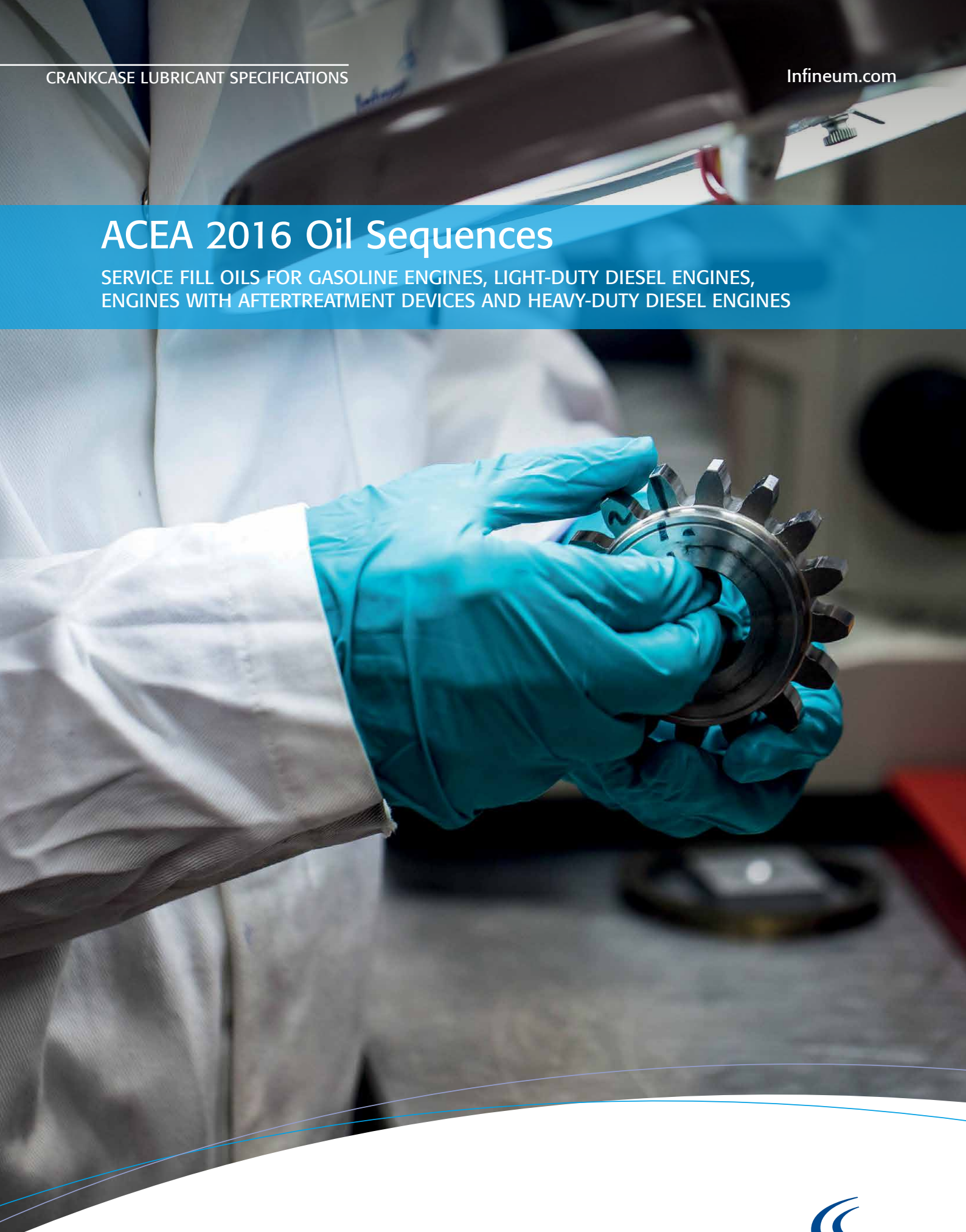
ACEA 2016 Oil Sequences

SERVICE FILL OILS FOR GASOLINE ENGINES, LIGHT-DUTY DIESEL ENGINES, ENGINES WITH AFTERTREATMENT DEVICES AND HEAVY-DUTY DIESEL ENGINES



Performance you can rely on.

Infineum

ACEA 2016

This publication has been derived from the official ACEA Oil Sequences 2016 document, the latest version of which can be found at: **www.acea.be**

The accuracy of this publication is the responsibility of Infineum, the aforementioned original document on **www.acea.be** remains the sole point of reference and will be updated in case of any changes to the ACEA Oil Sequences 2016.

The two big themes for ACEA 2016 are the introduction of additional measures against the impact of biofuel and upgrading hardware and structure for the sequences to keep up with changes in engine technology and lubricant developments.

Light-duty sequences

In order to keep up with the trend for lower viscosity lubricants, ACEA has introduced the C5 category now allowing lubricants with 2.6 to 2.9 HTHS (High Share-Rate Viscosity at 150 °C). In terms of performance requirements C5-16 mirrors C3-16, though with significantly higher fuel economy requirements.

With the aim of managing the complexity of the light-duty sequences the introduction of C5 resulted in the withdrawal of A1/B1 from the 2016 sequences. This was possible as A1/B1 performance requirements are fully covered by A5/B5 and C5 provides a new home for 2.6 HTHS lubricants.

Two new tests to protect against the impact of biofuels found their way into the ACEA sequences.

