



Oronite

# Classifications and Specifications Guide

## Automotive Engine Lubricants

### June 2019

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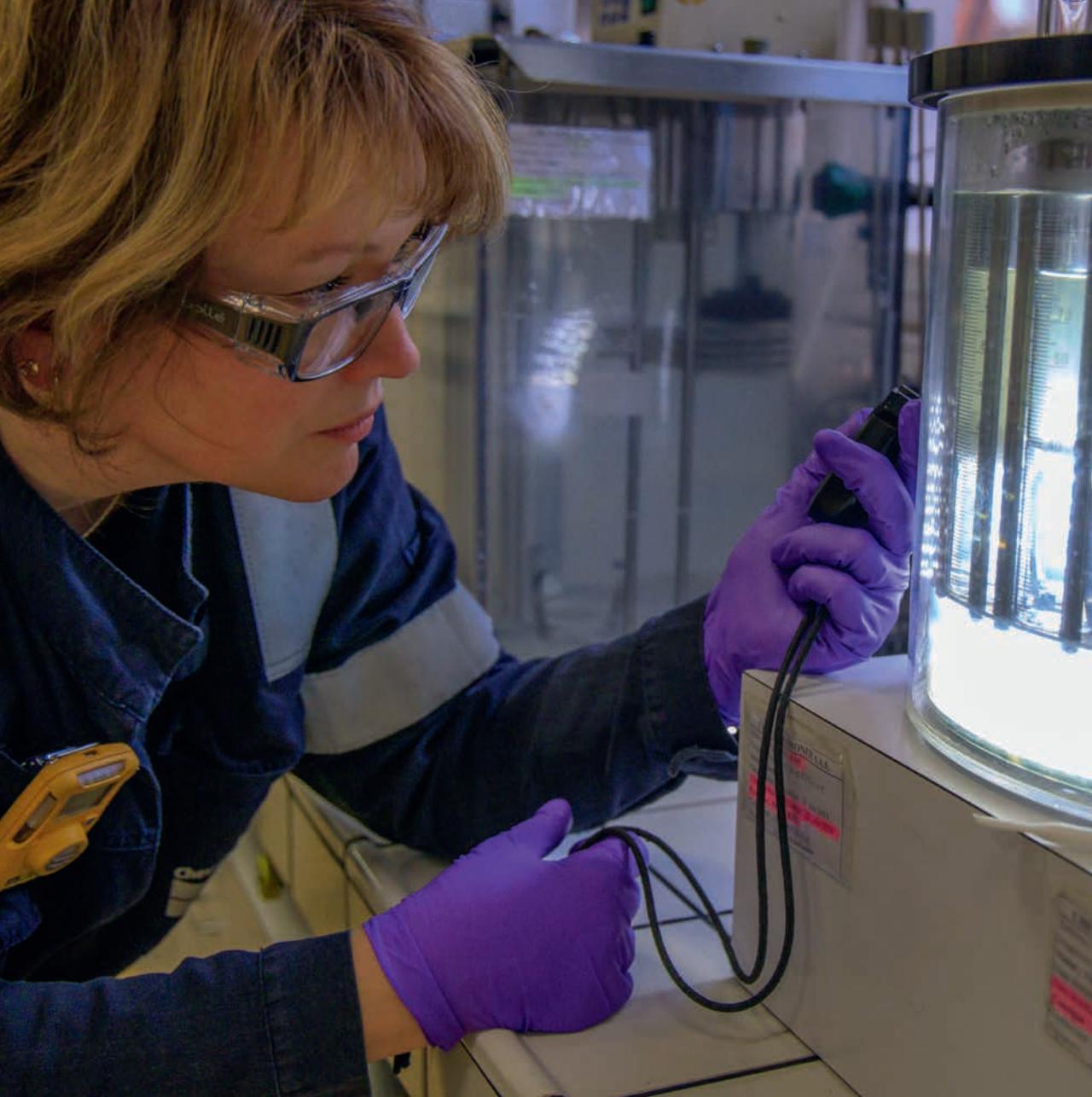
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# Viscosity classifications SAE J300



# SAE J300 revised January 2015 - SAE viscosity grades for engine oils<sup>(1) (2)</sup>



SAE Viscosity Grade	Low-Temperature (°C) Cranking Viscosity <sup>(3)</sup> , (mPa.s)	Low-Temperature (°C) Pumping Viscosity, (mPa.s, with No Yield Stress) <sup>(4)</sup>	Low-Shear-Rate Kinematic Viscosity <sup>(5)</sup> , (mm²/s) at 100°C	Low-Shear-Rate Kinematic Viscosity <sup>(5)</sup> , (mm²/s) at 100°C	High-Shear-Rate Viscosity <sup>(6)</sup> , (mPa.s) at 150°C
	Max.	Max.	Min.	Max.	Min.
0W	6200 at -35	60 000 at -40	3.8	-	-
5W	6600 at -30	60 000 at -35	3.8	-	-
10W	7000 at -25	60 000 at -30	4.1	-	-
15W	7000 at -20	60 000 at -25	5.6	-	-
20W	9500 at -15	60 000 at -20	5.6	-	-
25W	13000 at -10	60 000 at -15	9.3	-	-
8	-	-	4.0	<6.1	1.7
12	-	-	5.0	<7.1	2.0
16	-	-	6.1	<8.2	2.3
20	-	-	6.9	<9.3	2.6
30	-	-	9.3	<12.5	2.9
40	-	-	12.5	<16.3	3.5 (0W-40, 5W-40, 10W-40)
40	-	-	12.5	<16.3	3.7 (15W-40, 20W-40, 25W-40, 40)
50	-	-	16.3	<21.9	3.7
60	-	-	21.9	<26.1	3.7

**Notes:**

(1) 1 mPa.s = 1 cP; 1 mm²/s = 1 cSt

(2) All values, with the exception of the low-temperature cranking viscosity, are critical specifications as defined by ASTM D3244.

(3) ASTM D5293: Cranking viscosity - The non-critical specification protocol in ASTM D3244 shall be applied with a P value of 0.95.

(4) ASTM D4684: Note that the presence of any yield stress detectable by this method constitutes a failure regardless of viscosity.

(5) ASTM D445

(6) ASTM D4683, ASTM D4741, ASTM D5481, or CEC L-036-90.

# API and ILSAC requirements for gasoline and diesel engine oils



## API "S" and ILSAC gasoline service categories engine and laboratory test requirement summary - Current -



API CATEGORY	SJ	SL	SM	SN (SN PLUS)	SN (SN PLUS) + RC	ILSAC STANDARD	GF-5
SAE Viscosity grades	All					SAE Viscosity grades	0W-xx, 5W-xx, 10W-xx
L-38	X or Seq VIII	-	-	-	-	CRC L-38	-
Ball rust test	X <sup>(5)</sup> or Seq IID	X <sup>(5)</sup>	X <sup>(5)</sup>	X <sup>(5)</sup>	X <sup>(5)</sup>	Ball rust test	X
Sequence II	IID or BRT(5)	-	-	-	-	Sequence II	-
Sequence III	IIIE or IIIF or IIIG <sup>(8)(9)</sup>	IIIF or IIIG <sup>(9)</sup>	IIIG + IIIGA <sup>(1)</sup>	IIIG + (IIIGA or ROBO) <sup>(3)</sup> , or IIIH	IIIG + IIIGB + (IIIGA or ROBO), or IIIH + IIIHB	Sequence III	IIIG + IIIGB + (IIIGA or ROBO), or IIIH + IIIHB
Sequence IV	-	IVA	IVA	IVA	IVA	Sequence IV	IVA
Sequence V	VE or IVA + VG	VE <sup>(2)+VG</sup>	VG	VG <sup>(5)</sup>	VG <sup>(5)</sup>	Sequence V	VG
Sequence VI	-	-	-	-	VID <sup>(7)</sup>	Sequence VI	VID
Sequence VII	X or L-38	X	X	X	X	Sequence VII	X
Sequence IX	-	-	-	X <sup>(10)</sup>	X <sup>(10)</sup>		
Viscometrics	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	Viscometrics	SAE J300
Volatility	X	X	X	X	X	Volatility	X
Filterability	X	X	X	X	X	Filterability	X
Foaming	X	X	X	X	X	Foaming	X
Flash point	X	-	-	-	-	Flash point	-
Homog. & miscibility	X	X	X	X	X	Homog. & miscibility	X
TEOST	TEOST 33	TEOST MHT	TEOST MHT <sup>(6)</sup>	TEOST MHT <sup>(6)</sup>	TEOST 33C (4) & MHT <sup>(6)</sup>	TEOST	TEOST 33C <sup>(4)</sup> & MHT
Gelation index	X	X	X	X <sup>(5)</sup>	X <sup>(5)</sup>	Gelation index	X
Shear stability	X	X	X	X	X	Shear stability	X
ROBO test	-	-	-	X or IIIGA (3)	X or IIIGA	ROBO test	X or IIIGA
Catalyst compatibility	X	X	X	X <sup>(6)</sup>	X <sup>(6)</sup>	Catalyst compatibility	X
Emulsion retention	-	-	-	-	X	Emulsion retention	X
Elastomer compatibility	-	-	-	X	X	Elastomer compatibility	X
Phosphorus retention	-	-	-	-	X	Phosphorus retention	X
HTHS Viscosity, 150°C	X <sup>(10)</sup>	X <sup>(10)</sup>	X <sup>(10)</sup>	X <sup>(10)</sup>	X <sup>(10)</sup>		

**Notes:**

(1) IIIGA required only for SAE grades 0W-20, 5W-20, 0W-30, 5W-30 and 10W-30.

(2) VE not required for oils containing a minimum of 0.08% phosphorus in the form of zinc dialkyldithiophosphates (ZDDP).  
(3) Not required for monograde and 15W, 20W and 25W multigrade oils.

(4) Not required for 0W-20 and 0W-16.

(5) If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the "S" category and there is no API Certification Mark, the Sequence VG (ASTM D 6593), Ball Rust Test (ASTM D 6557), and Gelation Index (ASTM D5133) tests are not required.

(6) For all viscosity grades: if CF-4, CG-4 and/or CI-4 categories precede the 'S' category and there is no API Certification Mark, the limits for phosphorus, sulfur and the TEOST MHT do not apply.

Note that these oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.

(7) Viscosity grades are limited to 0W, 5W and 10W multigrade oils.

(8) For oils containing less than 0.08 % phosphorus, in the form of ZDDP, the Sequence IIIF plus Sequence VE test is allowed as an alternative to Sequence IIIE.

(9) For oils with a 0.06 mass % and < 0.08 % phosphorus, in the form of ZDDP, the Sequence IIIG test is allowed as an alternative to Sequence IIIF plus Sequence VE.

(10) Not required for some viscosity grades.

(11) Required only for oils claiming to meet API SN with SN PLUS or API SN with SN PLUS and Resource Conserving.

## API "S" and ILSAC gasoline service categories engine and laboratory test requirement summary - Obsolete -



API CATEGORY	SE	SF	SG	SH	ILSAC STANDARD	GF-1	GF-2	GF-3	GF-4
SAE Viscosity grades			All		SAE Viscosity grades			OW-xx, 5W-xx, 10W-xx	
CRC L-38	X	X	X	X or Seq VIII	CRC L-38	X	X	-	-
Ball rust test	-	-	-	X or Seq IID	Ball rust test	-	-	X	X
Sequence II	IID	IID	IID	IID or BRT	Sequence II	IID	IID	-	-
Sequence III	IIID	IIID	IIIIE	IIIE <sup>(2)</sup> or IIIF <sup>(2)</sup> or IIIG <sup>(3)</sup>	Sequence III	IIIIE	IIIIE	IIIF	IIIG + IIIGA
Sequence IV	-	-	-	-	Sequence IV	-	-	IVA	IVA
Sequence V	VD	VD	VE	VE or IVA + VG	Sequence V	VE	VE	VE <sup>(1)</sup> + VG	VG
Sequence VI	-	-	-	-	Sequence VI	VI	VIA	VIB	VIB
Sequence VIII	-	-	-	X or L-38	Sequence VIII	-	-	X	X
Caterpillar	-	-	1H2		Caterpillar	-	-	-	-
Ford Falcon	-	-	-		Ford Falcon	-	-	-	-
Viscometrics	SAE J 300	SAE J 300	SAE J 300	SAE J300	Viscometrics	SAE J 300	SAE J 300	SAE J 300	SAE J300
Volatility	-	-	-	X	Volatility	X	X	X	X
Filterability	-	-	-	X	Filterability	X	X	X	X
Foaming	-	-	-	X	Foaming	X	X	X	X
Flash point	-	-	-	X	Flash point	X	X	-	-
Homog. & miscibility	-	-	-	X	Homog. & miscibility	X	X	X	X
TEOST	-	-	-	-	TEOST	-	33C	MHT	MHT
Gelation index	-	-	-	-	Gelation index	-	X	X	X
Shear stability	-	-	-	X	Shear stability	X	X	X	X
Catalyst compatibility	-	-	-	X	Catalyst compatibility	X	X	X	X

**Notes:**

(1) Not required for oils containing a minimum of 0.08% mass phosphorus in the form of Zinc dialkyldithiophosphates (ZDDP).

(2) For oils containing less than 0.08% phosphorus, in the form of ZDDP, the Sequence IIIF plus Sequence VE test is allowed as an alternative to Sequence IIIIE.

(3) For oils with ≥0.06 mass% and <0.08% phosphorus, in the form of ZDDP, the Sequence IIIG test is allowed as an alternative to Sequence IIIF plus Sequence VE.

# API SM, SN, SN + RC gasoline service category laboratory test limits

- 1 -



API CATEGORY	SM		SN (SN PLUS)		SN (SN PLUS) + RC
SAE Viscosity grades	0W-20/30 , 5W-20/30, 10W-30	Other grades	0W-16/20/30 , 5W-16/20/30, 10W-30	Other grades	All Viscosity grades
<b>Laboratory test requirements</b>					
<b>Kinematic viscosity at 100°C</b> (ASTM D445), cSt.	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
<b>HTHS viscosity</b> (ASTM D4683, D4741, or D5481), mPa.s, min.	SAE J300	2.6	2.3	2.6	2.3
<b>Low temperature cranking viscosity</b> (ASTM D5293), cP at -xx°C	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
<b>Pumpability</b> (ASTM D4684), 60000 cP max./ no yield stress at -xx°C	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
<b>NOACK volatility</b> (ASTM D5800), % loss at 250°C, max.	15 <sup>(1)</sup>	15 <sup>(1)</sup>	15 <sup>(1)</sup>	15 <sup>(1)</sup>	15 <sup>(1)</sup>
<b>Volatility loss at 371°C</b> (ASTM D6417), %, max.	10	10	10	10	10
<b>Filterability</b> , % flow reduction, max.					
<b>EOFST</b> (ASTM D6795)	50	50	50	50	50
<b>EOWTT</b> (ASTM D6794), with 0.6, 1.0, 2.0, 3.0% H2O.	50	50	50	50	50
<b>Phosphorus</b> (ASTM D4951), % m/m, max. <sup>(3) (4)</sup>	0.08	-	0.08	-	0.08
<b>Phosphorus</b> (ASTM D4951), % m/m, min. <sup>(3) (4)</sup>	0.06	0.06	0.06	0.06	0.06
<b>Sulfur</b> (ASTM D4951 or D2622), sulfur, % m/m, max. <sup>(3) (4)</sup>	0.5 / 0.7 <sup>(13)</sup>	-	0.5 / 0.6 <sup>(13)</sup>	-	0.5 <sup>(16)</sup> / 0.6 <sup>(17)</sup>
<b>Sequence IIIGA</b> (ASTM D4684), aged oil low temperature viscosity or <b>ROBO Test</b> (ASTM D7528), aged oil low temperature viscosity <sup>(11) (12)</sup>	Pass	-	Pass	Pass <sup>(10)</sup>	Pass
<b>Foaming tendency option A</b> (ASTM D892), ml, max., foaming/settling					
Sequence I	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(6)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(6)</sup>
Sequence II	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(6)</sup>	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(6)</sup>
Sequence III	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(6)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(6)</sup>
<b>High temperature foaming</b> (option A) (ASTM D6082), max.	100 / 0 <sup>(6)</sup>	100 / 0 <sup>(6)</sup>	100 / 0 <sup>(6)</sup>	100 / 0 <sup>(6)</sup>	100 / 0 <sup>(6)</sup>
<b>Homogeneity and miscibility</b> (ASTM D6922).	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>
<b>TEOST MHT</b> (ASTM D7097), high temperature deposits, mg deposit, max. <sup>(3)</sup>	35	45	35	45	35
<b>Ball rust test</b> (ASTM D6557), avg. grey value, min.	100	100	100 <sup>(14)</sup>	100 <sup>(14)</sup>	100 <sup>(14)</sup>
<b>Phosphorus retention</b> (Sequence IIIB/IIICB) (ASTM D7320/D8111), min, %	-	-	-	-	79/81
<b>TEOST 33</b> (ASTM D6335), total deposit weight, mg, max.	-	-	-	-	30 <sup>(2)</sup>

