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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.

This standard has been approved for use by agencies of the Department of Defense.

INTRODUCTION

This document 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 SI units are to be regarded as the standard. The values in inch-pound units are provided for information only.

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

2. Referenced Documents

2.1 *ASTM Standards:*

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

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TABLE 1 Test Procedures

Test Procedure	ASTM Publications[A]
Sequence IIIF	RR:D02-1491[B]
Sequence IVA	RR:D02-1473[C]
Sequence VIB	RR:D02-1469[D]
Sequence VIII	RR:D02-1471[E]
TEOST MHT-4	Under development[F]
T-6	RR: D02-1219[G]
T-7	RR: D02-1220[H]
1K	RR: D02-1273[I]
1N	RR: D02-1321[J]
Oil Aeration	RR: D02-1379[K]
EOFT	under development[L]
EOWTT	Under development[M]
1P	RR: D02-1441[N]
M11	RR: D02-1439[O]

[A] Research Reports are available from ASTM 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] Sequence VIB fuel economy test.
[E] Sequence VIII bearing corrosion test.
[F] Thermo-Oxidation Engine Oil Simulation Test (MHT-4)—high temperature deposits test.
[G] Multicylinder Engine Test Procedure for the Evaluation of Lubricants—Mack T-6.
[H] Multicylinder Engine Test Procedure for the Evaluation of Lubricants—Mack T-7.
[I] Caterpillar 1K Test.
[J] Single Cylinder Piston Deposit Test, CAT 1N.
[K] Navistar Engine Oil Test.
[L] Engine Oil Filterability Test under development by ASTM D02.06.
[M] Engine Oil Water Tolerance Test under development by D02.06.
[N] Caterpillar 1P Test.
[O] Cummins M11 High Soot Test.

D 92 Test Method for Flash and Fire Points by Cleveland Open Cup[2]
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester[2]
D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[2]
D 892 Test Method for Foaming Characteristics of Lubricating Oils[2]
D 2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography[3]
D 3244 Practice for Utilization of Test Data to Determine Conformance with Specifications[3]
D 4684 Test Method for Determination of Yield Stress and Apparent Viscosity of Engine Oils at Low Temperature[4]
D 4951 Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry[4]
D 5119 Test Method for Evaluation of Automotive Engine Oils in the CRC L-38 Spark-Ignition Engine[4]
D 5133 Test Method for Low Temperature, Low Shear Rate, Viscosity/Temperature Dependence of Lubricating Oils Using a Temperature-Scanning Technique[4]
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)[4]
D 5290 Test Method for Measurement of Oil Consumption, Piston Deposits, and Wear in a Heavy-Duty High-Speed Diesel Engine—NTC-400 Procedure[5]
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[4]
D 5480 Test Method for Motor Oil Volatility by Gas Chromatography[4]
D 5533 Test Method for Evaluation of Automotive Engine Oils in the Sequence IIIE Spark-Ignition Engine[4]
D 5800 Test Method for Evaporation Loss of Lubricating Oils by the Noack Method[4]
D 5844 Test Method for Evaluation of Automotive Engine Oils for Inhibition of Rusting (Sequence IID)[4]
D 5862 Test Method for Evaluation of Engine Oils in the Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine[4]
D 5966 Test Method for Evaluation of Engine Oils for Roller Follower Wear in Light-Duty Diesel Engine[6]
D 5967 Test Method for Evaluation of Diesel Engine Oils in the T8 Diesel Engine[6]
D 5968 Test Method for Evaluation of Corrosiveness of Diesel Engine Oil[6]
D 6082 Test Method for High Temperature Foaming Characteristics of Lubricating Oils[6]
D 6202 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 VIA Spark Ignition Engine[6]
D 6278 Test Method for the Shear Stability of Polymer-Containing Fluids Using a European Diesel Injector Apparatus[6]
D 6335 Test Method for Determination of High Temperature Deposits by Thermo-Oxidation Engine Oil Simulation Test[6]
D 6417 Test Method for Estimation of Engine Oil Volalility by Capillary Gas Chromatography[6]
D 6483 Test Method For Evaluation of Diesel Engine Oils in the T-9 Diesel Engine[6]
D 6557 Test Method for Evaluation of Rust Preventative Characteristics of Automotive Engine Oils[6]
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[6]
D 6594 Test Method for Evaluation of Corrosiveness of Diesel Engine Oil at 135°C[6]
D 6618 Test Method for Evaluation of Engine Oils in the Diesel Four-Stroke Cycle Supercharged 1M-PC Single Cylinder Oil Test Engine[6]
E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[7]