- The CEC L-104 OM646 Bio engine test for the effects of biodiesel has been introduced in all light-duty categories but A3/B3. Piston cleanliness is the performance parameter for this test.
- The CEC L-109 biodiesel oxidation bench test is a glassware test that has been introduced to provide preventive protection against the consequences of biodiesel induced engine oil oxidation at elevated temperatures. The performance parameters of the test are oxidation increase and kinematic viscosity increase. The test comes at two severity levels: for A3/B3 and A3/B4 performance limits are specified at 168 h test length, whereas for A5/B5 and all C-Categories limits are set at 168 h and 216 h test length.

ACEA keeping up with advancements in engine technology and addressing the end of life of some established tests resulted in the following changes:

- With the CEC L-111 EP6 test, the first gasoline direct injection turbocharged engine found its way into the ACEA sequences. This test is replacing the TU5 engine test as the performance test for gasoline piston cleanliness, but furthermore the EP6 comes with a safety limit for turbocharger cleanliness.
- On the diesel side the DV6 is a 1:1 replacement of the DV4 oil dispersion test with EURO V hardware. In order to keep the test severity the absolute viscosity increase is now measured at 5.5 % soot whereas the DV4 assessment was at 6 % soot. Piston cleanliness remains a safety parameter.
- For the time being ACEA relies on the OM646 valve train wear test to cover the needs of diesel and gasoline vehicles as the TU3 gasoline valve train wear test has reached end of life and a successor test is not yet available.
- It is not only engine test hardware that reaches end of life and is subject to advancements in technology: the elastomer compatibility test was replaced by the new CEC L-112, introducing new materials, which are more representative of those used in the field.

With the exception of the introduction of a lower phosphorus limit for C2-16 and a harmonisation to two decimal places for the phosphorus limits the chemical requirements remained untouched.

The requirement in A5/B5 and all C-Categories to report HTHS at 100 °C is new.

Heavy-duty sequences

The heavy-duty sequences also make use of the new CEC L-112 elastomer test with common requirements across all light-duty and heavy-duty categories.

Also common with light-duty is the introduction of the two biodiesel tests.

- The CEC L-109 oxidation bench test features in all E-Categories. Here a common test length of 168 h is specified, but limits differ by category.
- The CEC L-104 OM646Bio engine test has been introduced to E6 and E9 with dedicated limits for each category.

For E9 the Mack T11 has been replaced by the Mack T8E in the 2016 sequences. However, the Mack T11 remains available as an alternative to the Mack T8E in E9.

Chemical/Physical requirements remained mostly unchanged. New is a harmonisation across all E-categories of the fresh oil oxidation induction time (PDSC) to a minimum of 65 minutes and the requirement to report HTHS at 100 °C.

Conditions for use of performance claims against the ACEA oil sequences

ACEA requires that any claims for oil performance to meet these Oil Sequences must be based on credible data and controlled tests in accredited test laboratories.

ACEA requires that engine performance testing used to support a claim of compliance with these ACEA Oil Sequences should be generated according to the European Engine Lubricants Quality Management System, EELQMS (available at **www.eelqms.eu**), but ACEA reserves the right to define alternatives in exceptional cases.

EELQMS addresses product development testing and product performance documentation, and involves the registration of all candidate and reference oil testing and defines the compliance process. Compliance with the ATIEL Code of Practice[1], which forms part of the EELQMS, is mandatory for any claim to meet the requirements of this issue of the ACEA sequences. Therefore, ACEA requires that claims against the ACEA Oil Sequences can only be made by oil companies or oil distributors who have signed the EELQMS oil marketers' Letter of Conformance **(for details: www.atiel.org)**.

The ACEA Oil Sequences are subject to continuous development. Replacement tests and other changes required by the European vehicle manufacturers are integrated and new issues are published on a regular basis. As new editions are published older editions have to be withdrawn. Validities of new and old editions are overlapping for limited periods of time as shown in the following table and the accompanying text below. When a new ACEA Oil Sequence is introduced, oils with claims against the previous can be marketed only for another two years.

Sequence issue	First allowable use	Mandatory for new claims	Oils with this claim may be marketed until
2004	1st November 2004	1st November 2005	31st December 2009
2007	1st February 2007	1st February 2008	23rd December 2010
2008	22nd December 2008	22nd December 2009	22nd December 2012
2010	22nd December 2010	22nd December 2011	22nd December 2014
2012	14th December 2012	14th December 2014	1st December 2018
2016	1st December 2016	1st December 2017	...

First allowable use means that claims cannot be made against the specification before the date indicated.

Mandatory for new claims means that from this date onward all claims for new oil formulations must be made according to the latest ACEA Oil Sequence Issue. Up to that date new claims can also be made according to the previous ACEA Oil Sequence Issue. After the date indicated no new claims to the previous ACEA sequence can be made. Then all oil formulations must be developed according to the latest ACEA release.

Oils with this claim may be marketed until means that no further marketing of oils with claims to this issue is allowed after the date indicated. The marketer of any oil claiming ACEA performance requirements is responsible for all aspects of product liability.

Where limits are shown relative to a reference oil, then these must be compared to the last valid Reference Result on that test stand prior to the candidate and using the same hardware. Further details are in the ATIEL Code of Practice.

Where claims are made that oil performance meets the requirements of the ACEA Oil Sequences (e.g. product literature, packaging, labels) they must specify the ACEA Class and Category (see Nomenclature & ACEA Process for definitions).

[1]The ATIEL Code of Practice is the sole property of ATIEL and is available from ATIEL (Association Technique de l'Industrie Européenne des Lubrifiants), Boulevard du Souverain 165, B-1160 Brussels, Belgium.

ACEA | ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines | December 2016 Rev. 2

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Individual member companies may indicate performance parameters other than those covered by the tests shown or more stringent limits.

