Designation: D 4485 – 04

An American National Standard

Standard Specification for Performance of Engine Oils[1]

This standard is issued under the fixed designation D 4485; 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 other organizations with specifications not subject to this process, such as the International Lubricant Standardization and Approval Committee (ILSAC), and the Association des Constructeurs Europeans d' Automobiles (ACEA). Their specifications are not covered in this document.

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 and CA, CB, CC, CD, CD-II, CE) (see 3.1.2). SA is not included because it does not have specified engine performance requirements. SG is not included because it was a category that could not be licensed for use in the API Service Symbol after December 31, 1995. 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.

1.2 This specification is not intended to cover engine oil applications such as outboard motors, snowmobiles, lawn mowers, motorcycles, railroad locomotives, or ocean-going 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 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 either SI units or other units shall be regarded separately as standard. The values given in parentheses are for information only.

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

Current edition approved May 1, 2004. Published June 2004. Originally approved in 1985. Last previous edition approved in 2003 as D 4485 – 03a.

1.6 The test procedures referred to in this specification that are not yet standards are listed in Table 1.

TABLE 1 Test Procedures

Test Procedure	ASTM Publications[A]
Sequence IIIF	RR: D02-1491[B]
Sequence IVA	RR: D02-1473[C]
TEOST MHT-4	under development[D]
T-6	RR: D02-1219[E]
T-7	RR: D02-1220[F]
T-10	under development[G]
M11 EGR	under development[H]
Elastomer Compatibility	under development[I]

[A] Research Reports are available from ASTM International Headquarters. Request by Research Report No.
[B] Sequence IIIF oil thickening, piston deposits, and valve train wear test.
[C] Sequence IVA valve train wear test.
[D] Thermo-Oxidation Engine Oil Simulation Test (MHT-4)-high temperature deposits test.
[E] Multicylinder Engine Test Procedure for the Evaluation of Lubricants-Mack T-6.
[F] Multicylinder Engine Test Procedure for the Evaluation of Lubricants-Mack T-7.
[G] Mack T-10 Test (and the associated T-10A Test) under development by D02.B0.
[H] Cummins M11 Exhaust Gas Recirculation Test under development by D02.B0.
[I] The Elastomer Compatibility Test; initial development by D11.15, to be completed by D02.B0.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 92 Test Method for Flash and Fire Points by Cleveland Open Cup
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test
D 892 Test Method for Foaming Characteristics of Lubricating Oils
D 2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D 3244 Practice for Utilization of Test Data to Determine Conformance with Specifications
D 4684 Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature
D 4951 Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry
D 5119 Test Method for Evaluation of Automotive Engine Oils in the CRC L-38 Spark-Ignition Engine
D 5133 Test Method for Low Temperature, Low Shear Rate, Viscosity/Temperature Dependence of Lubricating Oils Using a Temperature-Scanning Technique
D 5185 Test Method for the Determination of Additive Elements, Wear Metals, and Contaminants in Used Lubricating Oils and Determination of Selected Elements in Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
D 5290 Test Method for Measurement of Oil Consumption, Piston Deposits, and Wear in a Heavy-Duty High-Speed Diesel Engine—NTC-400 Procedure
D 5293 Test Method for Apparent Viscosity of Engine Oils Between –5 and –35°C Using the Cold-Cranking Simulator
D 5302 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
D 5480 Test Method for Engine Oil Volatility by Gas Chromatography
D 5533 Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIE, Spark-Ignition Engine
D 5800 Test Method for Evaporation Loss of Lubricating Oils by the Noack Method
D 5844 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID)
D 5862 Test Method for Evaluation of Engine Oils in the Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine
D 5966 Test Method for Evaluation of Engine Oils for Roller Follower Wear in Light-Duty Diesel Engine
D 5967 Test Method for Evaluation of Diesel Engine Oils in the T-8 Diesel Engine
D 5968 Test Method for Evaluation of Corrosiveness of Diesel Engine Oil at 121°C
D 6082 Test Method for High Temperature Foaming Characteristics of Lubricating Oils
D 6202 Test Method for Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light-Duty Trucks in the Sequence VIA Spark Ignition Engine
D 6278 Test Method for Shear Stability of Polymer-Containing Fluids Using a European Diesel Injector Apparatus
D 6335 Test Method for Determination of High Temperature Deposits by Thermo-Oxidation Engine Oil Simulation Test
D 6417 Test Method for Estimation of Engine Oil Volatility by Capillary Gas Chromatography
D 6483 Test Method For Evaluation of Diesel Engine Oils in T-9 Diesel Engine
D 6557 Test Method for Evaluation of Rust Preventive Characteristics of Automotive Engine Oils
D 6593 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
D 6594 Test Method for Evaluation of Corrosiveness of Diesel Engine Oil at 135°C
D 6618 Test Method for Evaluation of Engine Oils in Diesel Four-Stroke Cycle Supercharged 1M-PC Single Cylinder Oil Test Engine
D 6681 Test Method for Evaluation of Engine Oils in a High Speed, Single-Cylinder Diesel Engine-Caterpillar IP Test Procedure