[2] *Annual Book of ASTM Standards*, Vol 05.01.
[3] *Annual Book of ASTM Standards*, Vol 05.02.
[4] *Annual Book of ASTM Standards*, Vol 05.03.
[5] Discontinued; see 1997 *Annual Book of ASTM Standards*, Vol 05.03.
[6] *Annual Book of ASTM Standards*, Vol 05.04.
[7] *Annual Book of ASTM Standards*, Vol 14.02.

E 178 Practice for Dealing with Outlying Observations[7]

2.2 *Society of Automotive Engineers Standards:*[8]

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:*[9]

API 1509 Engine Oil Licensing and Certification System (EOLCS)

2.4 *Government Standard:*[10]

Federal Test Method Standard No. 791C, Method 3470

2.5 *General Motors Corporation Engineering Standard:*[11]

GM9099-P Engine Oil Filterability Test (EOFT)

2.6 *American Chemical Council Code:*[12]

ACC Petroleum Additives Product Approval Code of Practice

3. Terminology

3.1 *Definitions:*

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

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

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 *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.

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

3.1.7 *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.

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

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *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.

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

3.2.3 *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.

4. Performance Classification

4.1 Automotive engine oils are classified in three general arrangements, as defined in Section 3; 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:

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,[13] 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,[14] 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,[15] 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*) The Engine Oil Filterability Test (EOFT) screens for the formation of precipitates that can cause oil filter plugging.

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

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

[10] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20036.

[11] Available from General Motors Corporation, CPE-Engineering Standards, W-3, Warren, MI 48090.

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

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

[14] Available from ASTM Headquarters. Request RR:D02-1225.

[15] Available from ASTM Headquarters. Request RR:D02-1226.

(*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*) The H and M Test indicates the compatibility of an oil with standard test oils.

TABLE 2 S Engine Oil Categories

API SH Category

Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
D 5844 (Sequence IID)	Average engine rust rating,[A] min	8.5
	Number stuck lifters	none
D 5533 (Sequence IIIE)	Hours to 375 % kinematic viscosity increase at 40°C, min	64
	Average engine sludge rating,[B] 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[D])	none
D 5302 (Sequence VE)	Average engine sludge rating,[B] min	9.0
	Rocker arm cover sludge rating,[B] min	7.0
	Average piston skirt varnish rating,[C] min	6.5
	Average engine varnish rating,[C] min	5.0
	Oil ring clogging, %, max	Report
	Oil screen clogging, %, max	20.0
	Compression ring sticking (hot stuck)	none
	Cam wear, µm	
	Average, max	127
	Maximum, max	380
D 5119 (L-38)	Bearing weight loss, mg, max	40
	Shear stability[E]	

Bench Test and Measured Parameter (effective January 1, 1992)	Viscosity Grade Performance Criteria[F]		
	SAE 5W-30	SAE 10W-30	SAE 15W-40
Test Method D 5800 volatility loss, % max[G]	25	20	18
Test Method D 2887 volatility loss at 371°C (700°F), % max[G]	20	17	15
EOFT, % flow reduction, max	50	50	N.R.[H]
Test Method D 4951 or D 5185, phosphorus % mass, max	0.12	0.12	N.R.
Test Method D 92 flash point, °C, min[I]	200	205	215
Test Method D 93 flash point, °C, min[I]	185	190	200
Test Method D 892 foaming tendency (Option A)			
Sequence I, max, foaming/settling[J]	10/0	10/0	10/0
Sequence II, max, foaming/settling[J]	50/0	50/0	50/0
Sequence III, max, foaming/settling[J]	10/0	10/0	10/0
Test Method D 6082	report[K]	report[K]	report[K]
Federal Test Method 791C, Method 3470.1, homogeneity and miscibility	[L]	[L]	[L]