1. LABORATORY TESTS

REQUIREMENT	TEST METHOD	PROPERTIES	UNIT	LIMITS		
				A3/B3-16	A3/B4-16	A5/B5-16
1.1 **Viscosity grades**		Viscosity class according to SAE J300 - Latest active issue		No restriction except as defined by HTHS and Shear Stability requirements. Manufacturers may indicate specific Viscosity requirements related to ambient temperature.		
1.2 **Shear stability***	CEC L-14-93 or ASTM D6278 or ASTM D7109	100 °C viscosity after 30 cycles	mm^2/s	All grades to be 'stay in grade'		
1.3.1 **HTHS viscosity**	CEC L-36-90	Dynamic viscosity at 150 °C and shear rate of 10^6 s^{-1}	mPa·s	≥ 3.5		≥ 2.9 and ≤ 3.5
1.3.2 **HTHS viscosity at 100 °C***	CEC L-36-90	Dynamic viscosity at 100 °C and shear rate of 10^6 s^{-1}	mPa·s	—		Report
1.4 **Evaporative loss**	CEC L-40-93 (Noack)	Max. weight loss after 1 h at 250 °C	%	≤ 13		
1.5 **TBN**	ASTM D2896		mgKOH/g	≥ 8.0	≥ 10.0	≥ 8.0
1.6 **Sulphur***	ASTM D5185		% m/m	Report		
1.7 **Phosphorus***	ASTM D5185		% m/m	Report		
1.8 **Sulphated ash***	ASTM D874		% m/m	≥ 0.9 and ≤ 1.5	≥ 1.0 and ≤ 1.6	≤ 1.6
1.9 **Chlorine**	ASTM D6443		ppm	Report		
1.10 **Oil - elastomer compatibility***	CEC L-112-16	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing:		Elastomer type			
				RE6	RE7	RE8	RE9
		- Tensile strength	%	Report	Report	Report	Report
		- Elongation at rupture	%	-70/+20	-65/+15	-51/+9	-65/+19
		- Volume variation	%	-5.5/+2.1	-1.8/+8.9	0.0/+12.0	-2.5/+16.0
1.11 **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			
1.12 **High temperature foaming tendency**	ASTM D6082 High temperature foam test	Tendency - stability	ml	Sequence IV (150 °C) 100 - nil			
1.13 **Low-temperature pumpability**	CEC L-105-12	MRV	mPa·s	—	According to SAE J300 for fresh oil		
		Yield stress (MRV at SAE J300 temperatures, applicable for the fresh oil viscosity grade)	Pa				
1.14 **Oil oxidation with biodiesel for engine oils operating in the presence of biodiesel fuel**	CEC L-109-14	Oil oxidation at 168 h (DIN 51453)	A/cm	≤ 120	≤ 120	≤ 100
		Oil oxidation at 216 h (EOT) (DIN 51453)	A/cm	Report	Report	≤ 120
		Viscosity increase, relative at 168 h (Delta KV100)	%	≤ 150	≤ 150	≤ 60
		Viscosity increase, relative at 216 h (Delta KV100 at EOT 216 h)	%	Report	Report	≤ 150

*/**: Footnotes referring to the following Requirements in the A-/B- and C-Classes:

No. 1.2 Referring to the latest Version of the SAE J300 the minimum Viscosity for xW-20 Oils after Shearing is 6.9 cSt

No. 1.3.2 The CEC-L36-90 method is not yet approved for the parameter HTHS at 100 °C.

No. 1.6, 1.7, 1.8 Maximum limits, Values take into account method and production tolerances

No. 1.6, 1.7 Internal standard method must be used.

No. 1.10 For Categories A3/B3, A3/B4, A5/B5 and C1, C2, C3, C4: Available Test data from the Predecessor-Test CEC L-39-96 may be used for ACEA 2016 instead of CEC L-112-16 under the condition that a full L-39 data set including RE1, RE2, RE3 & RE4 + the Daimler DBL-AEM (requirements as specified by Daimler AG), provided the requirements as specified in ACEA 2012 are met.

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2. ENGINE TESTS

REQUIREMENT	TEST METHOD	PROPERTIES	UNIT	LIMITS		
				A3/B3-16	A3/B4-16	A5/B5-16
2.1 Gasoline DI engine cleanliness test	CEC L-111-16 (EP6CDT)	Piston cleanliness	Merit	≥ RL259		
		Turbo charger deposits **, average value of zones C, D, E & F	Merit	≥ 6.0		
2.2 Low temperature sludge*	ASTM D6593-00 (Sequence VG) Under protocol & requirements for API	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		
2.3 Valve train scuffing wear*						
2.4 Black sludge*	Daimler M271	Engine sludge, average	Merit	≥ RL140 + 4σ or ≥ RL261 + 1σ		
2.5 Fuel economy*	CEC L-54-96 (M111)	Fuel economy improvement	%	—		≥ 2.5
2.6 DI diesel oil dispersion at medium temperature	CEC L-106-16 (DV6C)	Absolute viscosity increase at 100 °C and 5.5 % soot	mm^2/s	≤ 0.9 x RL248		
		Piston cleanliness **	Merit	≥ 2.5		
2.7 Diesel engine wear	CEC L–99-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 140	≤ 120	
		Cam wear inlet (avg. max. wear 8 cams) **	µm	≤ 110	≤ 100	
		Cylinder wear (avg. 4 cylinders) **	µm	≤ 5.0	≤ 5.0	
		Bore polishing (13 mm) ** (max. value of 4 cylinders)	%	≤ 3.5	≤ 3.0	
		Tappet wear inlet ** (avg. max. wear 8 cams)	µm	Report	Report	
		Tappet wear outlet ** (avg. max. wear 8 cams)	µm	Report	Report	
		Piston cleanliness (avg. 4 pistons) **	Merit	Report	≥ 12	
		Engine sludge average **	Merit	Report	≥ 8.8	
2.8 DI diesel piston cleanliness & ring sticking*	CEC L-78-99 (VW TDI)	Piston cleanliness	Merit	≥ RL206 minus 4 points	≥ RL206	≥ RL206
		Ring sticking (Rings 1 & 2)				
		Average of all 8 rings	ASF	≤ 1.2	≤ 1.0	≤ 1.0
		Max. for any 1st ring	ASF	≤ 2.5	≤ 1.0	≤ 1.0
		Max. for any 2nd ring	ASF	0.0	0.0	0.0
		EoT TBN (ISO 3771) **	mgKOH/g	≥ 4.0	≥ 6.0	≥ 4.0
		EoT TAN (ASTM D664) **	mgKOH/g	Report	Report	Report
2.9 Effects of biodiesel	CEC L-104-16 (OM646LA Bio)	Piston cleanliness	Merit	—	≥ RL255 + 2	
		Ring sticking	ASF		Report	
		Sludge	Merit		Report	

