Crankcase

Contents Crankcase

Ethyl®

API Service Classification

"S" Service

"S" Service - (Service Stations, Garages, New Car Dealers etc.)

The following descriptions of the categories in the API Engine Service Classification System are intended as guides to aid in the selection of proper engine oils for significantly different engine service conditions. The performance requirements for these categories are technically described in SAE J183-June 1991, Engine Oil Performance and Engine Service Classification (except for SH).

SA **Formerly for Utility Gasoline and Diesel Engine Service**

Service typical of older engines operated under such mild conditions that the protection afforded by compounded oils is not required. This category should not be used in any engine unless specifically recommended by the equipment manufacturer.

SB **For Minimum Duty Gasoline Engine Service**

Service typical of older gasoline engines operated under such mild conditions that only minimum protection afforded by compounding is desired. Oils designed for this service have been used since the 1930's and provide only antiscuff capability and resistance to oil oxidation and bearing corrosion. They should not be used in any engine unless specifically recommended by the equipment manufacturer.

SC **For 1964 Gasoline Engine Warranty Maintenance Service**

Service typical of gasoline engines in 1964 through 1967 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Oils designed for this service provide control of high and low temperature deposits, wear, rust and corrosion in gasoline engines.

SD **For Gasoline Engine Warranty Maintenance Service**

Service typical of gasoline engines in 1968 through 1970 models of passenger cars and some trucks operating under engine manufacturers' warranties in effect during those model years. Also may apply to certain 1971 and/or later models as specified (or recommended) in the owners' manuals. Oils designed for this service provide more protection against high and low temperature engine deposits, wear, rust and corrosion in gasoline engines than oils which are satisfactory for API Engine Service Category SC and may be used when API Engine Service Category SC is recommended.

SE **For 1972 Gasoline Engine Warranty Service**

Service typical of gasoline engines in passenger cars and some trucks beginning with 1972 and certain 1971 models operating under engine manufacturers' warranties. Oils designed for this service provide more protection against oil oxidation, high temperature engine deposits, rust and corrosion in gasoline engines than oils which are satisfactory for API Engine Service Categories SD or SC and may be used when either of these classifications is recommended.

API Service Classification

"S" Service

SF **For 1980 Gasoline Engine Warranty Maintenance Service**

Service typical of gasoline engines in passenger cars and some trucks beginning with the 1980 model year operating under manufacturers' recommended maintenance procedures. Oils developed for this service provide increased oxidation stability and improved anti-wear performance relative to oils which meet the minimum requirements for API Service Category SE. The oils also provide protection against engine deposits, rust and corrosion. Oils meeting API Service Classification SF may be used where API Service Categories SE, SD or SC are recommended.

Oils meeting the performance requirements measured in the following gasoline engine tests: The IID gasoline engine test has been correlated with vehicles used in short-trip service prior to 1978, particularly with regard to rusting. The IIID gasoline engine test has been correlated with vehicles used in high temperature service prior to 1978, particularly with regard to oil thickening and valve train wear. The V-D gasoline engine test has been correlated with vehicles used in stop-and-go service prior to 1978, particularly with regard to varnish, sludge and valve train wear. The L-38 gasoline engine test requirement provides a measurement of copper-lead bearing weight loss under high-temperature operating conditions.

SG **For 1989 Gasoline Engine Warranty Maintenance Service**

Service typical of gasoline engine in passenger cars, vans and light trucks beginning with the 1989 model year operating under manufacturers' recommended maintenance procedures. Category SG quality oils include the performance properties of API service category CC. (Certain manufacturers of gasoline engines require oils also meeting API Category CD).

Oils developed for this service provide improved control of engine deposits, oil oxidation and engine wear relative to oils developed for previous categories. These oils also provide protection against rust and corrosion. Oils meeting API Service Category SG may be used where API Service Categories SF, SF/CC, SE or SE/CC are recommended.

Oils meeting the performance requirements measured in the following gasoline and diesel engine tests:

- The IID gasoline engine test has been correlated with vehicles used in short-trip service prior to 1978, particularly with regard to rusting.
- The 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.
- The 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.
- The L-38 gasoline engine test requirement provides a measurement of copper-lead bearing weight loss and piston varnish under high temperature operating conditions.
- The 1-H2 diesel engine test requirement provides a measurement of high-temperature deposits.

API Service Classification

"S" Service

SH

For 1992 Gasoline Engine Warranty Maintenance Service

Category SH covers the performance requirements of SG oils tested to the latest CMA protocol on engine testing. In addition, SH oils must meet various bench test requirements including volatility, filterability and foaming tests.

SJ

For 1997 Gasoline Engine Warranty Maintenance Service

API Service Category SJ was adopted for use in describing engine oils available in 1996. These oils are for use in service typical of gasoline engines in current and earlier passenger-car, sport utility vehicle, van, and light truck operations under vehicle manufacturers' recommended maintenance procedures.

Engine oils that meet API Service Category SJ designation may be used where API Service Category SH and earlier Categories have been recommended.

Engine oils that meet the API Service Category SJ designation have been tested in accordance with the CMA Code, may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing.

Engine oils that meet these requirements may display API Service Category SJ in the upper portion of the API Service Symbol.

SL

For 2001 Gasoline Engine Warranty Maintenance Service

API Service Category SL was adopted for use in describing engine oils available in 2001. These oils are for use in service typical of gasoline engines in current and earlier passenger cars, sport utility vehicles, vans, and light-duty trucks operating under vehicle manufacturers' recommended maintenance procedures.

Engine oils that meet API Service Category SL designation may be used where API Service Category SJ and earlier Categories have been recommended.

Engine oils that meet the API Service Category SL designation have been tested in accordance with the ACC Code and may use the API Base Oil Interchangeability Guidelines and the API Guidelines for SAE Viscosity-Grade Engine Testing.

Starting July 1, 2001, engine oils that meet these requirements may display API Service Category SL in the upper portion of the API Service Symbol.

API Commercial Classification

"C" Commercial

"C" Commercial - (Fleets, Contractors, Farmers, etc.)

CA **For Light Duty Diesel Engine Service**

Service typical of diesel engine operated in mild to moderate duty with high-quality fuels and occasionally has included gasoline engines in mild service. Oils designed for this service provide protection from bearing corrosion and from ring belt deposits in some naturally aspirated diesel engines when using fuels of such quality that they impose no unusual requirements for wear and deposit protection. They were widely used in the late 1940's and 1950's but should not be used in any engine unless specifically recommended by the equipment manufacturer.

CB **For Moderate Duty Diesel Engine Service**

Service typical of diesel engines operated in mild to moderate duty, but with lower-quality fuels which necessitate more protection for wear and deposits. Occasionally has included gasoline engines in mild service. Oils designed for this service provide necessary protection from bearing corrosion and from ring belt deposits in some naturally aspirated diesel engines with higher sulphur fuels. Oils designed for this service were introduced in 1949.

CC **For Moderate Duty Diesel and Gasoline Engine Service**

Service typical of many naturally aspirated diesel engines operated in moderate to severe-duty service and certain heavy-duty gasoline engines. Oils designed for this service provide protection from high temperature deposits and bearing corrosion and low temperature deposits in gasoline engines. These oils were introduced in 1961.

CD **For Severe Duty Diesel Engine Service**

Service typical of certain naturally aspirated, turbocharged or supercharged diesel engines where highly effective control of wear and deposits is vital, or when using fuels of a wide quality range including high sulphur fuels. Oils designed for this service were introduced in 1955 and provide protection from bearing corrosion and from high temperature deposits in these diesel engines.

Oil meeting the performance requirements measure in the following diesel and gasoline engine tests: The 1-G2 diesel engine test has been correlated with indirect injection engines used in heavy-duty operation, particularly with regard to piston and ring groove deposits. The L-38 gasoline engine test requirement provides a measurement of copper-lead bearing weight loss and piston varnish under high-temperature operating conditions.

API Commercial Classification

"C" Commercial

CD-II

For Severe Duty 2-Stroke Diesel Engine Service

Service typical of 2-stroke cycled engines requiring highly efficient control over wear and deposits. Oils designed for this service also meet the performance requirements of API service category CD.

Oils meeting the performance requirements measured in the following diesel and gasoline engine tests: The 1-G2 diesel engine test has been correlated with indirect injection engines used in heavy-duty operation, particularly with regard to piston and ring groove deposits. The 6V-53T diesel engine test has been correlated with vehicles equipped with two-stroke cycle diesel engines in high-speed operation prior to 1985, particularly with regard to ring and liner distress. The L-38 gasoline engine test requirement provides a measurement of copper-lead bearing weight loss and piston varnish under high-temperature operating conditions.

CE

For High Performance Diesel Engine Service

Service typical of many turbocharged or supercharged high performance diesel engines, operated under both low speed - high load and high speed - high load conditions. Oils designed for this service have been available since 1984 and provide improved control of oil consumption, oil thickening and piston assembly deposits and wear relative to the performance potential offered by oils designed for Category CD Service.

Oils meeting the performance requirements of the following diesel and gasoline engine tests: The 1-G2 diesel engine test has been correlated with indirect injection engines used in heavy-duty service, particularly with regard to piston and ring groove deposits. The T-6, T-7 and NTC-400 are direct injection diesel engine tests. The T-6 has been correlated with vehicles equipped with engines used in high-speed operation prior to 1980, particularly with regard to deposits, oil consumption and wear. The T-7 test has been correlated with vehicles equipped with engines used in lugging operation prior to 1984, particularly with regard to oil thickening. The NTC-400 diesel engine test has been correlated with vehicles equipped with engines in highway operation prior to 1983, particularly with regard to oil consumption, deposits and wear. The L-38 gasoline engine test requirement provides a measurement of copper-lead bearing weight loss under high-temperature operating conditions.

API Commercial Classification

"C" Commercial

CF

For Indirect Injected Diesel Engine Service

API Service Category CF denotes service typical of indirect injected diesel engines, and other diesel engines which use a broad range of fuel types including those using fuel with higher sulphur content, for example, over 0.5% wt. Effective control of piston deposits, wear and copper - containing bearing corrosion is essential for these engines which may be naturally aspirated, turbocharged or supercharged. Oils designated for this service have been in existence since 1994. Oils designated for this service may also be used when API service category CD is recommended.

CF-2

For Two-Stroke Cycle Diesel Engine Service

API Service category CF-2 denotes service typical of two-stroke cycle engines requiring highly effective control over cylinder and ring-face scuffing and deposits. Oils designated for this service have been in existence since 1994 and may also be used when API Service Category CD-II is recommended. These oils do not necessarily meet the requirements of CF or CF-4 unless passing test requirements for these categories.

CF-4

For High Performance Diesel Engine Service

This category was adopted in 1990 and describes oils for use in high speed, four-stroke diesel engines. API CF-4 oils exceed the requirements of the CE category, providing improved control of oil consumption and piston deposits.

Oils meeting the performance requirements in the following diesel and gasoline engine tests:

The T-6, T-7, NTC 400 and L-38 engines: See API CE Category above for explanation.

The 1K diesel engine test, which has been correlated with direct injection engines used in heavy-duty service prior to 1990, particularly with regard to piston and ring groove deposits. It has been demonstrated that the 1K test, in combination with test method D5968, the bench corrosion test, can be substituted for the NTC-400 test as an acceptable means to demonstrate performance against this category.

Test method D6483, the T-9 diesel engine test can be used as an alternate for the T-6 test and its limits.

Test method D5967, the F8A version, and its limits can be used as an alternate for the T-7 test and its limits.

API Commercial Classification

"C" Commercial

CG-4

For Severe Duty Diesel Engine Service

API Service Category CG-4 describes oils for use in high speed four stroke-cycle diesel engines used on both heavy-duty on-highway (less than 0.05% wt. sulphur fuel) and off highway (less than 0.5% wt. sulphur fuel) applications. CG-4 oils provide effective control over high temperature piston deposits, wear, corrosion, foaming, oxidation stability and soot accumulation. These oils are especially effective in engines designed to meet 1994 exhaust emission standards and may also be used in engines requiring API Service Categories CD, CE and CF-4. Oils designated for this service have been in existence since 1994.

CH-4

For 1998 Severe Duty Diesel Engine Service

API Service Category CH-4 describes oils for use in high-speed, four-stroke diesel engines designed to meet 1998 exhaust emissions standards as well as for previous model years. CH-4 oils are specifically compounded for use with diesel fuels ranging in sulphur content up to 0.5 percent weight.

These oils are especially effective to sustain engine durability even under adverse applications that may stress wear control, high temperature stability, and soot handling properties. In addition, optimum protection is provided against non-ferrous corrosion, oxidative and insoluble thickening, foaming, and viscosity loss due to shear. These oils also have the performance capability to afford a more flexible approach to oil drain intervals in accordance with the recommendations of the individual engine builders for their specific engines.

CH-4 oils are superior in performance to those meeting API CF-4 and API CG-4 and can effectively lubricate engines calling for those API Service Categories.