# API SM, SN, SN + RC gasoline service category laboratory test limits

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API CATEGORY	SM		SN (SN PLUS)		SN (SN PLUS) + RC
SAE Viscosity grades	0W-20/30 , 5W-20/30, 10W-30	Other grades	0W-16/20/30 , 5W-16/20/30, 10W-30	Other grades	All Viscosity grades
<b>Laboratory test requirements</b>					
Gelation index (ASTM D5133), max. <sup>(14)</sup>	12 <sup>(8)</sup>	-	12 <sup>(8)</sup>	-	12 <sup>(8)</sup>
Shear stability (Seq VIII) (ASTM D6709).	Pass <sup>(9)</sup>	Pass <sup>(9)</sup>	Pass <sup>(9)</sup>	Pass <sup>(9)</sup>	Pass <sup>(9)</sup>
Emulsion retention (ASTM D7563) : Oil mixed with 10% Water, 10 % E85 0°C, 24 Hrs. 25°C, 24 Hrs.	- -	- -	- -	- -	No water separation No water separation
Elastomer compatibility (ASTM D7216) <sup>(15)</sup>	-	-	Pass	Pass	Pass

**Notes:**

- (1) Calculated conversions specified in ASTM D5800 are allowed.
- (2) Not required for SAE XW-16 or XW-20.
- (3) For all viscosity grades: if CH-4, CI-4 and/or CJ-4 categories precede the "S" category and there is no API Certification Mark, the limits for phosphorus, sulfur and the TEOST MHT do not apply. However, the CJ-4 limits for phosphorus and sulfur do apply for CJ-4 oils. This footnote cannot be applied if CK-4 or FA-4 is also claimed. Note that these "C" category oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.
- (4) This is a non critical specification as described in ASTM D3244.
- (5) Settling volume determined at 10 minutes.
- (6) Settling volume determined at 1 minute.
- (7) Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible.
- (8) Shall be measured from 5°C to temperature at which 40,000 cP is attained or -40°C, or 2°C below the appropriate MRV TP-1 temperature (defined by SAE J 300), whichever occurs first.
- (9) 10-Hr Stripped Kinematic Viscosity at 100°C must remain in original SAE grade.
- (10) Not required for monograde and 15W, 20W and 25W multigrade oils.
- (11) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade.
- (12) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in SAEJ300, run ASTM D4684(MRV TP-1) at 5 °C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade)
- (13) For SAE 10W-30.
- (14) If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the "S" category and there is no API Certification Mark, the Sequence VG (ASTM D 6593), Ball Rust Test (ASTM D 6557), and Gelation Index (ASTM D5133) tests are not required.
- (15) Please refer to chapter "Elastomer Compatibility" for limits.
- (16) For SAE 0W-20/30, 5W-20/30 viscosity grades.
- (17) For all viscosity grades other than SAEs 0W-20/30, 5W-20/30.

# API SH, SJ and SL gasoline service category laboratory test limits

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API CATEGORY	SH <sup>(9)</sup>			SJ		SL	
SAE Viscosity grades	5W-30	10W-30	15W-40	0W-20, 5W-20, 5W-30, 10W-30	Other grades <sup>(14)</sup>	0W-20, 0W-30, 5W-20, 5W-30, 10W-30	Other grades <sup>(14)</sup>
<b>Laboratory test requirements</b>							
<b>Kinematic viscosity at 100°C (ASTM D445), mm<sup>2</sup>/s.</b>	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
<b>HTHS viscosity (ASTM D4683), mPa.s, min.</b>	SAE J300	SAE J300	SAE J300	SAE J300	2.6	SAE J300	2.6
<b>Low temperature cranking viscosity (ASTM D5293), mPa.s at -xx°C</b>	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
<b>Pumpability (ASTM D4684), 60000 mPa.s max./no yield stress at -xx°C</b>	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
<b>NOACK volatility (ASTM D5800), % loss at 250°C, max.</b>	25 <sup>(10)</sup>	20 <sup>(10)</sup>	18 <sup>(10)</sup>	22 <sup>(2)</sup>	20 <sup>(1)</sup>	15	15
<b>Volatility loss at 371°C (ASTM D6417), %, max.</b>	20 <sup>(11)</sup>	17 <sup>(11)</sup>	15 <sup>(11)</sup>	-	-	-	-
<b>Volatility loss at 371°C (ASTM D6417 or ASTM D5480), %, max.</b>	-	-	-	17 <sup>(2)</sup>	15 <sup>(1)</sup>	10	10
<b>Filterability, % flow reduction, max.</b>							
EOFT (ASTM D6795)	50	50	-	50	50	50	50
EOWTT (ASTM D6794), with 0.6, 1.0, 2.0, 3.0% H <sub>2</sub> O.	-	-	-	Report	Report	50	50
<b>Phosphorus (ASTM D4951 or D5185), % m/m, max.</b>	0.12	0.12	-	0.10 <sup>(3)</sup>	-	0.10 <sup>(3) (8)</sup>	-
<b>Phosphorus (ASTM D4951 or D5185), % m/m, min.</b>	0.06	0.06	0.06	0.06 <sup>(13)</sup>	0.06 <sup>(13)</sup>	0.06 <sup>(13)</sup>	0.06 <sup>(13)</sup>
<b>Foaming tendency option A (ASTM D892), ml, max., foaming/ settling</b>							
Sequence I	10 / 0 <sup>(12)</sup>	10 / 0 <sup>(12)</sup>	10 / 0(12)	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>
Sequence II	50 / 0 <sup>(12)</sup>	50 / 0 <sup>(12)</sup>	50 / 0(12)	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(5)</sup>
Sequence III	10 / 0 <sup>(12)</sup>	10 / 0 <sup>(12)</sup>	10 / 0(12)	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>
<b>High temperature foaming optional blending (ASTM D6082), ml, max., foaming/ settling</b>	Report <sup>(4)</sup>	Report <sup>(4)</sup>	Report <sup>(4)</sup>	200 / 50 <sup>(6)</sup>	200 / 50 <sup>(6)</sup>	100 / 0 <sup>(6)</sup>	100 / 0 <sup>(6)</sup>
<b>Homogeneity and miscibility (ASTM D6922)</b>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>
<b>TEOST 33 (ASTM D6335), total deposit weight, mg, max.</b>	-	-	-	60	60	-	-

## API SH, SJ and SL gasoline service category laboratory test limits

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API CATEGORY	SH <sup>(9)</sup>			SJ		SL	
	5W-30	10W-30	15W-40	0W-20, 5W-20, 5W-30, 10W-30	Other grades <sup>(14)</sup>	0W-20, 0W-30, 5W-20, 5W-30, 10W-30	Other grades <sup>(14)</sup>
<b>Laboratory test requirements</b>							
TEOST MHT (ASTM D7097), high temperature deposits, mg deposit, max.	-	-	-	-	-	45	45
Gelation index (ASTM D5133), max.	-	-	-	12 <sup>(15)</sup>	-	12 <sup>(15)</sup>	-
Flash point (ASTM D92) (10), °C, min.	200	205	215	200	-	-	-
Flash point (ASTM D93) (10), °C, min.	185	190	200	185	-	-	-
Ball rust test (ASTM D6557), avg. grey value, min.	-	-	-	100 <sup>(15)</sup>	100 <sup>(15)</sup>	100 <sup>(15)</sup>	100 <sup>(15)</sup>

**Notes:**

- (1) Only required for 15W-40 oils.
- (2) Meet the volatility requirement in either Test Method D5800, D5480, or D6417.
- (3) This is a non critical specification as described in ASTM D3244.
- (4) Report kinetic foam volume (ml), static foam volume (ml) and collapse time (s).
- (5) Settling volume determined at 10 minutes.
- (6) Settling volume determined at 1 minute.
- (7) Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible.
- (8) All viscosity grades if CF-4, CG-4 and/or CI-4 categories precede the "S" category and there is no API Certification Mark, the limits for phosphorus do not apply. However, the CJ-4 limits for phosphorus and sulfur do apply for CJ-4 oils. This footnote cannot be applied if CK-4 or FA-4 is also claimed. Note that these "C" category oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.
- (9) There are no bench tests and measured parameter requirements for other viscosity grades. Only the most recent edition of SAE J300 requirements have to be met on all oils.
- (10) Meet either Test Method D92 or D93 flash point requirement.
- (11) Meet either Test Method D5800 or D2887 volatility requirement.
- (12) Settling volume determined at 5 minutes.
- (13) Not required if passing Sequence VE (ASTM D5302) results are obtained.
- (14) Does not include 0W-16 and 5W-16.
- (15) If CI-4, CJ-4, CK-4 and/or FA-4 categories precede the "S" category and there is no API Certification Mark, the Sequence VG (ASTM D6593), Ball Rust Test (ASTM D6557), and Gelation Index (ASTM D5133) tests are not required.

# API "S" gasoline service categories engine test limits

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API CATEGORY	(SE)	(SF)	(SG)	SH <sup>(1)(6)</sup>	SJ <sup>(1)</sup>	SL	SM	SN (SN PLUS)	SN (SN PLUS) + RC			
	All	All	All	All	All	All	All	All	xW-16	xW-20	xW-30	10W-30 & other grades
SAE Viscosity grades	All	All	All	All	All	All	All	All	-	-	-	-
<b>CRC L-38 (ASTM D5119)</b>												
Bearing weight loss, mg, max.	40	40	40	40	40	-	-	-	-	-	-	-
Piston skirt varnish, min.	-	-	9.0	-	-	-	-	-	-	-	-	-
10 h. stripped viscosity	-	-	-	Stay in grade	Stay in grade	-	-	-	-	-	-	-
<b>Sequence VIII (ASTM D6709)</b>												
Bearing weight loss, mg, max.	-	-	-	26.4 (9)	26.4 (9)	26.4	26	26	-	-	-	26
10 h. stripped viscosity	-	-	-	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	-	-	-	Stay in grade <sup>(1)</sup>
<b>Sequence IID (ASTM D5844)</b>												
Average engine rust, min.	8.5	8.5	8.5	8.5	8.5	-	-	-	-	-	-	-
Lifter sticking, max.	none	none	none	none	none	-	-	-	-	-	-	-
<b>Sequence IIID, IIIE, IIIF<sup>(3)</sup>, IIIG, IIIH (ASTM D5533, D6984, D7320, D8111)</b>	IID	IID	IIIE	IIIE/IIIF/IIIG	IIIE/IIIF <sup>(3)</sup> /IIIG	IIIF <sup>(3)</sup> /IIIG	IIIG + IIIGA <sup>(8)</sup>	IIIG + IIIGA <sup>(8)</sup> / IIIH	IIIG + IIIGA <sup>(8)</sup> + IIIGB / IIIH + IIIHB			
Viscosity increase at 40°C, %, max.	375 at 40 h.	375 at 64 h.	375 at 64 h.	-/325 (10)/150	-/325 <sup>(10)</sup> /150	275 at 80 h./150 at 100 h.	150 at 100 h.	150 at 100 h.	150 at 100 h.			
Hours to 375 % vis. inc. at 40°C, min.	-	-	-	64/-	64/-	-	-	-	-			
Average engine sludge, min.	9.2	9.2	9.2	9.2/-	9.2/-	-	-	-	-			
Average piston skirt varnish, min.	9.1	9.2	8.9	8.9/8.5(13)/-	8.9/8.5 <sup>(3)</sup> /-	9.0/-	-	-	-			
Average oil ring land deposits, min.	4.0	4.8	3.5	3.5/-	3.5/-	-	-	-	-			
Weighted piston deposits, min.	-	-	-	-/3.2(13)/3.5	-/3.2 <sup>(3)</sup> /3.5	4.0/3.5	3.5	4.0/3.7	4.0/3.7			
Ring sticking (hot stuck)	None	None	None	None <sup>(2)(3)</sup>	None <sup>(2)(3)</sup>	None	None	None	None			
Lifter sticking	None	None	None	None/-	None/-	-	-	-	-			
Cam or lifter scuffing	None	None	None	None/-	None/-	-	-	-	-			
Maximum cam + lifter wear, µm (in.), max.	254 (0.0100)	203 (0.0080)	64 (0.0025)	64 (0.0025)/-/-	64 (0.0025)/-/-	-	-	-	-			
Average cam + lifter wear, µm (in.), max.	102 (0.0040)	102 (0.0040)	30 (0.0012)	30 (0.0012)/ <sup>(2)</sup> 60	30 (0.0012)/ <sup>(2)</sup> 60	20 <sup>(2)</sup> /60	60	-	-			
Low temperature Viscosity	-	-	-	-	-	Report <sup>(4)/Report<sup>(5)</sup></sup>	Pass <sup>(5)</sup>	Pass <sup>(5)</sup>	Pass <sup>(5)</sup>			
Phosphorus retention, %, min.	-	-	-	-	-	-	-	-	79 <sup>(7)</sup>			

## API "S" gasoline service categories engine test limits

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API CATEGORY	(SE)	(SF)	(SG)	SH <sup>(1) (6)</sup>	SJ <sup>(1)</sup>	SL	SM	SN (SN PLUS)	SN (SN PLUS) + RC				10W-30 & other grades
SAE Viscosity grades	All	All	All	All	All	All	All	All	xW-16	xW-20	xW-30		
Sequence VID (ASTM D7589)													
FEI 2, %, min.	-	-	-	-	-	-	-	-	1.2	1.2	0.9	0.6	
Sum of FEI, %, min.	-	-	-	-	-	-	-	-	2.8	2.6	1.9	1.5	

**Notes:**

(1) Alternative engine tests may be run instead of those presented as described in ASTM letter of April 28, 2000. Ball Rust Test instead of Sequence IID; Sequence IVA plus Sequence VG instead of Sequence VE; Sequence VIII instead of CRC L-38; Sequence IIIF as an alternative to Sequence IIIE (See ASTM D4485 -1lc for limits of these alternative engine tests).

(2) For IIIE in SH/SJ, an oil related stuck ring occurs on a piston with an individual oil ring land deposit rating < 2.6.

(3) Oil consumption is no longer a pass/fail limit. The test is invalid if oil consumption is ≥ 5.2 L and Noack Volatility is ≤ 15% or oil consumption is ≥ 6.5 L and Noack Volatility is > 15%.

(3) Evaluate the 80-hour test oil sample by ASTM 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 ASTM Test Method D5293 (CCS Viscosity).

(5) API SN Test Method D4684 (MRV TP-1) result on the 100-hour end of test sample must meet the requirements of the original grade or the next higher grade at the SAE J 300 temperature.

(6) API SH may only be considered if it is preceded by a "C" category in the Service symbol.

(7) API SN + Resource Conserving Sequence IIIGB (ASTM D7320).

(8) A Sequence IIIGA test is identical to a Sequence IIIG test, except only low temperature viscosity performance is measured.

(9) Alternative for CRC L-38.

(10) For IIIE in SH/SJ determine viscosity increase at 40°C at 60h.

(11) Data to support stay-in-grade requirement for read-across shall be supported by ASTM D6278 (30 passes). The following limits for kinematic viscosity at 100°C after shear must be met:

xW-20 ≥ 5.6 mm<sup>2</sup>/s / xW-30 ≥ 8.5 mm<sup>2</sup>/s / xW-40 ≥ 11.5 mm<sup>2</sup>/s / xW-50 ≥ 15.0 mm<sup>2</sup>/s.

(12) Calculate by eliminating the highest and lowest cam-plus-lifter wear results and then calculating an average based on the remaining ten rating positions. For SH and SJ, determine at 80 h.

(13) For IIIF in SH/SJ, determine at 80 h.