*/**: Footnotes referring to the following Requirements in the A-/B- and C-Classes:

No. 2.1, 2.6 … 2.9 ** Parameter is not an official CEC Parameter

No. 2.2 Alternatively, Sequence VH test may be used with limits as defined for API SN: Average engine sludge, merits: 7.6 (min); Average rocker cover sludge, merits: 7.7 (min); Average engine varnish, merits: 8.6 (min); Average piston skirt varnish, merits: 7.6 (min); Oil screen clogging, % area: Rate & Report; Hot-stuck compression rings: None. The limits shown are based on 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.

No. 2.3 The CEC L-38-94 (TU3M) Test was removed from these Oil Sequences since hardware will run out in early 2017. However, in order to assure/support Wear Protection although TU3 is removed, ACEA intends to introduce the ASTM Seq. IVB Test as a TU3-Sucessor regarding valve train wear with the next Oil Sequences Revision, with Limits for Seq. IVB then to be defined based on ILSAC Spec.

No. 2.4 Until the new CEC Test Method L-107 is fully developed, the Gasoline Sludge Protection Performance of Engine Oil Formulations must be proven by the M271 Sludge Test procedure as described by Daimler AG. Test results obtained by the M271 procedure will be accepted only under the condition that they come from Test Rigs being referenced and quality controlled by Daimler AG. Limits are based on the same Reference Oil as with the old M111 Sludge Test. Once the L-107 Procedure is fully CEC-approved, the L-107 may be used, with limits officially communicated by ACEA. Daimler M271 Sludge Reference Oil has changed from RL140 to RL261. ACEA claims may be demonstrated using either RL140 or RL261. The limits applicable to each reference oil are given above.

No. 2.8 * Test Report must give measured values before and after the test, all measurements to be taken in the same lab.
Note: EOT TAN is considered to become performance criteria in the future. Any test run prior to the publication of the ACEA 2012 Oil Sequences can be used whether or not it has data for EOT TAN.

ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices

ACEA | December 2016 Rev. 2

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1. LABORATORY TESTS

REQUIREMENT	TEST METHOD	PROPERTIES	UNIT	LIMITS				
				C1-16	C2-16	C3-16	C4-16	C5-16
1.1 **Viscosity grades**		Viscosity class according to SAE J300 - Latest active issue		No restriction except as defined by HTHS and shear stability requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature.				
1.2 **Shear stability***	CEC L-14-93 or ASTM D6278 or ASTM D7109	100 °C Viscosity after 30 cycles	mm^2/s	All grades to be 'stay in grade'				
1.3.1 **HTHS viscosity**	CEC L-36-90	Dynamic viscosity at 150 °C and shear rate of 10^6 s^{-1}	mPa·s	≥ 2.9		≥ 3.5		≥ 2.6 & < 2.9
1.3.2 **HTHS viscosity at 100 °C***	CEC L-36-90	Dynamic Viscosity at 100 °C and shear rate of 10^6 s^{-1}	mPa·s	Report		Report		Report
1.4 **Evaporative loss**	CEC L-40-93 (Noack)	Max. weight loss after 1 h at 250 °C	%	≤ 13			≤ 11	≤ 13
1.5 **TBN**	ASTM D2896		mgKOH/g	- - -		≥ 6.0		
1.6 **Sulphur***	ASTM D5185		% m/m	≤ 0.2	≤ 0.3		≤ 0.2	≤ 0.3
1.7 **Phosphorus***	ASTM D5185		% m/m	≤ 0.05	≥ 0.07 ≤ 0.09		≤ 0.09	≥ 0.07 ≤ 0.09
1.8 **Sulphated ash**	ASTM D874		% m/m	≤ 0.5	≤ 0.8		≤ 0.5	≤ 0.8
1.9 **Chlorine**	ASTM D6443		ppm	Report				
1.10 **Oil - elastomer compatibility***	CEC L-112-16	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing:		Elastomer type				
				RE6	RE7	RE8	RE9	
		- Tensile strength	%	Report	Report	Report	Report	
		- Elongation at rupture	%	-70/+20	-65/+15	-51/+9	-65/+19	
		- Volume variation	%	-5.5/+2.1	-1.8/+8.9	0.0/+12.0	-2.5/+16.0	
1.11 **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				
1.12 **High temperature foaming tendency**	ASTM D6082 High temperature foam test	Tendency - stability	ml	Sequence IV (150 °C) 100 – nil				
1.13 **Low temperature pumpability**	CEC L-105-12	MRV	mPa·s	According to SAE J300 for fresh oil				
		Yield stress (MRV at SAE J300 temperatures, applicable for the fresh oil viscosity grade)	Pa					
1.14 **Oil oxidation with biodiesel** for engine oils operating in the presence of biodiesel fuel	CEC L-109-14	Oil oxidation at 168 h (DIN 51453)	A/cm	≤ 100				
		Oil oxidation at 216 h (EOT) (DIN 51453)	A/cm	≤ 120				
		Viscosity increase, relative at 168 h (Delta KV100)	%	≤ 60				
		Viscosity increase, relative at 216 h (Delta KV100 at EOT 216 h)	%	≤ 150				