[2] 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.

D 6709 Test Method for Evaluation of Automotive Engine Oils in the Sequence VIII Spark-Ignition Engine (CLR Oil Test Engine)
D 6750 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)
D 6794 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
D 6795 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
D 6837 Test Method for Measurement of the Effects of Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light–Duty Trucks in the Sequence VIB Spark-Ignition Engine
D 6838 Test Method for Cummins M11 High Soot Test
D 6894 Test Method for the Evaluation of the Aeration Resistance of Engine Oils in a Direct-Injected Turbocharged Automotive Diesel Engine
D 6922 Test Method for the Determination of Homogeneity and Miscibility in Automotive Engine Oils
D 6923 Test Method for the Evaluation of Engine Oils in a High-Speed, Single-Cylinder Diesel Engine—Caterpillar 1R Test Procedure
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E 178 Practice for Dealing with Outlying Observations

2.2 *Society of Automotive Engineers Standards:*[3]

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

2.3 *American Petroleum Institute Publication:*[4]

API 1509 Engine Oil Licensing and Certification System (EOLCS)

2.4 *Government Standard:*[5]

DOD CID A-A-52039A (SAE 5W-30, 10W-30, and 15W-40)

2.5 *American Chemical Council Code:*[6]

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 SH, SJ, CF-4, CF, CF-2, CG-4, Energy Conserving, and so forth, for a given level of performance in specified engine tests.

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

3.1.4 *engine oil*, *n*—a liquid that reduces friction and wear between the moving parts within an engine, and also serves as a coolant.

3.1.4.1 *Discussion*—It can contain additives to enhance certain properties. Inhibition of engine rusting, deposit formation, valve train wear, oil oxidation, and foaming are examples.

3.1.5 *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.

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

3.1.6.1 *Discussion*—This type of engine is typically installed in large trucks and buses as well as farm, industrial, and construction equipment.

3.1.7 *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.

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

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

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

[3] Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096–0001.

[4] Available from American Petroleum Institute (API), 1220 L St. NW, Washington, DC 20005.

[5] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401.

[6] Available from American Chemical Council, 1300 Wilson Blvd., Arlington, VA 22209.

4.1.1.1 Test Method D 5844, the Sequence IID gasoline engine test, has been correlated with vehicles used in short-trip service prior to 1978,[7] particularly with regard to rusting.

4.1.1.2 Test Method D 5533, the Sequence IIIE gasoline engine test, has been correlated with vehicles used in high-temperature service prior to 1988,[8] particularly with regard to oil thickening and valve train wear.

4.1.1.3 Test Method D 5302, the Sequence VE gasoline engine test, has been correlated with vehicles used in stop-and-go service prior to 1988,[9] particularly with regard to sludge and valve train wear.

4.1.1.4 Test Method D 5119, the L-38 gasoline engine test, is used to measure copper-lead bearing weight loss under high-temperature operating conditions.

(*1*) Test Method D 5119 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 2), which are discussed in the following subsections:

(*1*) The volatility of engine oils relates to engine oil consumption.

(*2*) Test Method D 6795, the Engine Oil Filterability Test (EOFT) screens for the formation of precipitates that can cause oil filter plugging.

(*3*) Phosphorus compounds 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 can indicate if residual solvents and low-boiling fractions remain in the finished oil.

(*5*) 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 D 892 and D 6082 empirically rate the foaming tendency and stability of oils.

(*6*) Test Method D 6922, the H and M Test indicates the compatibility of an oil with standard test oils.

4.1.1.6 Licensing of the API SH category 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 *SJ*—Oil meeting the performance requirements measured in the following gasoline engine tests and bench tests:

4.1.2.1 Test Method D 5844, the Sequence IID, gasoline engine test has been correlated with vehicles used in short-trip service prior to 1978, particularly with regard to rusting.