**API "S" gasoline service categories engine test limits**  
**- 3 -**



API CATEGORY	(SE)	(SF)	(SG)	SH <sup>(1)</sup>	SJ <sup>(1)</sup>	SL		SM	SN (SN PLUS)	SN (SN PLUS) + RC
SAE Viscosity grades	All	All	All	All	All	All		All	All	All
<b>Sequence IVA (ASTM D6891)</b>										
Cam wear avg, µm, max.	-	-	-	120 <sup>(4)</sup>	120 <sup>(4)</sup>	120		90	90	90
<b>Sequence V</b>	VD	VD	VE	VE/VG <sup>(4)</sup>	VE/VG <sup>(4)</sup>	VE <sup>(2)</sup>	VG	VG	VG	VG
Average engine sludge, min.	9.2	9.4	9.0	9.0/7.8	9.0/7.8	-	7.8	7.8	8.0	8.0
Rocker arm cover sludge, min.	-	-	7.0	7.0/8.0	7.0/8.0	-	8.0	8.0	8.3	8.3
Average piston skirt varnish, min.	6.4	6.7	6.5	6.5/7.5	6.5/7.5	-	7.5	7.5	7.5	7.5
Average engine varnish, min.	6.3	6.6	5.0	5.0/8.9	5.0/8.9	-	8.9	8.9	8.9	8.9
Oil screen debris, %, max.	-	-	-	-	-	report	report	report	report	report
Oil screen clogging, %, max.	10.0	7.5	20	20/20	20/20	-	20	20	15	15
Oil ring clogging, %, max. <sup>(2)</sup>	10.0	10.0	15	report	report	-	report	report	report	report
Compression ring sticking (hot stuck)	none	none	none	none/none	none/none	-	none	none	none	none
Cold stuck rings	-	-	-	-	-	-	report	report	report	report
Maximum cam wear, µm (in.), max.	Rate & Report	64 (0.0025)	380 (0.015)	380 (0.015)/-	380 (0.015)/-	380(3)	-	-	-	-
Average cam wear, µm (in.), max.	Rate & Report	25 (0.0010)	130 (0.005)	127 (0.005)/-	127 (0.005)/-	127(3)	-	-	-	-
<b>Sequence IX (ASTM DXXXX)</b>										
Average number of events, max.	-	-	-	-	-			-	5 <sup>(5)</sup>	5 <sup>(5)</sup>

**Notes:**

(1) Alternative engine tests may be run instead of those presented as described in ASTM letter of April 28, 2000. Ball Rust Test instead of Sequence IID; Sequence IVA plus Sequence VG instead of Sequence VE; Sequence VIII instead of CRC L-38;

Sequence IIIF as an alternative to Sequence IIIE (See ASTM D4485 -04 for limits of these alternative engine tests).

(2) Oil ring clogging as a pass criterion, suspended indefinitely by ASTM on June 1, 1994.

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

(4) Demonstrate passing performance in Sequence VE, or alternatively, in both Sequence IVA and VG.

(5) Required only for oils claiming to meet API SN with SN PLUS or API SN with SN PLUS and Resource Conserving.

# ILSAC GF-4 & GF-5 standard laboratory test limits

- 1 -



ILSAC STANDARD	GF-4	GF-5
SAE Viscosity grades	0W-xx, 5W-xx, 10W-xx	0W-xx, 5W-xx, 10W-xx
<b>Laboratory test requirements</b>		
<b>Kinematic viscosity at 100°C</b> (ASTM D445), mm <sup>2</sup> /s.	SAE J300	SAE J300
<b>HTHS viscosity</b> (ASTM D4683), mPa.s, min.	SAE J300	SAE J300
<b>Low temperature cranking viscosity</b> (ASTM D5293), mPa.s at -xx°C	SAE J300	SAE J300
<b>Pumpability</b> (ASTM D4684), 60000 mPa.s max./ no yield stress at -xx°C	SAE J300	SAE J300
<b>NOACK volatility</b> (ASTM D5800), % loss at 250°C, max.	15 <sup>(2)</sup>	15 <sup>(2)</sup>
<b>Volatility loss at 37°C</b> (ASTM D6417), %, max.	10	10
<b>Filterability</b> , % flow reduction, max.		
<b>EOFT</b> (ASTM D6795)	50	50
<b>EOWTT</b> (ASTM D6794), with 0.6, 1.0, 2.0, 3.0% H2O.	50	50
<b>Phosphorus</b> (ASTM D4951), % m/m, max. <sup>(4)</sup>	0.08	0.08
<b>Phosphorus</b> (ASTM D4951), % m/m, min. <sup>(4)</sup>	0.06	0.06
<b>Sulfur</b> (ASTM D4951 or D2622), sulfur, % m/m, max. <sup>(4)</sup>	0.5 <sup>(10)/0.7 <sup>(15)</sup></sup>	0.5 <sup>(10)/0.6 <sup>(15)</sup></sup>
<b>Sequence IIIGA</b> (ASTM D4684), aged oil low temperature viscosity or <b>ROBO Test</b> (ASTM D7528), aged oil low temperature viscosity	-	Pass <sup>(2) <sup>(15)</sup></sup>
<b>Foaming tendency option A</b> (ASTM D892), ml, max., foaming/ settling		
Sequence I	10/0 <sup>(6)</sup>	10/0 <sup>(6)</sup>
Sequence II	50/0 <sup>(6)</sup>	50/0 <sup>(6)</sup>
Sequence III	10/0 <sup>(6)</sup>	10/0 <sup>(6)</sup>
<b>High temperature foaming</b> (option A) (ASTM D6082), max.	100/0 <sup>(7)</sup>	100/0 <sup>(7)</sup>
<b>Homogeneity and miscibility</b> (ASTM D6922).	Pass <sup>(8)</sup>	Pass <sup>(8)</sup>
<b>TEOST MHT</b> (ASTM D7097), high temperature deposits, mg deposit, max. <sup>(4)</sup>	35	35
<b>Ball rust test</b> (ASTM D6557), avg. grey value, min.	100	100
<b>Phosphorus volatility</b> (Sequence IIIGB) (ASTM D7320), min.	-	79%
<b>TEOST 33</b> (ASTM D6335), total deposit weight, mg, max.	-	30 <sup>(3)</sup>
<b>Gelation index</b> (ASTM D5133), max. <sup>(9)</sup>	12 <sup>(9)</sup>	12 <sup>(9)</sup>

# ILSAC GF-4 & GF-5 standard laboratory test limits

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ILSAC STANDARD	GF-4	GF-5
SAE Viscosity grades	0W-xx, 5W-xx, 10W-xx	0W-xx, 5W-xx, 10W-xx
<b>Laboratory test requirements</b>		
<b>Shear stability</b> (Seq VIII) (ASTM D6709).	Pass <sup>(10)</sup>	Pass <sup>(10) (14)</sup>
<b>Emulsion retention</b> (ASTM D7563): Oil mixed with 10% Water, 10 % E85 0°C, 24 Hrs.	-	No separation
25°C, 24 Hrs.	-	No separation
<b>Elastomer compatibility</b> (ASTM D7216) <sup>(1)</sup>	-	Pass

**Notes:**

- (1) Please refer to chapter "Elastomer Compatibility" for limits.
- (2) Calculated conversions specified in ASTM D5800 are allowed.
- (3) No limit for 0W-20.
- (4) For all viscosity grades: if CF-4, CG-4, CH-4 and/or CI-4 categories precede the "S" category and there is no API Certification Mark, the limits for phosphorus, sulfur and the TEOST MTH do not apply. This is a non-critical specification as described in ASTM D3244.  
Note that these oils have been formulated primarily for diesel engines and may not provide all of the performance requirements consistent with vehicle manufacturers' recommendations for gasoline-fueled engines.
- (5) Test formulation with highest additive (DI/VI) concentration. R/A 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.
- (6) Settling volume determined at 10 minutes.
- (7) Settling volume determined at 1 minute.
- (8) Shall remain homogeneous and, when mixed with ASTM reference oils, shall remain miscible.
- (9) To be calculated from -5°C to temperature at which 40,000 cP is attained or -40°C, or 2°C below the appropriate MRV TP-1 temperature (defined by SAE J 300), whichever occurs first.
- (10) For 0W-xx, 5W-xx.
- (11) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade.
- (12) a) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in SAEJ300, run ASTM D4684(MRV TP-1) at 5 °C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade).  
b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in SAEJ300, run ASTM D4684(MRV TP-1) at 5 °C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade).
- (13) EOT ROBO or IIIGA Sample must show no yield stress in the D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, as outlined in (12).
- (14) Data to support stay-in-grade requirement for read-across shall be supported by ASTM D6278 (30 passes). The following limits for kinematic viscosity at 100°C after shear must be met:  
 $xW-20 \pm 5.6 \text{ mm}^2/\text{s}$  /  $xW-30 \pm 8.5 \text{ mm}^2/\text{s}$  /  $xW-40 \pm 11.5 \text{ mm}^2/\text{s}$  /  $xW-50 \pm 15.0 \text{ mm}^2/\text{s}$ .
- (15) For 10W-xx.

# ILSAC GF-1, GF-2 and GF-3 standard laboratory test limits



ILSAC STANDARD	GF-1	GF-2	GF-3	
SAE Viscosity grades	0W-xx, 5W-xx	10W-xx	0W-xx, 5W-xx, 10W-xx	0W-xx, 5W-xx, 10W-xx
<b>Laboratory test requirements</b>				
Kinematic viscosity at 100°C (ASTM D445), mm <sup>2</sup> /s.	SAE J300	SAE J300	SAE J300	SAE J300
HTHS viscosity (ASTM D4683), mPa.s, min.	SAE J300	SAE J300	SAE J300	SAE J300
Low temperature cranking viscosity (ASTM D5293), mPa.s at -xx°C	SAE J300	SAE J300	SAE J300	SAE J300
Pumpability (ASTM D4684), 60000 mPa.s max./ no yield stress at -xx°C	SAE J300	SAE J300	SAE J300	SAE J300
NOACK volatility (ASTM D5800) <sup>(2)</sup> , % loss at 250°C, max.	25 <sup>(1)</sup>	20 <sup>(1)</sup>	22	15
Volatility loss at 371°C (ASTM D6417) <sup>(9)</sup> , %, max.	20 <sup>(1)</sup>	17 <sup>(1)</sup>	17	10
Filterability <sup>(8)</sup> , % flow reduction, max.				
EOFT (ASTM D6795)	50	50	50	50
EOWTT (ASTM D6794), with 0.6, 1.0, 2.0, 3.0% H <sub>2</sub> O.	-	-	Report	50
Phosphorus (ASTM D4951 or D5185), wt %, max.	-	-	0.1	0.1
Foaming tendency option A (ASTM D892), ml, max., foaming/ settling				
Sequence I	10 / 0 <sup>(3)</sup>	10 / 0 <sup>(3)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>
Sequence II	50 / 0 <sup>(3)</sup>	50 / 0 <sup>(3)</sup>	50 / 0 <sup>(5)</sup>	50 / 0 <sup>(5)</sup>
Sequence III	10 / 0 <sup>(3)</sup>	10 / 0 <sup>(3)</sup>	10 / 0 <sup>(5)</sup>	10 / 0 <sup>(5)</sup>
High temperature foaming (option A) (ASTM D6082), max.	-	-	200 / 50 <sup>(4)</sup>	100 / 0 <sup>(4)</sup>
Homogeneity and miscibility (ASTM D6922).	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>	Pass <sup>(7)</sup>
TEOST MHT (ASTM D7097), high temperature deposits, mg deposit, max.	-	-	-	45
Gelation index (ASTM D5133), max. <sup>(9)</sup>	-	-	-	12 <sup>(10)</sup>
TEOST 33 (ASTM D6335), total deposit weight, mg, max.	-	-	60	-
Flash point (ASTM D92) <sup>(6)</sup> , °C, min.	200	200	200	200
Flash point (ASTM D93) <sup>(6)</sup> , °C, min.	185	185	185	185

**Notes:**

(1) Can run either D5800 or D6417.

(2) ILSAC GF-1 requires CEC L-40-A-93 result. Test method CEC L-40-A-93 is equivalent to ASTM D5800.

(3) Settling volume determined at 5 minutes.

(4) Settling volume determined at 1 minute.

(5) Settling volume determined at 10 minutes.

(6) Meet either Test Method D92 or Test Method D93 flash point requirement.

(7) Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible. Formerly "Federal Test Method 791B, Method 3470".

(8) Formerly known as GM 9099P.

(9) Formerly known as D2887.

(10) To be evaluated from -5°C to temperature at which 40.000 mPa.s is attained or -40°C, or 2°Celsius below the appropriate MRV TP-1 temperature (defined by SAE J 300), whichever occurs first.

# ILSAC standard engine test limits

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ILSAC STANDARD	GF-1			GF-2			GF-3			GF-4			GF-5		
SAE Viscosity grades <sup>(1)</sup>	0W-xx	5W-xx	10W-xx	0W-20 5W-20	Other 0W-xx & 5W-xx	10W-xx	0W-20 5W-20	0W-30 5W-30	10W-xx & other grades	0W-20 5W-20	0W-30 5W-30	10W-xx & other grades	xW-20	xW-30	10W-xx & other grades
<b>CRC L-38 (ASTM D5119)</b>				40		40			-			-			-
Bearing weight loss, mg, max.				9.0		-			-			-			-
Piston skirt varnish, min.															
10 h stripped viscosity				Stay in grade <sup>(6)</sup>		Stay in grade <sup>(6)</sup>			-			-			-
<b>Sequence VIII (ASTM D6709)</b>									26.4			26			26
Bearing weight loss, mg, max.				-		-									
10 h stripped viscosity				-		-			Stay in grade <sup>(6)</sup>			Stay in grade <sup>(6)</sup>			Stay in grade <sup>(6)</sup>
<b>Sequence IID (ASTM D5844)</b>				8.5		8.5			-			-			-
Average engine rust, min.				none		none			-			-			-
Lifter sticking, max.															
<b>Sequence IIID, IIIE, IIIF, IIIG, IIIH (ASTM D5533, D6984, D7320, D8111)</b>				IIIE		IIIE			IIIF			IIIG + IIIGA <sup>(5)</sup>			IIIG / IIIH
Viscosity increase at 40°C, %, max.				375 at 64h		-			275 at 80h			150 at 100h			150 at 100h
Hours to 375% vis. increase at 40°C, min.				-		64			-			-			-
Average engine sludge, min.				9.2		9.2			-			-			-
Average piston skirt varnish, min.				8.9		8.9			9.0			-			-
Average oil ring land deposits, min.				3.5		3.5			-			-			-
Weighted piston deposits, min.				-		-			4.0			3.5			4.0 / 3.7
Ring sticking (oil related)				None <sup>(2)</sup>		None <sup>(2)</sup>			-			-			-
Hot stuck piston rings									None			None			None
Lifter sticking				None		-			-			-			-
Cam or lifter scuffing				None		-			-			-			-
Maximum cam + lifter wear, µm (in.), max.				64 (0.0025)		64 (0.0025)			-			-			-
Average cam + lifter wear, µm (in.), max.				30 (0.0012)		30 (0.0012)			20			60			-
Oil consumption, l, max.				5.1		5.1			5.2			-			-
Low temperature viscosity				-		-			Report <sup>(3)</sup>			Pass <sup>(4)</sup>			-

**Notes:**

(1) Allowed viscosity grades for ILSAC GF-1 / GF-2 / GF-3 / GF-4 / GF-5 are limited to SAE 0W-xx, 5W-xx and 10W-xx.

(2) An oil related stuck ring occurs on a piston with an individual oil ring land deposit rating < 2.6.

(3) Evaluate the 80-hour test oil sample by ASTM 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 ASTM Test Method D5293 (CCS Viscosity).

(4) The ASTM Test Method D4684 (MRV TP-1) result on the 100-hour end of test sample must meet the requirements of the original grade or the next higher grade at the SAE J 300 temperature.

(5) A Sequence IIIGA test is identical to a Sequence IIIG test, except only low temperature viscosity performance is measured.

(6) Data to support stay-in-grade requirement for read-across shall be supported by ASTM D6278 (30 passes).

The following limits for kinematic viscosity at 100°C after shear must be met:

xW-20  $\geq$  5.6 mm<sup>2</sup>/s / xW-30  $\geq$  8.5 mm<sup>2</sup>/s / xW-40  $\geq$  11.5 mm<sup>2</sup>/s / xW-50  $\geq$  15.0 mm<sup>2</sup>/s.