*/**: Footnotes referring to the following Requirements in the A-/B- and C-Classes:

No. 1.2	Referring to the latest Version of the SAE J300 the minimum Viscosity for xW-20 Oils after Shearing is 6.9 cSt
No. 1.3.2	The CEC-L36-90 method is not yet approved for the parameter HTHS at 100 °C.
No. 1.6, 1.7, 1.8	Maximum limits, Values take into account method and production tolerances
No. 1.6, 1.7	Internal standard method must be used.
No. 1.10	For Categories A3/B3, A3/B4, A5/B5 and C1, C2, C3, C4: Available Test data from the Predecessor-Test CEC L-39-96 may be used for ACEA 2016 instead of CEC L-112-16 under the condition that a full L-39 data set including RE1, RE2, RE3 & RE4 + the Daimler DBL-AEM (requirements as specified by Daimler AG), provided the requirements as specified in ACEA 2012 are met.

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2. ENGINE TESTS

REQUIREMENT	TEST METHOD	PROPERTIES	UNIT	LIMITS				
				C1-16	C2-16	C3-16	C4-16	C5-16
2.1 **Gasoline DI engine cleanliness**	CEC L-111-16 (EP6CDT)	Piston cleanliness	Merit	≥ RL259				
		Turbo charger deposits **, average value of zones C, D, E & F	Merit	≥ 6.0				
2.2 **Low temperature sludge***	ASTM D6593-00 (Sequence VG) Under protocol & requirements for API	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				
2.3 **Valve train scuffing wear***								
2.4 **Black sludge***	Daimler M271	Engine sludge, average	Merit	≥ RL140 + 4σ or ≥ RL261 + 1σ				
2.5 **Fuel economy***	CEC L-54-96 (M111)	Fuel economy improvement	%	≥ 3.0	≥ 2.5	≥ 1.0 (for xW-30 only, no limit for xW-40)		≥ 3.0
2.6 **DI diesel oil dispersion at medium temperature**	CEC L-106-16 (DV6C)	Absolute viscosity increase at 100 °C and 5.5 % soot	mm²/s	≤ 0.9 x RL248				
		Piston cleanliness **	Merit	≥ 2.5				
2.7 **Diesel engine Wear***	CEC L-99-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 120		≤ 120		
		Cam wear inlet (avg. max. wear 8 cams)**	µm	≤ 100		≤ 100		
		Cylinder wear (avg. 4 cylinders)**	µm	≤ 5.0		≤ 5.0		
		Bore polishing (13 mm)** max. value of 4 cylinders	%	≤ 3.0		≤ 3.0		
		Tappet wear inlet** (avg. max. wear 8 cams)	µm	Report		Report		
		Tappet wear outlet** (avg. max. wear 8 cams)	µm	Report		Report		
		Piston cleanliness (avg. 4 pistons)**	Merit	Report		≥ 12		
		Engine sludge average **	Merit	Report		≥ 8.8		
2.8 **DI diesel piston cleanliness & ring sticking***	CEC L-78-99 (VW TDI)	Piston cleanliness	Merit	≥ RL206	≥ RL206	≥ RL206		
		Ring sticking (Rings 1 & 2)						
		Average of all 8 rings	ASF	≤ 1.0	≤ 1.2	≤ 1.0		
		Max. for any 1st ring	ASF	≤ 1.0	≤ 2.5	≤ 1.0		
		Max. for any 2nd ring	ASF	0.0	0.0	0.0		
		EOT TBN (ISO 3771) **	mgKOH/g	Report	Report	Report		
		EOT TAN (ASTM D664) **	mgKOH/g	Report	Report	Report		
2.9 **Effects of biodiesel**	CEC L-104-16 (OM646LA Bio)	Piston cleanliness	Merit	≥ RL255 + 2				
		Ring sticking **	ASF	Report				
		Sludge **	Merit	Report				

*/**: Footnotes referring to the following Requirements in the A-/B- and C-Classes:

No. 2.1, 2.6 … 2.9 ** Parameter is not an official CEC Parameter

No. 2.2 Alternatively, Sequence VH test may be used with limits as defined for API SN: Average engine sludge, merits: 7.6 (min); Average rocker cover sludge, merits: 7.7 (min); Average engine varnish, merits: 8.6 (min); Average piston skirt varnish, merits: 7.6 (min); Oil screen clogging, % area: Rate & Report; Hot-stuck compression rings: None. The limits shown are based on 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.

No. 2.3 The CEC L-38-94 (TU3M) Test was removed from these Oil Sequences since hardware will run out in early 2017. However, in order to assure/support Wear Protection although TU3 is removed, ACEA intends to introduce the ASTM Seq. IVB Test as a TU3-Sucessor regarding valve train wear with the next Oil Sequences Revision, with Limits for Seq. IVB then to be defined based on ILSAC Spec.

