phosphorus level in the engine oil may reduce this tendency.

(4) The flash point may indicate if residual solvents and low-boiling fractions remain in the finished oil.

(5) Excessive foaming in engine oil can cause valve lifter collapse and a loss of lubrication due to the presence of air in the oil. Test Methods D892 and D6082 empirically rate the foaming tendency and stability of oils.

(6) Test Method D6922, the H and M Test indicates the compatibility of an oil with standard test oils.

(7) Newer engines designed to provide increased power and improved driveability and to meet future federal emissions and fuel economy requirements may be sensitive to internal deposits caused by elevated engine operating temperatures. Test Method D6335, the TEOST test, may be useful in determining the deposit control of oils recommended for these engines.

(8) Test Method D5133, the Gelation Index technique, might identify oils susceptible to air binding and might provide low temperature protection not adequately measured by the Test Method D4684.

4.1.1.6 Licensing of the API SJ category by the American Petroleum Institute (API) requires that candidate oils meet the performance requirements in this specification, and that the oils be tested in accordance with the protocols described in the ACC Petroleum Additives Product Approval Code of Practice. The methodology detailed in the ACC Code will help ensure that an engine oil meets its intended performance specification. (See Appendix X3 for more information.)

4.1.2 *SL*—Oil meeting the performance requirements measured in the following gasoline engine tests and bench tests:

4.1.2.1 Test Method D6984, the Sequence IIIF gasoline engine test, is used to measure oil thickening and piston deposits under high temperature conditions and provides information about valve train wear.[12] ~~(An alternative is~~ (Alternatives are Test Method D7320, the Sequence IIIG ~~test.)~~test, or Test Method D8111, the Sequence IIIH test using Appendix X5 IIIH70 hour guidelines.)

4.1.2.2 Test Method D6891, the Sequence IVA gasoline engine test, has been correlated with the Sequence VE gasoline engine test in terms of overhead cam and slider follower wear control.[9]

4.1.2.3 Test Method D5302, the Sequence VE gasoline engine test, has been correlated with vehicles used in stop-and-go service prior to 1988, with regard to valve train wear. It is included in the SL performance specification to augment assessment of the wear control performance of oils containing less than 0.08 % mass of phosphorus from ZDDP additive.

NOTE 2—Prior to May 2004, the API SH, SJ, and SL categories required that oils with passing Test Method D6984 (Sequence IIIF) results, and containing less than 0.08 % mass phosphorus in the form of ZDDP, also demonstrate passing performance in Test Method D5302 (Sequence VE). This requirement was included to address concerns over adequate wear protection with low levels of ZDDP. However, Test Method D5302 has not been available to industry for some time, and an alternative method was needed. In a related activity, the next level of gasoline engine oil performance, the ILSAC GF-4 standard, was developed outside the normal ASTM consensus process. Deliberations during the GF-4 development process included careful consideration of the suitability of Test Method D7320, the Sequence IIIG, a new test, to evaluate the wear protection of oils with less than 0.08 % mass phosphorus. Data on oils with less than 0.08 % mass phosphorus in the form of ZDDP were reviewed by members of the D02.B0 Passenger Car Engine Oil Classification Panel (PCEOCP). These data were from Test Method D7320 (Sequence IIIG) tests and from field tests on large populations of older vehicles with different engine types. Based on these data, the PCEOCP recommended a ballot to allow the use of Test Method D7320 (Sequence IIIG) as an alternative to Test

[11] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1273. Contact ASTM Customer Service at service@astm.org.

[12] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1391. Contact ASTM Customer Service at service@astm.org.

TABLE 1 S Engine Oil Categories

Required Test Method	API SJ Category: Engine Test Method	Rated or Measured Parameter		Primary Performance Criteria
Sequence IID (D5844[A,B]) or D6557[A] (Ball Rust Test)	D5844	Average engine rust rating,[C] min		8.5
		Number stuck lifters		none
	D6557	Average gray value, min		100
Sequence IIIE (D5533[B,D]) or Sequence IIIF (D6984[D]) or Sequence IIIG (D7320[J]) Sequence IIIH (D8111[AE] using Appendix X5 IIIH70 hour guideline)	D5533	Hours to 375 % kinematic viscosity increase at 40 °C, min		64
		Average engine sludge rating,[C] min		9.2
		Average piston skirt varnish rating,[C] min		8.9
		Average oil ring land deposit rating,[C] min		3.5
		Lifter sticking		none
		Scuffing and wear		
		Cam or lifter scuffing		none
		Cam plus lifter wear, µm	Average, max	30
			Maximum, max	64
		Ring sticking (oil-related)[E]		none
	D6984	Kinematic viscosity, % increase at 40 °C, max		325[F]
		Average piston skirt varnish rating,[C] min		8.5[G]
		Weighted piston deposit rating,[H] min		3.2[G]
		Screened average cam-plus–lifter wear, µm, max		20[G,I]
		Hot stuck rings		none[G]
	D7320	Kinematic viscosity, % increase at 40 °C, max		150
		Weighted piston deposit rating,[K] min		3.5
		Cam-plus-lifter wear avg, µm, max		60
		Hot stuck rings		none
	D8111(Using Appendix X5 IIIH70 hour guideline)	60 h kinematic viscosity, % increase at 40 °C, max		307
		70 h average weighted piston deposits,[H] merits, min		2.5
		70 h average piston skirt varnish,[C] merits, min		7.5
Sequence VE (D5302[B,L]) or Sequence IVA (D6891[L]) plus Sequence VG (D6593[L]) or Sequence IVA (D6891[L]) plus Sequence VH (D8256[L])	D5302	Average engine sludge rating,[C] min		9.0
		Rocker arm cover sludge rating,[C] min		7.0
		Average piston skirt varnish rating,[C] min		6.5
		Average engine varnish rating,[C] min		5.0
		Oil ring clogging, %		report
		Oil screen clogging, %, max		20.0
		Compression ring sticking (hot stuck)		none
		Cam wear, µm	Average, max	127
			Maximum, max	380
	D6891	Average cam wear, µm[M]		120
	D6593	Average engine sludge rating,[C] min		7.8
		Rocker arm cover sludge rating,[C] min		8.0
		Average piston skirt varnish rating,[C] min		7.5
		Average engine varnish rating,[N] min		8.9
		Oil screen clogging, %, max		20
		Hot stuck compression rings		none
	~~Sequence VH (D8256)~~ D8256			~~7.4~~
		Average engine sludge, merits, min		7.4
		Average rocker cover sludge, merits, min		7.4
		Average engine varnish, merits, min		8.6
		Average piston skirt varnish, merits, min		7.4
		Oil screen clogging, % area		Rate & Report
		Hot stuck compression rings		None
L-38 (D5119[O]) or Sequece VIII (D6709[O])	D5119	Bearing weight loss, mg, max		40
		Shear stability		[P]
	D6709	Bearing weight loss, mg, max		26.4
		Shear stability		[P]