API Gasoline Engine Performance Criteria

	Test	Primary Performance Criteria	Limits	
SA	None	None		
			L-4	**L-38**
SB	L-4 or L-38	Bearing Weight Loss, mg. max.	500	500
	Sequence IV	Cam Scuffing	None	
		Lifter Scuff Rating, max.	2	
SC	Sequences IIA and IIIA	Cam and Lifter Scuffing	None	
		Avg. Cam plus Lifter Wear, in. max.	0.0025	
		Avg. Rust Rating, min.	8.2	
		Avg. Sludge Rating, min.	9.5	
		Avg. Varnish Rating, min.	9.7	
	Sequence IV	Cam Scuffing	None	
		Lifter Scuff Rating, max.	2	
	Sequence V	Total Engine Sludge Rating, min.	40	
		Avg. Piston Skirt Varnish Rating, min.	7.0	
		Total Engine Varnish Rating, min.	35	
		Avg. Intake Valve Tip Wear, in. max.	0.0020	
		Ring Sticking	None	
		Oil Ring Clogging, %. max.	20	
		Oil Screen Plugging, %. max.	20	
	L-38	Bearing Weight Loss, mg. max.	50	
	L-1 (0.95% min. sulphur fuel)	Top Groove Filling, % vol. max. Second Groove and Below	25 Clean	
SD	Sequences IIB and IIIB	Cam and Lifter Scuffing	None	
		Avg. Cam and Lifter Wear, in. max.	0.0030	
		Avg. Rust Rating, min.	8.8	
		Avg. Sludge Rating, min.	9.6	
		Avg. Varnish Rating, min.	9.6	
	Sequence IV	Cam Scuffing	None	
		Lifter Scuff Rating, max.	1	
	Sequence VB	Total Engine Sludge Rating, min.	42.5	
		Avg. Piston Skirt Varnish Rating, min.	8.0	
		Total Engine Varnish Rating, min.	37.5	
		Avg. Intake Valve Tip Wear, in. max.	0.0015	
		Oil Ring Clogging, %. max.	5	
		Oil Screen Plugging, %. max.	5	
	L-38	Bearing Weight Loss, mg. max.	40	
			L-1	**1-H**
	L-1(0.95% min. S. fuel) or 1-H	Top Groove Filling, % vol. max.	25	30
		Second Groove and Below	-	Clean
		Weighted Total Demerits	-	140
	Falcon	Avg. Engine Rust Rating, min.	9	

API Gasoline Engine Performance Criteria

	Test	Primary Performance Criteria		
SE	Sequence IIC or IID		**IIC**	**IID**
		Avg. Engine Rust Rating, min.	8.4	8.5
		Lifter Sticking	None	None
	Sequence IIIC or IIID		**IIIC**	**IIID**
		Viscosity Increase @ 100°F. and 40 test hrs, %. max.	400	-
		Viscosity Increase @ 40°C. and 40 test hrs, %. max.	-	375
		Avg. Piston Skirt Varnish Rating, min.	9.3	9.1
		Ring Land Face Varnish Rating, min.	6.0	4.0
		Avg. Sludge Rating, min.	9.2	9.2
		Ring Sticking	None	None
		Lifter Sticking	None	None
		Cam & Lifter Scuffing	None	None
		Cam & Lifter Wear, in. average	0.0010	0.0040
		Cam & Lifter Wear, in. max.	0.0020	0.0100
	Sequence VC or VD		**VC**	**VD**
		Avg. Engine Sludge Rating, min.	8.7	9.2
		Avg. Piston Skirt Varnish Rating, min.	7.9	6.4
		Avg. Engine Varnish Rating, min.	8.0	6.3
		Oil Ring Clogging, %. max.	5	10
		Oil Screen Plugging, %. max.	5	10
		Compression Ring Sticking	None	None
		Cam Wear, in. average	-	0.0020*
		Cam Wear, in. max.	-	0.0040*
	CRC L-38	Bearing Weight Loss, mg. max.	40	
SF	Sequence IID	Avg. Engine Rust Rating, min.	8.5	
		Lifter Sticking	None	
	Sequence IIID	Viscosity Increase at 40°C. and 64 test hrs, %. max.	375	
		Avg. Piston Skirt Varnish Rating, min.	9.2	
		Ring Land Face Varnish Rating, min.	4.8	
		Avg. Sludge Rating, min.	9.2	
		Ring Sticking	None	
		Lifter Sticking	None	
		Cam & Lifter Scuffing	None	
		Cam & Lifter Wear, in. average	0.0040	
		Cam & Lifter Wear, in. max.	0.0080	
	Sequence VD	Avg. Engine Sludge Rating, min.	9.4	
		Avg. Piston Skirt Varnish Rating, min.	6.7	
		Avg. Engine Varnish Rating, min.	6.6	
		Oil Ring Clogging, %. max.	10	
		Oil Screen Plugging, %. max.	7.5	
		Compression Ring Sticking	None	
		Cam Wear, in. average	0.0010	
		Cam Wear, in. max.	0.0025	
	CRC L-38	Bearing Weight Loss, mg. max.	40	

Note:
* Suggested performance - not pass/fail limit.

API Gasoline Engine Performance Criteria

	Test	Primary Performance Criteria			
SG	Sequence IID	Avg. Engine Rust Rating, min.			8.5
		Lifter Sticking			None
	Sequence IIIE	Viscosity Increase at 40°C. and 64 test hrs, %. max.			375
		Avg. Piston Skirt Varnish Rating, min.			8.9
		Avg. Sludge Rating, min.			9.2
		Ring Land Face Varnish Rating, min.			3.5
		Ring Sticking			None
		Lifter Sticking			None
		Cam & Lifter Scuffing			None
		Cam & Lifter Wear, µm. average			30
		Cam & Lifter Wear, µm. max.			64
	Sequence VE	Avg. Engine Sludge Rating, min.			9.0
		Rocker Arm Cover Sludge Rating, min.			7.0
		Avg. Piston Skirt Varnish Rating, min.			6.5
		Avg. Engine Varnish Rating, min.			5.0
		Oil Ring Clogging, %. max.			15
		Oil Screen Plugging, %. max.			20
		Compression Ring Sticking			None
		Cam Wear, µm. average			122
		Cam Wear, µm. max.			381
	CRC L-38	Bearing Weight Loss, mg. max.			40
	1H2	Top Groove Filling, % vol. max.			45
		Weighted Total Demerits			140
SH	Sequence IID	API SG limits apply Tested according to CMA Code of Practice			
	Sequence IIIE				
	Sequence VE				
	CRC L-38				
	SAE (J300)	**5W30**	**10W30**	**15W40**	**All Others**
	CEC L-40-A-93/ L-40-T-87 (Noack), %	25 max.	20 max.	18 max.	-
	Phosphorus, % m.	0.12 max.	0.12 max.	-	-
	Flash Point (ASTM D92), °C.	200 min.	205 min.	215 min.	-
	Foaming (Tendency/Stability)				
	Sequence I, max.	10/0	10/0	10/0	-
	Sequence II, max.	50/0	50/0	50/0	-
	Sequence III, max.	10/0	10/0	10/0	-
	Sequence IV	Report	Report	Report	-
	Homogeneity/Miscibility	Pass	Pass	Pass	-
	GM EOFT Filterability, Flow Reduction, %	50 max.	50 max.	-	-

API Gasoline Engine Performance Criteria

	Test	Primary Performance Criteria	
SJ	Sequence IID	API SG limits apply Tested according to CMA Code of Practice	
	Sequence IIIE		
	Sequence VE		
	CRC L-38		
	SAE (J300)	**0W20, 5W20, 5W30, 10W30**	**All Others**
	CEC L-40-A-93/ L-40-T-87 (Noack), %	22 max.	20 max.
	Phosphorus, % m.	0.10 max.	-
	Flash Point (ASTM D92), °C.	200 min. 205 min. (10W-30)	-
	Foaming (Tendency/Stability)		
	Sequence I, max.	10/0	10/0
	Sequence II, max.	50/0	50/0
	Sequence III, max.	10/0	10/0
	High Temp. (ASTM 1392), max.	200/50	200/50
	Homogeneity/Miscibility	Pass	Pass
	GM EOFT Filterability, Flow Reduction, %	50 max.	50 max.
	High Temp. Deposits (TEOST) mg.	60 max.	60 max.
	Gelation Index	12 max.	-

API Gasoline Engine Performance Criteria

	Test	Primary Performance Criteria	Limits
SL	ASTM Ball Rust Test	Avg. Grey Value, min.	100
	Sequence IIIF	Viscosity Increase (KV 40°C), %. max.	275
		Avg. Piston Skirt Varnish, min.	9.0
		Weighted Piston Demerit Rating, min.	4.0
		Hot Stuck Piston Rings	None
		Avg. Cam and Lifter Wear, µm. max.	20
		Oil Consumption	5.2
		Low Temp. Viscosity	Report (1)
	Sequence VE (2)	Cam Wear Average µm. max.	127
		Cam Wear Average µm. max.	380
	Sequence IVA	Avg. Cam Wear µm, max.	120
	Sequence VG	Avg. Engine Sludge Rating, min.	7.8
		Rocker Cover Sludge Rating, min.	8.0
		Average Engine Varnish Rating, min.	8.9
		Average Piston Skirt Varnish, min.	7.5
		Oil Screen Clogging, max.	20
		Hot Stuck Compression Ring	None
		Cold Stuck Rings	Rate & Report
		Oil Screen Debris (%)	Rate & Report
		Oil Ring Clogging	Rate & Report
	Sequence VIII	Bearing Wt. Loss, mg. max.	26.4
	Volatility Loss ASTM D5800, %. max.	15	15
	Volatility Loss at 37°C ASTM D6417, %. max.	10	10
	SAE (J300)	**0W20, 5W20, 5W30, 10W30**	**All Others**
	Phosphorus, % m.	0.10 max.	-
	Flash Point (ASTM D92), °C.	200 min. 205 min. (10W-30)	-
	Foaming (Tendency/Stability)		
	Sequence I, max.	10/0	10/0
	Sequence II, max.	50/0	50/0
	Sequence III, max.	10/0	10/0
	High Temp. (ASTM 1392), max.	100/10	100/10
	Homogeneity/Miscibility	Pass	Pass
	GM EOFT Filterability, Flow Reduction, %. max.	50	50
	High Temp. Deposits (TEOST) mg. max.	45	45
	Gelation Index, max.	12	-
	Shear Stability - Seq. VIII 10hr. Stripped KV100°C.	Stay-in-grade	Stay-in-grade

Notes: (1) The 80 hour test sample shall be evaluated by test method D4684 (MRV TP-1) at the temperature indicated by the low-temperature grade of oil as determined on the 80 hour sample by test method D5293 (CCS Viscosity).

(2) Not required for oils containing a minimum of 0.08% phosphorus in the form of ZDDP.

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API Diesel Engine Performance Criteria

	Test	Primary Performance Criteria	Limits	
			L-4	**L-38**
CA	L-4 or L-38	Bearing Weight Loss, mg. max.	120-135	50
		Piston Skirt Varnish Rating, min.	9.0	9.0
	L-1 (0.35% min. sulphur fuel)	Top Groove Filling, % vol. max.	25	
		Second Groove and below	Essentially clean	
CB	L-4 or L-38	Same as CA		
	L-1 (0.95% min. sulphur fuel)	Same as CA, except Top Groove Filling, % vol. max.	30	
CC	L-38	Bearing Weight Loss, mg. max.	50	
		Piston Skirt Varnish Rating, min.	9.0	
			LTD	**Mod LTD**
	LTD or Modified LTD	Piston Skirt Varnish Rating, min.	7.5	7.5
		Total Engine Varnish Rating, min.	-	42
		Total Engine Sludge Rating, min.	35	42
		Oil Ring Plugging, %. max.	25	10
		Oil Screen Clogging, %. max.	25	10
			IIC	**IID**
	IIC or IID	Avg. Engine Rust Rating, min.	7.6	7.7
	1-H2	Top Groove Fill, % vol. max.	45	
		Weighted Total Demerits, max.	140	
		Ring Side Clearance Loss, in. max.	0.0005	
CD	1-G2	Top Groove Fill, % vol. max.	80	
		Weighted Total Demerits, max.	300	
		Ring Side Clearance Loss, in. max.	0.0005	
	L-38	Bearing Weight Loss, mg. max.	50	
		Piston Skirt Varnish Rating, min.	9.0	
CD-II	I-G2	Top Groove Fill, % vol. max.	80	
		Weighted Total Demerits, max.	300	
		Ring Side Clearance Loss, in. max.	0.0005	
	L-38	Bearing Weight Loss, mg. max.	50	
		Piston Varnish Rating, min.	9.0	
	6V-53T	Piston Area		
		Weighted Total Demerits, avg. max.	400	
		Hot Stuck Rings	None	
		2 and 3 Ring Face Distress avg. Demerits, max.	13	
		Liner and Head Area		
		Liner Distress, avg. % Area, max.	12	
		Valve Distress	None	

API Diesel Engine Performance Criteria

	Test	Primary Performance Criteria	Limits
CE	1G2	Top Groove Fill, % vol. max.	80
		Weighted Total Demerits, max.	300
		Ring Side Clearance loss, in. max.	0.0005
	L-38	Bearing Weight Loss, mg. max.	50
	T-6	Merit Rating, min.	90
	T-7	Avg. Rate of Viscosity increase during last 50 hrs, cSt. 100°C/hr. max.	0.040
	NTC-400	Oil Consumption	Candidate oil consumption second order regression curve must fall completely below the published mean plus one standard deviation curve for the applicable reference oil
		Camshaft Roller Follower Pin Wear average, max. mm. (in).	0.051 (0.002)
		Crownland (Top Land) Deposits, % area covered with heavy carbon, average, max.	25
		Piston Deposits, Third Ring Land, total CRC demerits for all six pistons, max.	40

API Diesel Engine Performance Criteria

	Test	Primary Performance Criteria	Number of Test Runs		
			1	2	3
CF	1M-PC	Top Groove Filling (TGF), % vol. max.	70	70	70
		Weighted Total Demerits (WTD), max.	240	240	240
		Ring Side Clearance Loss, mm. max.	0.013	0.013	0.013
		Piston Ring Sticking	None	None	None
		Piston, Ring and Liner Scuffing	None	None	None
	L-38	Bearing Weight Loss, mg. max.	43.7	48.1	50.0
CF-2	1M-PC	Weighted Total Demerits (WTD), max.	100	100	100
	6V-92TA	Cylinder Line Scuffing, %. max.	45.0	48.0	50.0
		Port Plugging, %. max.			
		Average	2	2	2
		Single Cylinder	5	5	5
		Piston Ring Face Distress Demerits, max.			
		No. 1 (Fire Ring)	0.23	0.24	0.26
		Avg. No. 2 & 3	0.20	0.21	0.22
	L-38	Bearing Weight Loss, mg. max.	43.7	48.1	50.0
CF-4	1-K	A 1-K test programme with a minimum of two tests, acceptable to the limits shown in the columns to the right, is required to demonstrate performance for this category	**Number of Test Runs**		
			2	**3**	**4**
		Weighted Demerits (WDK), max.	332	339	342
		Top Groove Carbon Fill (TGF), % vol. max.	24	26	27
		Top Land Heavy Carbon (TLHC), %. max.	4	4	5
		Avg. Oil Consumption, g/kW-h. (0-252hr) max.	0.5	0.5	0.5
		Final Oil Consumption, g/kW-h. (228-252hr) max.	0.27	0.27	0.27
		Scuffing, (piston-rings-liner)	None	None	None
			Limits (1 test)		
	T6	Merit Rating (*), min.	90		
	or T9 (D6483)	or Top Piston Ring wt. loss, avg. mg. max.	150		
		Linear Wear, µm. max.	40		
	T7	Average rate of KV inc. during last 50hrs. max.	0.040		
	or T8A (D5967)	or Average rate of KV inc. 100-150 hrs. max.	0.20		
	L-38	Bearing Weight Loss, mg. max.	50		
	CBT (D5968)	Copper, mg/kg. (ppm) increase, max.	20		
		Lead, mg/kg. (ppm) increase, max.	60		
		Tin, mg/kg. (ppm) increase, max.	Report		
		Copper Corrosion, max.	3		

Note:

* Requires greater than zero unit on all individual rating.