## ILSAC standard engine test limits

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ILSAC STANDARD	GF-1			GF-2			GF-3			GF-4			GF-5		
SAE Viscosity grades <sup>(1)</sup>	0W-xx	5W-xx	10W-xx	0W-20 5W-20	Other 0W-xx & 5W-xx	10W-xx	0W-20 5W-20	0W-30 5W-30	10W-xx & other grades	0W-20 5W-20	0W-30 5W-30	10W-xx & other grades	xW-20	xW-30	10W-xx & other grades
<b>Sequence IVA (ASTM D6891)</b>	-	-	-	-	-	-	120	-	90	-	-	-	90	-	-
Average cam wear, µm, max.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Sequence VE (ASTM D5302)</b>	9.0	-	-	9.0	-	-	-	-	-	-	-	-	-	-	-
Average engine sludge, min.	7.0	-	-	7.0	-	-	-	-	-	-	-	-	-	-	-
Rocker arm cover sludge, min.	6.5	-	-	6.5	-	-	-	-	-	-	-	-	-	-	-
Average piston skirt varnish, min.	5.0	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-
Average engine varnish, min.	-	-	-	To report	-	-	-	-	-	-	-	-	-	-	-
Piston undercrown deposits	-	-	-	To report	-	-	-	-	-	-	-	-	-	-	-
Ring land deposits	-	-	-	To report	-	-	-	-	-	-	-	-	-	-	-
Cylinder bore wear	-	-	-	To report	-	-	-	-	-	-	-	-	-	-	-
Oil screen clogging, %, max.	20	-	-	20	-	-	-	-	-	-	-	-	-	-	-
Oil ring clogging, %, max. <sup>(2)</sup>	15	-	-	To report	-	-	-	-	-	-	-	-	-	-	-
Compression ring sticking (hot stuck)	None	-	-	None	-	-	-	-	-	-	-	-	-	-	-
Maximum cam wear, µm (in.), max.	380 (0.015)	-	-	380 (0.015)	-	-	380 <sup>(3)</sup>	-	-	-	-	-	-	-	-
Average cam wear, µm (in.), max.	130 (0.005)	-	-	127 (0.005)	-	-	127 <sup>(3)</sup>	-	-	-	-	-	-	-	-

**Notes:**

(1) Allowed viscosity grades for ILSAC GF-1 / GF-2 / GF-3 / GF-4 GF-5 are limited to SAE 0W-xx, 5W-xx and 10W-xx.

(2) Effective 8, October 1993, the oil ring clogging parameter has been suspended indefinitely as a requirement for the sequence VE.

(3) Not required for oils containing a minimum of 0.08% mass phosphorus in the form of Zinc dialkyldithiophosphates (ZDDP).

## ILSAC standard engine test limits

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ILSAC STANDARD	GF-1			GF-2			GF-3			GF-4			GF-5		
SAE Viscosity grades <sup>(1)</sup>	0W-xx	5W-xx	10W-xx	0W-20 5W-20	Other 0W-xx & 5W-xx	10W-xx	0W-20 5W-20	0W-30 5W-30	10W-xx & other grades	0W-20 5W-20	0W-30 5W-30	10W-xx & other grades	xW-20	xW-30	10W-xx & other grades
<b>Sequence VG (ASTM D6593)</b>								7.8			7.8			8.0	
Average engine sludge, min.								8.0			8.0			8.3	
Rocker arm cover sludge, min.								7.5			7.5			7.5	
Average piston skirt varnish, min.								8.9			8.9			8.9	
Average engine varnish, min.								20			20			15	
Oil screen clogging, %, max.									Rate and report			Rate and report			Rate and report
Oil screen debris, %.									Rate and report			Rate and report			Rate and report
Oil ring clogging, %.									None			None			None
Hot stuck compression rings, max.									Rate and report			Rate and report			Rate and report
Cold stuck compression rings									-			Rate and report			-
Average follower pin wear, cyl #8, µm.									-			Rate and report			-
Average ring gap increase, cyl #1 & #8, µm.									-			Rate and report			-
<b>Sequence VI (ASTM RR-D:2-1204)</b>															
EEFI (fuel economy improvement), %, min.		2.7													
<b>Sequence VIA (ASTM D6202)</b>															
FEI vs. ASTM BC-2, %, min.		-		1.4 <sup>(4)</sup>	1.1 <sup>(5)</sup>	0.5 <sup>(6)</sup>									
<b>Sequence VIB (ASTM D6837)</b>								2.0	1.6	0.9	2.3	1.8	1.1		
FEI relative to ref. oil BC, %, min.: FEI 1		-						1.7	1.3	0.6	2.0	1.5	0.8		
FEI relative to ref. oil BC, %, min.: FEI 2								-	3.0	1.6	-	-	-		
Sum of FEI 1 + FEI 2, min.															
<b>Sequence VID (ASTM D7589)</b>															
FEI 2, %, min.		-												1.2	0.9
Sum of FEI, %, min.		-		-	-	-		-					2.6	1.9	0.6

**Notes:**

(1) Allowed viscosity grades for ILSAC GF-1 / GF-2 / GF-3 / GF-4 are limited to SAE 0W-xx, 5W-xx and 10W-xx.

(2) Effective 8, October 1993, the oil ring clogging parameter has been suspended indefinitely as a requirement for the sequence VE.

(3) Not required for oils containing a minimum of 0.08% mass phosphorus in the form of Zinc dialkylidithiophosphates (ZDDP).

(4) 1.7% min. if Sequence VIB is used (calculated FEI at 16h. vs. ASTM reference oil BC run before the candidate oil).

(5) 1.3% min. if Sequence VIB is used (calculated FEI at 16h. vs. ASTM reference oil BC run before the candidate oil).

(6) 0.6% min. if Sequence VIB is used (calculated FEI at 16h. vs. ASTM reference oil BC run before the candidate oil).

## API "C" diesel service categories engine and laboratory test requirement summary - Current -



API CATEGORY	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4	FA-4
SAE Viscosity grades		All			xW-30, xW-40	xW-30
<b>Sequence IIIF or IIIG</b>	X <sup>(1)</sup>	X	X	X	-	-
CATERPILLAR SINGLE CYLINDER	1P+1K	(1R or 1P) + (1K or 1N)	(1R or 1P) + (1K or 1N)	1N	1N	1N
CATERPILLAR C13	-	-	-	X	X	X
MACK T-8E <sup>(2)</sup>	X	X	X <sup>(2)</sup>	-	-	-
MACK T-9 <sup>(3)</sup>	X or T-10 or T-12	-	-	-	-	-
MACK T-10 <sup>(4)</sup>	-	X or T-12	X or T-12	-	-	-
MACK T-11	-	-	X	X	X	X
MACK T-12	-	-	-	X	X	X
MACK T-13	-	-	-	-	X	X
CUMMINS M11/M11 EGR <sup>(5)</sup>	M11 or ISM	M11-EGR or ISM	M11-EGR or ISM	-	-	-
CUMMINS ISM	-	-	-	X	X	X
CUMMINS ISB	-	-	-	X	X	X
RFWT	X	X	X	X	X	X
NAVISTAR EOAT (HEUI)	X	X	X	X	-	-
COAT	-	-	-	-	X	X
HTHS ASTM D4683	-	X	X	X	X	X
Sheared oil stay in grade ASTM D6278 or D7109	X	X	X	X	X	X
Sooted Oil MRV, ASTM D6896 Mack T-10A <sup>(6)</sup> or Mack T-11A	-	T-10A or T-12A	T-10A or T-12A	T-11A	T-11A	T-11A
HTCBT, ASTM D6594	X	X	X	X	X	X
ASTM D874, ASTM D4951 P and S	-	-	-	X	X	X
Volatility, ASTM D5800	X	X	X	X	X	X
Foam, ASTM D892, no option A	X	X	X	X	X	X
Elastomer compatibility	-	X	X	X	X	X

**Notes:**

(1) Seq IIIF 60h viscosity increase.

(2) A passing Mack T-11 can be used in place of the T-8E.

(3) The Mack T-9 and T-10 tests are no longer available to run. This requirement can be satisfied by passing a Mack T-12 against API CH-4 limits.

(4) The Mack T-10 test is no longer available to run. This requirement can be satisfied by passing a Mack T-12 against API CI-4 limits.

(5) The Cummins M11 and M11EGR tests are no longer available to run. This requirement can be satisfied by passing a Cummins ISM against API CH-4 or CI-4 limits.

(6) A passing Mack T-12A can be used in place of the T-10A.

# API "C" diesel service categories laboratory test limits - Current -

- 1 -



API CATEGORY	CH-4		CI-4		CI-4 PLUS		CJ-4		CK-4		FA-4
SAE Viscosity grades					All				xW-30, xW-40		xW-30
<b>Foaming tendency</b> , (ASTM D892), ml, max., foaming/ settling											
Sequence I	10 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	10 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	10 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	10 / 0		10 / 0		10 / 0
Sequence II	20 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	20 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	20 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	20 / 0		20 / 0		20 / 0
Sequence III	10 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	10 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	10 / 0	( <sup>1</sup> ) ( <sup>4</sup> )	10 / 0		10 / 0		10 / 0
<b>HTCBT at 135°C</b> (ASTM D6594), ppm increase, max.											
Copper	20		20		20		20		20		20
Lead	120		120		120		120		120		120
Tin	Report		Report		Report		-		-		-
Copper strip rating (acc. to ASTM D130), max.	3		3		3		3		3		3
<b>HTHS viscosity</b> (ASTM D4683), mPa.s, min.	SAE J300		3.5		3.5		3.5		xW-30: 3.5, xW-40: SAE J300		2.9
<b>HTHS viscosity</b> (ASTM D4683), mPa.s, max.	-		-		-		-		xW-30: NA, xW-40: SAE J300		3.2
<b>Kinematic viscosity at 100°C</b> (ASTM D445), mm <sup>2</sup> /s, min.	SAE J300		SAE J300		SAE J300		SAE J300		SAE J300		SAE J300
<b>Low temperature cranking viscosity</b> (ASTM D5293), mPa.s at -xx°C	SAE J300		SAE J300		SAE J300		SAE J300		SAE J300		SAE J300
<b>Pumpability</b> (ASTM D4684), 60000 mPa.s max./ no yield stress at -xx°C	SAE J300		SAE J300		SAE J300		SAE J300		SAE J300		SAE J300
<b>NOACK volatility</b> (ASTM D5800)	10W-30	15W-40					Not 10W-30	For 10W-30			
% loss at 250°C, max.	20	18	15		15		13	15		13	13
<b>Volatility loss at 371°C</b> (ASTM D6417), %, max.	17	15	-		-		-	-		-	-
<b>Kinematic Viscosity after shearing</b> (ASTM D6278)	xW-30	xW-40	xW-30	xW-40	xW-30	xW-40					
Kin. Visc. at 100°C after 30 cycle Bosch shearing, mm <sup>2</sup> /s, min.	9.3	12.5	9.3	12.5	9.3	12.5					
<b>Kinematic Viscosity after shearing</b> (ASTM D7109)							xW-30	xW-40	xW-30	OW-40	Other xW-40
Kin. Visc. at 100°C after 90 cycle Bosch shearing, mm <sup>2</sup> /s, min.	-		-		-		9.3	12.5	9.3	12.5	12.8
HTHS Visc, at 150°C after 90 cycle Bosch shearing, mm <sup>2</sup> /s, min.	-		-		-		-	-	3.4	-	-
											2.8

**API "C" diesel service categories laboratory test limits - Current -**  
**- 2 -**



API CATEGORY	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4	FA-4
SAE Viscosity grades			All		xW-30, xW-40	xW-30
<b>Elastomer Compatibility (ASTM D7216) <sup>(2)</sup></b>						
Nitrile NBR		Pass	Pass	Pass	Pass	Pass
Silicone VMQ	-	Pass	Pass	Pass	Pass	Pass
Polyacrylate ACM		Pass	Pass	Pass	Pass	Pass
Fluorelastomer FKM		Pass	Pass	Pass	Pass	Pass
Vamac G		-	-	Pass	Pass	Pass
<b>MRV TP-1 (ASTM D4684)</b>						
Viscosity of the 180 h. used oil drain sample from a T-11 test <sup>(3)</sup> , tested at -20°C, mPa.s, max.	-	25000	25000	-	-	-
If yield stress is detected, use the modified test method (external preheat), then measure the viscosity, mPa.s, max.		25000	25000			
Measure the yield stress, Pa.		<35	<35			
<b>MRV TP-1 (ASTM D6896)</b>						
Viscosity of the 180 h. used oil drain sample from a T-11 test, tested at -20°C, mPa.s, max.	-	-		25000	25000	25000
If yield stress is detected, use the modified test method (external preheat), then measure the viscosity, mPa.s, max.				25000	25000	25000
Measure the yield stress, Pa.				<35	<35	<35
<b>Sulfated ash (ASTM D874), % m/m, max. (non critical)</b>	-	-	-	1.0	1.0	1.0
<b>Phosphorus (ASTM D5185), % m/m, max. (non critical)</b>	-	-		0.12	0.12	0.12
<b>Sulfur (ASTM D5185), % m/m, max. (non critical)</b>	-	-		0.4	0.4	0.4

**Notes:**

(1) 10 minutes settling.

(2) Please refer to chapter "Elastomer Compatibility" for limits.

(3) Results from T-10A or T-12A can be used as an alternative to T-11A results.

(4) Option A not allowed.

**API "C" diesel service categories engine test limits - Current -**  
**- 1 -**



API CATEGORY	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4	FA-4
SAE Viscosity grades		All			xW-30, xW-40	xW-30
<b>Sequence IIIF, IIIG (ASTM D6984, D7320)</b>	IIIF (60h) or IIIG	IIIF or IIIG	IIIF or IIIG	IIIF or IIIG		
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	-	-
Viscosity (at 40°C), increase from 10 min sample, %, max. (IIIF)	295 - 295 - 295 (MTAC) <sup>(1)</sup>	275 - 275 - 275 (MTAC)	275 - 275 - 275 (MTAC)	275 - 275 - 275 (MTAC)		
Kinematic viscosity, % increase at 40°C, max. (IIIG)	150 - 150 - 150 (MTAC)	150 - 150 - 150 (MTAC)	150 - 150 - 150 (MTAC)	150 - 150 - 150 (MTAC)		
<b>CATERPILLAR SINGLE CYLINDER 1K, 1N (ASTM D6750)</b>	1K	1K <sup>(2)</sup>	1K <sup>(2)</sup>	1N	1N	1N
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Top groove fill (TGF), %, max.	24 - 27 - 29	24 - 27 - 29	24 - 27 - 29	20 - 23 - 25	20 - 23 - 25	20 - 23 - 25
Weighted demerits (WD), max.	332 - 347 - 353	332 - 347 - 353	332 - 347 - 353	286.2 - 311.7 - 323.0	286.2 - 311.7 - 323.0	286.2 - 311.7 - 323.0
Top land heavy carbon (TLHC),%, max.	4 - 5 - 5	4 - 5 - 5	4 - 5 - 5	3 - 4 - 5	3 - 4 - 5	3 - 4 - 5
Piston, ring and liner scuffing	none	none	none	none	none	none
Ring sticking	-	-	-	none	none	none
Avg. oil cons., g/MJ max., 0-252 h.	0.139	0.139	0.139	0.15	0.15	0.15
<b>CATERPILLAR SINGLE CYLINDER 1P, 1R (ASTM D6681, D6923)</b>	1P	1R <sup>(3)</sup>	1R (3)			
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3			
Top groove carbon (TGC), demerits, max.	36 - 39 - 41	52 - 57 - 59	52 - 57 - 59			
Weighted demerits (WD), max.	350 - 378 - 390	382 - 396 - 402	382 - 396 - 402			
Top land carbon (TLC), demerits, max.	40 - 46 - 49	31 - 35 - 36	31 - 35 - 36			
Piston, Ring and Liner scuffing	none	none	none			
Ring sticking	-	none	none	-	-	-
Avg. oil cons., g/h, max., 0-360 h	12.4	-	-			
Initial oil cons. g/h, max., 0-252 h	-	13.1	13.1			
Final oil cons., g/h, max., 432-504 h	-	Initial + 1.8	Initial + 1.8			
Final oil cons., g/h, max., 312-360 h	14.6	-	-			

**Notes:**

(1) MTAC - use method without transformations.