No. 2.4 Until the new CEC Test Method L-107 is fully developed, the Gasoline Sludge Protection Performance of Engine Oil Formulations must be proven by the M271 Sludge Test procedure as described by Daimler AG. Test results obtained by the M271 procedure will be accepted only under the condition that they come from Test Rigs being referenced and quality controlled by Daimler AG. Limits are based on the same Reference Oil as with the old M111 Sludge Test. Once the L-107 Procedure is fully CEC-approved, the L-107 may be used, with limits officially communicated by ACEA. Daimler M271 Sludge Reference Oil has changed from RL140 to RL261. ACEA claims may be demonstrated using either RL140 or RL261. The limits applicable to each reference oil are given above.

No. 2.8 * Test Report must give measured values before & after the test, all measurements to be taken in the same lab.

Note: EOT TAN is considered to become performance criteria in the future. Any test run prior to the publication of the ACEA 2012 Oil Sequences can be used whether or not it has data for EOT TAN.

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1. LABORATORY TESTS

REQUIREMENT	TEST METHOD	PROPERTIES	UNIT	LIMITS			
				E4-16	E6-16	E7-16	E9-16
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 temperature.			
1.2 Shear stability	CEC L-14-93 or ASTM D6278 or ASTM D7109	Viscosity after 30 cycles measured at 100 °C.	mm^2/s	Stay in grade			
	ASTM D7109	Viscosity after 90 cycles measured at 100 °C	mm^2/s		Stay in grade		
1.3 HTHS viscosity	CEC L-36-90	Dynamic viscosity at 150 °C and shear rate of 10^6 s^{-1}	mPa·s	≥ 3.5			
		Dynamic viscosity at 100 °C and shear rate of 10^6 s^{-1}	mPa·s	Report			
1.4 Evaporative loss	CEC L-40-93 (Noack)	Max. weight loss after 1 h at 250 °C	%	≤ 13			
1.5 Sulphated ash	ASTM D874		% m/m	≤ 2.0	≤ 1.0	≤ 2.0	≤ 1.0
1.6 Phosphorus	ASTM D5185		% m/m		≤ 0.08		≤ 0.12
1.7 Sulphur	ASTM D5185		% m/m		≤ 0.3		≤ 0.4
1.8 Oil / elastomer compatibility*	CEC L-112-16	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing		Elastomer type			
				RE6	RE7	RE8	RE9
		- Tensile strength	%	Report	Report	Report	Report
		- Elongation at break	%	-70/+20	-65/+15	-51/+9	-65/+19
		- Volume change	%	-5.5/+2.1	-1.8/+8.9	0.0/+12	-2.5/+16
1.9 Foaming tendency	ASTM D892 without option A	Tendency - stability	ml ml ml	Sequence I (24 °C) 10 – nil Sequence II (94 °C) 50 – nil Sequence III (24 °C) 10 – nil			Seq I 10/0 Seq II 20/0 Seq III 10/0
1.10 High temperature foaming tendency	ASTM D6082	Tendency - stability	ml	Sequence IV (150 °C) 200-50			
1.11 Oxidation	CEC L-85-99 (PDSC)	Oxidation induction time	min.	≥ 65			
1.12 Corrosion	ASTM D6594	Copper increase Lead increase Copper strip rating	ppm ppm	Report Report Report		Report ≤ 100 Report	≤ 20 ≤ 100 ≤ 3
1.13 TBN*	ASTM D2896		mg KOH/g	≥ 12	≥ 7	≥ 9	≥ 7
1.14 Low temperature pumpability	CEC L-105-12	MRV Yield stress (MRV at SAE J300 Temperatures applicable for the fresh oil viscosity grade)	mPa·s Pa	According to SAE J300 for fresh oil			
1.15 Oil oxidation with biodiesel	CEC L-109-14	Oxidation increase after 168 h KV100 increase after 168 h	A/cm %	≤ 90 ≤ 130	≤ 80 ≤ 130	≤ 120 ≤ 300	≤ 90 ≤ 150

*/**: Footnotes referring to the following requirements in the E-Class:

No. 1.8 Full data sets being obtained on CEC L-39-96 + the Daimler requirements for DBL-AEM as specified by Daimler AG can be used instead of CEC L-112-16, provided the requirements as specified in ACEA 2012 are met.

No. 1.13 For E7, values < 9.00 are not accepted.

ACEA	ACEA 2016 European oil sequence for service-fill oils for heavy-duty diesel engines	December 2016 Rev. 2

This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.
Individual member companies may indicate performance parameters other than those covered by the tests shown or more stringent limits.