Bench Test and Measured Parameter	Viscosity Grade Performance Criteria: SAE 0W-20, SAE 5W-20, SAE 5W-30, SAE 10W-30		All Others
Test Method D4683, D4741, D5481, high temperature/high shear viscosity @ 150 °C, mPa·s, min	[Q]		2.6
Test Method D5800 volatility loss, % max[R]	22		20[S]
Test Method D6417 volatility loss at 371 °C, % max[R]	17		15[S]
Test Method D5480 volatility loss at 371 °C, % max[R]	17		15[S]
Test Method D6795 (EOFT), % flow reduction, max	50		50
Test Method D6794 (EOWTT), % flow reduction, max	with 0.6 % H_20	report	report
	with 1.0 % H_20	report	report
	with 2.0 % H_20	report	report
	with 3.0 % H_20	report	report
Test Method D4951 or D5185, mass fraction phosphorus, %, max	0.10[T]		NR[U]
Test Method D4951 or D5185, mass fraction phosphorus, %, min (unless valid passing Test Method D5302 results are obtained)	0.06		0.06
Test Method D92 flash point, °C, min[V]	200		NR[U]
Test Methods D93 or D7094 flash point, °C, min[V]	185		NR[U]

TABLE 1 *Continued*

Bench Test and Measured Parameter	Viscosity Grade Performance Criteria		
		SAE 0W-20, SAE 5W-20, SAE 5W-30, SAE 10W-30	All Others
Test Method D892 foaming tendency (Option A)	Sequence I, max, foaming/settling[W]	10/0	10/0
	Sequence II, max, foaming/settling[W]	50/0	50/0
	Sequence III, max, foaming/settling[W]	10/0	10/0
Test Method D6082 (optional blending required) Static foam, max, tendency/stability		200/50[X]	200/50[X]
Test Method D6922 homogeneity and miscibility		[Y]	[Y]
Test Method D6335 High temperature deposits (TEOST 33), deposit mass, mg, max		60	60
Test Method D5133 Gelation Index, max		12	NR[U]

API SL Category

Required Test Method	Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
Sequence IIIF (D6984) or Sequence IIIG (D7320[J]) or Sequence IIIH (D8111[AE] using Appendix X5 IIIH70 hour guideline)	D6984	Kinematic viscosity, % increase at 40 °C, max	275
		Average piston skirt varnish rating,[C] min	9.0
		Weighted piston deposit rating,[H] min	4.0
		Screened average cam-plus-lifter wear, µm, max	20[I]
		Hot Stuck Rings	none
		Low temperature viscosity performance[Z]	report
	D7320	Kinematic viscosity, % increase at 40 °C, max	150
		Weighted piston deposit rating,[K] min	3.5
		Cam-plus-lifter wear avg, µm, max	60
		Hot stuck rings	none
		Low temperature viscosity performance[AA]	report
	D8111 (Using Appendix X5 IIIH70 hour guideline)	70 h kinematic viscosity, % increase at 40 °C, max	181
		70 h average weighted piston deposits, merits, min	3.3
		70 h average piston skirt varnish,[C] merits, min	7.9
Sequence IVA (D6891)	D6891	Cam wear average, µm,[M] max	120
Sequence VE (D5302[AB,J])	D5302	Cam wear average, µm, max	127
		Cam wear max, µm, max	380
Sequence VG (D6593) or Sequence VH (D8256)	D6593	Average engine sludge rating,[C] min	7.8
		Rocker arm cover sludge rating,[C] min	8.0
		Average piston skirt varnish rating,[C] min	7.5
		Average engine varnish rating,[N] min	8.9
		Oil screen clogging, %, max	20
		Hot stuck Compression rings	none
		Cold stuck rings	report
		Oil screen debris, %	report
		Oil ring clogging, %	report
	D8256	Average engine sludge, merits, min	7.4
		Average rocker cover sludge, merits, min	7.4
		Average engine varnish, merits, min	8.6
		Average piston skirt varnish, merits, min	7.4
		Oil screen clogging, % area	Rate & Report
		Hot stuck compression rings	None
Sequence VIII (D6709)	D6709	Bearing weight loss, mg, max	26.4
		Shear stability	[P]