(2) Alternatively, Test Method D6750 (IN) can be used; if this test method is used, the measured parameters and primary performance criteria are the same as those shown for Test Method D6750 (IN) in the CJ-4 category, except that oil consumption, max, is 0.5 g/MJ.

(3) Oils shall pass either Cat 1P or Cat 1R. Cat 1P limits are those required for API CH-4.

**API "C" diesel service categories engine test limits - Current -**  
**- 2 -**



API CATEGORY	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4	FA-4
SAE Viscosity grades			All		xW-30, xW-40	xW-30
<b>CUMMINS M11/M11-EGR<sup>(1)</sup></b>	M11	M11 EGR	M11 EGR			
Run number.	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3			
Rocker pad avg. weight loss norm. to 4.5% Soot, mg, max.	6.5 - 7.5 - 8.0	-	-		-	-
Average crosshead weight loss, mg, max.	-	20.0 - 21.8 - 22.6	20.0 - 21.8 - 22.6	-	-	-
Oil filter ΔP at EOT, kPa, max.	79 - 93 - 100	275 - 320 - 341	275 - 320 - 341			
Average engine sludge, CRC merits at EOT, min.	8.7 - 8.6 - 8.5	7.8 - 7.6 - 7.5	7.8 - 7.6 - 7.5			
Average top ring weight loss, mg	-	report	report			
<b>CUMMINS ISM<sup>(1)</sup> (ASTM D7468)</b>						
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Merit rating, min.	-	-	-	1000 - 1000 - 1000	1000 - 1000 - 1000	1000 - 1000 - 1000
Top ring weight loss, mg, max.	-	-	-	100 - 100 - 100	100 - 100 - 100	100 - 100 - 100
Crosshead wear, mg, max. (anchor)	7.5 - 7.8 - 7.9	7.5 - 7.8 - 7.9	7.5 - 7.8 - 7.9	7.1 (5.7)	7.1 (5.7)	7.1 (5.7)
Oil filter ΔP at 150 h., kPa, max. (anchor)	79 - 95 - 103	55 - 67 - 74	55 - 67 - 74	19 (13)	19 (13)	19 (13)
Valve adj. screw mass loss, mg, max. (anchor)	-	-	-	49 (27)	49 (27)	49 (27)
Engine sludge, CRC merits at EOT, min. (anchor)	8.1 - 8.0 - 8.0	8.1 - 8.0 - 8.0	8.1 - 8.0 - 8.0	8.7 (9.0)	8.7 (9.0)	8.7 (9.0)
<b>ROLLER FOLLOWER WEAR TEST (RFWT) (ASTM D5966)</b>						
Run number.	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Average pin wear, mils, max.	0.30 - 0.33 - 0.36	0.30 - 0.33 - 0.36	0.30 - 0.33 - 0.36	0.30 - 0.33 - 0.36	0.30 - 0.33 - 0.36	0.30 - 0.33 - 0.36
Average pin wear, ( $\mu\text{m}$ ), max.	(7.6 - 8.4 - 9.1)	(7.6 - 8.4 - 9.1)	(7.6 - 8.4 - 9.1)	(7.6 - 8.4 - 9.1)	(7.6 - 8.4 - 9.1)	(7.6 - 8.4 - 9.1)
<b>ENGINE OIL AERATION TEST (EOAT)</b>						
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	-	-
Oil aeration at 20 h, %, max.	8.0 - 8.0 - 8.0 (MTAC) <sup>(2)</sup>	8.0 - 8.0 - 8.0 (MTAC) <sup>(2)</sup>	8.0 - 8.0 - 8.0 (MTAC) <sup>(2)</sup>	8.0 - 8.0 - 8.0 (MTAC)		
<b>CATERPILLAR OIL AERATION TEST (COAT)</b>						
Run number	-	-	-	-	1 - 2 - 3	1 - 2 - 3
Average aeration, 40 h to 50 h, %, max.					11.8 - 11.8 - 11.8	11.8 - 11.8 - 11.8

**Notes:**

(1) A Cummins ISM test and its limits can be used as an alternative for the Cummins M11/ M11-EGR test.

(2) MTAC - use method without transformations.

**API "C" diesel service categories engine test limits - Current -**  
**- 3 -**



API CATEGORY	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4	FA-4
SAE Viscosity grades			All		xW-30, xW-40	xW-30
<b>CATERPILLAR C13 (ASTM D7549)</b>						
Run number				1 - 2 - 3 1000 - 1000 - 1000	1 - 2 - 3 1000 - 1000 - 1000	1 - 2 - 3 1000 - 1000 - 1000
Merit rating, min.				31 (25) 35 (30) 53 (46) 33 (22) none	- - - -	- - - -
Oil consumption, g/h, max. (anchor)	-	-	-			
Top land carbon avg., max., %. (anchor)						
Top groove carbon avg., max., %. (anchor)						
Second ring top carbon, max., %. (anchor)						
Hot stuck piston ring						
<b>MACK T-8E<sup>(1)</sup></b>						
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	-	-	-
Relative viscosity at 100°C at 4.8% soot, max.	2.1 - 2.2 - 2.3 <sup>(2)</sup>	1.8 - 1.9 - 2.0 <sup>(3)</sup>	1.8 - 1.9 - 2.0 <sup>(3)</sup>			
Visc. Inc. at 100°C at 3.8% soot, mm <sup>2</sup> /s, max.	11.5 - 12.5 - 13	-	-			
<b>MACK T-11<sup>(1)</sup> (ASTM D7156)</b>						
Run number			1 - 2 - 3 -	1 - 2 - 3 3.5 - 3.4 - 3.3	1 - 2 - 3 3.5 - 3.4 - 3.3	1 - 2 - 3 3.5 - 3.4 - 3.3
Minimum % TGA soot at 4.0 mm <sup>2</sup> /s increase at 100°C.	-	-	-			
Minimum % TGA soot at 12.0 mm <sup>2</sup> /s increase at 100°C.			6.00 - 5.89 - 5.85	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9
Minimum % TGA soot at 15.0 mm <sup>2</sup> /s increase at 100°C.			-	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5
<b>CUMMINS ISB (ASTM D7484)</b>						
Run number.				1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Slider tappet weight loss, mg, average, max.	-	-	-	100 - 108 - 112	100 - 108 - 112	100 - 108 - 112
Cam lobe wear, µm, average, max.				55 - 59 - 61	55 - 59 - 61	55 - 59 - 61
Crosshead weight loss, mg, average.				report	report	report

**Notes:**

(1) A Mack T-11 test and its limits can be used as an alternative for the Mack T8-E test in the applicable categories.

(2) Relative viscosity = Viscosity at 4.8% Soot / (viscosity of new oil - 50% of viscosity loss by ASTM D3945).

(3) Relative viscosity = Viscosity at 4.8 % Soot / Viscosity of New Oil sheared in ASTM D6278.

**API "C" diesel service categories engine test limits - Current -**  
**- 4 -**



API CATEGORY	CH-4	CI-4	CI-4 PLUS	CJ-4	CK-4	FA-4
SAE Viscosity grades		All			xW-30, xW-40	xW-30
<b>MACK T-9<sup>(1)</sup></b>						
Run number	1 - 2 - 3					
Avg. liner wear norm. to 1.75% soot, µm, max.	25.4 - 26.6 - 27.1	-	-	-	-	-
Average top ring weight loss, mg, max.	120 - 136 - 144					
Lead increase, ppm, max.	25 - 32 - 36					
<b>MACK T-10<sup>(2)</sup></b>						
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3			
Merit rating, min.	-	1000 - 1000 - 1000	1000 - 1000 - 1000			
Liner wear, µm, max. (anchor)	32 - 34 - 35	32.0 (30)	32.0 (30)			
Ring wear, mg, max. (anchor)	150 - 159 - 163	158 (140)	158 (140)			
Lead content at EOT mg/kg, max. (anchor)	50 - 56 - 59	35 (30)	35 (30)			
Lead content 250-300 h, mg/kg, max. (anchor)	-	14 (10)	14 (10)			
Used oil pumpability at 75 h, MRV at -20°C, mPa.s, max. <sup>(3)</sup>	-	25000 (NYS) <sup>(4)</sup>	25000 (NYS) <sup>(4)</sup>			
<b>Mack T-12 (ASTM D7422)</b>						
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Merit rating, min.	-	1000 - 1000 - 1000	1000 - 1000 - 1000	1000 - 1000 - 1000	-	-
Liner wear, µm, max. (anchor)	30.0 - 30.8 - 31.1	26 (23)	26 (23)	24 (20)	24.0 - 24.0 - 24.0	24.0 - 24.0 - 24.0
Top ring weight loss, mg, max. (anchor)	120 - 132 - 137	117 (82)	117 (82)	105 (70)	105 - 105 - 105	105 - 105 - 105
Oil consumption, g/h, max. (anchor)	-	95 (82)	95 (82)	85.0 (65.0)	-	-
Lead content at EOT, mg/kg, max. (anchor)	65 - 75 - 79	42 (35)	42 (35)	35 (25)	-	-
Lead content 250-300 h, mg/kg, max. (anchor)	-	18 (13)	18 (13)	15 (10)	-	-
Used oil pumpability at 75 h, MRV at -20°C, mPa.s, max. <sup>(3)</sup>	-	25000 (NYS) <sup>(4)</sup>	25000 (NYS) <sup>(4)</sup>	25000 (NYS) <sup>(4)</sup>	-	-
<b>MACK T-13</b>					1 - 2 - 3	1 - 2 - 3
Run number					125 - 130 - 133	125 - 130 - 133
IR Peak at EOT, Abs., cm <sup>-1</sup>	-		-		75 - 85 - 90	75 - 85 - 90
Kinematic viscosity increase at 40°C, % max.					Report	Report
Average oil consumption, 48 h to 192 h, g/h, max.						

- Notes:**  
(1) A Mack T-12 or Mack T-10 test and its limits can be used as an alternative for the Mack T-9 test.  
(2) A Mack T-12 test and its limits can be used as an alternative for the Mack T-10 test.  
(3) Sample to test can also be from a Mack T-10A test or a Mack T-12A test to generate the sample for ASTM D4684 as used to measure this parameter. (Mack T-10A is the name given to a Mack T-10 test run for 75 h. Mack T-12A is the name given to a Mack T-12 test run for 100 h.).  
(4) If Yield stress is detected, use modified ASTM D4684 (external preheat); then limits become Viscosity : 25.000 cP max and Yield Stress, < 35 Pa.

## API "C" diesel service categories engine and laboratory test requirement summary - Obsolete -



API CATEGORY	CC	CD	CD-II	CE	CF	CF-2	CF-4	CG-4
SAE Viscosity grades	All							
Sequence VIII (or CRC L-38 <sup>(1)</sup> )	X	X	X	X	X	X	X	X
Sequence III	-	-	-	-	-	-	-	IIIF or IIIG
CATERPILLAR	1H/1H2	1G2	1G2	1G2	1M-PC	1M-PC	1K	1N
DD6V-53T	-	-	X	-	-	-	-	-
DD6V-92TA	-	-	-	-	-	X	-	-
MACK T-6	-	-	-	X	-	-	X or T-9 or T10	-
MACK T-7	-	-	-	X	-	-	X or T-8A	-
MACK T-8 / T-8E	-	-	-	-	-	-	-	T-8
CUMMINS NTC-400	-	-	-	X	-	-	X <sup>(2)</sup>	-
RFWT	-	-	-	-	-	-	-	X
EOAT aeration Navistar	-	-	-	-	-	-	-	X
Cummins corrosion	-	-	-	-	-	-	X	X
Metals, AN, BN	-	-	-	-	X	X	X	X

**Notes:**

(1) Test no longer available.

(2) Cummins NTC 400 can be replaced by one additional Cat 1K, meeting CF-4 limits.

# API "C" diesel service categories engine test limits - Obsolete -

- 1 -



API CATEGORY	CC	CD	CD-II	CE	CF	CF-2	CF-4	CG-4
SAE Viscosity grades	All							
<b>CRC L-38 (ASTM D5119)</b>								
Bearing weight loss, mg, max.	50	50	50	50	-	-	-	-
Piston skirt varnish, min.	9.0	9.0	9.0	-				
<b>Sequence VIII (ASTM D6709) <sup>(3)</sup></b>								
Run number	-	-	-	-	1 - 2 - 3	1 - 2 - 3	-	1 - 2 - 3
Bearing weight loss, mg, max.					29.3 - 31.9 - 33.0	29.3 - 31.9 - 33.0	33.0	29.3 - 31.9 - 33.0
Used oil vis., mm <sup>2</sup> /s > SAE grade limit, min.					-	-	-	0.5 <sup>(2) (4)</sup>
<b>Sequence III</b>								
Run number	-	-	-	-	-	-	-	IIIF or IIIG 1 - 2 - 3
60 h. Viscosity (at 40°C), increase from 10 min. sample, %, max. (IIIF)								325 - 349 - 360
Kinematic viscosity, % increase at 40°C,max. (IIIG)								150 - 173 - 184
<b>CATERPILLAR</b>	1H2	1G2	1G2	1G2	1M-PC	1M-PC	1K	1N
Run number	-	-	-	-	-	-	1 - 2 - 3	1 - 2 - 3
Top groove fill, %, max.	45	80	80	80	70	-	24 - 26 - 27	20 - 23 - 25
Weighted total demerit, max.	140	300	300	300	240	100(5)	332 - 339 - 342	286.2 - 311.7 - 323.0
Top land heavy carbon (TLHC),%, max.	0.013	0.013	0.013	0.013 (0.0005)	-	-	4 - 4 - 5	3 - 4 - 5
Piston, ring and liner scuffing	-	-	-	-	none	-	none	none
Ring sticking	-	-	-	-	none	-	none	none
Avg. oil cons., g/Mj max., 0-252 h.	-	-	-	-	-	-	0.139	0.139
Avg. oil cons., g/Mj max., 228-252 h.	-	-	-	-	-	-	0.075	-
<b>CUMMINS NTC 400</b>					<ref. oil + 1std dev			
Oil cons. (2 <sup>nd</sup> order regression)							< ref oil	
Cam follower pin wear, in., max.	-	-	-	0.002	-	-	0.002	-
Crownland heavy carbon, %, max.				25			15	
Piston deposits, third ring land, total CRC demerits for all 6 pistons, max				40			-	

**API "C" diesel service categories engine test limits - Obsolete -**  
**- 2 -**



API CATEGORY	CC	CD	CD-II	CE	CF	CF-2	CF-4	CG-4
SAE Viscosity grades					All			
<b>DETROIT DIESEL</b>								
Run number						DD6V53T	1 - 2 - 3	
Weighted total demerit, avg., max.					400		-	
Hot stuck rings.					none		-	
Liner distress, avg. % area, max.					12.0		-	
Valve distress	-	-			none	-	-	-
Piston rings face distr.fire ring, demerit, max.					-		0.23 - 0.24 - 0.26	
Piston rings face distr., avg. 2 <sup>nd</sup> +3 <sup>rd</sup> ring, demerit, max.					13.0		0.20 - 0.21 - 0.22	
Cylinder liner scuffing, area %, max.					-		45 - 48 - 50	
Cylinder liner port plugging area, avg., %, max.					-		2 - 2 - 2	
Cylinder liner port plugging area, single cylinder, %, max.					-		5 - 5 - 5	
<b>ROLLER FOLLOWER WEAR TEST (RFWT)</b>								
Run number.								1 - 2 - 3
Average pin wear, mils, max.								0.45 - 0.49 - 0.50
Average pin wear, ( $\mu$ m), max.								(11.4 - 12.4 - 12.7)
<b>ENGINE OIL AERATION TEST (EOAT)</b>								
Oil aeration at 20 h, %, max.								10.0
<b>MACK T-6</b>								
Merit rating, min.						(1)		
<b>MACK T-7</b>								
Avg. rate of vis. inc. at 100°C/h. for last 50 h, mm <sup>2</sup> /s/h, max.					90 (2)		90 (2)	
					0.040			
							0.04 (7)	

**API "C" diesel service categories engine test limits - Obsolete -**  
**- 3 -**



API CATEGORY	CC	CD	CD-II	CE	CF	CF-2	CF-4	CG-4
SAE Viscosity grades	All							
<b>MACK T-8 / T-8A</b>							T-8A <sup>(7)</sup>	T-8
Run number							-	1 - 2 - 3
100-150 hour avg. rate of vis. Inc. at 100°C/h, mm <sup>2</sup> /s/h, max.							0.20	-
Relative viscosity at 100°C at 4.8% soot, max.	-	-	-	-	-	-	-	-
Visc. Inc. at 100°C at 3.8% soot, mm <sup>2</sup> /s, max.							-	11.5 - 12.5 - 13.0
Filter plugging, diff. press., Kpa (psi), max.							-	138 (20)
Oil consumption, avg. lb/bhp-h(g/kWh), max.							-	0.0005 (0.304)
<b>MACK T-9</b>							(6)	
Avg. liner wear norm. to 1.75% soot, µm, max.							40	
Average top ring weight loss, mg, max.							150	
Lead increase, ppm, max.							-	
<b>MACK T-10</b>							(9)	
Avg. liner wear norm. to 1.75% soot, µm, max.							47	
Average top ring weight loss, mg, max.							180	

**Notes:**

- (1) 151 mg or greater gives 0 Mack merit.
- (2) All individual ratings must be greater than 0.
- (3) ASTM D4495-5a issue shows that a Sequence VIII is required to meet API CF, API CF-2, API CF-4 and API CG-4. Sequence VIII has been shown to correlate with CRC L-38, now no more available.
- (4) Limit do not apply to monograde oils.
- (5) Rating of top and 2<sup>nd</sup> groove carbon and lead carbon.
- (6) A Mack T-9 test and its limits (as reported in CF-4 above) can be used as an alternate for the Mack T-6 test.
- (7) A Mack T-8A test version and its limits (as reported in CF-4 above) can be used as an alternate for the Mack T-7 test.
- (8) Cummins NTC 400 is no longer available and can be replaced by one additional Caterpillar 1K and ASTM D5968 CBT at copper.
- (9) A Mack T-9 test and its limits (as reported in CF-4 above) can be used as an alternate for the Mack T-6 test.