API Diesel Engine Performance Criteria

	Test	Primary Performance Criteria	Number of Test Runs		
			1	2	3
CG-4	1N	WDN (Weighted Demerits-1N), avg. max.	286.2	311.7	323.0
		TGF (Top Groove Fill), % vol. avg. max.	20	23	25
		TLHC (Top Land Heavy Carbon), % avg. max.	3	4	5
		Oil Consumption, g/kW-h. avg. max.	0.5	0.5	0.5
		Scuffing, Piston-Rings-Liner			
		Number of Tests Allowed	None	None	None
		Stuck Rings	None	None	None
	T-8	Viscosity Increase @ 3.8% soot, cSt. avg. max.	11.5	12.5	13.0
		Filter Plugging, Differential Pressure, kPa. avg. max.	138	138	138
		Oil Consumption, g/kW-h. avg. max.	0.304	0.304	0.304
	IIIE	Hours to 375% Viscosity Increase, avg. min.	67.5	65.1	64.0
	L-38	Bearing Weight Loss, mg. avg. max.	43.7	48.1	50.0
		Used Oil Viscosity, cSt. greater than SAE J300 lower limit for Grade, avg. min.	0.5	0.5	0.5
	6.2L	Wear, µm. (mils), avg. max.	11.4 (0.45)	12.4 (0.49)	12.7 (0.50)
	Foam	Foaming/Settling, ml. max.			
		Sequence I	10/0		
		Sequence II	20/0		
		Sequence III	10/0		
	Bench Corrosion Test	ppm. Increase, max.			
		Copper	20		
		Lead	60		
		Tin	50		
		Copper Corrosion, max. D130	3		

Note:
Limits do not apply to monograde oils

API Diesel Engine Performance Criteria

	Test	Primary Performance Criteria	Number of Test Runs		
			1	2	3
CH-4	1P	WDP (Weighted Demerits - 1P), max.	350	378	390
		TGC (Top Groove Carbon), % vol. max.	36	39	41
		TLC (Top Land Carbon), %. max.	40	46	49
		Avg. Oil Consumption, 0-360 hours	11.0 max./test		
		Final Oil Consumption, 336-360 hours	10.0 max./test		
	M-11	Crosshead Weight Loss, 4.5% soot mg. max.	6.5	7.5	8.0
		Sludge, min.	8.7	8.6	8.5
		Differential Pressure/Oil Filter, kPa. max.	79	93	100
	T-9	Avg. Liner Wear, µm. max.	25.4	26.6	27.1
		Top Ring Weight Loss, mg. max.	120	136	144
		Increase in Lead Content, ppm. max.	25	32	36
	T8-E	Viscosity Increase, 3.8% soot cSt. max.	11.5	12.5	13.0
		Relative Viscosity, 4.8% soot max.	2.1	2.2	2.3
	1K	WDK (Weighted Demerits - 1K), max.	332	347	353
		TGF (Top Groove Fill), % vol. max.	24	27	29
		TLHC (Top Land Heavy Carbon), %. max.	4	5	5
		Oil Consumption, g/bhp-hr. max.	0.5	0.5	0.5
		Piston, Ring and Liner Scuffing	None	None	None
	6.5L	Pin Wear, mils. max.	0.30	0.33	0.36
	IIIE	Viscosity Increase, %. max.	200	200	200
	HEUI	Aeration Volume, %. max.	8.0	8.0	8.0
	Bench Corrosion	Copper, ppm. Increase, max.	20	20	20
		Lead, ppm. Increase, max.	120	120	120
		Tin, ppm. Increase, max.	50	50	50
		Copper Corrosion, ASTM D130. max.	3	3	3

ACEA 2002 Service Fill Oils for Gasoline Engines — Laboratory Tests

Requirements		Method	Properties	Unit	Limits				
						A1-02	A2-96 Issue 3	A3-02	A5-02
1.1	Viscosity Grade				SAE J 300 Latest active issue	No restriction except as defined by shear stability and HTHS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperatures.			
1.2	Shear Stability	CEC L-14-A-93 (Bosch injector)	Viscosity after 30 cycles measured at 100°C.	mm^2/s.		XW-20: stay-in-grade XW-30 ≥ 8.6 XW-40 ≥ 12.0	XW-30 ≥ 9.0 XW-40 ≥ 12.0 XW-50 ≥ 15.0	All grades to be stay-in-grade	All grades to be stay-in-grade
1.3	Viscosity - High Temperature High Shear Rate	CEC L-36-A-97 (Ravenfield)	Viscosity at 150°C. and $10^6 s^{-1}$ shear rate	mPa.s		max 3.5 XW-20 min 2.6 All others min 2.9	> 3.5	> 3.5	min 2.9 max 3.5
1.4	Evaporative Loss (Noack)	CEC L-40-A-93	Max. weight loss after 1hr. at 250°C.	%		≤ 15	≤ 15 for 10W-X or lower. ≤ 13 for others	≤ 13	≤ 13
1.5	Sulphated Ash	ASTM D874		% m/m		≤ 1.3	≤ 1.5	≤ 1.5	≤ 1.5
						The following sections apply to all Sequences			
1.6	Sulphur			ppm m/m		Report			
1.7	Phosphorus			ppm m/m		Report			
1.8	Chlorine			ppm m/m		Report			
1.9	Oil/Elastomer Compatibility See Notes (1)	CEC L-39-T-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing			Elastomer type			
						RE1	RE2-99	RE3	RE4	AEM
			Hardness DIDC	points		-1/+5	-5/+8	-25/+1	-5/+5	(VAMAC)
			Tensile strength	%		-40/+10	-15/+18	-45/+10	-20/+10	As per
			Elongation rupture	%		-50/+10	-35/+10	-20/+10	-50/+10	Daimler
			Volume variation	%		-1/+5	-7/+5	-1/+30	-5/+5	Chrysler
1.10	Foaming Tendency	ASTM D892 without option A	Tendency - stability	ml.		Sequence I (24°C) 10 - nil			
						Sequence II (94°C) 50 - nil			
						Sequence III (24°C) 10 - nil			
1.11	High Temperature Foaming Tendency	ASTM D6082 High Temp foam test	Tendency - stability	ml.		Sequence IV (150°C) 100 - nil			

Notes:

(1) Use either complete Daimler Chrysler requirements (VDA 675301, 7 days, ±2 hr, 4 materials (NBR; NBR34 DIN 53538 T3 (100ºC +/- 2ºC); FPM: AK6 (150ºC +/- 2ºC); ACM: E7503 (150ºC +/- 2ºC); AEM: D8948/200.1 (150ºC +/- 2ºC) + RE3 according to requirement 1.9 above or complete requirements according to 1.9 above plus DC requirements for AEM. New CEC RE3 material and limits are to be developed and added to Sequences as soon as possible.

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ACEA 2002 Service Fill Oils for Gasoline Engines — Laboratory Tests

Requirements		Method	Properties	Unit	Limits				
						A1-02	A2-96 Issue 3	A3-02	A5-02
1.1	Viscosity Grade				SAE J 300 Latest active issue	No restriction except as defined by shear stability and HTHS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperatures.			
1.2	Shear Stability	CEC L-14-A-93 (Bosch injector)	Viscosity after 30 cycles measured at 100°C.	mm^2/s.		XW-20: stay-in-grade XW-30 ≥ 8.6 XW-40 ≥ 12.0	XW-30 ≥ 9.0 XW-40 ≥ 12.0 XW-50 ≥ 15.0	All grades to be stay-in-grade	All grades to be stay-in-grade
1.3	Viscosity - High Temperature High Shear Rate	CEC L-36-A-97 (Ravenfield)	Viscosity at 150°C. and $10^6 s^{-1}$ shear rate	mPa.s		max 3.5 XW-20 min 2.6 All others min 2.9	> 3.5	> 3.5	min 2.9 max 3.5
1.4	Evaporative Loss (Noack)	CEC L-40-A-93	Max. weight loss after 1hr. at 250°C.	%		≤ 15	≤ 15 for 10W-X or lower. ≤ 13 for others	≤ 13	≤ 13
1.5	Sulphated Ash	ASTM D874		% m/m		≤ 1.3	≤ 1.5	≤ 1.5	≤ 1.5
						The following sections apply to all Sequences			
1.6	Sulphur			ppm m/m		Report			
1.7	Phosphorus			ppm m/m		Report			
1.8	Chlorine			ppm m/m		Report			
1.9	Oil/Elastomer Compatibility See Notes (1)	CEC L-39-T-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing			Elastomer type			
						RE1	RE2-99	RE3	RE4	AEM
			Hardness DIDC	points		-1/+5	-5/+8	-25/+1	-5/+5	(VAMAC)
			Tensile strength	%		-40/+10	-15/+18	-45/+10	-20/+10	As per
			Elongation rupture	%		-50/+10	-35/+10	-20/+10	-50/+10	Daimler
			Volume variation	%		-1/+5	-7/+5	-1/+30	-5/+5	Chrysler
1.10	Foaming Tendency	ASTM D892 without option A	Tendency - stability	ml.		Sequence I (24°C) 10 - nil			
						Sequence II (94°C) 50 - nil			
						Sequence III (24°C) 10 - nil			
1.11	High Temperature Foaming Tendency	ASTM D6082 High Temp foam test	Tendency - stability	ml.		Sequence IV (150°C) 100 - nil			

Notes:

(1) Use either complete Daimler Chrysler requirements (VDA 675301, 7 days, ±2 hr, 4 materials (NBR; NBR34 DIN 53538 T3 (100ºC +/- 2ºC); FPM: AK6 (150ºC +/- 2ºC); ACM: E7503 (150ºC +/- 2ºC); AEM: D8948/200.1 (150ºC +/- 2ºC) + RE3 according to requirement 1.9 above or complete requirements according to 1.9 above plus DC requirements for AEM. New CEC RE3 material and limits are to be developed and added to Sequences as soon as possible.

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ACEA 2002 Service Fill Oils for Gasoline Engines — Engine Tests

Requirements		Method	Properties	Unit	Limits			
					A1-02	A2-96 Issue 3	A3-02	A5-02
2.1	High Temp. deposits Ring Sticking Oil Thickening	CEC L-88-T-xx (TU5JP - L4) 72 hour test	Ring Sticking (each part)	merit	≥ 9.0			
			Piston Varnish (6 elements) average of 4 pistons	merit	≥ RL216			
			Absolute Viscosity Increase at 40°C. between min. and max. values during test	$mm^2/s.$	≤ RL216	≤1.5 x RL216	≤0.8 x RL216	≤0.8 x RL216
			Oil Consumption	kg/test	Report			
2.3	Low Temp. Sludge	ASTM D6593-00 (Sequence VG) Under protocol & requirements for API SJ See Note(2)	Average Engine Sludge	merit	≥ 7.8			
			Rocker Cover Sludge	merit	≥ 8.0			
			Average Piston Skirt Varnish	merit	≥ 7.5			
			Average Engine Varnish	merit	≥ 8.9			
			Comp. Ring (hot stuck)		None			
			Oil Screen Clogging	%	≤ 20			
2.4	Valve Train Scuffing Wear	CEC L-38-A-94 (TU3M)	Cam Wear, average	µm.	≤ 10			
			Cam Wear, max.	µm.	≤ 15			
			Pad Merit (avg. of 8 pads)	merit	≥ 7.5			
2.5	Black Sludge	CEC L-53-T-95 (M111)	Engine Sludge, average	merit	≥ RL140			
2.6	Fuel Economy See Note(3)	CEC L-54-T-96 (M111)	Fuel Economy Improvement vs. Reference Oil RL 191 (15W-40)	%	≥ 2.5	-	-	≥ 2.5

Notes:

(2) The limits shown are based upon those applied in U.S. market requirements. ACEA will continuously review the situation to ensure that these limits are appropriate for European vehicles and lubricants.

(3) ACEA considers the CEC L-54-T-96 test the only valid comparator against which claims of lubricant fuel economy improvement should be made.