Bench Test and Measured Parameter		Viscosity Grade Performance Criteria	
		SAE 0W-20 SAE 5W-20 SAE 5W-30 SAE 10W-30	All Others
Test Method D4683, D4741, or D5481, high temperature/high shear viscosity @ 150 °C, mPa·s, min		[Q]	2.6
Test Method D6557 (Ball Rust Test), average gray value, min		100	100
Test Method D5800 volatility loss, % max		15	15
Test Method D6417 volatility loss at 371 °C, % max		10	10
D6795 (EOFT), % flow reduction, max		50	50
D6794 (EOWTT), % flow reduction, max	With 0.6 % H_2O	50	50
	With 1.0 % H_2O	50	50
	With 2.0 % H_2O	50	50
	With 3.0 % H_2O	50	50
Test Method D4951 or D5185, mass fraction phosphorus %, max		0.10[T]	NR[U]
Test Method D4951 or D5185, mass fraction phosphorus %, min (unless valid passing Test Method D5302 results are obtained)[J]		0.06	0.06
Test Method D892 foaming tendency (Option A)	Sequence I, max, foaming/settling[W]	10/0	10/0
	Sequence II, max, foaming/settling[W]	50/0	50/0
	Sequence III, max, foaming/settling[W]	10/0	10/0
Test Method D6082 (optional blending required) static foam max, tendency/stability		100/0[X]	100/0[X]

TABLE 1 *Continued*

Bench Test and Measured Parameter	Viscosity Grade Performance Criteria	
	SAE 0W-20 SAE 5W-20 SAE 5W-30 SAE 10W-30	All Others
Test Method D6922 homogeneity and miscibility	[Y]	[Y]
Test Method D7097 high temperature deposits (TEOST MHT-4), deposit mass, mg, max	45	45
Test Method D5133 (Gelation Index), max[AC]	12[AD]	12[AD]

[A] Demonstrate passing performance in either Test Method D5844 or D6557.
[B] Monitoring of this test method was discontinued in June 20, 2001. Valid test results shall predate the end of the last calibration period for the test stand in which this test method was conducted.
[C] ASTM Deposit Rating Manual 20, available from ASTM Customer Relations, ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.
[D] Demonstrate passing performance in either Test Method D5533 or D6984. However, an oil passing Test Method D6984 and containing less than 0.08 % mass phosphorus in the form of ZDDP shall also pass the wear limits in Test Method D5302 (see also footnote [J]).
[E] An oil-related stuck ring occurs on a piston with an individual oil ring land deposit rating <2.6.
[F] Determine at 60 h.
[G] Determine at 80 h.
[H] Determine weighted piston deposits by rating the following piston areas and applying the corresponding weightings: undercrown, 10 %; second land, 15 %; third land, 30 %; piston skirt, 10 %; first groove, 5 %; second groove, 10 %; and third groove, 20 %. Use ASTM Deposit Rating Manual 20 for all ratings.
[I] Calculate by eliminating the highest and lowest cam-plus-lifter wear results and then calculating an average based on the remaining ten rating positions.
[J] For oils containing at least 0.06 % mass phosphorus in the form of ZDDP, demonstrating passing performance in the Sequence IIIG test obviates the need to also conduct Test Method D5302 (Sequence VE), which was previously required for oils with less than 0.08 % mass phosphorus.
[K] Unlike the Sequence IIIF test, piston skirt varnish rating is not required in the Sequence IIIG test.
[L] Demonstrate passing performance in Test Method D5302, or alternatively, in both Test Method D6891 and Test Method D6593, or alternatively, in both Test Method D6891 and Test Method D8256.
[M] Determine cam wear according to Test Method D6891. Seven wear measurements are made on each cam lobe and the seven measured values are added to obtain an individual cam lobe wear result. The overall cam wear value is the average of the twelve individual cam lobe wear results.
[N] Determine the average engine varnish rating by averaging the piston skirt, right rocker arm cover, and left rocker arm cover varnish ratings. Use ASTM Deposit Rating Manual 20 for all ratings.
[O] Demonstrate passing performance in either Test Method D5119 or D6709.
[P] Ten-hour stripped kinematic viscosity (oil shall remain in original viscosity grade).
[Q] Minimum high temperature/high shear viscosity @ 150 °C for these viscosity grades as defined in SAE J300.
[R] Meet the volatility requirement in either Test Method D5800, D5480, or D6417.
[S] Passing volatility loss only required for SAE 15W-40 oils.
[T] This is a noncritical specification as described in Practice D3244.
[U] NR stands for Not Required.
[V] Meet either Test Methods D92, D93, or D7094 flash point requirement.
[W] Determine settling volume, in mL, at 10 min.
[X] Determine settling volume, in mL, at 1 min.
[Y] Homogeneous with SAE reference oils.
[Z] Evaluate the 80 h test oil sample by Test Method D4684 at the temperature indicated by the low temperature grade of oil as determined on the 80 h sample by Test Method D5293.
[AA] Measure the viscosity of the EOT oil sample by Test Method D4684. The measured viscosity shall meet the requirements of the original grade or the next higher grade. The EOT sample can be either from a Sequence IIIG or a Sequence IIIGA test. (A Sequence IIIGA test is identical to a Sequence IIIG test, except only low temperature viscosity performance is measured.) Additional details are provided in the Sequence IIIG test method, in Section 13.6.
[AB] Not required for oils containing a minimum of 0.08 % mass phosphorus in the form of ZDDP.
[AC] Requirement applies only to SAE 0W-20, 5W-20, 0W-30, 5W-30, and 10W-30 viscosity grades.
[AD] For gelation temperatures at or above the W grade pumpability temperature as defined in SAE J300.
[AE] Alternatively, Test Method D8111 (Sequence IIIH) at 90 hours, passing at the API SM level of performance can be used to meet this requirement.