4.1.2.2 Test Method D 5533, the Sequence IIIE gasoline engine test, has been correlated with vehicles used in high-temperature service prior to 1988, particularly with regard to oil thickening and valve train wear.

4.1.2.3 Test Method D 5302, the Sequence VE gasoline engine test, has been correlated with vehicles used in stop-and-go service prior to 1988, particularly with regard to sludge and valve train wear.

4.1.2.4 Test Method D 5119, the L-38 gasoline engine test, is used to measure copper-lead bearing weight loss under high-temperature operating conditions.

(*1*) Test Method D 5119 is also used to determine the ability of an oil to resist permanent viscosity loss due to shearing in an engine.

4.1.2.5 In addition to passing performance in the engine tests, specific viscosity grades shall also meet bench test requirements (see Table 2), 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 D 6795, 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 D 892 and D 6082 empirically rate the foaming tendency and stability of oils.

(*6*) Test Method D 6922, 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 D 6335, the TEOST test, may be useful in determining the deposit control of oils recommended for these engines.

(*8*) Test Method D 5133, the Gelation Index technique, might identify oils susceptible to air binding and might provide low temperature protection not adequately measured by the Test Method D 4684.

4.1.2.6 Licensing of the API SJ category 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.

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

[7] Available from ASTM International in *STP 3151 (Part 1)*. Also available from the Society of Automotive Engineers as Technical Paper No. 780931.[3]

[8] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1225.

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1226.

TABLE 2 S Engine Oil Categories

API SH Category

Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
D 5844[A,B]	Average engine rust rating,[C] min	8.5
(Sequence IID)	Number stuck lifters	none
or, D 6557[A]	Average gray value, min	100
(Ball Rust Test)		
D 5533[B,D] (Sequence IIIE)	Hours to 375 % kinematic viscosity increase at 40°C, min	64
	Average engine sludge rating,[E] min	9.2
	Average piston skirt varnish rating,[F] min	8.9
	Average oil ring land deposit rating,[F] 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[G])	none
or, Sequence IIIF[D]	Kinematic viscosity, % increase at 40°C, max	325[H]
	Average piston skirt varnish rating,[F] min	8.5[I]
	Weighted piston deposit rating,[J] min	3.2[I]
	Screened average cam-plus-lifter wear, µm, max	20[I,K]
	Hot stuck rings	none[I]
D 5302[B,L]	Average engine sludge rating,[E] min	9.0
(Sequence VE)	Rocker arm cover sludge rating,[E] min	7.0
	Average piston skirt varnish rating,[F] min	6.5
	Average engine varnish rating,[F] 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
or, Sequence IVA[L]	Average cam wear, µm[M]	120
plus, D 6593[L]	Average engine sludge rating,[E] min	7.8
(Sequence VG)	Rocker arm cover sludge rating,[E] min	8.0
	Average piston skirt varnish rating,[F] min	7.5
	Average engine varnish rating,[N] min	8.9
	Oil screen clogging, %, max	20
	Hot stuck compression rings	none
D 5119[O]	Bearing weight loss, mg, max	40
(L-38)	Shear stability	[P]
or, D 6709[O]	Bearing weight loss, mg, max	26.4
(Sequence VIII)	Shear stability	[P]

Bench Test and Measured Parameter (effective January 1, 1992)	Viscosity Grade Performance Criteria[Q]		
	SAE 5W-30	SAE 10W-30	SAE 15W-40
Test Method D 5800 volatility loss, % max[R]	25	20	18
Test Method D 2887 volatility loss at 371°C (700°F), % max[R]	20	17	15
Test Method D 6795 (EOFT), % flow reduction, max	50	50	NR[S]
Test Method D 4951 or D 5185, phosphorus % mass, max	0.12	0.12	NR
Test Method D 92 flash point, °C, min[T]	200	205	215
Test Method D 93 flash point, °C, min[T]	185	190	200
Test Method D 892 foaming tendency (Option A)			
Sequence I, max, foaming/settling[U]	10/0	10/0	10/0
Sequence II, max, foaming/settling[U]	50/0	50/0	50/0
Sequence III, max, foaming/settling[U]	10/0	10/0	10/0
Test Method D 6082 (optional blending required)	report[V]	report[V]	report[V]
Test Method D 6922 homogeneity and miscibility	[W]	[W]	[W]