ACEA 2002 Service Fill Oils for Light Duty Diesel Engines — Laboratory Tests

Requirements		Method	Properties	Unit	Limits				
					B1-02	B2-98 Issue 2	B3-98 Issue 2	B4-02	B5-02
1.1	Viscosity Grade		SAE J 300 Latest active issue		No restriction except as defined by shear stability and HTHS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperatures.				
1.2	Shear Stability	CEC L-14-A-93 (Bosch injector)	Viscosity after 30 cycles measured @ 100°C.	mm^2/s.	XW-20: stay-in-grade XW-30 ≥ 8.6 XW-40 ≥ 12.0	XW-30 ≥ 9.0 XW-40 ≥ 12.0 XW-50 ≥ 15.0	All grades to be stay-in-grade	All grades to be stay-in-grade	All grades to be stay-in-grade
1.3	Viscosity - High Temperature High Shear Rate	CEC L-36-A-97 (Ravenfield)	Viscosity @ 150°C. and $10^6 s^{-1}$ shear rate	mPa.s	max 3.5 XW-20 min 2.6 All others min 2.9	> 3.5	> 3.5	>3.5	min 2.9 max 3.5
1.4	Evaporative Loss (Noack)	CEC L-40-A-93	Max. weight loss after 1hr. @ 250°C.	%	≤ 15	≤ 15 for 10W-X or lower. ≤ 13 for others	≤ 13	≤ 13	≤ 13
1.5	Sulphated Ash	ASTM D874		% m/m	≤ 1.3	≤ 1.8	≤ 1.5	≤ 1.6	≤ 1.6
					The following sections apply to all Sequences				
1.6	Sulphur			ppm m/m	Report				
1.7	Phosphorus			ppm m/m	Report				
1.8	Chlorine			ppm m/m	Report				
1.9	Oil/Elastomer Compatibility See Notes (1)	CEC L-39-T-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing		Elastomer type				
					RE1	RE2-99	RE3	RE4	AEM (VAMAC)
			Hardness DIDC	points	-1/+5	-5/+8	-25/+1	-5/+5	As per Daimler Chrysler
			Tensile strength	%	-40/+10	-15/+18	-45/+10	-20/+10	
			Elongation rupture	%	-50/+10	-35/+10	-20/+10	-50/+10	
			Volume variation	%	-1/+5	-7/+5	-1/+30	-5/+5	
1.10	Foaming Tendency	ASTM D892 without option A	Tendency - stability	ml.	Sequence I (24°C) 10 - nil				
					Sequence II (94°C) 50 - nil				
					Sequence III (24°C) 10 - nil				
1.11	High Temperature Foaming Tendency	ASTM D6082 High Temp foam test	Tendency - stability	ml.	Sequence IV (150°C) 100 - nil				

Notes:

(1) Use either complete Daimler Chrysler requirements (VDA 675301, 7 days, ±2 hr, 4 materials (NBR; NBR34 DIN 53538 T3 (100ºC +/- 2ºC); FPM: AK6 (150ºC +/- 2ºC); ACM: E7503 (150ºC +/- 2ºC); AEM: D8948/200.1 (150ºC +/- 2ºC) + RE3 according to requirement 1.9 above or complete requirements according to 1.9 above plus DC requirements for AEM. New CEC RE3 material and limits are to be developed and added to Sequences as soon as possible.

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ACEA 2002 Service Fill Oils for Light Duty Diesel Engines

Engine Tests

Requirements		Method	Properties	Unit	Limits				
					B1-02	B2-98 Issue 2	B3-98 Issue 2	B4-02	B5-02
2.1	Ring Sticking and Piston Cleanliness	CEC L-46-T-93 (VW 1.6 TC D) See Note (4)	Ring Sticking	merit	≥ RL148	≥ RL148	≥ RL148	-	-
			Piston Cleanliness	merit	≥ RL148	≥ RL148	≥ RL148	-	-
2.2	Medium Temp. Dispersivity	CEC L-56-T-98 (XUD11BTE)	Absolute Viscosity Increase @ 100°C. and 3% soot (measurement with CEC L-83-A-97 method)	$mm^2/s.$	≤ 0.50 x RL197 result	≤ 0.90 x RL197 result	≤ 0.50 x RL197 result	≤ 0.50 x RL197 result	≤ 0.50 x RL197 result
			Piston Merit (5 elements) average for 4 pistons	merit	≥ (RL197 minus 6 pts)	≥ (RL197 minus 6 pts)	≥ RL197	≥ RL197	≥ RL197
2.3	Wear, Viscosity Stability & Oil Consumption	CEC L-51-A-98 (OM 602A)	Cam Wear, avg.	µm.	≤ 50.0				
			Viscosity Increase at 40°C.	%	≤ 90				
			Bore Polishing	%	≤ 7.0				
			Cylinder Wear, avg.	µm.	≤ 20.0				
			Oil Consumption	kg/test	≤ 10.0				
2.4	DI Diesel Piston Cleanliness & Ring Sticking	CEC L-78-T-99 (VW DI)	Piston Cleanliness	merit	-	-	-	≥ (RL206 minus 3 points)	> RL20
			Ring Sticking (Rings 1 & 2)						
			Avg. of all 8 rings	ASF	-	-	-	≤ 1.2	≤ 1.2
			Max. for any 1st ring	ASF	-	-	-	≤ 2.5	≤ 2.5
			Max. for any 2nd ring	ASF	-	-	-	≤ 0.0	≤ 0.0
2.5	Fuel Economy See Note (3)	CEC L-54-T-96 (M111E)	Fuel Economy Improvement vs. Ref. Oil RL191 (15W-40)	%	≥ 2.5	-	-	-	≥ 2.5

Notes:

(3) ACEA considers the CEC L-54-T-96 test the only valid comparator against which claims of lubricant fuel economy improvement should be made.

(4) A passing result in the CEC L-78-T-99 test (VW Di) to the B4 requirements may be used in place of the CEC L-46-T-93 test.

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ACEA 2002 Service Fill Oils for Heavy Duty Diesel Engines — Laboratory Tests

Requirements		Method	Properties	Unit	Limits			
					E2-96 Issue 3	E3-96 Issue 3	E4-99	E5-02
1.1	Viscosity		SAE J300 Latest active issue		No restriction except as defined by shear stability and HTHS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperatures.			
1.2	Shear Stability	CEC L-14-A-93 (Bosch injector) measured @ 100°C.	Viscosity after 30 cycles	$mm^2/s.$	XW-30 ≥ 9.0 XW-40 ≥ 12.0 XW-50 ≥ 15.0 No requirements for single grades		Stay-in-grade	
1.3	Viscosity - High Temperature High Shear Rate	CEC L-36-A-97 (Ravenfield)	Viscosity @ 150°C. and $10^6 s^{-1}$ shear rate	mPa.s	≥ 3.5			
1.4	Evaporative Loss	CEC L-40-A-93 (Noack)	Max. weight loss after 1hr. @ 250°C.	%	≤ 13			
1.5	Sulphated Ash	ASTM D874		% m/m.	≤ 2.0			
					The following sections apply to all Sequences			
1.6	Oil/Elastomer Compatibility	CEC L-39-T-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing		Elastomer type			
					RE1	RE2-99	RE3	RE4	AEM
			Hardness DIDC	points	-1/+5	-5/+8	-25/+1	-5/+5	(VAMAC)
			Tensile Strength	%	-50/+10	-15/+18	-45/+10	-20/+10	As per
			Elongation Rupture	%	-60/+10	-35/+10	-20/+10	-50/+10	Daimler
			Volume Variation	%	-1/+5	-7/+5	-1/+30	-5/+5	Chrysler
1.7	Foaming Tendency	ASTM D982 without option A	Tendency - stability	ml.	Sequence I (24°C) 10-nil			
					Sequence II (94°C) 50-nil			
					Sequence III (24°C) 10-nil			
1.8	High Temperature Foaming Tendency	ASTM D6082 High temp.	Tendency - stability	ml.	Sequence IV (150°C) 200-50			
1.9	Oxidation	CEC L-85-T-99 (PDSC)	Oxidation Induction Time	min.	-	-	-	≥ 35
1.10	Corrosion (HTCBT)	ASTM D5968 (Test temperature 135°C)	Used oil lead conc.	ppm.	-	-	-	≤ 100

Notes: (1) Use either complete Daimler Chrysler requirements (VDA 675301, 7 days, ±2 hr, 4 materials (NBR; NBR34 DIN 53538 T3 (100ºC +/- 2ºC); FPM: AK6 (150ºC +/- 2ºC); ACM: E7503 (150ºC +/- 2ºC); AEM: D8948/200.1 (150ºC +/- 2ºC) + RE3 according to requirement 1.9 above or complete requirements according to 1.9 above plus DC requirements for AEM. New CEC RE3 material and limits are to be developed and added to sequences as soon as possible.

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ACEA 2002 Service Fill Oils for Heavy Duty Diesel Engines

Engine Tests

Requirements		Method	Properties	Unit	Limits			
					E2-96 Issue 3	E3-96 Issue 3	E4-99	E5-02
2.1	Bore Polishing/ Piston Cleanliness	CEC L-42-T-99 (OM 364LA)	Bore Polishing	%	≤ 3.5	≤ 1.0	-	-
			Piston Cleanliness	merit	≥ 40.0	≥ 45.0	-	-
			Average Cylinder Wear	µm.	≤ 3.5	≤ 3.0	-	-
			Sludge	merit	≥ 9.4	≥ 9.5	-	-
			Oil Consumption	kg/test	≤ 16.0	≤ 12.0	-	-
2.2	Wear (OM 602A)	CEC L-51-A-97	Cam Wear average	µm.	≤ 50.0	≤ 50.0	≤ 50.0	≤ 50.0
			Viscosity Increase @ 40°C.	%	-	-	≤ 90	≤ 90
			Bore Polishing	%	-	-	≤ 7.0	≤ 7.0
			Cylinder Wear, avg.	µm.	-	-	≤ 20.0	≤ 20.0
			Oil Consumption	kg/test	-	-	≤ 10	≤ 10
2.3	Soot in Oil	ASTM D5967 (Mack T-8E) (300 hours)	Relative Viscosity, 4.8% soot					
			1 test	-	-	-	≤ 2.1	≤ 2.1
			2 test average	-	-	-	≤ 2.2	≤ 2.2
			3 test average	-	-	-	≤ 2.3	≤ 2.3
		ASTM D4485 (Mack T-8) (250 hours)	Viscosity Increase, 3.8% soot					
			1 test	cSt.	-	≤ 11.5	≤ 11.5	≤ 11.5
			2 test average	cSt.	-	≤ 12.5	≤ 12.5	≤ 12.5
			3 test average	cSt.	-	≤ 13.0	≤ 13.0	≤ 13.0
			Filter Plugging Differential Pressure	kPa.	-	≤ 138	≤ 138	≤ 138
			Oil Consumption	g/kWh.	-	≤ 0.304	≤ 0.304	≤ 0.304
2.4	Bore Polishing Piston Cleanliness Turbo Charger Deposits	CEC L-52-T-97 (OM 441LA)	Bore Polishing	%	-	-	≤ 2.0	≤ 2.0
			Piston Cleanliness	merit	-	-	≥ 40.0	≥ 25.0
			Boost Pressure Loss at 400 hours	%	-	-	≤ 4	≤ 4
			Oil Consumption	kg/test	-	-	≤ 40	≤ 40

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ACEA 2002 Service Fill Oils for Heavy Duty Diesel Engines

Engine Tests

Requirements		Method	Properties	Unit	Limits			
					E2-96 Issue 3	E3-96 Issue 3	E4-99	E5-02
2.5	Soot Induced Wear	(Cummins M11) ASTM RR: D2 - 1440	Rocker Pad Average Weight Loss @ 4.5% soot					
			1 test	mg.	-	-	-	≤ 6.5
			2 test average	mg.	-	-	-	≤ 7.5
			3 test average	mg.	-	-	-	≤ 8.0
			Oil Filter Differential Pressure EOT					
			1 test	kPa.	-	-	-	≤ 79
			2 test average	kPa.	-	-	-	≤ 93
			3 test average	kPa.	-	-	-	≤ 100
			Engine Sludge					
			1 test	merit	-	-	-	≥ 8.7
			2 test average	merit	-	-	-	≥ 8.6
			3 test average	merit	-	-	-	≥ 8.5
2.6	Wear (liner ring-bearings)	(Mack T-9) ASTM D6483	Avg. Liner Wear normalised to 1.75% soot					
			1 test	µm.	-	-	-	≤ 25.4
			2 test average	µm.	-	-	-	≤ 26.6
			3 test average	µm.	-	-	-	≤ 27.1
			Avg. Top Ring Weight Loss					
			1 test	µm.	-	-	-	≤ 100
			2 test average	µm.	-	-	-	≤ 115
			3 test average	µm.	-	-	-	≤ 130
			Used Oil Lead Content Increase	ppm.	-	-	-	≤ 20
			Used Oil Lead Content Increase at 300-400 hr.	ppm.	-	-	-	≤ 10

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ILSAC Specifications: GF-1

Test		Limits
Viscosity Requirements		As defined by SAE J300
Engine Test Requirements	Sequence IID, Sequence IIIE, Sequence VE, CRC L-38	API SG Limits apply. Tested according to CMA Code of Practice
Bench Test Requirements	HTHS Viscosity @ 150°C. and $10^6 s^{-1}$	2.9 min. (for all viscosity grades)
	Volatility Sim. dis. (ASTM D2887) or Evaporative Loss (CEC L-40-T-87)	
	SAE 0W and 5W multigrades	20% max. at 371°C. 25% max. 1 hr. at 250°C.
	All other SAE viscosity grades	17% max. at 371°C. 20% max. 1 hr. at 250°C.
	GM EOFT Filterability	50% max. flow reduction
	Foaming (Tendency/Stability) ASTM D892 (Option A)	
	Sequence I, max.	10/0
	Sequence II, max.	50/0
	Sequence III, max.	10/0
	Sequence IV, max.	Report & Report
	Flash Point	
	ASTM D92 or	185°C. min.
	ASTM D93	200°C. min.
	Shear Stability	
	L-38 10 hour stripped viscosity	Must stay-in-grade
	Homogeneity and Miscibility	
	Federal test method 791B, method 3470	Shall remain homogeneous and when mixed with SAE reference oils, shall remain miscible
Additional Requirements	Sequence VI, EFEI	2.7% min.
	Catalyst Compatibility	
	Phosphorus Content, %. wt.	0.12% max.
	SAE J 300 Low Temperature Viscosity, mPa.s	
	Cranking	3500 max. at -20°C.
	Pumping	30000 max. at -25°C.

ILSAC Specifications: GF-2

ILSAC GF-2 is applicable to SAE viscosity grades 0W-X, 5W-X and 10W-X grades only. Oils can be licensed with the API Engine Oil Licensing and Certification System (EOLCS) from 15 October 1996.

The Sequence VI fuel economy engine test from ILSAC GF-1 is replaced with the Sequence VI-A. Three categories of fuel economy improvement are possible with ILSAC GF-2.