**ACEA  
sequences  
for gasoline  
and diesel  
engine oils**



## ACEA sequences - Overview of validity periods



Issue year of full document	First allowable use	Mandatory for new claims	Oils with this claim may be marketed until
1996	January 1, 1996	March 1, 1997	March 1, 2000
1998	March 1, 1998	March 1, 1999	March 1, 2002
1999	September 1, 1999	September 1, 2000	February 1, 2004
2002	February 1, 2002	February 1, 2003	November 1, 2006
2004	November 1, 2004	November 1, 2005	December 31, 2009
2007	February 1, 2007	February 1, 2008	December 23, 2010
2008	December 22, 2008	December 22, 2009	December 22, 2012
2010	December 22, 2010	December 22, 2011	December 22, 2014
2012	December 14, 2012	December 14, 2013	December 1, 2018
2016	December 1, 2016	December 1, 2017	...

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines</b>	<b>Dec. 2016</b>
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits		
				A3/B3-16	A3/B4-16	A5/B5-16
<b>1. Laboratory tests</b>						
<b>1.1 Viscosity Grades</b>		According to 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.		
<b>1.2 *Shear Stability</b>	CEC L-014-93 or ASTM D6278 or ASTM D7109	Viscosity after 30 cycles measured at 100°C	mm <sup>2</sup> /s	All grades to be "stay in grade"		
<b>1.3.1 HTHS Viscosity</b>	CEC L-036-90	Dynamic Viscosity at 150°C and shear rate of 10 <sup>6</sup> s <sup>-1</sup>	mPa.s	≥ 3.5		≥ 2.9 and ≤ 3.5
<b>1.3.2 *HTHS Viscosity at 100°C</b>	CEC L-036-90	Dynamic Viscosity at 100°C and shear rate of 10 <sup>6</sup> s <sup>-1</sup>	mPa.s	-		Report
<b>1.4 Evaporative Loss (Noack)</b>	CEC L-040-93	Max. weight loss after 1 h at 250°C	%	≤ 13		
<b>1.5 TBN</b>	ASTM D2896		mg KOH/g	≥ 8.0	≥ 10.0	≥ 8.0
<b>1.6 *Sulphur</b>	ASTM D5185		% m/m	Report		
<b>1.7 *Phosphorus</b>	ASTM D5185		% m/m	Report		
<b>1.8 *Sulfated ash</b>	ASTM D874		% m/m	≥ 0.9 and ≤ 1.5	≥ 1.0 and ≤ 1.6	≤ 1.6
<b>1.9 Chlorine</b>	ASTM D6443		ppm m/m	Report		
<b>1.10 *Oil / Elastomer compatibility</b>	CEC L-112-16	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing		Elastomer type		
		Tensile strength	%	RE6	RE7	RE8
		Elongation at rupture	%	-70 / +20	-65 / +15	-51 / +9
		Volume variation	%	-5.5 / +2.1	-1.8 / +8.9	0.0 / +12.0
<b>1.11 Foaming tendency</b>	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		

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines</b>	<b>Dec. 2016</b>
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Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits		
				A3/B3-16	A3/B4-16	A5/B5-16
<b>1. Laboratory tests</b>						
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 Yield stress (MRV at SAE J300 temperatures applicable for fresh oil viscosity grade)	mPa.s Pa	-	According to SAE J300 for fresh oil	
1.14 Oil oxidation with biodiesel	CEC L-109-14	Oil oxidation at 168h (DIN 51453)	A/cm	≤ 120	≤ 120	≤ 100
		Oil oxidation at 216h EOT (DIN 51453)	A/cm	Report	Report	≤ 120
		Viscosity increase, relative at 168h (delta KV100)	%	≤ 150	≤ 150	≤ 60
		Viscosity increase, relative at 216h (delta KV100 at EOT 216h)	%	Report	Report	≤ 150

**Notes:**

\* Additional information is given as footnotes underneath the table for the C-categories.

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines</b>	<b>Dec. 2016</b>
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Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits		
				A3/B3-16	A3/B4-16	A5/B5-16
<b>2. Engine tests</b>						
2.1 Gasoline DI engine cleanliness	CEC L-111-16 (EP6CDT)	Piston cleanliness Turbo charger deposits **, average value of zones C, D, E and F	merit merit		≥ RL259 ≥ 6.0	
2.2 Low temperature sludge	ASTM D6593-00 (Sequence VG)	Average engine sludge	merit		≥ 7.8	
		Rocker cover sludge	merit		≥ 8.0	
		Average piston skirt varnish	merit		≥ 7.5	
	Under protocol & requirements for API	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-054-96 (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 Piston cleanliness **	mm²/s merit		≤ 0.9 x RL248 result ≥ 2.5	
2.7 Diesel engine wear	CEC L-099-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 140		≤ 120
		Cam wear inlet (avg. max. 8 cams) **	µm	≤ 110		≤ 100
		Cylinder wear (avg. 4 cyl.) **	µm	≤ 5.0		≤ 5.0
		Bore polishing (13mm) (max of 4 cyl.) **	%	≤ 3.5		≤ 3.0
		Tappet wear inlet (avg. max. wear 8 cams) **	µm	Report		Report
		Tappet outlet wear (avg. max.wear 8 cams) **	µm	Report		Report
		Piston cleanliness (avg. 4 pistons) **	merit	Report		≥ 12
		Engine sludge average **	merit	Report		≥ 8.8

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines</b>	Dec. 2016
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Requirements	Test method	Properties	Unit	Limits		
				A3/B3-16	A3/B4-16	A5/B5-16
<b>2. Engine tests</b>						
2.8 *DI diesel piston cleanliness & ring sticking	CEC L-078-99 (VW TDI)	Piston cleanliness	merit	≥ RL 206 minus 4 points	≥ RL 206	≥ RL 206
		Ring sticking (Rings 1 & 2)				
		Average of all 8 rings	ASF	≤ 1.2	≤ 1.0	≤ 1.0
		Max. for any 1 <sup>st</sup> ring	ASF	≤ 2.5	≤ 1.0	≤ 1.0
		Max. for any 2 <sup>nd</sup> ring	ASF	0.0	0.0	0.0
		EOT TBN (ISO 377) **	mg KOH/g	≥ 4.0	≥ 6.0	≥ 4.0
2.9 Effects of biodiesel	CEC L-104-16 (OM646LA Bio)	EOT TAN (ASTM D 664) **	mg KOH/g	Report	Report	Report
		Piston cleanliness	merit	-	≥ RL255 + 2	
		Ring sticking **	ASF	-	Report	
		Sludge **	merit	-	Report	

**Notes:**

\*/\*\* Additional information is given as footnotes underneath the table for the C-categories.

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	<b>Dec. 2016</b>
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits				
				C1-16	C2-16	C3-16	C4-16	C5-16
<b>1. Laboratory tests</b>								
<b>1.1 Viscosity Grades</b>		According to SAE J300 Latest Active Issue		No restriction except as defined by shear stability and HHTS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature.				
<b>1.2 *Shear Stability</b>	CEC L-014-93 or ASTM D6278 or ASTM D7109	Viscosity after 30 cycles measured at 100°C	mm <sup>2</sup> /s	All grades to be "stay in grade"				
<b>1.3.1 HHTS Viscosity</b>	CEC L-036-90	Dynamic viscosity at 150°C and shear rate of 10 <sup>6</sup> s <sup>-1</sup>	mPa.s	≥ 2.9		≥ 3.5		≥ 2.6 and < 2.9
<b>1.3.2 *HHTS Viscosity at 100°C</b>	CEC L-036-90	Dynamic viscosity at 100°C and shear rate of 10 <sup>6</sup> s <sup>-1</sup>	mPa.s	Report		Report		Report
<b>1.4 Evaporative loss</b>	CEC-L-040-93 (Noack)	Max. weight loss after 1 h at 250°C	%	≤ 13		≤ 11		≤ 13
<b>1.5 TBN</b>	ASTM D2896		mg KOH/g	-	≥ 6.0	≥ 6.0	≥ 6.0	≥ 6.0
<b>1.6 *Sulphur</b>	ASTM D5185		% m/m	≤ 0.2	≤ 0.3	≤ 0.2	≤ 0.3	≤ 0.3
<b>1.7 * Phosphorus</b>	ASTM D5185		% m/m	≤ 0.05	≥ 0.07 ≤ 0.09	≥ 0.07 ≤ 0.09	≤ 0.09	≥ 0.07 ≤ 0.09
<b>1.8 *Sulfated ash</b>	ASTM D874		% m/m	≤ 0.5	≤ 0.8	≤ 0.5	≤ 0.8	≤ 0.8
<b>1.9 Chlorine</b>	ASTM 6443		ppm m/m	Report				
<b>1.10 *Oil / Elastomer compatibility</b>	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	
				Report	Report	Report	Report	
		Tensile strength	%	-70 / +20	-65 / +15	-51 / +9	-65 / +19	
		Elongation at rupture	%					
		Volume variation	%	-5.5 / +2.1	-1.8 / +8.9	0.0 / +12.0	-2.5 / +16.0	
<b>1.11 Foaming tendency</b>	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				

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	<b>Dec. 2016</b>
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits				
				C1-16	C2-16	C3-16	C4-16	C5-16
<b>1. Laboratory tests</b>								
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 Yield stress (MRV at SAE J300 temperatures applicable for fresh oil viscosity grade)	mPa.s Pa	According to SAE J300 for fresh oil				
1.14 Oil oxidation with biodiesel	CEC L-109-14	Oil oxidation at 168h (DIN 51453)		≤ 100	≤ 100	≤ 100	≤ 100	≤ 100
		Oil oxidation at 216h EOT (DIN 51453)		≤ 120	≤ 120	≤ 120	≤ 120	≤ 120
		Viscosity increase, relative at 168h (delta KV100)		≤ 60	≤ 60	≤ 60	≤ 60	≤ 60
		Viscosity increase, relative at 216h (delta KV100 at EOT 216h)		≤ 150	≤ 150	≤ 150	≤ 150	≤ 150

**Notes:**

\* Additional information is given as footnotes underneath the table for the C-categories.

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	Dec. 2016
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits				
				C1-16	C2-16	C3-16	C4-16	C5-16
<b>2. Engine tests</b>								
2.1 Gasoline DI engine cleanliness	CEC L-111-16 (EP6CDT)	Piston cleanliness Turbo charger deposits **, average value of zones C, D, E and F	merit merit			≥ RL259 ≥ 6.0		
2.2 Low temperature sludge	ASTM D6593-00 (Sequence VG)	Average engine sludge	merit			≥ 7.8		
		Rocker cover sludge	merit			≥ 8.0		
		Average piston skirt varnish	merit			≥ 7.5		
	Under protocol & requirements for API	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-054-96 (M111)	Fuel economy improvement	%	≥ 3.0	2.5	≥ 1.0 (for -W-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 Piston cleanliness **	mm²/s merit			≤ 0.9 x RL248 result ≥ 2.5		
2.7 Diesel engine wear	CEC L-099-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 120		≤ 120		
		Cam wear inlet (avg. max. 8 cams) **	µm	≤ 100		≤ 100		
		Cylinder wear (avg. 4 cyl.) **	µm	≤ 5.0		≤ 5.0		
		Bore polishing (13mm) (max of 4 cyl.) **	%	≤ 3.0		≤ 3.0		
		Tappet wear inlet (avg. max. wear 8 cams) **	µm	Report		Report		
		Tappet outlet wear (avg. max.wear 8 cams) **	µm	Report		Report		
		Piston cleanliness (avg. 4 pistons) **	merit	Report		Report		
		Engine sludge average **	merit	Report		Report		

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	Dec. 2016
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits				
				C1-16	C2-16	C3-16	C4-16	C5-16
<b>2. Engine tests</b>								
2.8 *DI diesel piston cleanliness & ring sticking	CEC L-078-99 (VW TDI)	Piston cleanliness Ring sticking (Rings 1 & 2) Average of all 8 rings Max. for any 1 <sup>st</sup> ring Max. for any 2 <sup>nd</sup> ring EOT TBN (ISO 3771) ** EOT TAN (ASTM D 664) **	merit ASF ASF ASF mg KOH/g mg KOH/g	≥ RL 206 ≤ 1.0 ≤ 1.0 0 Report Report	≥ RL 206 ≤ 1.2 ≤ 2.5 0 Report Report		≥ RL 206 ≤ 1.0 ≤ 1.0 0 Report Report	
2.9 Effects of biodiesel	CEC L-104-16 (OM646LA Bio)	Piston cleanliness Ring sticking ** Sludge **	merit ASF merit			≥ RL255 + 2 Report Report		

**Notes:**

- (1) 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 L-036-90 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 has to 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-039-96 may be used for ACEA 2016 instead of CEC L-112-16 under the condition that a Full L-039 Data set including RE1, RE2, RE3 & RE4 + the Daimler DBL-AEM (requirements as specified by Daimler AG), provided that the requirements specified in ACEA 2012 are met.
  - No. 2.1, 2.6, 2.9 \*\* Parameter is not an official CEC Parameter.
  - No. 2.2 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 Alternatively. Sequence VH test may be used with limits as defined for API SN: Average engine sludge merit: 76 (min); Average engine sludge merit: 77 (min); Average engine wear merits: 86 (min); Average piston skirt wear, merits: 76 (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-039-94 (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-Successor 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 M11 Sludge Test. Once the L-107 Procedure is fully CEC-approved, the L-107 may be used, with limits officially communicated by ACEA.
  - No. 2.8 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.
  - \* 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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 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits					
				E4-16	E6-16	E7-16	E9-16		
<b>1. Laboratory tests</b>									
<b>1.1 Viscosity grades</b>		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.					
<b>1.2 Shear stability</b>	CEC L-014-93 or ASTM D6278 or ASTM D7109	Viscosity after 30 cycles measured at 100°C	mm <sup>2</sup> /s	Stay in grade					
	ASTM D7109	Viscosity after 90 cycles measured at 100°C	mm <sup>2</sup> /s			Stay in grade			
<b>1.3 HTHS viscosity</b>	CEC L-036-90	Dynamic Viscosity at 150°C and Shear Rate of 10 <sup>6</sup> s <sup>-1</sup>	mPa.s		≥ 3.5				
		Dynamic Viscosity at 100°C and Shear Rate of 10 <sup>6</sup> s <sup>-1</sup>	mPa.s		Report				
<b>1.4 Evaporative loss (Noack)</b>	CEC L-040-93	Max. weight loss after 1 h at 250°C	%		≤ 13				
<b>1.5 Sulfated ash</b>	ASTM D874		% m/m	≤ 2.0	≤ 1.0	≤ 2.0	≤ 1.0		
<b>1.6 Phosphorus</b>	ASTM D5185		% m/m		≤ 0.08		≤ 0.12		
<b>1.7 Sulphur</b>	ASTM D5185		% m/m		≤ 0.3		≤ 0.4		
<b>1.8 *Oil / Elastomer compatibility</b>	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		
<b>1.9 Foaming tendency</b>	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			Sequence I 10/0 Sequence II 20/0 Sequence III 10/0		
<b>1.10 High temperature foaming tendency</b>	ASTM D6082	Tendency – stability	ml	Sequence IV (150°C) 200 – 50					

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 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				E4-16	E6-16	E7-16	E9-16
<b>1. Laboratory tests</b>							
1.11 Oxidation	CEC-L-085-99 (PDSC)	Oxidation induction time	min.		≥ 65		
1.12 Corrosion	ASTM D6594 (HTCBT)	Copper increase	ppm	Report		Report	≤ 20
		Lead increase	ppm	Report		≤ 100	≤ 100
		Copper strip rating	max	Report		Report	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 fresh oil viscosity grade)					
1.15 Oil oxidation with biodiesel	CEC L-109-14	Oil oxidation at 168h (DIN 51453) Viscosity increase, relative at 168h (delta KV100)	A/cm %	≤ 90 ≤ 130	≤ 80 ≤ 130	≤ 120 ≤ 300	≤ 90 ≤ 150

**Notes:**

\* Additional information is given as footnotes underneath the table for the E-categories.