API SJ Category

Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
D 5844[A,B] (Sequence IID)	Average engine rust rating,[C] min	8.5
	Number stuck lifters	none
or, D 6557[A]	Average gray value, min	100
(Ball Rust Test)		
D 5533[B,D] (Sequence IIIE)	Hours to 375 % kinematic viscosity increase at 40°C, min	64
	Average engine sludge rating,[E] min	9.2

TABLE 2 *Continued*

API SJ Category		
Engine Test Method	**Rated or Measured Parameter**	**Primary Performance Criteria**
	Average piston skirt varnish rating,[F] min	8.9
	Average oil ring land deposit rating,[F] 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)[G]	none
or, Sequence IIIF[D]	Kinematic viscosity, % increase at 40°C, max	325[H]
	Average piston skirt varnish rating,[F] min	8.5[I]
	Weighted piston deposit rating,[J] min	3.2[I]
	Screened average cam-plus–lifter wear, µm, max	20[I,K]
	Hot stuck rings	none[I]
D 5302[B,L]	Average engine sludge rating,[E] min	9.0
(Sequence VE)	Rocker arm cover sludge rating,[E] min	7.0
	Average piston skirt varnish rating,[F] min	6.5
	Average engine varnish rating,[F] 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
or, Sequence IVA[L]	Average cam wear, µm[M]	120
plus, D 6593[L]	Average engine sludge rating,[E] min	7.8
(Sequence VG)	Rocker arm cover sludge rating,[E] min	8.0
	Average piston skirt varnish rating,[F] min	7.5
	Average engine varnish rating,[N] min	8.9
	Oil screen clogging, %, max	20
	Hot stuck compression rings	none
D 5119[O]	Bearing weight loss, mg, max	40
(L-38)	Shear stability	[P]
or, D 6709[O]	Bearing weight loss, mg, max	26.4
(Sequence VIII)	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 D 5800 volatility loss, % max[X]	22	20[Y]
Test Method D 6417 volatility loss at 371°C (700°F), % max[X]	17	15[Y]
Test Method D 5480 volatility loss at 371°C (700°F), % max[X]	17	15[Y]
Test Method D 6795 (EOFT), % flow reduction, max	50	50
Test Method D 6794 (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 D 4951 or D 5185, phosphorus % mass, max	0.10[Z]	NR[S]
Test Method D 92 flash point, °C, min[T]	200	NR[S]
Test Method D 93 flash point, °C, min[T]	185	NR[S]
Test Method D 892 foaming tendency (Option A)		

TABLE 2 *Continued*

Bench Test and Measured Parameter	Viscosity Grade Performance Criteria	
	SAE 0W-20, SAE 5W-20, SAE 5W-30, SAE 10W-30	All Others
Sequence I, max, foaming/settling[AA]	10/0	10/0
Sequence II, max, foaming/settling[AA]	50/0	50/0
Sequence III, max, foaming/settling[AA]	10/0	10/0
Test Method D 6082 (optional blending required) Static foam, max, tendency/stability	200/50[AB]	200/50[AB]
Test Method D 6922 homogeneity and miscibility	[W]	[W]
Test Method D 6335 High temperature deposits (TEOST 33), deposit wt, mg, max	60	60
Test Method D 5133 Gelation Index, max	12	NR[S]

API SL CATEGORY

Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
Sequence IIIF	Kinematic viscosity, % increase at 40°C, max	275
	Average piston skirt varnish rating,[F] min	9.0
	Weighted piston deposit rating,[J] min	4.0
	Screened average cam-plus-lifter wear, µm, max	20[K]
	Hot Stuck Rings	none
	Low temperature viscosity performance[AC]	report
Sequence IVA	Cam wear average, µm,[M] max	120
D 5302[B]	Cam wear average, µm, max	127
(Sequence VE[AD])	Cam wear max, µm, max	380
D 6593		
(Sequence VG)	Average engine sludge rating,[E] min	7.8
	Rocker arm cover sludge rating,[E] min	8.0
	Average piston skirt varnish rating,[F] 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
D 6709	Bearing weight loss, mg, max	26.4
(Sequence VIII)	Shear stability	[P]