ILSAC GF-2 oils have a phosphorus limitation of 0.10% maximum compared with 0.12% maximum for GF-1.

Test		Limits
Viscosity Requirements	0W-X, 5W-X, 10W-X	As defined by SAE J 300
Engine Test Requirements	Sequence IID, Sequence IIIE, Sequence VE, CRC L-38	API SG Limits apply. Tested according to CMA Code of Practice
Bench Test Requirements	CEC L-40-A-93/L-40-T-87 (Noack), %	22 max.
	Phosphorus, % m.	0.10 max.
	Flash Point (ASTM D92), °C.	200 min.
	Foaming (Tendency/Stability)	
	Sequence I, max.	10/0
	Sequence II, max.	50/0
	Sequence III, max.	10/0
	High temp. (ASTM 1392), max.	200/50
	Homogeneity/Miscibility	Pass
	GM EOFT Filterability	
	Flow reduction, %	50 max.
	GM EOFT Modified	
	0.6/1.0% water	Rate & Report
	2.0/3.0% water	Rate & Report
	High Temp. Deposits (TEOST)	
	Deposit wt. mg.	60 max.
	Gelation Index	12.0 max.
Additional Requirements	Sequence VI-A Fuel Economy	
	SAE 0W-20, 5W-20	1.4% min.
	Other SAE 0W-X, 5W-X	1.1% min.
	SAE 10W-X	0.5% min.

ILSAC Specifications: GF-3

ILSAC GF-3 is applicable to SAE viscosity grades 0W-X, 5W-X and 10W-X grades only. Oils can be licensed with the API Engine Oil Licensing and Certification System (EOLCS) from 15 October 1996.

The Sequence VI-A fuel economy engine test from ILSAC GF-2 is replaced with the Sequence VI-B. Three categories of fuel economy improvement are possible with ILSAC GF-3.

ILSAC GF-3 oils maintain a phosphorus limitation of 0.10% maximum established in ILSAC GF-2 to maintain acceptable catalyst protection.

Test		Limits		
Viscosity Requirements	0W-X, 5W-X, 10W-X	As defined by SAE J 300		
Engine Test Requirements	Sequence IIIF, Sequence IVA, Sequence VG, Sequence VIII, BRT	API SL Limits apply. Tested according to ACC Code of Practice		
Bench Test Requirements	Evaporation Loss (ASTM D5800)	15% max. 1hr. at 250ºC.		
	Simulated Distillation (ASTM D6417)	10% max. at 371ºC.		
	Phosphorus, % m.	0.10 max.		
	Foaming (Tendency/Stability)			
	Sequence I, max.	10/0		
	Sequence II, max.	50/0		
	Sequence III, max.	10/0		
	High temp. (ASTM 1392), max.	100/0		
	Homogeneity/Miscibility	Pass		
	GM EOFT Filterability			
	Flow reduction, %	50 max.		
	GM EOFT Modified (EOWTT) (*)			
	0.6/1.0% water	50 max.		
	2.0/3.0% water	50 max.		
	High Temp. deposits (TEOST-MHT-4)			
	Deposit wt. mg.	45 max.		
	Gelation Index	12.0 max.		
Additional Requirements	Sequence VI-B Fuel Economy	FE1 (16hr)	FE2 (96hr)	Sum FE1/FE2
	SAE 0W-20, 5W-20	2.0 min	1.7 min.	-
	Other SAE 0W-30, 5W-30	1.6 min.	1.3 min.	3.0 min.
	SAE 10W-30 & all other viscosity grades	0.9 min.	0.6 min.	1.6 min.

Notes:

(*) Test formulation with highest additive (DI/VI) concentration.
Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination..
Each different DI/VI combination must be tested.

US Military Specifications: Engine Test Requirements

	MIL-L	46152D	46152E	2104E
L-38	Bearing Weight Loss, mg. max.	40	40	50
IID	Avg. Rust, min.	8.5	8.5	8.1
	Stuck Lifters	None	None	None
IIIE	Viscosity Increase 64 hrs. 40°C. %. max.	375	375	-
	Piston Varnish, min.	8.9	8.9	-
	Oil Ring Land Varnish, min.	3.5	3.5	-
	Sludge, min.	9.2	9.2	-
	Ring Sticking	None	None	-
	Lifter Sticking	None	None	-
	Cam or Lifter Scuffing	None	None	None
	Cam plus Lifter Wear, avg. max. µm.	30	30	64
	max. µm.	64	64	178
VE	Avg. Sludge, min.	9.0	9.0	8.5
	Rocker Cover Sludge, min.	7.0	7.0	6.5
	Avg. Varnish, min.	5.0	5.0	4.2
	Piston Varnish, min.	6.5	6.5	6.0
	Oil Ring Clogging, %. max.	15	15	15
	Oil Screen Plugging, %. max.	20	20	23
	Ring Sticking	None	None	None
	Cam Wear, avg. max. µm.	127	127	203
	max. µm.	381	381	457
1-H2	TGF, vol. %. max.	45	45	-
	WTD, max.	140	140	-
1-G2	TGF, vol. %. max.	-	-	80
	WTD, max.	-	-	300

Additional Test Requirements for MIL-L-2104E

Test	Parameter	MIL-L-2104E
Detroit Diesel 6V-53T (FTM 355T)	Piston Area	
	Avg. total deposits, max.	400
	Hot stuck rings	None
	Avg. Ring Face Distress, demerits, %. max.	
	Fire ring	Report
	No.'s 2 and 3 compression	13.0
	Liner and Head Area	
	Avg. liner scuffing, %. max.	12.0
	Valve distress	None
	Port plugging, %	Report
Allison C-3 (Seal)	Total Immersion (Buna N)	
	Volume change, %	0 to +5
	Hardness change, points	-5 to +5
	Dip Cycle (Polyacrylate)	
	Volume change, %	0 to 10
	Hardness change, points	10 to 0
	Tip Cycle (Silicone)	
	Volume change, %	0 to +5
	Hardness change, points	-10 to 0
C-3 (Time/Torque)	Slip Time at 5500 cycles max.	0.85
	Torque, Nm. at 0.2s. slip time, min.	101.7
	Δ between 1500 & 5500 cycles, max.	40.7
Caterpillar TO-2	Stopping Time Increase, %. max.	15[(1), (2)]
	Avg. Total Wear, µm. max.	350

Notes:
(1) 20% max. for 10W
(2) In duplicate tests

MIL-L-2104F Engine Test Requirements

		Number of Tests Run		
		1	2	3
1K	Top Groove Fill (TGF) %. max.	24	27	29
	WDK Demerits, max.	332	347	353
	Top Land Heavy Carbon (TLHC) %. max.	4	5	5
	Oil Consumption, g/kWhr. max.	0.5	0.5	0.5
	Scuffing and Ring Sticking	None	None	None
IIIE	Viscosity Increase, 40°C. %. max.	750		
	Oil Ring Land Deposits, min.	1.5		
	Piston Skirt Varnish, min.	8.7		
	Sludge, min.	9.0		
	Stuck Rings	None		
	Stuck Lifters	None		
	Cam and Lifter Scuffing	None		
	Cam plus Lifter Wear:			
	Avg. max. µm.	64		
	Maximum, µm.	145		
L-38	Bearing Weight Loss, mg. max.	50		
	Piston Skirt Varnish, min.	9.0		
Mack T7	Avg. rate of Viscosity Increase, last 50hr. cSt. @ 100°C./hr. max.	0.040		
6V-92TA	Skirts, Tin Removed	Report	Report	Report
	Wrist Pin Slipper Bushing, Copper removed	Report	Report	Report
	Ring Face Distress, demerits, max.			
	Fire Ring	0.33	0.34	0.36
	No. 2 & 3 Compression Rings	0.28	0.29	0.30
	Broken Rings	None	None	None
	Cylinder Liner scuffing, %. max.	60.0	63.5	65.0
	Port Plugging, % area, max.			
	Average	2	2	2
	Single Cylinder	5	5	5

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MIL-L-2104F Transmission Test Requirements

		Graphite	Paper	
		5500	0 -5,000	5,000 - 10,000
Allison C-4	Slip Time at Cycles, secs. max.	0.74	0.67	0.56
Friction	Mid-Point Co-efficient of Friction at Cycles min.	0.097	0.066	0.086
Seals	Total Immersion (Buna N)			
	Volume change, %	0 to +5		
	Hardness change, pts.	-5 to +5		
	Dip Cycle (Polyacrylate)			
	Volume change, %	0 to +10		
	Hardness change, pts.	0 to +5		
	Tip Cycle (Silicone)			
	Volume change, %	0 to +5		
	Hardness change, pts.	-10 to 0		
	Total Immersion (Flouroelastomer)			
	Volume change, %	0 to +4		
	Hardness change, pts.	-4 to +4		

					Sequence 1220	Sequence FRRET
Cat TO-4	Average	Dynamic Co-efficient, %	90 - 140	-		
		After 3,000 cycles		-	85 - 130	
		After 8,000 cycles		-	90 - 125	
		After 15,000 cycles		-	90 - 125	
		After 25,000 cycles		-	95 - 125	
	Average	Static Co-efficient, %	91 - 127	95 - 120		
	Disc Wear, mm. max.		0.04	-		
	Energy Limit, %		25	-		
Cat TO-3	Stopping Time Increase, %				Report	
	Average Total Wear, µm.				Report	
	Seals				Report	

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Japanese Automotive Diesel Engine Oil Standard - JASO DH-1

Test	Performance Criteria		Limits
Nissan TD25 Piston Detergency	TGF (Top Groove Fill), % vol.		60.0 max.
	Piston Ring Sticking		All free
	Deposits on Ring Lands, merit rating		Report
Mitsubishi 4D34T4 Valve Train Wear Protection	Cam Diameter Loss, µm. (Normalized at 4.5 mass % Carbon Residue Increase)		95.0 max.
Mack T8A Soot Dispersency	Viscosity Increase (100-150hr) at 100°C. $mm^2/s/h$.		0.2 max.
Sequence IIIE High Temperature Oxidation Stability	Viscosity Increase at 40°C. %		200 max.
JASO Hot Tube Test Hot Surface Deposit Control	At 280°C. merit rating		7.0 min.
Foaming	Sequence I	Tendency / Stability, ml/ml	10/0 max.
	Sequence II		50/0 max.
	Sequence III		10/0 max.
Volatility	Evaporation Loss at 250°C. mass %		18.0 max.
Anti-corrosion	Copper, mass ppm.		20 max.
	Lead, mass ppm.		120 max.
	Tin, mass ppm.		50 max.
	Discoloration of Copper Coupon after Test at 135°C.		3 max.
Shear Stability	Kinetic Viscosity of Oil after Test at 100°C. mm^2/s.		Stay-in-grade of virgin oil viscosity classification in SAE J300
Total Base Number	mgKOH/g. (*)		10.0 min.
Seal Compatibility	RE1 (Flouro)		
	Hardness Change Point		-1/+5
	Tensile Strength %, Rate of Change		-40/+10
	Elongation Rate of Change, %		-50/+10
	Volume Rate of Change, %		-1/+5
	RE2-99 (Acrylic)		
	Hardness Change Point		-5/+8
	Tensile Strength %, Rate of Change		-15/+18
	Elongation Rate of Change, %		-35/+10
	Volume Rate of Change, %		-7/+5
	RE3 (Silicon)		
	Hardness Change Point		-25/+1
	Tensile Strength %, Rate of Change		-45/+10
	Elongation Rate of Change, %		-20/+10
	Volume Rate of Change, %		-1/+30
	RE4 (Nitrile)		
	Hardness Change Point		-5/+5
	Tensile Strength %, Rate of Change		-20/+10
	Elongation Rate of Change, %		-50/+10
	Volume Rate of Change, %		-5/+5

Note:

(*)According to JIS K2501 or ASTM D-4739 test method.

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Global Engine Oil Service Specification DHD-1 — Engine Tests

Test	Performance Criteria	Limits
Caterpillar 1R ([1])	Weighted Demerits (WDR), max.	397 / 416 / 440
	Total Groove Carbon, %. max.	40 / 42 / 44
	Top Land Carbon, %. max.	37 / 42 / 46
	Oil Consumption g./hr. Initial max./Final max.	13.1 / 1.5 X Initial
Cummins M11 HST	Oil Filter Diff. Press. kPa. max.	79 / 93 / 100
	Eng. Sludge, CEC Merits, min.	8.7 / 8.6 / 8.5
	Rocker Pad Average Weight Loss, Normalized to 4.5% soot mg. max.	6.5 / 7.5 / 8.0
Mack T-9	Used Oil Lead, ppm. max.	15 ([2])
	TAN Increase at EOT, max.	2.0
	Average Wear Normalized to 1.75% soot Liner µm. max.	25.4 / 26.6 / 27.1
	Top Ring Wt Loss, mg. max.	120 / 136 / 144
Mack T-8E	Relative Viscosity at 4.8% soot	2.1 / 2.2 / 2.3
6.5L RFWT	Pin Wear, µm. max.	7.6 / 8.4 / 9.1
Seq IIIF, 60 hrs. ([2])	Kv 40C Viscosity Increase, %. max.	200
HEUI	Aeration, vol. %. max.	8.0
Mercedes Benz OM 441LA	Bore Polish, % Area. max.	2.0
	Boost Pressure Loss at 400 Hours, %. max.	4
	Weighted Merits, min.	25.0
	Oil Consumption, kg./test max.	40
Mitsubishi 4D34T4 160 hrs.	Avg. Cam Lobe Wear, µm.	95.0

Note:

([1]) The requirements for this characteristic may be met with a CH-4 level passing result in an original API CH-4 qualification.

([2]) Lead Maximum 25 ppm if fresh oil has TBN (ASTM D4739) greater than 10.