Method D6984 (Sequence IIIF) plus Test Method D5302 (Sequence VE) for demonstration of acceptable API SH, SJ, and SL performance on low phosphorus oils, establishing at least the mass fraction of phosphorus is 0.06 % as the minimum level. That ballot was approved by Subcommittee D02.B0 in May 2004.

4.1.2.4 Test Method D6593, the Sequence VG gasoline engine test, has been correlated with the Sequence VE gasoline engine test and with vehicles used in stop-and-go service prior to 2000, with regard to sludge and varnish deposit control. (An alternative is Test Method D8256, the Sequence VH Test.)

4.1.2.5 Test Method D6709, the Sequence VIII gasoline engine test, is used to measure copper-lead bearing weight loss under high-temperature operating conditions and has been shown to correlate with the L-38 gasoline engine test.[10]

(1) The Sequence VIII gasoline engine test is also used to determine the ability of an oil to resist permanent viscosity loss due to shearing in an engine.

4.1.2.6 In addition to passing performance in the engine tests, oils shall also meet bench test requirements (see Table 1), which are discussed in the following subsections:

(1) Test Method D6557 (Ball Rust Test), was developed to replace the Sequence IID gasoline engine test, and evaluates the ability of an oil to prevent the formation of rust under short-trip service conditions.

(2) The volatility of engine oils is one of several factors that relates to engine oil consumption. For this engine oil category, volatility is measured by Test Methods D5800 and D6417.

(3) Test Method D6795, the Engine Oil Filterability Test (EOFT) and Test Method D6794, the Engine Oil Water Tolerance Test (EOWTT) screen for the formation of precipitates and gels which form in the presence of water and can cause oil filter plugging.

(4) Phosphorus compounds in excessive amounts can cause glazing of automotive catalysts and exhaust gas oxygen sensors and, thereby, deactivate them. Control of the phosphorus level in the engine oil may reduce this tendency. For this engine oil category, phosphorus content is measured by either Test Method D4951 or D5185.

(5) Excessive foaming in engine oil can cause valve lifter collapse and a loss of lubrication due to the presence of air in the oil. Test Methods D892 and D6082 empirically rate the foaming tendency and stability of oils.

(6) Test Method D6922, the H and M Test indicates the compatibility of an oil with standard test oils.

(7) Newer engines designed to provide increased power and improved driveability and to meet future federal emissions and fuel economy requirements may be sensitive to internal deposits caused by elevated engine operating temperatures. Test Method D7097, the TEOST MHT-4 test may be useful in determining the piston deposit control capability of oils recommended for these engines.

(8) Test Method D5133, the Gelation Index technique, might identify oils susceptible to air binding and might provide low-temperature protection not adequately measured by Test Method D4684.

4.1.2.7 Licensing of the API SL category by the American Petroleum Institute (API) requires that candidate oils meet the performance requirements in this specification, and that the oils be tested in accordance with the protocols described in the ACC Petroleum Additives Product Approval Code of Practice. The methodology detailed in the ACC Code will help ensure that an engine oil meets its intended performance specification. (See Appendix X3 for more information.)

4.1.3 *CH-4*—Oil meeting the performance requirements measured in the following diesel and gasoline engine tests and bench tests.

4.1.3.1 Test Method D6750, the 1K diesel engine test, has been correlated with vehicles equipped with engines used in high speed operation prior to 1989, particularly with respect to aluminum piston deposits and oil consumption when the mass fraction of sulfur content is nominally 0.4 %.[11]

4.1.3.2 Test Method D6681, the 1P diesel engine test, has been used to predict iron piston deposit formation and oil consumption in four-stroke-cycle, direct injection, diesel engines that have been calibrated to meet 1998 U.S. federal exhaust emissions requirements for heavy duty engines operated on fuel containing the mass fraction of sulfur less than 0.05 %.[13]

4.1.3.3 Test Method D6483, the T-9 diesel engine test, has been correlated with vehicles equipped with engines used in high speed operation prior to 1998, particularly in regard to ring and liner wear and used oil lead content.[14] (Alternatives are Test Method D6987/D6987M, the T-10 diesel engine test—see 4.1.4.2, and Test Method D7422, the T-12 diesel engine test—see 4.1.3.2.)

4.1.3.4 Test Method D5967 extended, the T-8E engine test, has been shown to generate soot-related oil thickening in a manner similar to 1998 emissions-controlled heavy duty diesel engines using electronic injection control systems.

4.1.3.5 Test Method D6838, The M11 High Soot diesel engine test has been correlated with vehicles equipped with four-stroke-cycle diesel engines used in high speed operations prior to 1998, particularly with regard to soot related valve train wear, filter plugging, and sludge control.[15] (An alternative is Test Method D7468, the Cummins ISM diesel engine test. See 4.1.5.5.)

4.1.3.6 Test Method D5966, the Roller Follower Wear Test, has been correlated with hydraulic roller cam follower pin wear in medium-duty indirect injection diesel engines used in broadly based field operations.