Bench Test and Measured Parameter	Performance Criteria
Test Method D 6557 (Ball Rust Test), average gray value, min	100
Test Method D 5800 volatility loss, % max	15
Test Method D 6417 volatility loss at 371°C (700°F), % max	10
D 6795 (EOFT), % flow reduction, max	50
D 6794 (EOWTT), % flow reduction, max	
With 0.6 % H_2O	50
With 1.0 % H_2O	50
With 2.0 % H_2O	50
With 3.0 % H_2O	50
Test Method D 4951 or D 5185, phosphorus % mass, max[AE]	0.10[Z]
Test Method D 892 foaming tendency (Option A)	
Sequence I, max, foaming/settling[AA]	10/0
Sequence II, max, foaming/settling[AA]	50/0
Sequence III, max, foaming/settling[AA]	10/0
Test Method D 6082 (optional blending required) static foam max, tendency/stability	100/0[AB]
Test Method D 6922 homogeneity and miscibility	[W]
High temperature deposits (TEOST MHT-4), deposit wt, mg, max	45
Test Method D 5133 (Gelation Index), max[AE]	12[AF]

[A] Demonstrate passing performance in either Test Method D 5844 or D 6557.
[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] CRC Rust Rating Manual No. 7, available from Coordinating Research Council, 219 Perimeter Center Pkwy., Atlanta, GA 30346.
[D] Demonstrate passing performance in either Test Method D 5533 or the Sequence IIIF test. However, an oil passing the Sequence IIIF test and containing less than 0.08 % mass phosphorus in the form of ZDDP, shall also pass the wear limits in Test Method D 5302.
[E] CRC Sludge Rating Manual No. 12, available from Coordinating Research Council, 219 Perimeter Center Pkwy., Atlanta, GA 30346.
[F] CRC Varnish Rating Manual No. 14, available from Coordinating Research Council, 219 Perimeter Center Pkwy., Atlanta, GA 30346.
[G] An oil-related stuck ring occurs on a piston with an individual oil ring land deposit rating <2.6.
[H] Determine at 60 h.

[I] Determine at 80 h.
[J] 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 CRC Varnish Rating Manual No. 14 for all ratings.
[K] Calculate by eliminating the highest and lowest cam-plus-lifter wear results and then calculating an average based on the remaining ten rating positions.
[L] Demonstrate passing performance in Test Method D 5302, or alternatively, in both the Sequence IVA test and Test Method D 6593.
[M] Determine cam wear according to the Sequence IVA test procedure. 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 the CRC Varnish Rating Manual No. 14 for all ratings.
[O] Demonstrate passing performance in either Test Method D 5119 or D 6709.
[P] Ten-hour stripped kinematic viscosity (oil shall remain in original viscosity grade).
[Q] Passing bench test performance is only required for SAE 5W-30, SAE 10W-30, and SAE 15W-40 viscosity grades as defined in SAE J300.
[R] Meet either Test Method D 5800 or Test Method D 2887 volatility requirement.
[S] NR stands for Not Required.
[T] Meet either Test Method D 92 or Test Method D 93 flash point requirement.
[U] Determine settling volume at 5 min.
[V] Report kinetic foam volume (mL), static foam volume (mL), and collapse time, s.
[W] Homogeneous with SAE reference oils.
[X] Meet the volatility requirement in either Test Method D 5800, D 5480, or D 6417.
[Y] Passing volatility loss only required for SAE 15W-40 oils.
[Z] This is a noncritical specification as described in Practice D 3244.
[AA] Determine settling volume, in mL, at 10 min.
[AB] Determine settling volume, in mL, at 1 min.
[AC] Evaluate the 80-h test oil sample by Test Method D 4684 at the temperature indicated by the low temperature grade of oil as determined on the 80-h sample by Test Method D 5293.
[AD] Not required for oils containing a minimum of 0.08 % mass phosphorus in the form of ZDDP.
[AE] Requirement applies only to SAE 0W-20, 5W-20, 0W-30, 5W-30, and 10W-30 viscosity grades.
[AF] For gelation temperatures at or above the W grade pumpability temperature as defined in SAE J300.

4.1.3.1 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.[10]

4.1.3.2 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.[11]

4.1.3.3 Test Method D 5302, 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 % of phosphorus from ZDDP additive.

4.1.3.4 Test Method D 6593, 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.

4.1.3.5 Test Method D 6709, 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.[12]

(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.

4.1.3.6 In addition to passing performance in the engine tests, oils shall also meet bench test requirements (see Table 2), which are discussed in the following subsections:

(1) Test Method D 6557 (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 D 5800 and D 6417.

(3) Test Method D 6795, the Engine Oil Filterability Test (EOFT) and Test Method D 6794, 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 D 4951 or D 5185.