2. ENGINE TESTS

REQUIREMENT	TEST METHOD	PROPERTIES	UNIT	LIMITS			
				E4-16	E6-16	E7-16	E9-16
2.1 **Wear**	CEC L-99-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 140		≤ 155	
2.2 **Soot in oil***	ASTM D5967 (Mack T-8E)	Test duration 300 h Relative viscosity at 4.8 % soot and 50 % shear loss 1 test/2 test/3 test average		≤ 2.1/2.2/2.3			
2.3 **Bore polishing piston cleanliness***	CEC L-101-08 (OM501LA)	Piston cleanliness, average	Merit	≥ 26		≥ 17	
		Bore polishing, average **	%	≤ 1.0		≤ 2.0	
		Oil consumption **	kg/Test	≤ 9		≤ 9	
		Engine sludge, average **	Merit	Report		Report	
2.4 **Soot induced wear***	ASTM D7468 (Cummins ISM)	Merit					≥ 1000
		Crosshead, weight loss					
		1 test/2 test/3 test average	mg			≤ 7.5/7.8/7.9	≤ 7.1
		Oil Filter Diff. Press at 150 h					
		1 test/2 test/3 test average	kPa			≤ 55/67/74	≤ 19
		Engine sludge					
		1 test/2 test/3 test average	Merit			≥ 8.1/8.0/8.0	≥ 8.7
		Adj. screw weight loss	mg				≤ 49
2.5 **Wear (liner-ring-bearings)***	ASTM D7422 (Mack T12)	Merit			≥ 1000		≥ 1000
		Cylinder liner wear (CLW)	µm		≤ 26		≤ 24
		Top ring weight loss (TRWL)	mg		≤ 117		≤ 105
		End of test lead	ppm		≤ 42		≤ 35
		Delta lead 250-300 hrs	ppm		≤ 18		≤ 15
		Oil consumption (Phase II)	g/hr		≤ 95		≤ 85
2.6 **Biofuel impacted piston cleanliness and engine sludge**	CEC L-104-16 (OM646LA Bio)	Piston cleanliness, average	Merit		≥ RL255 + 4		≥ RL255 + 2
		Ring sticking **	ASF		Report		Report
		Engine sludge, average **	Merit		Report		Report

*/**: Footnotes referring to the following requirements in the E-Class:

No. 2.2 Mack T11 results obtained as part of an API CI-4, CI-4 plus, CJ-4, CK-4 or FA-4 approval program, can be used in place of Mack T8E.

No. 2.3, 2.6 ** Not CEC approved parameters.

No. 2.4 Merit number shall be calculated according to the API CI-4 specification

No. 2.5 For E6 & E7 Merit number shall be calculated according to the API CI-4 specification. For E6 & E7 Mack T10 results obtained as part of an API CI-4 or CI-4 plus approval program, can be used in place of Mack T12. Mack T-12 Cylinder Liner Wear and Top Ring Weight Loss results obtained as part of an API CK-4 or FA-4 approval program, which includes a passing Volvo T-13 at the API CK-4 or API FA-4 level, may be used to satisfy the requirements of the Mack T-12 in the ACEA Oil Sequences.

Certification and registration

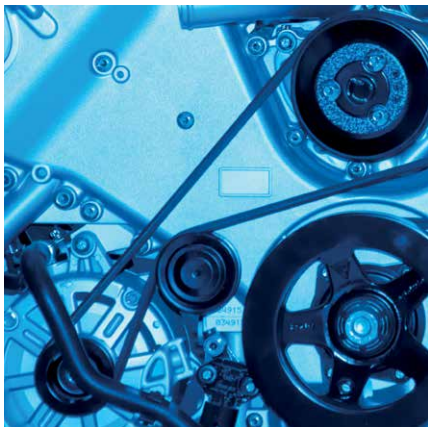
Claims against the ACEA Oil Sequences can be made on a self-certification basis. For any claim being made against these ACEA Oil Sequences, ACEA currently recommends oil marketers to register their products with the ACEA registration system on the ACEA website. ACEA will introduce a mandatory registration scheme within 2017 and will inform stakeholders about the procedures to be followed for mandatory registration three months in advance of the date of mandatory registration.

All information needed for registration is available on the ACEA website, see: **http://acea.dossier-on-web.com/eor/engine-oil-registrations/menu/eor/front-page**

Engine oils claiming any of the ACEA Oil Sequences should be registered directly after their launch into the market. After completing the form, it will be saved on the ACEA server. If claims are no longer needed oil companies are asked to delete their registration.

If claims continue to be used after three years, re-registration is required.

Nomenclature and ACEA process:



Each set of Oil Sequences is designated for consumer use by a 2-part code comprising a letter to define the CLASS (e.g. C), and a number to define the CATEGORY (e.g. C1).

In addition, for industry use, each sequence has a two-digit number to identify the YEAR of implementation of that severity level (e.g. A3/B4-16).

The CLASS indicates oil intended for a general type of engines – currently: A/B = Gasoline and Light-duty Diesel Engines; C = Catalyst compatible oils for Gasoline and Light-duty Diesel Engines with Aftertreatment devices; E = Heavy-duty Diesel Engines. Other classes may be added in future if, for example, Natural Gas Engines may prove to require oil characteristics which cannot readily be incorporated into existing classes.

The CATEGORY indicates oils for different purposes or applications within that general class, related to some aspect or aspects of the performance level of the oil. Typical applications for each sequence are described below for guidance only. Specific applications of each sequence are the responsibility of the individual motor manufacturer for their own vehicles and engines. Oils within a category may also meet the requirements of another category but some engines may only be suited to oils of one category within a class.

The YEAR numbers for ACEA Sequence is intended only for industry use and indicates the year of implementation of that severity level for the particular category. A new year number will indicate, for example, that a new test, parameter or limit has been incorporated in the category to meet new/upgraded performance requirements whilst remaining compatible with existing applications. An update must always satisfy the applications of the previous issue. If this is not the case, then a new category is required.

An administrative ISSUE Number is added for industry use where it is necessary to update the technical requirements of a sequence without the intention to increase severity (e.g. when a CEC test engine is updated to the latest version whilst maintaining equivalent severity; or where a severity shift in the test requires modification of the specified limits.).

Consumer language

Where claims are made that Oil Performance meets the requirements of the ACEA Oil Sequences (e.g. product literature, packaging, labels) they must specify the ACEA Class and Category (see Nomenclature & ACEA Process for definitions).

A/B : Gasoline and diesel engine oils – 'High SAPS'

A1/B1 Category is removed with these Oil Sequences.