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 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				E4-16	E6-16	E7-16	E9-16
<b>2. Engine tests</b>							
2.1 *Wear	CEC L-099-08 (OM 646LA)	Cam wear outlet (avg. Max. wear 8 cams)	µm	≤ 140	≤ 140	≤ 155	≤ 155
2.2 *Soot in oil	ASTM D5967 (Mack T8-E)	Test duration 300 h, Relative viscosity at 4.8% soot and 50% shear loss, 1 test / 2 test avg / 3 test average	mm <sup>2</sup> /s			≤ 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	mg	-		≤ 7.5 / 7.8 / 7.9	≤ 7.1
		1 test / 2 test avg / 3 test avg Oil filter diff. press at 150h	kPa	-		≤ 55 / 67 / 74	≤ 19
		1 test / 2 test avg / 3 test avg Engine sludge	merit	-		≥ 8.1 / 8.0 / 8.0	≥ 8.7
		1 test / 2 test avg / 3 test avg Adj. screw weight loss	mg	-			≤ 49
2.5 *Wear (liner-ring-bearings)	ASTM D7422 (Mack T-I2)	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
		Δ lead 250 h -300 h	ppm	-	≤ 18		≤ 15
		Oil consumption (phase II)	g/h	-	≤ 95		≤ 85

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 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				E4-16	E6-16	E7-16	E9-16
<b>2. Engine tests</b>							
2.6 Biofuel impacted piston cleanliness and engine sludge	CEC L-104-16 (OM646LA Bio)	Piston cleanliness Ring sticking ** Engine Sludge, average **	merit ASF merit	- - -	≥ RL255 + 4 Report Report	- - -	≥ RL255 + 2 Report Report

**Notes:**

- \* Footnotes referring to the following requirements in the E-Class:
  - No. 1.8 Full Data sets being obtained on CEC L-039-96 + 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.
  - No. 21 Additional parameters may be included once approved by CEC.
  - 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.

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines</b>	<b>Dec. 2012</b>
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Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				A1/B1-12	A3/B3-12	A3/B4-12	A5/B5-12
<b>1. Laboratory tests</b>							
1.1 Viscosity grades		SAE J300 Latest Active Issue		No restriction except as defined by shear stability and HHTS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature.			
1.2 *Shear stability	CEC L-014-93 (Bosch Injector) or ASTM D6278	Viscosity after 30 cycles measured at 100°C	mm <sup>2</sup> /s	xW-20 ≥ 5.6 xW-30 ≥ 9.3 xW-40 ≥ 12.0	All grades to be stay in grade		
1.3 Viscosity at high temperature & high shear rate	CEC-L-036-90 (2 <sup>nd</sup> Edition)	Viscosity at 150°C and 10 <sup>6</sup> s <sup>-1</sup> Shear rate	mPa.s	≥2.9 and ≤3.5 xW-20: 2.6 min.	≥ 3.5	≥ 2.9 and ≤3.5	
1.4 Evaporative loss	CEC-L-040-93 (Noack)	Max. weight loss after 1 h at 250°C	%		≤ 13		
1.5 TBN	ASTM D 2896		mg KOH/g	≥ 8.0	≥ 8.0	≥ 10.0	≥ 8.0
1.6 *Sulphur	ASTM D5185		% m/m		Report		
1.7 *Phosphorus	ASTM D5185		% m/m		Report		
1.8 *Sulfated ash	ASTM D874		% m/m	≤ 1.3	≥ 0.9 and ≤ 1.5	≥ 1.0 and ≤ 1.6	≤ 1.6
1.9 Chlorine	ASTM 6443		% m/m		Report		
1.10 *Oil / Elastomer compatibility	CEC-L-039-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing	points		Elastomer type		
		Hardness DIDC		RE1 FLUORO	RE2-99 ACM	RE3-04 SILICONE	RE4 NBR
		Tensile strength	%	-1 / +5 -40 / +10	-5 / +8 -15 / +18	-22 / +1 -30 / +10	-5 / +5 -20 / +10
		Elongation at rupture	%	-50 / +10	-35 / +10	-20 / +10	-50 / +10
		Volume variation	%	-1 / +5	-7 / +5	-1 / +22	-5 / +5
1.11 Foaming tendency	ASTM D892 without option A	Tendency - stability	ml	Sequence I (24°C) 10 - nil Sequence II (94°C) 50 - ni Sequence III (24°C) 10 - nil			

ACEA	ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines	Dec. 2012
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Requirements	Test method	Properties	Unit	Limits			
				A1/B1-12	A3/B3-12	A3/B4-12	A5/B5-12
<b>1. Laboratory tests</b>							
1.12 High temperature foaming tendency	ASTM D6082 High temperature foam test	Tendency – stability	ml		Sequence IV (150°C) 100 – nil		
1.13 *Oxidation in presence of biodiesel/w	GFC-Lu-43A-11	Catalysed ageing test until 144h at 170°C & with air bubbling: 1. on pure oil 2. with B10 added (B71 1892 GO B10 LUB) PAI at 144h Kin. Viscosity at 100°C variation: - at 72h - at 96h - at 120h - at 144h	%  cST & % cST & % cST & % cST & %				Report  Report Report Report and at 144 h: < +200% (no solidification)
1.14 Low-temperature pumpability	CEC L-105	MRV at SAE J300 temperatures applicable for fresh oil viscosity grade  Viscosity Yield stress	mPa.s  Pa	Acc to SAE J300 for fresh oil		Acc to SAE J300 for fresh oil	Acc to SAE J300 for fresh oil

**Notes:**

\* Additional information is given as footnotes underneath the table for the C-categories.

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines</b>	Dec. 2012
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Requirements	Test method	Properties	Unit	Limits			
				A1/B1-12	A3/B3-12	A3/B4-12	A5/B5-12
<b>2. Engine tests</b>							
2.1 High temperature deposits Ring sticking oil thickening	CEC-L-088-02 (TU5JP-L4) 72 Hour test	Ring sticking (each part)  Piston varnish (5 elements, average of 4 pistons)  Absolute viscosity increase at 40°C between min and max values during test  Oil consumption	merit  merit  mm <sup>2</sup> /s  kg/test			≥ 9.0  ≥ RL 216  ≤ 0.8 x RL 216  Report	
2.2 *Low temperature sludge	ASTM D6593-00 (Sequence VG)  Under protocol & requirements for API	Average engine sludge  Rocker cover sludge  Average piston skirt varnish  Average engine varnish  Comp. ring (hot stuck)  Oil screen clogging	merit  merit  merit  merit  %			≥ 7.8  ≥ 8.0  ≥ 7.5  ≥ 8.9  None  ≤ 20	
2.3 Valve train scuffing wear	CEC-L-038-94 (TU3M)	Cam wear, average  Cam wear, max.  Pad merit (avg. of 8 pads)	µm  µm  merit			≤ 10  ≤ 15  ≥ 7.5	
2.4 *Black sludge		Engine sludge, average	merit			≥ RL140 + .4σ	
2.5 *Fuel economy	CEC-L-054-96 (M111)	Fuel economy improvement vs. reference oil RL 191 (15W40)	%	≥ 2.5	-	-	≥ 2.5
2.6 Medium temperature dispersivity	CEC-L-093-04 (DV4TD) To be replaced by DV6C	Absolute viscosity increase at 100°C and 6% soot  Piston merit	mm <sup>2</sup> /s  merit			≤ 0.60 x RL 223 result  ≥ (RL 223 minus 2.5 pts)	
2.7 *DV6C oil dispersion at medium temperature for passenger car direct injection diesel engines	CEC L-106 (DV6C)	Absolute viscosity increase at 100°C and 6% soot  Piston merit	mm <sup>2</sup> /s  merit			Limits to defined	

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Requirements	Test method	Properties	Unit	Limits			
				A1/B1-12	A3/B3-12	A3/B4-12	A5/B5-12
<b>2. Engine tests</b>							
2.8 *Wear	CEC-L-099-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 120	≤ 140	≤ 120	≤ 120
		Cam wear inlet (avg. max. 8 cams)	µm	≤ 100	≤ 110	≤ 100	≤ 100
		Cylinder wear (avg. 4 cyl.)	µm	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
		Bore polishing (13mm) (max of 4 cyl.)	%	≤ 3.0	≤ 3.5	≤ 3.0	≤ 3.0
		Tappet wear inlet (avg. max. wear 8 cams)	µm	Report	Report	Report	Report
		Tappet outlet wear (avg. max.wear 8 cams)	µm	Report	Report	Report	Report
		Piston cleanliness (avg. 4 pistons)	merit	Report	Report	≥ 12	≥ 12
		Engine sludge avg.	merit	Report	Report	≥ 8.8	≥ 8.8
2.9 *DI diesel piston cleanliness & ring sticking	CEC-L-078-99 (VW DI)	Piston cleanliness	merit	≥ RL 206	≥ RL 206 minus 4 points	≥ RL 206	≥ RL 206
		Ring sticking (Rings 1 & 2)					
		Average of all 8 rings	ASF	≤ 1.0	≤ 1.2	≤ 1.0	≤ 1.0
		Max. for any 1 <sup>st</sup> ring	ASF	≤ 1.0	≤ 2.5	≤ 1.0	≤ 1.0
		Max. for any 2 <sup>nd</sup> ring	ASF	0.0	0.0	0.0	0.0
		EOT TBN (ISO 3771)	mg KOH/g	≥ 4.0	≥ 4.0	≥ 6.0	≥ 4.0
2.10 *Effects of bio- diesel	CEC L-104	EOT TAN (ASTM D 664)	mg KOH/g	Report	Report	Report	Report
		Piston cleanliness	merit			Report	
		Ring sticking	ASF			Report	
		Sludge	merit			Report	

**Notes:**

\* Additional information is given as footnotes underneath the table for the C-categories.

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	<b>Dec. 2012</b>
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Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits					
				C1-12	C2-12	C3-12	C4-12		
<b>1. Laboratory tests</b>									
<b>1.1 Viscosity grades</b>		SAE J300 Latest Active Issue		No restriction except as defined by shear stability and HHTS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature.					
<b>1.2 *Shear stability</b>	CEC L-014-93 or ASTM D6278	Viscosity after 30 cycles measured at 100°C	mm <sup>2</sup> /s	All grades to be stay in grade					
<b>1.3 Viscosity at high temperature &amp; high shear rate</b>	CEC-L-036-90	Viscosity at 150°C and 10 <sup>6</sup> s <sup>-1</sup> Shear rate	mPa.s	≥2.9		≥3.5			
<b>1.4 Evaporative loss</b>	CEC-L-040-93 (Noack)	Max. weight loss after 1 h at 250°C	%	≤13		≤ 11			
<b>1.5 TBN</b>	ASTM D 2896		mg KOH/g	-		≥ 6.0			
<b>1.6 *Sulphur</b>	ASTM D5185		% m/m	≤ 0.2	≤ 0.3		≤ 0.2		
<b>1.7 *Phosphorus</b>	ASTM D5185		% m/m	≤ 0.05	≤ 0.09	≥ 0.07 and ≤ 0.09	≤ 0.09		
<b>1.8 *Sulfated ash</b>	ASTM D874		% m/m	≤ 0.5	≤ 0.8		≤ 0.5		
<b>1.9 Chlorine</b>	ASTM 6443		ppm m/m	Report					
<b>1.10 *Oil / Elastomer compatibility</b>	CEC-L-039-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing	points	Elastomer type					
				RE1 FLUORO	RE2-99 ACM	RE3-04 SILICONE	RE4 NBR	DBL-AEM	
		Hardness D1DC	%	-1 / +5	-5 / +8	-25 / +1	-5 / +5	-5 / +10	
		Tensile strength		-50 / +10	-15 / +18	-45 / +10	-20 / +10	-35 / -	
		Elongation at rupture		-60 / +10	-35 / +10	-20 / +10	-50 / +10	-50 / -	
		Volume variation	%	-1 / +5	-7 / +5	-1 / +30	-5 / +5	-5 / +15	
<b>1.11 Foaming tendency</b>	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					

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Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				C1-12	C2-12	C3-12	C4-12
<b>1. Laboratory tests</b>							
1.12 High temperature foaming tendency	ASTM D6082 High temperature foam test	Tendency – stability	ml				Sequence IV (150°C) 100 – nil
1.13 *Oxidation in presence of biodiesel/w	GFC-Lu-43A-11	Catalysed ageing test until 144h at 170°C & with air bubbling: 1. on pure oil 2. with B10 added (B71 1892 GO B10 LUB) PAI at 144h Kin. Viscosity at 100°C variation: - at 72h - at 96h - at 120h - at 144h	%	cST & % cST & % cST & % cST & %		Report Report Report Report and at 144 h: < +200% (no solidification)	
1.14 Low-temperature pumpability	CEC L-105	MRV at SAE J300 temperatures applicable for fresh oil viscosity grade  Viscosity Yield stress	mPa.s Pa				Acc to SAE J300 for fresh oil

**Notes:**

\* Additional information is given as footnotes underneath the table for the C-categories.