4.1.3.7 Test Method D6984, the Sequence IIIF test, is used to measure bulk oil viscosity increase, which indicates an oil's ability to withstand the higher temperatures found in modern diesel engines. ~~(An alternative is~~ (Alternatives are Test Method D7320, the Sequence IIIG ~~test.)~~test, or Test Method D8111, the Sequence IIIH test using Appendix X4 IIIH60 guideline.)

[13] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1441. Contact ASTM Customer Service at service@astm.org.

[14] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1440. Contact ASTM Customer Service at service@astm.org.

[15] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1439. Contact ASTM Customer Service at service@astm.org.

4.1.3.8 Test Method D6894, the EOAT has been correlated with oil aeration in diesel engines equipped with HEUI used in medium-duty diesel engines.[16]

4.1.3.9 Test Method D892, a foaming test, Sequences I, II and III, has been shown to predict foaming of engine oils in diesel engines.

4.1.3.10 Test Method D6594 operated at 135 °C, a High Temperature Corrosion Bench Test (HTCBT), has been shown to predict the corrosion of engine oil-lubricated copper and lead containing components used in diesel engines.

4.1.3.11 Test Method D6278, the Diesel Injector Shear Test, has been shown to correlate with permanent shear loss of engine oils in medium-duty direct injection diesel engines used in broadly based field operations.

4.1.3.12 Test Method D5800, Noack Volatility or, alternatively, Test Method D6417, are used to measure engine oil volatility loss under high temperature operating conditions.

4.1.3.13 Licensing of the API CH-4 category by the American Petroleum Institute (API) requires that candidate oils meet the performance requirements in this specification, and that the oils be tested in accordance with the protocols described in the ACC Petroleum Additives Product Approval Code of Practice. The methodology detailed in the ACC Code will help ensure that an engine oil meets its intended performance specification. (See Appendix X3 for more information.)

4.1.4 *CI-4*—Oil meeting the performance requirements measured in the following diesel and gasoline engine tests and bench tests.

4.1.4.1 Test Method D6923, the 1R single cylinder diesel engine test is used to measure engine oil performance with respect to piston deposits, oil consumption, piston and piston ring scuffing, and ring sticking using a two-piece iron/aluminum piston similar to that used in modern, production heavy-duty diesel engines. (An alternative is Test Method D6681, the 1P diesel engine test, see 4.1.3.2.)

4.1.4.2 Test Method D6987/D6987M, the T-10 diesel engine test, is used to measure engine oil performance with respect to piston ring and cylinder liner wear, bearing lead corrosion, and oil consumption in an electronically governed, open chamber, in-line six-cylinder, four-stroke cycle, turbocharged, compression-ignition engine with exhaust gas recirculation. (An alternative is Test Method D7422, the T-12 diesel engine test, see 4.1.5.2.)

4.1.4.3 Test Method D6975, the M11 EGR heavy-duty diesel engine test, is used to evaluate oil performance with respect to valve train wear, sludge deposits, and oil filter plugging in an exhaust gas recirculation environment. (An alternative is the Cummins ISM diesel engine test. See 4.1.5.5.)

4.1.4.4 Test Method D5967 extended, the T-8E engine test, has been shown to generate soot-related oil thickening in a manner similar to 1998 emissions-controlled heavy-duty diesel engines using electronic injection control systems.

4.1.4.5 Test Method D6984, the Sequence IIIF gasoline engine test, is used to measure oil thickening under high temperature conditions in spark-ignition engines. ~~(An alternative is~~ (Alternatives are Test Method D7320, the Sequence IIIG ~~test.)~~test, or Test Method D8111, the Sequence IIIH test using Appendix X5 IIIH70 guideline or the Footnote F 60-80 h value.)

4.1.4.6 Test Method D6750 (1K), the 1K diesel engine test, or, alternatively, Test Method D6750 (1N), the 1N diesel engine test, is used to evaluate performance in diesel engines equipped with aluminum pistons. The 1K test has been correlated with vehicles used in high speed operation prior to 1989, particularly with respect to aluminum piston deposits and oil consumption, when the mass fraction of fuel sulfur was nominally 0.4 %. The 1N test has been used to predict aluminum piston deposit formation in four-stroke cycle, direct-injection, diesel engines that have been calibrated to meet 1994 U.S. federal exhaust emissions requirements for heavy-duty engines operated on fuel containing the mass fraction of sulfur less than 0.05 %.

4.1.4.7 Test Method D5966, the Roller Follower Wear Test, has been correlated with hydraulic roller cam follower pin wear in medium-duty indirect injection diesel engines used in broadly based field operations.

4.1.4.8 Test Method D6894, the EOAT procedure, has been correlated with oil aeration in diesel engines equipped with HEUI used in medium-duty diesel engines.

[16] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1379. Contact ASTM Customer Service at service@astm.org.

4.1.4.9 Test Methods D4741, D4683, and D5481 High Temperature High Shear (HTHS) tests are part of the SAE J300 Viscosity Classification System.

4.1.4.10 Test Method D4684 (MRV TP-1) has been shown to predict field failures resulting from poor low temperature pumpability.

4.1.4.11 Test Method D5800, Noack Volatility, is used to measure engine oil volatility loss under high temperature operating conditions.

4.1.4.12 Test Method D6594 operated at 135 °C, a high temperature corrosion bench test (HTCBT), has been shown to predict corrosion of engine oil-lubricated copper and lead containing components used in diesel engines.