API SJ Category

Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
D 5844 (Sequence IID)	Average engine rust rating,[A] min	8.5
	Number stuck lifters	None

TABLE 2 *Continued*

D 5533 (Sequence IIIE)	Hours to 375 % kinematic viscosity increase at 40°C, min	64
	Average engine sludge rating,[B] 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[D])	None
D 5302 (Sequence VE)	Average engine sludge rating,[B] min	9.0
	Rocker arm cover sludge rating,[B] min	7.0
	Average piston skirt varnish rating,[C] min	6.5
	Average engine varnish rating,[C] min	5.0
	Oil ring clogging, %, max	Report
	Oil screen clogging, %, max	20.0
	Compression ring sticking (hot stuck)	None
	Cam wear, µm	
	Average, max	127
	Maximum, max	380
D 5119 (L-38)	Bearing weight loss, mg, max	40
	Shear stability[E]	

Bench Test and Measured Parameter	Viscosity Grade Performance Criteria: SAE 0W-20, SAE 5W-20, SAE 5W-30, SAE 10W-30	Viscosity Grade Performance Criteria: All Others
Test Method D 5800 volatility loss, % max[M]	22	20[N]
Test Method D 6417 volatility loss at 371°C (700°F), % max[M]	17	15[N]
Test Method D 5480 volatility loss at 371°C (700°F), % max[M]	17	15[N]
EOFT, % flow reduction max	50	50
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[O]	NR[H]
Test Method D 92 flash point, °C, min[I]	200	NR[H]
Test Method D 93 flash point, °C, min[I]	185	NR[H]
Test Method D 892 foaming tendency (Option A)		
Sequence I, max, foaming/settling[P]	10/0	10/0
Sequence II, max, foaming/settling[P]	50/0	50/0
Sequence III, max, foaming/settling[P]	10/0	10/0
Test Method D 6082 (optional blending required) static foam max, Tendency/Stability	200/50[Q]	200/50[Q]
Federal Test Method 791C, Method 3470, homogeneity and miscibility	[L]	[L]
Test Method D 6335 High temperature deposits (TEOST), deposit wt, mg, max	60	60
Test Method D 5133 Gelation Index, max	12	NR[H]

API SL CATEGORY

Engine Test Method	Rated or Measured Parameter	Primary Performance Criteria
Sequence IIIF	Kinematic viscosity, % increase at 40°C, max	275
	Avg piston skirt varnish rating,[C] min	9.0
	Weighted piston deposit rating,[R] min	4.0
	Cam plus lifter wear avg. µm, max	20
	Hot Stuck Rings	none
	Oil Consumption, liters, max	5.2
	Low temperature viscosity performance[S]	Report
Sequence IVA	Cam wear avg, µm, max[T]	120
D 5302 (Sequence VE[U])	Cam wear avg, µm, max	127
	Cam wear max, µm, max	380

TABLE 2 *Continued*

D 6593 (Sequence VG)	Avg engine sludge rating,[B] min	7.8
	Rocker arm cover sludge rating,[B] min	8.0
	Avg piston skirt varnish rating,[C] min	7.5
	Avg engine varnish rating,[V] min	8.9
	Oil screen clogging, %, max	20.0
	Hot stuck Compression rings	None
	Cold stuck rings	Report
	Oil screen debris, %	Report
	Oil ring clogging, %	Report
Sequence VIII	Bearing weight loss, mg, max	26.4
	Shear stability	[E]

Bench Test and Measured Parameter	Performance Criteria
Test Method D 6557 (Ball Rust Test), avg 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
EOFT, % flow reduction, max	50
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[W]	0.10[O]
Test Method D 892 foaming tendency (Option A)	
Sequence I, max, foaming/settling[P]	10/0
Sequence II, max, foaming/settling[P]	50/0
Sequence III, max, foaming/settling[P]	10/0
Test Method D 6082 (optional blending required) static foam max, Tendency/Stability	100/0[Q]
Federal Test Method 791C, Method 3470, homogeneity and miscibility	[L]
High temperature deposits (TEOST MHT-4), deposit wt, mg, max	45
Test Method D 5133 (Gelation Index), max[W]	12[X]