(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 D 892 and D 6082 empirically rate the foaming tendency and stability of oils.

(6) Test Method D 6922, 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. The TEOST MHT-4 test may be useful in determining the piston deposit control capability of oils recommended for these engines.[13]

(8) Test Method D 5133, the Gelation Index technique, might identify oils susceptible to air binding and might provide low-temperature protection not adequately measured by Test Method D 4684.

[10] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02–1491.

[11] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1473.

[12] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1471.

[13] Test under development by D02.B0.

4.1.3.7 Licensing of the API SL category 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.

4.1.4 *CF-4*—Oil meeting the performance requirements in the following diesel and gasoline engine tests and bench test:

4.1.4.1 Test Method D 6750, the 1K diesel engine test, has been correlated with vehicles equipped with engines used in high-speed operation prior to 1989,[14] particularly with regard to deposits and oil consumption.

4.1.4.2 The T-6 has been correlated with vehicles equipped with engines used in high-speed operation prior to 1980,[15] particularly with regard to deposits, oil consumption, and ring wear.

4.1.4.3 The T-7 test has been correlated with vehicles equipped with engines operated largely under lugging conditions prior to 1984,[16] particularly with regard to oil thickening.

4.1.4.4 Test Method D 5968, the bench corrosion test, has been shown to predict corrosion of engine oil-lubricated copper, lead, or tin-containing components used in diesel engines.[17] Test Method D 5290, the NTC-400 diesel engine test, has been correlated with vehicles equipped with engines in highway operation prior to 1983,[18] particularly with regard to oil consumption control, deposits, and wear. Test Method D 5290 is not listed in Table 3, as calibrated test stands are no longer available due to unavailability of critical test parts. It has been demonstrated that the 1K test, in combination with Test Method D 5968, can be substituted for the NTC-400 test as an acceptable means to demonstrate performance against this category; however, data from NTC-400 tests, run in calibrated stands, can be used to support this category in accordance with the provisions of Specification D 4485–94.

4.1.4.5 Test Method D 6709, 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.[12]

4.1.5 *CF*—Oil meeting the performance requirements in the following diesel and gasoline engine tests:

4.1.5.1 Test Method D 6618, the 1M-PC diesel engine test, has been shown to provide correlation with engine oil performance when used in naturally aspirated, turbocharged, or supercharged indirect injection engines.[19]

4.1.5.2 Test Method D 6709, 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.[12]

4.1.5.3 Licensing of the API CF category requires that candidate oils meet the performance requirements of 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.

4.1.6 *CF-2*—Oil meeting the performance requirements in the following diesel and gasoline engine tests:

4.1.6.1 Test Method D 6618, the 1M-PC diesel engine test, has been shown to provide correlation with engine oil performance when used in naturally aspirated, turbocharged, or supercharged indirect injection engines, *with modified piston deposit rating methodology to relate to effective piston and ring groove deposit control for two-stroke cycle diesel engines*.

4.1.6.2 Test Method D 5862, the 6V92TA diesel engine test, has been correlated with two-stroke cycle diesel engines in heavy-duty service, particularly with regard to ring face distress and liner scuffing.

4.1.6.3 Test Method D 6709, 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.[12]

4.1.6.4 Licensing of the API CF-2 category requires that candidate oils meet the performance requirements of 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.

4.1.7 *CG-4*—Oil meeting the performance requirements in the following diesel and gasoline engine tests and bench tests:

4.1.7.1 Test Method D 6750, 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 less than 0.05 % weight sulfur.[20]

4.1.7.2 Test Method D 5967, the T-8 diesel engine test, has been shown to generate soot-related oil thickening in a manner similar to 1992 emission-controlled heavy-duty diesel engines using mechanical injection control systems.

4.1.7.3 The Sequence IIIF test method is used to measure bulk oil viscosity increase, which indicates an oil's ability to withstand the higher temperatures found in modern diesel engines.

4.1.7.4 Test Method D 6709, 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.[12]

[14] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1273.

[15] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1219.

[16] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1220.

[17] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1322.

[18] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1194.

[19] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1320.

[20] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02–1321.