Global Engine Oil Service Specification DHD-1 — Laboratory Tests

Test	Performance Criteria	Limits			
Corrosion Bench Test	Used Oil Element Content above Baseline, ppm, max.	Copper 20, Lead 120, Tin 50			
Elastomer Compatibility *	Variation after 7 days fresh oil, No pre-aging	Elastomer Type			
		RE 1	RE 2	RE 3	RE 4
	Hardness DIDC, points, max.	-1/+5	-5/+5	-25/+1	-5/+5
	Tensile Strength, %. max.	-50/+10	-15/+10	-45/+1	-20/+10
	Elongation rupture, %. max.	-60/+10	-35/+10	-20/+10	-50/+10
	Volume variation, %. max.	-1/+5	-5/+5	-1/+30	-5/+5
Foaming Tendency	Tendency / Stability, ml. max. after 1 min. settling	Sequence I (24°C) 10 - nil			
		Sequence II (94°C) 50 - nil			
		Sequence III (24°C) 10 - nil			
Foaming - High Temperature	Tendency / Stability, ml. max. after 1 min. settling	Sequence IV (150°C) 200 - 50			
PDSC	Oxid. Induction Time, min. min.	35			
Shear Stability Bosch Injector Test	Viscosity after 30 Cycles, measured at 100°C.	stay-in-grade			
Sulphated Ash	Mass %. max.	2.0			
HT/HS Viscosity Tapered Bearing Simulator / Ravenfield	High Tempeature / High Shear Rate Viscosity, cP. min.	35			
NOACK Volatility	% Mass Loss, max.	15			

Note:

(*) The Elastomer Compatability Limits are those stated in ACEA 1999 European Oil Sequences and apply to the elastomer batches available at that time. Consult the most recent ACEA Oil Sequence publication for the information on the limits with more recent elastomer batches.

Global Engine Oil Service Specification DHD-1 — Engine Tests

Test	Performance Criteria	Limits
Caterpillar 1R ([1])	Weighted Demerits (WDR), max.	397 / 416 / 440
	Total Groove Carbon, %. max.	40 / 42 / 44
	Top Land Carbon, %. max.	37 / 42 / 46
	Oil Consumption g./hr. Initial max./Final max.	13.1 / 1.5 X Initial
Cummins M11 HST	Oil Filter Diff. Press. kPa. max.	79 / 93 / 100
	Eng. Sludge, CEC Merits, min.	8.7 / 8.6 / 8.5
	Rocker Pad Average Weight Loss, Normalized to 4.5% soot mg. max.	6.5 / 7.5 / 8.0
Mack T-9	Used Oil Lead, ppm. max.	15 ([2])
	TAN Increase at EOT, max.	2.0
	Average Wear Normalized to 1.75% soot Liner µm. max.	25.4 / 26.6 / 27.1
	Top Ring Wt Loss, mg. max.	120 / 136 / 144
Mack T-8E	Relative Viscosity at 4.8% soot	2.1 / 2.2 / 2.3
6.5L RFWT	Pin Wear, µm. max.	7.6 / 8.4 / 9.1
Seq IIIF, 60 hrs. ([2])	Kv 40C Viscosity Increase, %. max.	200
HEUI	Aeration, vol. %. max.	8.0
Mercedes Benz OM 441LA	Bore Polish, % Area. max.	2.0
	Boost Pressure Loss at 400 Hours, %. max.	4
	Weighted Merits, min.	25.0
	Oil Consumption, kg./test max.	40
Mitsubishi 4D34T4 160 hrs.	Avg. Cam Lobe Wear, µm.	95.0

Note:

([1]) The requirements for this characteristic may be met with a CH-4 level passing result in an original API CH-4 qualification.

([2]) Lead Maximum 25 ppm if fresh oil has TBN (ASTM D4739) greater than 10.

Two-Stroke Classification: API TC

	Engine	Parameter	Limits
API TC (CEC TSC-3)	Yamaha CE 50S	Tightening, Mean Torque Drop	≤ Ref. Oil
	Yamaha CE 50S	Pre-ignition, occurences	1 max. in 50 hr. test
	Yamaha 350 M2	Piston Varnish Ring Sticking Piston Deposits Piston Scuffing	Better than or equal to ref. oil

Notes:

TA (TSC-1) not released as a full specification, but the test methods are recognised by ASTM as valid for assessing the capabilities of two stroke oils.

TB (TSC-2) not released as a full specification due to the withdrawal of the supporting OEM. No new work is in progress.

Two-Stroke Classification: API TC

	Engine	Parameter	Limits
API TC (CEC TSC-3)	Yamaha CE 50S	Tightening, Mean Torque Drop	≤ Ref. Oil
	Yamaha CE 50S	Pre-ignition, occurences	1 max. in 50 hr. test
	Yamaha 350 M2	Piston Varnish Ring Sticking Piston Deposits Piston Scuffing	Better than or equal to ref. oil

Notes:

TA (TSC-1) not released as a full specification, but the test methods are recognised by ASTM as valid for assessing the capabilities of two stroke oils.

TB (TSC-2) not released as a full specification due to the withdrawal of the supporting OEM. No new work is in progress.

Two-Stroke Classification: ISO/JASO

ISO	-	EGB	EGC	EGD
JASO	**FA**	**FB**	**FC**	**-**
Lubricity	90 min.	95 min.	95 min.	95 min.
Torque Index	98 min.	98 min.	98 min.	98 min.
Detergency	80 min.	85 min.	95 min.	125 min.
Piston Skirt Deposits	-	85 min.	90 min.	95 min.
Exhaust Smoke	40 min.	45 min.	85 min.	85 min.
Exhaust Blocking	30 min.	45 min.	90 min.	90 min.

Notes:
All limits are indices relative to reference oil, JATRE-1

Test Engines

Honda DIO AF27	Lubricity
	Torque Index
	Detergency, Piston Skirt Varnish
Suzuki SX800R	Exhaust Smoke
	Exhaust Blocking

Piston Skirt Deposits rating not required by JASO

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Two-Stroke Classification: TISI 1040

Test	Parameter	Limits
Bench Tests	Viscosity, 100°C. cSt.	5.6 - 16.3
	Viscosity Index	95 min.
	Flash Point, °C.	70 min.
	Pour Point, °C.	-5 max.
	Sulphated Ash, % wt.	0.5 max.
	Metallic Element content, % wt.	Report
Kawasaki KH 125M	Piston Seizure and Ring Scuffing at fuel-oil ratio of 200:1	No seizure
	Detergency (general cleanliness)	
	Ring Sticking	8 merit min.
	Piston Cleanliness	48 merit min.
	Exhaust Port Blocking	None
Suzuki SX 800R (JASO M 342-92)	Exhaust Smoke	85 min.

Note:
Since mid-1991, all two-stroke oils used in Thailand are required to meet TISI requirements.

Two-Stroke Classification: NMMA TC-W3

Test	Parameter	Limits
ASTM Lubricity	Torque Drop, average	≤ Ref. Oil
NMMA Detergency	Top Ring Sticking, average	Max. 0.6 points below ref. oil
	Piston Deposits, average	Max. 0.6 points below ref. oil
	Spark Plug Fouling, occurrences	Max. 1 more than ref. oil
	Exhaust Port Blocking	Max. 10% greater than ref. oil
	Pre-ignition, occurrences	≤ Ref. oil
ASTM Pre-ignition	Pre-ignition (major), occurrences	Max. of 1 in 100 hr. test
NMMA Rust Test	-	Equal or better than ref. oil
SAE Miscibility Fluidity	-	Category 3 or 4 of SAE J1536
NMMA Filterability	Decrease in Flow Rate, %	20 max.

Note:

This specification was introduced in April 1992 to replace NMMA TC-W2 and offers improved ring-stick protection and lubricity, with higher anti-scuff performance.

OEM Specification: Mercedes-Benz Engine Test Requirements for Diesel Engine Oils

Sheet Number	227.0	227.1	228.0	228.1	228.2	228.3	228.5
Viscosity Grade	Mono	Multi	Mono	Multi	Mono	Multi	Multi
OM 602A (After 11.6.97, Euroval tappets)							
Piston Cleanliness (No ring sticking)	20 min.		22 min.		24 min.		26 min.
Bore Polishing, %. (23mm)	7.0 max.		6.0 max.		4.5 max.		3.0 max.
Cylinder Wear, avg. µm. (new/old)	20.0 max./12.0 max.		18.0 max./11.0 max.		15.0 max./10.0 max.		15.0 max./10.0 max.
Cam Wear, avg. µm. (new/old)	50.0 max./30.0 max.		50.0 max./29.0 max.		45.0 max./28.0 max.		45.0 max./28.0 max.
Oil Consumption, kg.	10.0 max.		10.0 max.		10.0 max.		10.0 max.
Viscosity Increase, 40°C. %	90 max.		80 max.		70 max.		60 max.
Engine Sludge, avg.	8.8 min.		8.9 min.		8.9 min.		9.0 min.
OM 364A/OM 364LA	OM 364A/OM 364LA		OM 364A/OM 364LA		OM 364A/OM 364LA		OM 364A/OM 364LA
Bore Polishing, %. max.	14.0/6.0		8.0/3.5		2.5/1.0		1.0/0.5
Piston Cleanliness, min.	24.0/35.0		31.0/40.0		35.0/45.0		50.0/50.0
Cylinder Wear, avg. µm. max.	8.0/4.0.		7.0/3.5		6.0/3.0		3.0/2.5
Engine Sludge, avg. min.	9.0/9.3		9.0/9.4		9.5/9.5		9.5/9.6
Oil Consumption, kg. max.	25.0/20.0		18.0/16.0		12.0/12.0		10.0/10.0
OM 441LA Euro II							
Bore Polishing, %					2.0 max.		2.0 max.
Piston Cleanliness					25.0 max.		40.0 min
Cylinder Wear, avg. µm.					8.0 max.		8.0 max.
Engine Sludge, avg.					9.0 max.		9.0 min.
Engine Deposits demerit					3.0 max.		3.0 max.
Wear Rating demerit					2.5 max.		2.5 max.
Ring Sticking, ASF					1.0 max.		1.0 max.
Oil Consumption, g/hr.					100.0 max.		100.0 max.
Boost Pressure loss, 400 hrs. %					4.0 max. (*)		4.0 max. (*)

Note:
(*) For OM 441LA tests started after 1.9.1999.

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OEM Specification: Mercedes-Benz Engine Test Requirements for Diesel Engine Oils

Sheet Number	227.0	227.1	228.0	228.1	228.2	228.3	228.5
Viscosity Grade	Mono	Multi	Mono	Multi	Mono	Multi	Multi
OM 602A (After 11.6.97, Euroval tappets)							
Piston Cleanliness (No ring sticking)	20 min.		22 min.		24 min.		26 min.
Bore Polishing, %. (23mm)	7.0 max.		6.0 max.		4.5 max.		3.0 max.
Cylinder Wear, avg. µm. (new/old)	20.0 max./12.0 max.		18.0 max./11.0 max.		15.0 max./10.0 max.		15.0 max./10.0 max.
Cam Wear, avg. µm. (new/old)	50.0 max./30.0 max.		50.0 max./29.0 max.		45.0 max./28.0 max.		45.0 max./28.0 max.
Oil Consumption, kg.	10.0 max.		10.0 max.		10.0 max.		10.0 max.
Viscosity Increase, 40°C. %	90 max.		80 max.		70 max.		60 max.
Engine Sludge, avg.	8.8 min.		8.9 min.		8.9 min.		9.0 min.
OM 364A/OM 364LA	OM 364A/OM 364LA		OM 364A/OM 364LA		OM 364A/OM 364LA		OM 364A/OM 364LA
Bore Polishing, %. max.	14.0/6.0		8.0/3.5		2.5/1.0		1.0/0.5
Piston Cleanliness, min.	24.0/35.0		31.0/40.0		35.0/45.0		50.0/50.0
Cylinder Wear, avg. µm. max.	8.0/4.0.		7.0/3.5		6.0/3.0		3.0/2.5
Engine Sludge, avg. min.	9.0/9.3		9.0/9.4		9.5/9.5		9.5/9.6
Oil Consumption, kg. max.	25.0/20.0		18.0/16.0		12.0/12.0		10.0/10.0
OM 441LA Euro II							
Bore Polishing, %					2.0 max.		2.0 max.
Piston Cleanliness					25.0 max.		40.0 min
Cylinder Wear, avg. µm.					8.0 max.		8.0 max.
Engine Sludge, avg.					9.0 max.		9.0 min.
Engine Deposits demerit					3.0 max.		3.0 max.
Wear Rating demerit					2.5 max.		2.5 max.
Ring Sticking, ASF					1.0 max.		1.0 max.
Oil Consumption, g/hr.					100.0 max.		100.0 max.
Boost Pressure loss, 400 hrs. %					4.0 max. (*)		4.0 max. (*)

Note:
(*) For OM 441LA tests started after 1.9.1999.

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OEM Specification: Mercedes-Benz Sheet 229.1 for Passenger Car Engine Oils

Sheet Number	229.1
ACEA	A3-96 B3-96
Viscosity Grades, SAE	5W-30, 5W-40, 5W-50, 10W-30, 10W-40, 10W-50, 10W-60, 15W-40, 15W-50, 20W-40, 20W-50
Sulphated Ash	1.5 max.
Relative Permittivity	Rate & Report
Seals Tests	See last page of this section
Engine Tests M111E Sludge	
Engine Sludge, avg.	RL 140 + 2 std. deviation
Cam Wear, avg. µm.	5.0 max.
OM 602A	
Piston Cleanliness (no ring sticking)	20 min.
Bore Polishing, % (23mm)	7.0 max.
Cylinder Wear, avg. µm. (new/old)	20.0 max./12.0 max.
Cam Wear, avg. µm. (new/old)	50.0 max./30.0 max.
Oil Consumption, kg.	10.0 max.
Viscosity Increase, 40°C. %	90 max.
Engine Sludge, avg.	8.8 min.