4.1.4.13 Test Method D6278, a diesel injector shear test, has been shown to correlate with permanent shear loss of engine oils in medium-duty direct injection diesel engines used in broadly based field operations.

4.1.4.14 Test Method D892, a foaming test, Sequences I, II, and III, has been shown to predict foaming of engine oils in diesel engines.

4.1.4.15 Test Method D7216, the Elastomer Compatibility Test is used to measure the performance of four widely used elastomer compounds when exposed to diesel engine oils.

4.1.4.16 Licensing of the API CI-4 category by the American Petroleum Institute (API) requires that candidate oils meet the performance requirements in this specification, and that the oils be tested in accordance with the protocols described in the ACC Petroleum Additives Product Approval Code of Practice. The methodology detailed in the ACC Code will help ensure that an engine oil meets its intended performance specification. (See Appendix X3 for more information.)

4.1.5 *CJ-4*—Oil meeting the performance requirements measured in the following diesel and gasoline engine tests, and bench and chemical tests.

4.1.5.1 Test Method D7156, the Mack T-11 diesel engine test has been shown to generate soot-related oil thickening in a manner similar to 2002 EGR emission-controlled heavy-duty engines with electronic injection control. This engine test uses fuel with sulfur content of 500 mg/kg.

4.1.5.2 Test Method D7422, the Mack T-12 diesel engine test is used to measure engine oil performance with respect to piston ring and cylinder liner wear, bearing corrosion, and oil consumption, using an in-line six cylinder, four-stroke, direct injection, turbo-charged engine with exhaust gas recirculation at levels expected for 2007 emission control engines. This engine test uses fuel with ultra low sulfur content of 15 mg/kg.

4.1.5.3 Test Method D7549, the Caterpillar C13 *Advanced Combustion Emission Reduction Technology* (ACERT) is an in-line six-cylinder engine used to measure engine oil consumption and piston deposits. The engine is equipped with a single-piece forged steel piston used in emission controlled engines. This engine test uses fuel with ultra low sulfur content of 15 mg/kg.

4.1.5.4 Test Method D7484, the Cummins ISB diesel engine test is used to evaluate oil performance with respect to cam and tappet wear with high soot level in the engine oil. This is an in-line six cylinder turbo-charged engine with a common-rail fuel system for emission control. This engine test uses fuel with ultra low sulfur content of 15 mg/kg.

4.1.5.5 Test Method D7468, the Cummins ISM diesel engine test is used to evaluate oil performance with respect to valve train wear, sludge and oil filter plugging with a high soot level in the engine oil. This is an in-line six cylinder, turbo-charged engine with EGR for emission control. This engine test uses fuel with sulfur content of 500 mg/kg.

4.1.5.6 Test Method D6750, the 1N diesel engine test, has been used to predict piston deposit formation in four-stroke cycle, direct injection, diesel engines that have been calibrated to meet 1994 U.S. federal exhaust emissions requirements for heavy-duty engines operated on fuel containing the mass fraction of sulfur less than 0.05 %.[17]

4.1.5.7 Test Method D6984, the Sequence IIIF test, is used to measure bulk oil viscosity increase, which indicates an oil's ability

[17] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1321. Contact ASTM Customer Service at service@astm.org.

to withstand the higher temperatures found in modern diesel engines. (An alternative is (Alternatives are Test Method D7320, the Sequence IIIG test.)test, or Test Method D8111, the Sequence IIIH test using Appendix X5 IIIH70 guideline or the Footnote C 60-80 h value.)

4.1.5.8 Test Method D5966, the roller follower wear test (RFWT), has been correlated with hydraulic roller cam follower pin wear in medium-duty indirect injection diesel engines used in broadly based field operations.

4.1.5.9 Test Method D4684 (MRV TP-1) has been shown to predict field failures resulting from poor low temperature pumpability.

4.1.5.10 Test Method D7109, a diesel injector shear test, has been shown to correlate with permanent shear loss of engine oils in medium-duty direct injection diesel engines used in broadly based field operations.

4.1.5.11 Test Method D6594 operated at 135 °C, a high temperature corrosion bench test (HTCBT), has been shown to predict corrosion of engine oil-lubricated copper and lead containing components used in diesel engines.

4.1.5.12 Test Methods D4171, D4683, and D5481 High Temperature High Shear (HTHS) tests are part of the SAE J300 Viscosity Classification System.

4.1.5.13 Test Method D892, a foaming test, Sequences I, II, and III, has been shown to predict foaming of engine oils in diesel engines.

4.1.5.14 Test Method D7216, the Elastomer Compatibility Test, is used to measure the performance of four widely used elastomer compounds when exposed to diesel engine oils.

4.1.5.15 Test Method D6894, the EOAT procedure, has been correlated with oil aeration in diesel engines equipped with HEUI used in medium-duty diesel engines.

4.1.5.16 Licensing of the API CJ-4 category by the American Petroleum Institute (API) requires that candidate oils meet the performance requirements in this specification, and that the oils be tested in accordance with the protocols described in the ACC Petroleum Additives Product Approval Code of Practice. The methodology detailed in the ACC Code will help ensure that an engine oil meets its intended performance specification. (See Appendix X3 for more information.)

4.1.6 *CK-4 or FA-4*—Oil meeting the performance requirements measured in the following diesel engine tests, and bench and chemical tests.