TABLE 3 C Engine Oil Categories

Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CF-4	D 6709 (Sequence VIII)	Bearing weight loss, mg, max	33.0		
	T-6	Merit rating,[A] min	90		
	or				
	D 6483 (T-9)[B]	Top piston ring weight loss,[C] average, mg, max	150		
		Liner wear, µm, max	40		
	T-7	Average rate of kinematic viscosity increase during last 50 h, mm^2/s at 100°C/h, max	0.040		
	or				
	D 5967 (T-8A)[B]	Average rate of kinematic viscosity increase from 100 to 150 h, mm^2/s at 100°C/h, max	0.20		
	D 5968 (CBT)[D]	Copper, mg/kg (ppm) increase, max	20		
		Lead, mg/kg (ppm) increase, max	60		
		Tin, mg/kg (ppm) increase, max	report		
		Copper strip rating,[E] max	3		
			Two-test[F]	Three-test[F]	Four-test[F]
	D 6750 (1K)	A 1K test program[F] with a minimum of two tests, acceptable according to the limits shown in the columns to the right, is required to demonstrate performance for this category.			
		Weighted demerits (WDK),[G,H] max	332	339	342
		Top groove fill (TGF),[G] %, max	24	26	27
		Top land heavy carbon (TLHC),[G] % max	4	4	5
		Average oil consumption, g/kW·h, (0-252 h), max	0.5	0.5	0.5
		Final Oil consumption, g/kW·h, (228-252 h) max	0.27	0.27	0.27
		Piston, ring, and liner scuffing			
		Number of tests allowed	none	none[E]	none[I]
		Piston ring sticking	none	none	none
CF	D 6618 (1M-PC)	Top groove fill (TGF),[G] %, max	70[J]	MTAC[J]	MTAC[J]
		Weighted total demerits (WTD),[G] max	240[J]		
		Piston ring sticking	none		
		Piston, ring and liner scuffing	none		
			One-Test	Two-Test[K]	Three-Test[K]
	D 6709 (Sequence VIII)	Bearing weight loss, mg, max	29.3	31.9	33.0
CF-2	D 6618 (1M-PC)	Weighted total demerits (WTD),[G] max	100[J]	MTAC[J]	MTAC[J]
			One-Test	Two-Test[L]	Three-Test[L]
	D 5862 (6V 92TA)	Cylinder liner scuffing area, % max	45.0	48.0	50.0
		Cylinder liner port plugging area,			
		Average, % max	2	2	2
		Single cylinder, % max	5	5	5
		Piston rings face distress demerits			
		No. 1 (fire ring), max	0.23	0.24	0.26
		Average of No. 2 and 3, max	0.20	0.21	0.22
	D 6709 (Sequence VIII)	Bearing weight loss, mg, max	29.3	31.9[K]	33.0[K]
			One-Test	Two-Test[M]	Three-Test[M]
CG-4	D 6750 (1N)	Weighted demerits (WDN)[G,N]	286.2	311.7	323.0
		Top groove fill (TGF),[G] %, max	20	23	25
		Top land heavy carbon (TLHC),[G] % max	3	4	5
		Oil consumption, g/kW·h, (0-252 h) max	0.5	0.5	0.5
		Piston, ring, and liner scuffing			
		Number of tests allowed	none	none	none[I]
		Piston ring sticking	none	none	none
	D 5967 (T-8)	Viscosity increase at 3.8 % soot, cSt, max	11.5	12.5	13.0
		Filter plugging, differential pressure, kPa (psi), max	138 (20)	138 (20)	138 (20)
		Oil consumption, g/kW·h (lb/bhp·h), max	0.304 (0.0005)	0.304 (0.0005)	0.304 (0.0005)
	Sequence IIIF	60 h viscosity (at 40°C) increase from 10 min sample, %, max	325	349	360
	D 6709 (Sequence VIII)	Bearing weight loss, mg, max	29.3	31.9[K]	33.0[K]
		Used oil viscosity, cSt greater than SAE J300 lower limit for grade, min[O]	0.5	0.5	0.5
	D 5966 (RFWT)	Wear, mils, max	0.45	0.49	0.50
		µm, max	(11.4)	(12.4)	(12.7)
	D 892 (Option A not allowed)	Foaming characteristics			
		Foaming/settling,[P] mL, max			
		Sequence I	10/0		
		Sequence II	20/0		
		Sequence III	10/0		
	D 6894 (EOAT)[Q]	Aeration, volume % max	10.0		
	D 5968	Copper, mg/kg (ppm) increase, max	20		
		Lead, mg/kg (ppm) increase, max	60		
		Tin, mg/kg (ppm) increase, max	report		