OEM Specification: Mercedes-Benz Sheet 229.3 for Passenger Car Engine Oils

Sheet Number	229.3
ACEA	A3-98, B3-98, B4-98
Viscosity Grades, SAE	0W-X, 5W-X
Chlorine, ppm.	100 max.
Sulphur, wt. %	0.5 max.
Seals Tests	See last page of this section
Engine Tests	
M111E Sludge	
Engine Sludge, avg.	RL 140 + 3 std. deviation (Batch 2 fuel) RL 140 + 2 std. deviation (Batch 1 fuel)
Cam Wear, avg. µm.	3.0 max.
M111E Fuel Economy	1.0 % min.
OM 602A	
Piston Cleanliness	24 min.
Bore Polishing, %	4.5 max.
Cylinder Wear, avg. µm. (new/old)	15.0 max.
Cam Wear, avg. µm. (new/old)	45.0 max./10.0 max.
Oil Consumption, kg.	10.0 max./28.0 max.
Viscosity Increase, 40°C. %	70 max.
Engine Sludge, avg.	8.9 min.
VW PV 1449 (VW T4)	To VW 502.00 limits

OEM Specification: Mercedes-Benz Sheet 229.5 for Passenger Car Engine Oils

Sheet Number	229.5
ACEA	A3-98, B3-98, B4-98
Viscosity Grades, SAE	0W-X, 5W-X, 10W-X
Chlorine, ppm.	50 max.
Sulphur wt. %	0.5 max.
Seals Tests	See last page of this section
Engine Tests	
M111E Sludge	
Engine Sludge, avg.	n.n. (439 hr) (Note a)
Cam Wear, avg. µm	5.0 max. (439 hr)
M111E Fuel Economy	1.8% min.
OM 602A	
Piston Cleanliness (no ring sticking)	26 min.
Bore Polishing, % (23mm)	3.0 max.
Cylinder Wear, avg. µm. (new/old)	15.0 max./10.0 max.
Cam Wear, avg. µm. (new/old)	45.0 max./28.0 max.
Oil Consumption, kg.	10.0 max.
Viscosity Increase, 40°C. %	60.0 max.
Engine Sludge, avg.	9.0 min.
VW PV 1449 (VW T4)	To VW 502.00 limits
VW TDI or PV 1452	To B4 or VW 506.00 limits
Wartung 2000 Tests (Note a)	
Bench Tests @ DC:-	
M111 E23 (Prufstand-Snail-Programme-PSP)	Yes
OM 611 DE 22LA (12 Pkt DL)	Yes
M166 E16 (12 Pkt DL)	Yes
M111 E23ML (40 Pkt DL)	Yes
Field Tests (S=Snail, B=Barracuda):-	
S: 1 x A140; 1x C230T Kompressor	Yes
B: 1 x E220T CDi 99; 1 x A170 CDi	Yes

Note a: For sheet 229.5 please contact EP/MPO before starting tests. Further requirements are listed in the performance standard. Approvals will not be given before 3/2002.

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OEM Specifications: MAN 270, MAN 271

Requirements	MAN 270	MAN 271
Performance Level: ACEA	E2-96	E2-96
SAE Viscosity Grades (J300)[1]	10W, 20W-20 20W-30, 30, 40	10W-40 15W-40 20W-50
Viscosity after Shear, mm^2/sec. min.	-	12.0[2]
HTHS, mPa.s, min.	-	3.5
Zinc, % wt. min.	0.08	0.08
Ethylene Glycol, % wt. max.	0.05	0.05
Foaming Tendency, max. ml.	10/50/10	10/50/10
Foam Stability, nil after (s) max.	180/90/180	180/90/180
NBR-28 Compatibility (100°C/7 days)		
Change in Hardness (Shore A), max.	-10	-10
Tensile Strength, % change, max.	-20	-20
Elongation Change, % of %, max.	-30	-30
Volume Change, %	0/+10	0/+10
FPM-AK6 Compatibility (150°C/7 days)		
Change in Hardness (Shore A)	-5/+5	-5/+5
Tensile Strength, % change, max.	-30	-30
Elongation Change, % of %, max.	-40	-40
Volume Change, %	-2/+5	-2/+5

Note:
(1) Other viscosities need MAN agreement, 10W-40 must contain 25% of unconventional base stocks.
(2) 15 min. for SAE 20W-50.

Additional Notes

1. MWM ‘B’ tests are no longer required or accepted for new oil approvals. Approvals based on MWM ‘B’ tests invalid after 31 May 1996.

2. Evaporation loss, pour point and flash point limits:

	Evaporation Loss %. max.	Pour Point max. °C.	Flash Point (COC) min. °C.
SAE 10-W	15	-33	205
SAE 10W-40	13	-30	215
SAE 15W-40	13	-27	215
SAE 20W-20	13	-24	210
SAE 20W-30	13	-24	210
SAE 20W-50	13	-24	215
SAE 30	10	-18	220
SAE 40	10	-15	225

3. Base oil blends to meet requirements of MAN N699.
Un-conventional base oils may require additional testing.

OEM Specification: MAN M 3275

Requirements	MAN M 3275		
SAE Viscosity Grades (J300)	5W-30 5W-40	10W-30 10W-40	15W-30 15W-40
HTHS Viscosity, mPa.s	3.5 min.		
Viscosity after Shear, mm^2/s.	XW-30 9 min. XW-40 12 min.		
Noack Evaporation Loss, %	13 max.		
Flash Point (COC), °C.	215 min.		
Pour Point, °C.	-40 max.	-30 max.	-27 max.
Zinc, % m.	0.08 min.		
Ethylene Glycol, % m.	0.05 max.		
Foaming Tendency, ml. Foam Stability, nil after s.	10/50/10 max. (Seq I/II/III) 180/90/180 max. (Seq I/II/III)		
Seal Tests NBR 28, AK6	Pass (See last page of this section)		
Engine Tests			
OM 602A			
Cam Wear, av. µm.	50 max.		
Viscosity Increase @ 40°C.	90 max.		
Bore Polishing, %	7.0 max.		
Cylinder Wear, av. µm.	20 max		
Oil Consumption, kg.	10.0 max.		
OM 441LA			
Bore Polishing, %	2.0 max.		
Piston Cleanliness	25.0 min.		
Boost Pressure Loss @ 400hrs.	4 max.		
Oil Consumption, kg/test	40 max.		

Note:

Viscosity Grades:

Generally SAE 15W-40 with mineral base oil. Other viscosity grades may be approved by agreement e.g. SAE 10W-40 with unconventional base oil (minimum 25% in fully formulated oil), SAE 5W-30, 5W-40 (unconventional base oil only).

OEM Specification: MAN M 3277

Requirements	MAN M 3277		
SAE Viscosity Grades (J300)	**5W-X**	**10W-X**	**15W-X**
HTHS Viscosity, mPa.s	3.5 min.		
Viscosity after Shear, mm^2/s.	XW-30 9 min. XW-40 12 min.		
Noack Evaporation Loss, %	13 max.		
Flash Point (COC), °C.	215 min.		
Pour Point, °C.	-40 max.	-30 max.	-27 max.
Zinc, % m.	0.08 min.		
Sulphated Ash, % m.	2.0 max.		
Ethylene Glycol, % m.	0.05 max.		
Foaming Tendency, ml.	10/50/10 max. (Seq I/II/III)		
Foam Stability, nil after s.	180/90/180 max. (Seq I/II/III)		
Seal Tests NBR 28, AK6	Pass		
Turbocharger Deposits (MTU), mg.	120 max.		
Engine Tests			
OM 441LA			
Viscosity Increase, 100°C. %	Rate & Report		
Soot in oil, %	Rate & Report		
Piston Cleanliness	40 min.		
Bore Polishing, %	2.0 max.		
Visual Wear, points	2.5 max.		
Cylinder Wear, mm.	0.008 max.		
Total Deposits, points	3.0 max.		
Sludge	9.0 min.		
Oil Consumption, g/hr.	100 max.		
OM 602A			
Viscosity Increase, 40°C. %	60 max.		
Viscosity Increase, 100°C. %	Rate & Report		
Soot in oil, %	Rate & Report		
Bore Polishing, %	3.0 max.		
Piston Cleanliness	26 min.		
Sludge	9.0 min.		
Cylinder Wear, avg. µm.	10 max.		
Cam Wear, avg. µm.	28.0 max		
Oil Consumption, kg.	10 max.		

Note:
Viscosity Grades
Generally SAE 10W-40 using a minimum 25% of unconventional base oil. SAE 5W-X to use unconventional base oil only.

OEM Specifications: Volkswagen 500.00, 501.01, 505.00, 502.00

Requirements	VW 500.00	VW 501.01	VW 505.00	VW 502.00
Performance Level, CCMC, min. ACEA, min.	G5	G4	PD-2	A2-96 or A3-96
Viscosity Grades, SAE	5W-30 5W-40 10W-30 10W-40	As listed in Note (c) below		0W-30, 0W-40, 5W-30, 5W-40, 5W-50 10W-30,10W-40,10W-50,10W-60 15W-40,15W-50, 20W-40, 20W-50
Sulphated Ash, % m.	1.5 max.	1.5 max.	-	1.5 max.
HTHS, 150°C. $10^6 s^{-1}$	3.5 min.	3.5 min.	3.5 min.	3.5 min.
Seal Compatibility, PV-3344	✔	✔	✔	✔
Valve Train Wear, PV-5106	✔	✔	✔	✔
Piston Cleanliness/Wear, PV-9800 (VW 1302)	✔	✔	(a)	-
PV-1449 (VW T4)	-	-	-	✔
Piston Cleanliness, PV-1435 (b)	✔	✔	-	-
Piston Cleanliness, Intercooled T/C Diesel	-	-	✔	-
Sludge, M102E	✔	✔	(a)	-
Sludge, M111E	-	-	-	✔
Evaporation Loss, %	13 max.	(c)	(c)	0W-X, 15 max. 5W-X, 10W-X, 15 max. 15W-X, 20W-X, 13 max.

Notes:

(a) Only required when sulphated ash is less than 1.5%.

(b) Not required when Intercooled T/C Diesel data is available.

(c) 13 max for SAE 5W-50, 10W-50/60, 15W-40/50, 20W-40/50; 15 max for SAE 5W-30/40, 10W-30/40.

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OEM Specifications: Volkswagen 503.00, 506.00

Requirements	VW 503.00	VW 506.00
Performance Level, ACEA	A3-98	B4-98
Viscosity Grades, SAE	0W-30, 0W-40, 5W-30, 5W-40, 10W-30, 10W-40	
HTHS, 150°C. 10^6 s^{-1}	2.9 - 3.4	
Sulphated Ash, % m.	1.5 max.	-
Evaporation Loss, % m.	13.0 max.	
M111E Sludge	✓	-
VW T4 (PV 1449)	✓	-
Fuel Economy (PV 1451)	✓	-
Cam and Tappet (PV 5106)	✓	✓
RNT Wear Test	✓	✓
VW DI Diesel (PV 1452)	-	✓
Seals Tests		
AK6	✓	✓
ACM	✓	✓
VAMAC	✓	✓

Notes:
Based on Factory Fill Oil specification VW 521 73.
VW 503.00 is Service Fill for gasoline engines with extended drain capability 30,000km. or two years, from May 1999 (2000 model year).
VW 506.00 is Service Fill for diesel engines with extended drain capability 50,000km. or two years, from May 1999 (2000 model year).

Volvo Drain Specification (VDS)

Performance Requirements

API CD/CE

Viscosities shall be 10W-30 or 15W-40,
(10W-30 approval includes 15W-40 but not vice versa).

Field Trial Requirements

Minimum of three trucks required equipped with Volvo 12 litre intercooled engine. Field trial shall run for minimum 300,000 km. with 50,000 km. oil and filter changes. Test vehicles should be run on fuel with max. 0.7% by weight sulphur. Oil samples taken after 15,000, 30,000 and 50,000 km. of the change interval are tested for viscosity at 100°C (ASTM D445). The values must not be less than:

9 cSt for 10W-30
12 cSt for 15W-40

TBN (ASTM D2896) value must not be less than 50% of the fresh oil value. Wear rate must not increase during the test. Oil consumption must not increase during the test. Bore polishing to be 300 cm^2 max. for the entire engine (100 cm^2 max. for any individual liner).

Volvo Drain Specification (VDS)

Performance Requirements

API CD/CE

Viscosities shall be 10W-30 or 15W-40,
(10W-30 approval includes 15W-40 but not vice versa).

Field Trial Requirements

Minimum of three trucks required equipped with Volvo 12 litre intercooled engine. Field trial shall run for minimum 300,000 km. with 50,000 km. oil and filter changes. Test vehicles should be run on fuel with max. 0.7% by weight sulphur. Oil samples taken after 15,000, 30,000 and 50,000 km. of the change interval are tested for viscosity at 100°C (ASTM D445). The values must not be less than:

9 cSt for 10W-30
12 cSt for 15W-40

TBN (ASTM D2896) value must not be less than 50% of the fresh oil value. Wear rate must not increase during the test. Oil consumption must not increase during the test. Bore polishing to be 300 cm^2 max. for the entire engine (100 cm^2 max. for any individual liner).

Volvo Drain Specification - 2 (VDS-2)

Oils meeting VDS-2 are recommended for Volvo truck engines meeting the 1996 European emission requirements.

To meet the requirements of “Volvo Drain Specification-2” a field test as specified below is necessary. Upon completion of the test, various engine parts shall be inspected and evaluated.

Test Conditions

Field test to involve a minimum of three trucks.

Test oil shall be minimum ACEA E3 or API CG-4 of viscosity 5W30, 5W40, 10W30, 10W40 or 15W40. Other viscosity grades can be accepted after agreement with Volvo.

Trucks used for the test to be equipped with Volvo TD 123 Series, 12 litre intercooled engine.

Field Test

Field test to be run for minimum of 300,000 km. with 60,000 km. oil change intervals.

During the test, oil samples are taken after 15,000, 30,000, 45,000 and 60,000 km. of the change interval and checked with respect to:-

Viscosity at 100°C: (ASTM D445)	To be between 9 cSt. and 140% of the fresh oil value for XW-30 oils, and between 12 cSt. and 140% of the fresh oil value for XW-40 oils.
TBN (ASTM D4739):	Value must not be less than 50% of the fresh oil value, or below 4, whichever is the greater.
TAN (ASTM D664):	Report
Pentane Insolubles:	Report
Wear Metals:	Concentration must not increase during the test.
Additive elements:	Report

In addition, oil and fuel consumption are measured during the test, oil consumption must not increase.