4.1.6.1 Test Method D8048, the Volvo T-13 diesel engine test method, is used to evaluate the oxidation resistance performance of engine oils in turbocharged and intercooled four-cycle diesel engines equipped with EGR and running on ultra-low sulfur diesel fuel.

4.1.6.2 Test Method D8047, the Caterpillar-C13 Engine Oil Aeration Test (COAT) method, evaluates an engine oil's resistance to aeration under high-engine-speed, zero load conditions using a direct-injection, turbocharged, after-cooled, six-cylinder diesel engine.

4.1.6.3 Test Method D7156, the Mack T-11 diesel engine test, has been shown to generate soot-related oil thickening in a manner similar to 2002 EGR emission-controlled heavy-duty engines with electronic injection control. This engine test uses fuel with sulfur content of 500 mg/kg.

4.1.6.4 Test Method D7422, the Mack T-12 diesel engine test, is used to measure engine oil performance with respect to piston ring and cylinder liner wear, using an in-line six cylinder, four-stroke, direct injection, turbo-charged engine with exhaust gas recirculation at levels expected for 2007 emission control engines. This engine test uses fuel with ultra low sulfur content of 15 mg/kg.

4.1.6.5 Test Method D7549, the Caterpillar C13 Advanced Combustion Emission Reduction Technology (ACERT) is an in-line six-cylinder engine used to measure engine oil consumption and piston deposits. The engine is equipped with a single-piece forged steel piston used in emission controlled engines. This engine test uses fuel with ultra low sulfur content of 15 mg/kgmg/kg.

4.1.6.6 Test Method D7484, the Cummins ISB diesel engine test, is used to evaluate oil performance with respect to cam and tappet wear with high soot level in the engine oil. This is an inline six cylinder turbo-charged engine with a common-rail fuel system for emission control. This engine test uses fuel with ultra low sulfur content of 15 mg/kg.

4.1.6.7 Test Method D7468, the Cummins ISM diesel engine test, is used to evaluate oil performance with respect to valve train wear, sludge and oil filter plugging with a high soot level in the engine oil. This is an in-line six cylinder, turbo-charged engine with EGR for emission control. This engine test uses fuel with sulfur content of 500 ~~mg/kg~~mg/kg.

4.1.6.8 Test Method D6750, the 1N diesel engine test, has been used to predict piston deposit formation in four-stroke cycle, direct injection, diesel engines that have been calibrated to meet 1994 U.S. federal exhaust emissions requirements for heavy-duty engines operated on fuel containing sulfur content of 500 mg/kg.

4.1.6.9 Test Method D5966, the roller follower wear test (RFWT), has been correlated with hydraulic roller cam follower pin wear in medium-duty indirect injection diesel engines used in broadly based field operations.

4.1.6.10 Test Method D6896 (MRV TP-1) has been shown to predict field failures resulting from poor low temperature pumpability of used engine oils.

4.1.6.11 Test Method D7109, a diesel injector shear test, has been shown to correlate with permanent shear loss of engine oils in medium-duty direct injection diesel engines used in broadly based field operations.

4.1.6.12 Test Method D6594 operated at 135 °C, a high temperature corrosion bench test (HTCBT), has been shown to predict corrosion of engine oil-lubricated copper and lead containing components used in diesel engines.

4.1.6.13 Test Methods D4741, D4683, and D5481 High Temperature High Shear (HTHS) tests are part of the SAE J300 Viscosity Classification System.

4.1.6.14 Test Method D892, a foaming test, Sequences I, II, and III, has been shown to predict foaming of engine oils in diesel engines.

4.1.6.15 Test Method D7216, the Elastomer Compatibility Test, is used to measure the performance of four widely used elastomer compounds when exposed to diesel engine oils.

4.1.6.16 Licensing of the API CK-4 or FA-4 category by the American Petroleum Institute (API) requires that candidate oils meet the performance requirements in this specification, and that the oils be tested in accordance with the protocols described in the ACC Petroleum Additives Product Approval Code of Practice. The methodology detailed in the ACC Code will help ensure that an engine oil meets its intended performance specification. (See Appendix X3 for more information.)

5. Performance Requirements

5.1 The oils identified by the categories discussed in Section 4 shall conform to the requirements listed in Tables 1-6.

NOTE 3—API has developed a symbol that can be licensed for use on containers of oils that conform to the requirements of one or more categories that are currently of commercial importance. API 1509 describes the symbol and licensing procedure.

NOTE 4—In practice, engine oils are often labeled with service category designations having some combination of both S and C prefixes.

NOTE 5—Intended service applications for the various categories described in 4.1.1 – 4.1.3 can be found in API 1509. Several applicable sections of that publication have been included in Appendix X2.

6. Test Procedures

6.1 The requirements listed in this specification shall be determined in accordance with those standard test methods listed in Section 2.

6.2 Engine tests are run in test stands calibrated using reference oils.

6.3 For tests monitored by the TMC, results are valid only if the tests are run in currently calibrated stands/equipment.