A3/B3 Stable, stay-in-grade engine oil intended for use in passenger car and light-duty van gasoline and diesel engines and/or for extended drain intervals where specified by the engine manufacturer, and/or for year-round use of low viscosity oils, and/or for severe operating conditions as defined by the engine manufacturer.

A3/B4 Stable, stay-in-grade engine oil intended for use in passenger car and light-duty van gasoline and DI diesel engines, but also suitable for applications described under A3/B3.

A5/B5 Stable, stay-in-grade engine oil intended for use at extended drain intervals in passenger car and light-duty van gasoline and diesel engines designed to be capable of using low viscosity oils with HTHS viscosity of 2.9 to 3.5 mPa·s. These oils are unsuitable for use in certain Engines - consult vehicle OEM's owner's manual/ handbook in case of doubt.

C : Catalyst & GPF/DPF compatible engine oils for gasoline and diesel engines – 'Low SAPS'

Note: *These oils will increase the DPF/GPF and TWC life and maintain the vehicle's fuel economy.*

Warning: *Some of these categories may be unsuitable for use in certain engine types – consult the vehicle-OEM's owner's manual/handbook in case of doubt.*

C1 Stable, stay-in-grade engine oil with lowest SAPS Level, intended for use as catalyst compatible oil at extended drain intervals in vehicles with all types of modern aftertreatment systems and high performance passenger car and light-duty van gasoline and DI diesel engines that are designed to be capable of using low viscosity oils with a minimum HTHS viscosity of 2.9 mPa·s.

C2 Stable, stay-in-grade engine oil with mid SAPS Level, intended for use as catalyst compatible oil at extended drain intervals in vehicles with all types of modern aftertreatment systems and high performance passenger car and light-duty van gasoline and DI diesel engines that are designed to be capable of using low viscosity oils with a minimum HTHS viscosity of 2.9 mPa·s.

C3 Stable, stay-in-grade engine oil with mid SAPS Level, intended for use as catalyst compatible oil at extended drain intervals in vehicles with all types of modern aftertreatment systems and high performance passenger car and light-duty van gasoline and DI diesel engines that are designed to be capable of using oils with a minimum HTHS viscosity of 3.5 mPa·s.

C4 Stable, stay-in-grade engine oil with low SAPS Level, intended for use as catalyst compatible oil at extended drain intervals in vehicles with all types of modern aftertreatment systems and high performance passenger car and light-duty van gasoline and DI diesel engines that are designed to be capable of using oils with a minimum HTHS viscosity of 3.5 mPa·s.

C5 Stable, stay-in-grade engine oil with mid SAPS Level, for further improved fuel economy, intended for use as catalyst compatible oil at extended drain intervals in vehicles with all types of modern aftertreatment systems and high performance passenger car and light-duty van gasoline and DI diesel engines that are designed to be capable and OEM approved for use of low viscosity oils with a minimum HTHS viscosity of 2.6 mPa·s.

E : Heavy-duty Diesel engine oils

E4 Stable, stay-in-grade oil providing excellent control of piston cleanliness, wear, soot handling and lubricant stability. It is recommended for highly rated diesel engines meeting Euro I, Euro II, Euro III, Euro IV and Euro V emission requirements and running under very severe conditions, e.g. significantly extended oil drain intervals according to the manufacturer's recommendations. It is suitable for engines without particulate filters, and for some EGR engines and some engines fitted with SCR NOx reduction systems. However, recommendations may differ between engine manufacturers so driver manuals and/or dealers shall be consulted if in doubt.

E6 Stable, stay-in-grade oil providing excellent control of piston cleanliness, wear, soot handling and lubricant stability. It is recommended for highly rated diesel engines meeting Euro I, Euro II, Euro III, Euro IV, Euro V and Euro VI emission requirements and running under very severe conditions, e.g. significantly extended oil drain intervals according to the manufacturer's recommendations. It is suitable for EGR engines, with or without particulate filters, and for engines fitted with SCR NOx reduction systems. E6 quality is strongly recommended for engines fitted with particulate filters and is designed for use in combination with low sulphur diesel fuel. However, recommendations may differ between engine manufacturers so driver manuals and/or dealers shall be consulted if in doubt.

E7 Stable, stay-in-grade oil providing effective control with respect to piston cleanliness and bore polishing. It further provides excellent wear control, soot handling and lubricant stability. It is recommended for highly rated diesel engines meeting Euro I, Euro II, Euro III, Euro IV and Euro V emission requirements and running under severe conditions, e.g. extended oil drain intervals according to the manufacturer's recommendations. It is suitable for engines without particulate filters, and for most EGR engines and most engines fitted with SCR NOx reduction systems. However, recommendations may differ between engine manufacturers so driver manuals and/or dealers shall be consulted if in doubt.

E9 Stable, stay-in-grade oil providing effective control with respect to piston cleanliness and bore polishing. It further provides excellent wear control, soot handling and lubricant stability. It is recommended for highly rated diesel engines meeting Euro I, Euro II, Euro III, Euro IV, Euro V and Euro VI emission requirements and running under severe conditions, e.g. extended oil drain intervals according to the manufacturer's recommendations. It is suitable for engines with or without particulate filters, and for most EGR engines and for most engines fitted with SCR NOx reduction systems. E9 is strongly recommended for engines fitted with particulate filters and is designed for use in combination with low Sulphur diesel fuel. However, recommendations may differ between engine manufacturers so driver manuals and/or dealers should be consulted if in doubt.

SAPS: Sulphated Ash, Phosphorus, Sulphur

HTHS: High Temperature High Shear Viscosity

DI: Direct Injection

DPF: Diesel Particle Filter

GPF: Gasoline Particle Filter

TWC: Three-Way Catalyst

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