[A] CRC Rust Rating Manual No. 7, available from Coordinating Research Council, 219 Perimeter Center Pkwy., Atlanta, GA 30346.
[B] CRC Sludge Rating Manual No. 12, available from Coordinating Research Council, 219 Perimeter Center Pkwy., Atlanta, GA 30346.
[C] CRC Varnish Rating Manual No. 14, available from Coordinating Research Council, 219 Perimeter Center Pkwy., Atlanta, GA 30346.
[D] An oil-related stuck ring occurs on a piston with an individual oil ring land deposit rating < 2.6.
[E] Ten-hour stripped kinematic viscosity (oil shall remain in original viscosity grade).
[F] 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.
[G] EitherTest Method D 5800 or Test Method D 2887 volatility requirement shall be met.
[H] N.R. stands for Not Required.
[I] Either Test Method D 92 or Test Method 93 flash point requirement shall be met.
[J] Settling volume determined at 5 min.
[K] Kinetic foam volume; mL/static foam volume, and mL/collapse time in seconds.
[L] Homogeneous with SAE reference oils.
[M] Volatility requirement shall be met in either Test Method D 5800, D 5480, or D 6417.
[N] Passing volatility loss performance only required for 15W-40 oils.
[O] This is a non-critical specification as described in Practice D 3244.
[P] Settling volume determined at 10 min.
[Q] Settling volume determined at 1 min.
[R] Weighted piston deposits shall be determined 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 %. All parts are to be rated using CRC Varnish Rating Manual No. 14.
[S] The 80-hour test oil sample shall be evaluated by Test Method D 4684 (MRV TP-1) at the temperature indicated by the low temperature grade of oil as determined on the 80-hr sample by Test Method D 5293 (CCS viscosity).
[T] Cam wear shall be determined as specified in the Sequence IVA 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. Cam wear is the average of the twelve individual cam lobe wear results in a particular test engine.
[U] Not required for oils containing a minimum of 0.08 % mass phosphorus in the form of ZDDP.
[V] Average engine varnish shall be the average of piston skirt, right rocker cover, and left rocker cover varnish ratings, determined by CRC Varnish Rating Manual No. 14.
[W] Requirement applies only to SAE 0W-20, 5W-20, 0W-30, 5W-30, and 10W-30 viscosity grades.
[X] For gelation temperatures at or above the W grade pumpability temperature as defined in SAE J300.

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.

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*) 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*) 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:

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.[16]

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.[17]

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% mass 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 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.[18]

*(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)*The Engine Oil Filterability Test (EOFT) and 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)*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

[16] Available from ASTM Headquarters. Request RR:D02–1491.
[17] Available from ASTM Headquarters. Request RR: D02-1473.
[18] Available from ASTM Headquarters. Request RR: D02-1471.

deposit control capability of oils recommended for these engines.[19]

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

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:

4.1.4.1 The 1K diesel engine test has been correlated with vehicles equipped with engines used in high-speed operation prior to 1989,[20] particularly with regard to deposits, oil consumption, and ring wear.

4.1.4.2 The T-6 has been correlated with vehicles equipped with engines used in high-speed operation prior to 1980,[21] 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,[22] 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.[23] Test Method D 5290, the NTC-400 diesel engine test, has been correlated with vehicles equipped with engines in highway operation prior to 1983,[24] 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.

[19] Test under development by ASTM D02.B

[20] Available from ASTM Headquarters. Request RR: D02-1273.

[21] Available from ASTM Headquarters. Request RR: D02-1219.

[22] Available from ASTM Headquarters. Request RR: D02-1220.

[23] Available from ASTM Headquarters. Request RR: D02-1322.

[24] Available from ASTM Headquarters. Request RR: D02-1194.