TABLE 2 Diesel Engine Oil Category CH-4

Required Test Method	Test Method	Rated or Measured Parameter		Primary Performance Criteria One-test	Two-test[A]	Three-test[A]
1P (D6681[B])	D6681	Weighted demerits (WDP), max		350	378	390
		Top groove carbon (TGC), demerits, max		36	39	41
		Top land carbon (TLC), demerits, max		40	46	49
		Average Oil Consumption, g/h (0 h – 360 h), max		12.4	12.4	12.4
		Final Oil Consumption, g/h (312 h – 360 h), max		14.6	14.6	14.6
		Piston, ring, and liner scuffing		none	none	none[C]
1K (D6750[D])	D6750	Weighted demerits (WDK), %, max		332	347	353
		Top groove fill (TGF), %, max		24	27	29
		Top land heavy carbon (TLHC), %, max		4	5	5
		Average Oil Consumption	g/kWh (0 h – 252 h), max	0.54	0.54	0.54
			g/MJ (0 h – 252 h), max	0.15	0.15	0.15
		Piston, ring, and liner scuffing		none	none	none[C]
T-9 (D6483) or T-10 (D6987/D6987M) or T-12 (D7422)	D6483	Average Liner Wear, normalized to 1.75 % soot, µm max		25.4	26.6	27.1
		Average Top Ring Mass Loss, mg max[E]		120	136	144
		EOT Used Oil Lead Content less New Oil Lead Content, mg/kg, max		25	32	36
	D6987/D6987M	Liner wear, µm, max		32	34	35
		Ring wear, mg, max		150	159	163
		Lead content at EOT, mg/kg, max		50	56	59
	D7422	Liner wear, µm, max		30.0	30.8	31.1
		Top Ring Mass Loss, mg, max		120	132	137
		Lead content at EOT, mg/kg, max		65	75	79
RFWT (D5966)	D5966	Average Pin Wear	mils, max	0.30	0.33	0.36
			(µm) max	(7.6)	(8.4)	(9.1)
M11 (D6838[F]) or ISM (D7468)	D6838	Rocker Pad Average Mass Loss, normalized to 4.5 % soot, mg max		6.5	7.5	8.0
		Oil Filter Differential Pressure at EOT, kPa max		79	93	100
		Average Engine Sludge, CRC Merits at EOT, min		8.7	8.6	8.5
	D7468	Crosshead wear, mg, max		7.5	7.8	7.9
		Oil filter delta pressure, at 150 h, kPa, max		79	95	103
		Sludge rating, CRC merits, min		8.1	8.0	8.0
Ext. T-8E (D5967[G])	D5967	Relative Viscosity at 4.8 % Soot by TGA, max		2.1	2.2	2.3
		Viscosity increase at 3.8 % Soot by TGA, mm²/s, max		11.5	12.5	13.0
Sequence IIIF (D6984) or Sequence IIIG (D7320[I]) or Sequence IIIH (D8111 using IIIH60 Appendix X4)	D6984	60 h Viscosity at 40 °C, increase from 10 min sample, % max		295	295 (MTAC)[H]	295 (MTAC)[H]
	D7320	Kinematic viscosity, % increase at 40 °C max		150	150 (MTAC)	150 (MTAC)
	D8111 (IIIH60 Appendix X4)	60 h Kinematic viscosity, % increase at 40 °C max		249	249 (MTAC)	249 (MTAC)
EOAT (D6894[J])	D6894	Aeration, volume, % max		8.0	8.0 (MTAC)[H]	8.0 (MTAC)[H]

CH-4 Bench Tests		Measured Parameter		Primary Performance Criteria		
		~~Used Oil Elemental Concentration~~		~~N/A~~		~~N/A~~
		Used Oil Elemental Concentration				
~~HTCBT, 135 °C (D6594)~~	~~D6594~~	~~Copper, mg/kg increase, max~~		~~20~~		~~N/A~~
		HTCBT, 135 °C (~~D6594~~) Copper, mg/kg increase, max	D6594	20		
		Lead, mg/kg increase, max		120		
		Tin, mg/kg increase		report		
		Copper strip rating,[K] max		3		
		~~Foaming/Settling,[L] mL, max~~		~~One-test~~		~~Two-test[A]~~
~~D892 (Option A not allowed)~~	~~D892 (Option A not allowed)~~	Foaming/Settling,[L] mL, max				
		~~D892 (Option A not allowed)~~ Sequence I	D892 (Option A not allowed)	~~10/0~~		~~N/A~~
		Sequence I		10/0		
		~~Sequence II~~		~~20/0~~		~~N/A~~
		Sequence II		20/0		
		~~Sequence III~~		~~10/0~~		~~N/A~~
		Sequence III		10/0		
~~Noack (D5800) or D6417~~				~~SAE 10W-30~~	~~SAE 15W-40~~	~~N/A~~
	Noack (D5800) or D6417	SAE 10W-30			SAE 15W-40	
		~~D5800~~ ~~percent volatility loss at 250 °C, max~~	~~20~~		~~18~~	~~N/A~~
D5800		percent volatility loss at 250 °C, max		20	18	
~~D6417~~		~~percent volatility loss at 371 °C, max~~		~~17~~	~~15~~	~~N/A~~
D6417		percent volatility loss at 371 °C, max		17	15	
~~D6278~~	~~D6278~~	~~Kinematic Viscosity after shearing, mm²/s at 100 °C, min~~		~~SAE XW-30~~	~~SAE XW-40~~	~~N/A~~
		~~Kinematic Viscosity after shearing, mm²/s at 100 °C, min~~		D6278	SAE XW-40 ~~D6278~~	SAE XW-30
~~9.3~~					~~12.5~~	~~N/A~~
9.3					12.5	

[A] See Annex A3 for additional information.
[B] Refer to RR:D02-1441.
[C] If three or more operationally valid tests have been run, the majority of these tests shall not have scuffing. The scuffed tests are considered uninterpretable, and all data from these tests are eliminated from averaging.
[D] Refer to RR:D02-1273.