Inspection and Evaluation

Upon completion of the field test, the following engine components are inspected:-

Pistons, Piston rings, Cylinder liners, Tappets, Camshaft, Rocker arms, Valves, Bearings. Cleanliness of covers and oil sump also inspected.

For oils qualified to VDS-2, “read-across” to other viscosity grades, VI improvers or base oils than those used in the field test can be accepted after agreement with Volvo.

Volvo Drain Specification - 3 (VDS-3)

VDS-3 is the oil quality intended for Volvo Truck Euro 3 engines.

Engine:

D12C (any version > 400 hp) fitted to FH12 or FM12 trucks.

Field Test:

European Long Haul Service only, two trucks minimum.

Test Length and Drain Intervals:

GVW up to 44t: 3 x 100,000 km oil drains with oil samples taken at 0, 25,000, 50,000, 75,000 and 100,000 km.

GVW over 44t: 4 x 75,000 km oil drains with oil samples taken at 0, 25,000, 50,000 and 75,000 km.

Field test to commence before engine reaches 50,000 km.

Limits:

On completion of field trial, engine parts will be inspected for piston cleanliness, bore polish and ring wear.

Limits are tiered according to two or three truck tests and cover Volvo VDS-2 and VDS-3 approval categories.

Draft Limits VDS-3:	**Average 2 trucks**	**Average 3 trucks**	**Max liner/piston per engine**
Piston Cleanliness (1^{st} G + 2^{nd} G + 2^{nd} L)	40 min.	35 min.	-
Ring Riding (max. %)	25 max.	30 max.	30 max.
(avg. %)	12 max.	15 max.	-
Bore Polish (Total, cm^2)	100 max.	120 max.	30 max.

Draft Limits VDS-2:	**Average 2 trucks**	**Average 3 trucks**	**Max liner/piston per engine**
Piston Cleanliness (1^{st} G + 2^{nd} G + 2^{nd} L)	30 min.	25 min.	-
Ring Riding (max. %)	35 max.	40 max.	40 max.
(avg. %)	20 max.	25 max.	-
Bore Polish (Total, cm^2)	120 max.	140 max.	35 max.

Other Requirements:

For VDS-3 oils sold in Europe, ACEA E5-99 or DHD-1 performance to be demonstrated.

For VDS-3 oils sold outside Europe, DHD-1 performance to be demonstrated for global markets or API CH4 for US market.

For new VDS-3 trials to start - Mack EO-M+ limits in the Mack T9.

OEM Specification: MTU MTL 5044

Engine Test Requirements	OM 364A		OM 602A	
	Type 1/1*	Type 2	Type 1/1*	Type 2
Bore Polishing, %	14.0 max.	2.5 max.	7.0 max.	4.5 max.
Piston Cleanliness	24 min.	35 min.	20 min.	24 min.
Cylinder Wear, avg. µm.	8 max.	6 max.	12.0 max.	10.0 max.
Cam Wear, avg. µm.	-	-	30.0 max.	28.0 max.
Engine Sludge	9.0 min.	9.5 min.	8.8 min.	8.9 min.
Oil Consumption, kg.	25.0 max.	12.0 max.	10 max.	10 max.
Viscosity Increase, 40°C. %	-	-	90 max.	70 max.

Chemical - Physical Requirements Oil Types 1, 1*, 2	Single Grade		Multigrade	
Viscosity, SAE	30	40	5W-30, 10W-30, 15W-30	5W-40, 10W-40, 15W-40
HTHS, 150°C. $10^6 s^{-1}$	-		3.5 min.	
Flash Point (COC), °C.	225 min.		215 min.	
Evaporation Loss, % m.	10 max.		13 max.	
Sulphated Ash, % m.	1.0 - 2.0		1.0 - 2.0	
TBN, mg KOH/g	8 min.		8 min.	
Viscosity after Shear, cSt.	-		9 min.	12 min.
Chlorine, ppm.	150 max.		150 max.	
Zinc, % m.	0.035 min.		0.035 min.	
Deposits, MTV5040, mg.	-		100 max.	
Seals, NBR 28, AK6	See last page		See last page	

Classification of Engine Oils:

Oil Type 1: Normal quality (ACEA E1-96, E2-96)
Oil Type 1*: Type 1 with increased corrosion inhibition. Type 1* oils also require corrosion testing, Hydrobromic Acid/Sea Water.
Oil type 2: High quality (SHPD, ACEA E3-96)

Other tests required, Rate and Report only.

OEM Specification: Mack EO-K/2

Test	Parameter	Limits	
		Absolute	Preferred
Mack T-6	Oil Consumption (2100 rpm), lb/BHP hr. avg. max.	0.0014	0.0010
	Ring Weight Loss (Nos. 1 and 2 avg), mg. max.	200	150
	Ring Proudness, inches, max.	0.020	0.015
	Viscosity Increase @ 99°C. cSt. max.	14	5.5
	Piston Demerits, max.	650	600
	* Total Merits, min.	90	100
Mack T-7	Rate of Viscosity Increase, 100 - 150 hr. cSt/hr. max.	0.04	-
Field Test	To involve more than one vehicle, using the product in Mack engines at Mack's recommended drain intervals for 200,000 miles.		

Note:

* Mack Merit Rating System - Relative Importance of Test Criteria and Merit Calculations.

	% of Total Merits
Oil Consumption	25
Ring Weight Loss	25
Proudness	20
Viscosity Increase	20
Piston Demerits	10

OEM Specification: Mack EO-L / Mack EO-L Plus

Test	Parameter	Limits	
		EO-L	EO-L Plus
Mack T-6	Oil Consumption (2100 rpm), lb/BHP hr. avg. max.	0.0010	0.0010
	Ring Weight Loss (Nos. 1 and 2 avg), mg. max.	150	100
	Ring Proudness, inches, max.	0.015	0.015
	Viscosity Increase, 100°C. cSt. max.	5.0	5.0
	Piston Demerits, max.	600	600
	Total Merits, min.*	110	120
Mack T-8	TGA soot at end of test, min. %	3.8	3.8
	Pressure differential across oil filter assembly, PSI. max.	20	20
	Oil Viscosity Increase, 100°C. from minimum during test.		
	Total number of tests	Viscosity increase	
	1	11.5 cSt. max.	11.5 cSt. max.
	2	12.5 cSt. max.	12.5 cSt. max.
	3	13.0 cSt. max.	13.0 cSt. max.
	Oil Consumption, lb/BHP hr. max.	0.0005	0.0005
	End of Test Oil Viscosity, TGA soot level	Report	Report
Mack T-9	Top ring weight loss, mg. max.	-	120
	Cylinder liner wear, av. mls. max.	-	1.2
	PPM lead in 500hr oil analysis, max.	-	40
	EOT TBN (ASTM D4739), min.	-	2.00

Note:
* See EO-K/2 specification for explanation of Mack Merit Rating System.

Approvals:
Preferred viscosity: SAE 15W-40 for Mack EO-L; 15W-40 or 5W-40 (formulated with high VI base oil) for Mack EO-L Plus.
Base Oil Characterisation Analysis: Data to be presented.
Read across requests are evaluated on an individual basis depending on additive package, VI Improver and base-stock properties.
Approved lubricant supplier agrees to participate in the Mack EO-L Monitoring Program.

Application:
1997 Vehicle Model Year
V-MAC II engines, 6.0 min. Miles per Gallon
Mack Centri-Max Rotor & Oil Filtration System

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OEM Specification: Mack EOM / Mack EOM Plus

Test	Parameter	Limits	
		EOM	EOM Plus
Mack T-8E (300 hr)	Viscosity Increase, 3.8% soot, cSt.	11.5 max.	11.5 max.
	Relative Viscosity, 4.8% soot	2.1 max.	1.8 max.
	Slope @ 4.8% soot	0.75 max.	0.5 max.
	Slope @ 275 hours or 5.8% soot	1.00 max.	0.75 max.
Mack T-9	Top Ring Weight Loss, mg. max.	120	100/75[(1)]
	Cylinder Liner Wear, µm.	25.4 max.	25.4 max.
	Increase in Lead concentration, ppm.	25 max.	20 max.
	Increase in Lead, 400-500 hr. ppm.	-	10 max.
	Increase in TAN	-	3.0 max.
	Increase in TBN	-	Rate & Report
Cummins M11 (200 hr)	Cross Head Wear, 4.5% soot, mg.	6.5 max.	
	Filter Delta P. KPa.	79	
	Avg. Sludge Rating	8.7	
Cummins M11 (300 hr)	Cross Head Wear, 6.5% soot, mg.	-	12.0 max.
Sequence IIIE	Viscosity Increase, 64 hrs. %	-	100 max.

Note:
(1) According to ring batch

Application: V-MAC Engines
Mack Centri-Max Rotor & Oil Filtration System.

Viscosity Grades: SAE 10W-30, 15W-40 or SAE 5W-30, 5W-40, 10W-40 using unconventional base oils.

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Cummins Engine Oil Specifications

CES	20071	20072	20076	20077
API	CH-4		CH4+	
ACEA		E3-96		E5-99
SAE Viscosity Grades	10W30	10W30	XW30	10W30
		10W40	XW40	10W40
	15W40	15W40		15W40
Sulphated Ash, %. max.	1.5	1.85	1.85	1.85
Tests				
Cummins M11 (200 hrs)	✓	✓		
Cummins M11 (300 hrs)			✓	✓
Caterpillar 1P	✓		✓	
Caterpillar 1K	✓		✓	
Mack T-9	✓		✓	✓
Mack T-8 (250 hrs)		✓		
Mack T-8E (300 hrs)	✓		✓	✓
Roller Follower Wear Test	✓		✓	
Sequence IIIE	✓		✓	
HEUI	✓		✓	
Corrosion Bench Test	✓	✓	✓	✓
OM 364A/LA		✓		
OM 441LA				✓
OM 602A		✓		✓
PDSC				✓

Cummins 20071
- Test limits as per AP1 CH4 category except Caterpillar IP with relaxed oil consumption limits.

Cummins 20072
- Test limits as per ACEA E3-96 plus Cummins M11 HST test to API CH4 limits.

Cummins 20076
- Test limits as per API CH4 category with the following modifications (ref table attached).

Cummins 20077
- Test limits as per E5-99 category with the following modifications.

Mack T8E - Relative viscosity at 4.8% soot to Cummins 20076 limits
(1 test: 1.8 max. 2 test: 1.9 max. 3 test: 2.0 max.)

OM602A - Cam Wear to 45.0 µm. max.

Cummins M11 - Extended test limits for crosshead wear as per Cummins 20076.
Crosshead Wear avg. mg. at 6.5% soot - 12.0 max.

Cummins 20076 Engine Performance Criteria

	Test	Primary Performance Criteria	Number of Test Runs		
			1	2	3
CES 20076	1P	WDP (Weighted Demerits - 1P), max.	Report		
		TGC (Top Groove Carbon), % vol. max.	Report		
		TLC (Top Land Carbon), %. max.	Report		
		Avg. Oil Consumption, 0-360 hours	Report		
		Final Oil Consumption, 336-360 hours	Report		
	M-11 (300hrs extended)	Crosshead Weight Loss, 6.5% soot mg. max.	12.0		
		Sludge, min. (200hrs)	8.7	8.6	8.5
		Differential Pressure/Oil Filter, kPa. max. (200hrs)	79	93	100
	T-9	Avg. Liner Wear, µm. max.	25.4	26.6	27.1
		Top Ring Weight Loss, mg. max.	120	136	144
		Increase in Lead Content, ppm. max.	20	27	31
		Lead Increase from 400-500hrs max. ppm.	10		
	T8-E	Viscosity Increase, 3.8% soot cSt. max.	11.5	12.5	13.0
		Relative Viscosity, 4.8% soot max.	1.8	1.9	2.0
	1K	WDK (Weighted Demerits - 1K), max.	332	347	353
		TGF (Top Groove Fill), % vol. max.	24	27	29
		TLHC (Top Land Heavy Carbon), %. max.	4	5	5
		Oil Consumption, g/bhp-hr. max.	0.5	0.5	0.5
		Piston, Ring, Liner Scuffing	None	None	None
	6.5L	Pin Wear, mils. max.	0.30	0.33	0.36
	IIIE	Viscosity Increase, %. max.	100	100	100
	HEUI	Aeration Volume, %. max.	8.0	8.0	8.0
	Bench Corrosion	Copper, ppm. Increase, max.	20	20	20
		Lead, ppm. Increase, max.	120	120	120
		Tin, ppm. Increase, max.	50	50	50
		Copper Corrosion, ASTM D130, max.	3	3	3

European OEM Seal Test Requirements for Automotive Engine Oils

				Test Conditions		Test Limits				
OEM	**Specs**	**Test Method**	**Elastomer**	**Temp. (°C)**	**Time (Hrs)**	**Elongation (%)**	**Tensile Strength (%)**	**Hardness (Shore-A)**	**Volume (%)**	**Cracking**
Mercedes Benz	Sheets 229.1, 229.3 227.0/1 228.0/1 228.2/3 228.5	VDA 675301 Closed test cup	NBR 34	100	168	-35 max.	-20% max.	-8/+2	0/+10	-
			AK6	150	168	-50 max.	-40% max.	-5/+5	0/+5	-
			ACM E7503	150	168	-45 max.	-30% max.	-2/+6	-3/+10	-
			EAM D8948-200	150	168	-45 max.	-35% max.	-5/+5	0/+15	-
MAN	270, 271 M 3275 M 3277	DIN 53521	NBR 28	100	168	-30 max.	-20 max.	-10 max	0/+10	-
			AK6	150	168	-40 max.	-30 max.	-5/+5	-2/+5	
Volkswagen	500.00 501.01 502.00 505.00	PV 3344	AK6	150	282	160 min.	8.0 MPa min.	Report	-	No cracks, 100% elongation after 30 mins.
	503.00 506.00	PV 3344	AK6	150	168	160 min.	7.0 MPa min.	-	-	None
			ACM	150	500	-40 max.	-40 max.	-4/+10	-	-
			VAMAC	150	500	-40 max.	-40 max.	-4/+10	-	-

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