TABLE 3 C Engine Oil Categories

Category	Test Method	Rated or Measured Parameter	Primary Performance Criteria		
CF-4	D 5119 (L-38)	Bearing weight loss, mg, max	50		
	T-6	Merit rating[A], min	90		
	or				
	D 6483 (T-9)[B]	Top piston ring weight loss[C], average, mg, max	150		
		Linear wear, µm, max	40		
	T-7 or	Average rate of kinematic viscosity increase during last 50 h, mm^2/s at 100°C/h, max	0.040		
	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]
	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
		Groove No. 1 (top) carbon fill (TGF),[G] % volume, 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
		Scuffing, piston-rings-liner			
		Number of tests allowed	none	none[I]	none[I]
		Piston ring sticking	none	none	none
CF	D 6618 (1M-PC)	Top groove fill (TGF)[G], volume, max	70[J]	MTAC[J]	MTAC[J]
		Weighted total demerits (WTD[G], max	240[J]		
		Ring side clearance loss[G] mm, max	0.013[J]		
		Piston ring sticking	none		
		Piston, ring and liner scuffing	none		
			First-Test	Two-Test[K]	Three-Test[K]
	D 5119 (L-38)	Bearing weight loss, mg, max	43.7	48.1	50.0
CF-2	D 6618 (1M-PC)	Weighted total demerits (WTD)[G]	100[J]	MTAC[J]	MTAC[J]
			First-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	0.20	0.21	0.22
	D 5119 (L-38)	Bearing weight loss, mg, max	43.7	48.1[K]	50.0[K]
			First-Test	Two-Test[M]	Three-Test[M]
CG-4	1N	Weighted demerits—1N (WDN)[G,N]	286.2	311.7	323.0
		Top groove fill (TGF)[G], % volume, 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
		Scuffing, piston-rings-liner			
		Number of tests allowed	none	none	none[I]
		Stuck rings	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, max	0.304	0.304	0.304
		lb/bhp·h, max	(0.0005)	(0.0005)	(0.0005)
	D 5533 (Sequence IIIE)	Hours to 375 % viscosity increase, min	67.5	65.1	64.0
	D 5119 (L-38)	Bearing weight loss, mg, max	43.7	48.1	50.0
		Used oil viscosity, cSt greater than SAE J300 lower limit for grade, min[O]	0.5	0.5	0.5
	D 5966 (RFWT)	Wear, µm, max	11.4	12.4	12.7
		mils, max	(0.45)	(0.49)	(0.50)
	D 892 (Option A not allowed)	Foaming characteristics			
		Foaming/settling, ml, max[P]			
		Sequence I	10/0		
		Sequence II	20/0		

TABLE 3 *Continued*

		Sequence III	10/0		
	EOAT[Q]	Aeration, volume % at 20 h, max	10.0		
	D 5968				
		Copper, ppm increase, max	20		
		Lead, ppm increase, max	60		
		Tin, ppm increase, max	report		
		Copper strip rating[E], max	3		
			First-test	Two-test[R]	Three-test[R]
CH-4	1P[S]	WDP, max	350	378	390
		TGC, max	36	39	41
		TLC, max	40	46	49
		Average Oil Consumption, g/h (0-360 h), max	12.4	12.4	12.4
		Final Oil Consumption, g/h (312-360 h), max	14.6	14.6	14.6
		Scuffing, piston-rings-liner	none	none	none[I]
	1K[H]	WDK, max	332	347	353
		TGF, max	24	27	29
		TLHC, max	4	5	5
		Oil Consumption, g/kW-h (0-252h), max	0.5	0.5	0.5
		Scuffing, piston-ring-liner	none	none	none[I]
	D 6483 (T-9)	Average Liner Wear, normalized to 1.75 % soot, µm max	25.4	26.6	27.1
		Average Top Ring Weight Loss, mg max[C]	120	136	144
		EOT Used Oil Lead Content less New Oil Lead Content, ppm max	25	32	36
	D 5966 (RFWT)	Average Pin Wear, µm max	7.6	8.4	9.1
		(mils max)	(0.30)	(0.33)	(0.36)
	M11[T]	Rocker Pad Average Wt. 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
		Engine Sludge, CRC Merits at EOT, min	8.7	8.6	8.5
	D 5967 (Ext. T-8E)	Relative Viscosity at 4.8 % Soot by TGA, max	2.1	2.2	2.3
		Viscosity increase at 3.8 % Soot by TGA, cSt max	11.5	12.5	13.0
	D 5533	64 Hour Viscosity at 40°C, max increase from 10 minute sample, %	200	200 (MTAC)[U]	200 (MTAC)[U]
	EOAT[Q]	Aeration, Vol. % max	8.0	8.0 (MTAC)[U]	8.0 (MTAC)[U]