ACEA	ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices	Dec. 2012
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 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				C1-12	C2-12	C3-12	C4-12
<b>2. Engine tests</b>							
2.1 High temperature deposits Ring sticking oil thickening	CEC-L-088-02 (TU5JP-L4) 72 Hour test	Ring sticking (each part)  Piston varnish (5 elements, average of 4 pistons)  Absolute viscosity increase at 40°C between min and max values during test  Oil consumption	merit  merit  mm <sup>2</sup> /s  kg/test			≥ 9.0  ≥ RL 216  ≤ 0.8 x RL 216  Report	
2.2 *Low temperature sludge	ASTM D6593-00 (Sequence VG)  Under protocol & requirements for API	Average engine sludge  Rocker cover sludge  Average piston skirt varnish  Average engine varnish  Comp. ring (hot stuck)  Oil screen clogging	merit  merit  merit  merit  %			≥ 7.8  ≥ 8.0  ≥ 7.5  ≥ 8.9  None  ≤ 20	
2.3 Valve train scuffing wear	CEC-L-038-94 (TU3M)	Cam wear, average  Cam wear, max.  Pad merit (avg. of 8 pads)	µm  µm  merit			≤ 10  ≤ 15  ≥ 7.5	
2.4 *Black sludge		Engine sludge, average	merit			≥ RL140 + 4σ	
2.5 *Fuel economy	CEC-L-054-96 (M111)	Fuel economy improvement vs. reference oil RL 191 (15W40)	%	≥ 3.0	≥ 2.5	≥ 1.0 (for xW-30 grades)	
2.6 Medium temperature dispersivity	CEC-L-093-04 (DV4TD)" To be replaced by DV6C	Absolute viscosity increase at 100°C and 6% soot  Piston merit	mm <sup>2</sup> /s  merit			≤ 0.60 x RL 223 result  ≥ (RL 223 minus 2.5 pts)	
2.7 *DV6C oil dispersion at medium temperature for passenger car direct injection diesel engines <sup>(1)</sup>	CEC L-106 (DV6C)	Absolute viscosity increase at 100°C and 6% soot  Piston merit	mm <sup>2</sup> /s  merit			Limits to defined	

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	Dec. 2012
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				C1-12	C2-12	C3-12	C4-12
<b>2. Engine tests</b>							
2.8 *Wear	CEC-L-099-08 (OM646LA)	Cam wear outlet (avg. max. wear 8 cams)	µm	≤ 120	≤ 120	≤ 120	≤ 120
		Cam wear inlet (avg. max. 8 cams)	µm	≤ 100	Report	≤ 100	≤ 100
		Cylinder wear (avg. 4 cyl.)	µm	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
		Bore polishing (13mm) (max of 4 cyl.)	%	≤ 3.0	≤ 3.0	≤ 3.0	≤ 3.0
		Tappet wear inlet (avg. max. wear 8 cams)	µm	Report	Report	Report	Report
		Tappet outlet wear (avg. max.wear 8 cams)	µm	Report	Report	Report	Report
		Piston cleanliness (avg. 4 pistons)	merit	Report	Report	Report	≥ 12
		Engine sludge avg.	merit	Report	Report	Report	≥ 8.8
2.9 *DI diesel piston cleanliness & ring sticking	CEC-L-078-99 (VW DI)	Piston cleanliness	merit	≥ RL 206	≥ RL 206	≥ RL 206	≥ RL 206
		Ring sticking (Rings 1 & 2)					
		Average of all 8 rings	ASF	≤ 1.0	≤ 1.2	≤ 1.0	≤ 1.0
		Max. for any 1 <sup>st</sup> ring	ASF	≤ 1.0	≤ 2.5	≤ 1.0	≤ 1.0
		Max. for any 2 <sup>nd</sup> ring	ASF	0.0	0.0	0.0	0.0
		EOT TBN (ISO 3771)	mg KOH/g	Report	Report	Report	Report
		EOT TAN (ASTM D 664)	mg KOH/g	Report	Report	Report	Report

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for gasoline and diesel engines with after treatment devices</b>	Dec. 2012
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				C1-12	C2-12	C3-12	C4-12
<b>2. Engine tests</b>							
2.10 *Effects of bio-diesel	CEC L-104	Piston cleanliness Ring sticking Sludge	merit ASF merit		Report Report Report		

**Notes:**

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

No. 1.2 The minimum viscosity for xW-20 oils after shearing is 5.6 cSt.

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 has to be used.

No. 1.0 All reference materials and limits for RE1, RE2, RE3, RE4 and DBL-AEM can be used until acceptable new reference materials (proposed from CEC L-039-96) are available and appropriate limits have been set.

The Daimler requirements for DBL-AEM D 8948/200 are VDA 675301, 7 days 3.2h, 150°C 3.2°C, closed cup test.

RE-1, RE-2, RE-3, RE-4 based on CEC and DBL-AEM based on Daimler AG data may continue to be used "grandfathered" for the lifetime of the ACEA 2012 sequences.

On April 16, 2016 ACEA issued a clarification advising that CEC has declared the CEC L-039-96 test method to be out of control in respect of the elastomers RE3 (VMQ) and RE4 (NBR). Those elastomers are therefore deleted from the CEC L-039-96 test method and the CEC test method has been updated accordingly.

No. 1.13 Until a CEC Test Method is developed, the oxidation behavior of engine oil formulations must be proved by GFC-LU-43A-1.

No. 2.2 Test results obtained by this procedure will be accepted under the condition that they come from labs having participated to the official round robin and comply with the quality criteria of GFC.

No. 2.4 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. 2.4 Until a new CEC Test Method is developed, the gasoline sludge protection performance of engine oil formulations must be proved by the M 271 sludge test procedure as described by Daimler AG.

No. 2.4 Test results obtained by the M 271 procedure will be accepted under the condition that they come from test rigs being referenced and quality controlled by Daimler AG.

M111 SL data, in place of M271 data, can be used to support a claim against the ACEA 2012 Sequences concerning the sludge requirement.

No. 2.5 Limits are based on the same reference oil as with the old M111 sludge test.

No. 2.5 ACEA considers the CEC L-54-96 test the valid comparative test which claims of lubricant fuel economy improvement should be made.

No. 2.7 May be performed instead of it if necessary. An alternative to the DV4 test, ACEA will decide when the DV4 test will be finally deleted from this specification.

No. 2.8 CEC-L-093-04 (DV4 Test) test results obtained in accordance with the ATIEL guidelines may be used by a grandfathering process also after this test has become unavailable to run and is replaced by the CEC-L-106 (DV6 Test) procedure.

No. 2.9 Not all parameters are yet official CEC parameters. C2 limit for inlet cam wear under definition.

No. 2.9 Test report has to give measured values before & after the test, all measurements to be taken in the same lab.

No. 2.9 Note: TAN is considered to become performance criteria in the future. Not all parameters are yet official CEC parameters.

No. 2.10 Any test run prior to the publication of the ACEA 2012 Sequences can be used whether or not it has EOT TAN. Test run since the ACEA 2012 Sequences became active on 1 December 2012 require VWTDI EOT TAN.

No. 2.10 Test is still under development at the time of publishing of this specification.

No. 2.10 Test has to be performed for all qualifications against 2012 Oil Sequences from the time the test is officially released by CEC (running programs only).

No. 2.10 All test criteria is rate and report.

<b>ACEA</b>	<b>ACEA 2016 European oil sequence for service-fill oils for heavy duty diesel engines</b>	<b>Dec. 2012</b>
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits				
				E4-12	E6-12	E7-12	E9-12	
<b>1. Laboratory tests</b>								
1.1 Viscosity grades		SAE J300 Latest Active Issue		No restriction except as defined by shear stability and HHTS requirements. Manufacturers may indicate specific viscosity requirements related to ambient temperature.				
1.2 Shear stability	CEC-L-014-93 (Bosch Injector) or ASTM D6278	Viscosity after 30 cycles measured at 100°C	mm <sup>2</sup> /s	Stay in grade				
	ASTM D6278	Viscosity after 90 cycles measured at 100°C	mm <sup>2</sup> /s			Stay in grade		
1.3 Viscosity at high temperature & high shear rate	CEC L-036-90	Viscosity at 150°C and 10 <sup>6</sup> s <sup>-1</sup> Shear rate	mPa.s			≥ 3.5		
1.4 Evaporative loss	CEC L-040-93 (Noack)	Max. weight loss after 1 h at 250°C	%			≤ 13		
1.5 Sulfated 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-039-96	Max. variation of characteristics after immersion for 7 days in fresh oil without pre-ageing	points	Elastomer type				
				RE1 FLUORO	RE2-99 ACM	RE3-04 SILICONE	RE4 NBR	DBL-AEM
1.9 Foaming tendency	ASTM D892 without option A	Tendency - stability	ml	-1 / +5 -40 / +10 -50 / +10 -1 / +5	-5 / +8 -15 / +18 -35 / +10 -7 / +5	-22 / +1 -30 / +10 -20 / +10 -1 / +22	-5 / +5 -20 / +10 -50 / +10 -5 / +5	+5 / +10 -35 / - -50 / - -5 / +15
				Sequence I (24°C) 10 - nil				Sequence I 10/0
				Sequence II (94°C) 50 - nil				Sequence II 20/0
				Sequence III (24°C) 10 - nil				Sequence III 10/0
1.10 High temperature foaming tendency	ASTM D6082	Tendency - stability	ml	Sequence IV (150°C) 200 - 50				

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for heavy duty diesel engines</b>	Dec. 2012
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				E4-12	E6-12	E7-12	E9-12
<b>1. Laboratory tests</b>							
1.11 Oxidation	CEC-L-085-99 (PDSC)	Oxidation induction time	min.		R&R		≥ 65
1.12 Corrosion	ASTM D6594 (HTCBT)	Copper increase	ppm		R&R	R&R	≤ 20
		Lead increase	ppm		R&R	≤ 100	≤ 100
		Copper strip rating	max		R&R	R&R	3
1.13 *TBN	ASTM D2896		mg KOH/g	≥ 12	≥ 7	≥ 9	≥ 7
1.14 Low-temperature pumpability	CEC L-105	MRV at SAE J300 temperatures applicable for fresh oil viscosity grade	mPa.s		Acc to SAE J300 for fresh oil		
		Viscosity	Pa				
		Yield stress					

**Notes:**

\* Additional information is given as footnotes underneath the table for the E-engine test categories.

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for heavy duty diesel engines</b>	Dec. 2012
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				E4-12	E6-12	E7-12	E9-12
<b>2. Engine tests</b>							
2.1 *Wear	CEC L-099-08 (OM 646LA)	Cam wear outlet (avg. Max. wear 8 cams)	µm	≤ 140	≤ 140	≤ 155	≤ 155
2.2 *Soot in oil	ASTM D5967 (Mack T8-E)	Test duration 300 h, Relative viscosity at 4.8% soot and 50% shear loss, 1 test / 2 test avg / 3 test avg	mm <sup>2</sup> /s	≤ 2.1 / 2.2 / 2.3	≤ 2.1 / 2.2 / 2.3	≤ 2.1 / 2.2 / 2.3	
2.3 Soot in oil	Mack T-11 (ASTM D7156)	Min TGA soot @ 4.0 cSt (100°C)	%				3.5 / 3.4 / 3.3
		Min TGA soot @ 12.0 cSt (100°C)	%				6.0 / 5.9 / 5.9
		Min TGA soot @ 15.0 cSt (100°C)	%				6.7 / 6.6 / 6.5
2.4 *Bore polishing Piston cleanliness	CEC L-101-08 (OM501LA)	Bore polishing, average	%	≤ 1.0	≤ 1.0	≤ 2.0	≤ 2.0
		Piston Cleanliness, average	merit	≥ 26	≥ 26	≥ 17	≥ 17
		Oil consumption	kg/test	≤ 9	≤ 9	≤ 9	≤ 9
		Engine sludge, average	merit	R&R	R&R	R&R	R&R
2.5 *Soot-induced wear	Cummins ISM (ASTM D7468)	Merit				≤ 7.5 / 7.8 / 7.9	≤ 1000
		Rocker pad avg weight loss at 3.9% soot	mg			≤ 55 / 67 / 74	≤ 71
		1 test / 2 test avg / 3 test avg Oil filter diff.press at 150h	kPa			≥ 8.1 / 8.0 / 8.0	≤ 19
		1 test / 2 test avg / 3 test avg Engine sludge	merit			≥ 8.7	≥ 8.7
		1 test / 2 test avg / 3 test avg Adj. screw weight loss	mg			≤ 49	

ACEA	<b>ACEA 2016 European oil sequence for service-fill oils for heavy duty diesel engines</b>	<b>Dec. 2012</b>
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This sequence defines the minimum quality level of a product for self-certification to EELQMS and for presentation to ACEA members.  
 Performance parameters other than those covered by the tests shown or more stringent limits may be indicated by individual member companies.

Requirements	Test method	Properties	Unit	Limits			
				E4-12	E6-12	E7-12	E9-12
<b>2. Engine tests</b>							
2.6 *Wear (liner-ring-bearings)	Mack T-12 (ASTM D7422)	Merit	-	-	≥ 1000	≥ 1000	≥ 1000
		Avg. liner wear	µm	-	≤ 26	≤ 26	≤ 24
		Average top ring weight loss	mg	-	≤ 117	≤ 117	≤ 105
		End of test lead	ppm	-	≤ 42	≤ 42	≤ 35
		Δ lead 250-300 hrs	ppm	-	≤ 18	≤ 18	≤ 15
		Oil consumption (phase II)	g/hr	-	≤ 95	≤ 95	≤ 85

**Notes:**

(1) Footnotes referring to the following requirements in the E-Class:

No. 1.6; 1.7 Internal standard method has to be used.

No. 1.8 All reference materials and limits for RE1, RE2, RE3, RE4 and DBL-AEM can be used until acceptable new reference materials (proposed from CEC L-039-96) are available and appropriate limits have been set.

The Daimler requirements for DBL-AEM D (proposed from CEC L-039-96) are available and appropriate limits have been set.

The Daimler requirements for DBL-AEM D 8948/200 are VDA 675301, 7 days 3 h, 150°C 3.2°C, closed cup test.

RE-1, RE-2, RE-3, RE-4 based on CEC and DBL-AEM based on Daimler AG data may continue to be used "grandfathered" for the lifetime of the ACEA 2012 sequences.

On April 16, 2016 ACEA issued a clarification advising that CEC has declared the CEC L-039-96 test method to be out of control in respect of the elastomers RE3 (VMO) and RE4 (NBR). Those elastomers are therefore deleted from the CEC L-039-96 test method and the CEC test method has been updated accordingly.

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

No. 2.1 OM602A data can be used instead of OM646LA data providing it meets the requirements as specified in the 2007 ACEA sequences.

Additional parameters may be included once approved by CEC.

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

No. 2.4 Bore polish, oil consumption and engine sludge are non-approved CEC parameters.

No. 2.5 OM441LA data can be used instead of OM501LA data providing it meets the requirements as specified in the 2007 ACEA sequences.

No. 2.6 For E7 results from MIHST (ASTM D6838), at API CH-4, or MITEGR (ASTM D6975), at API CI-4 or CI-4 Plus, can be used in place of Cummins ISM. Merit number shall be calculated according to the API CI-4 specification.

No. 2.6 For E6 & E7 merit shall be calculated according to the API CI-4 specification.

No. 2.6 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.

**China GB,  
Global DHD-1,  
JASO HD-DL  
and US Military  
requirements  
for diesel  
engine oils**



# GB 11121 - 2006 <sup>(#)</sup> - Passenger car gasoline engine oil

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PERFORMANCE CATEGORY		SE	SF	SG	SH	SJ	SL	GF-1 <sup>(2)</sup>	GF-2 <sup>(2)</sup>	GF-3 <sup>(2)</sup>
	Viscosity grades <sup>(1)</sup>			0W-20, 0W-30, 5W-20, 5W-30, 5W-40, 5W-50, 10W-30, 10W-40, 10W-50, 15W-30, 15W-40, 15W-50, 20W-40, 20W-50, 30, 40, 50						
<b>Viscosity at 100°C (ASTM D445) <sup>(3)</sup>, mm<sup>2</sup>/s</b>							SAE J300 <sup>(1)</sup>			
<b>Low temp cranking</b> (ASTM D5293), mPa.s, max.	0W-xx	3250 (-30°C)	6200 (-35°C)	6200 (-35°C)	6200 (-35°C)	6200 (-35°C)	6200 (-35°C)	6200 (-35°C)	6200 (-35°C)	6200 (-35°C)
	5W-xx	3500 (-25°C)	6600 (-30°C)	6600 (-30°C)	6600 (-30°C)	6600 (-30°C)	6600 (-30°C)	6600 (-30°C)	6600 (-30°C)	6600 (-30°C)
	10W-xx	3500 (-20°C)	7000 (-25°C)	7000 (-25°C)	7000 (-25°C)	7000 (-25°C)	3500 (-20°C)	3500 (-20°C)	7000 (-20°C)	7000 (-25°C)
	15W-xx	3500 (-15°C)	7000 (-20°C)	7000 (-20°C)	7000 (-20°C)	7000 (-20°C)	7000 (-20°C)	7000 (-20°C)	7000 (-20°C)	7000 (-20°C)
	20W-xx	4500 (-10°C)	9500 (-15°C)	9500 (-15°C)	9500 (-15°C)	9500 (-15°C)	9500 (-15°C)	9500 (-15°C)	9500 (-15°C)	9500 (-15°C)
<b>Viscosity index</b> (ASTM D2270), min.	xW-xx						-			
	30						75			
	40, 50						80			
<b>Pour point</b> (ASTM D97), °C, max.	0W-xx	-40					-40			
	5W-xx	-35					-35			
	10W-xx	-30					-30			
	15W-xx	-23					-25			
	20W-xx	-18					-20			
	30	-15					-15			
	40	-10					-10			
	50	-5					-5			
<b>Borderline pumping temperature</b> (ASTM D3829), °C, max.	0W-xx	-35	-							
	5W-xx	-30	-							
	10W-xx	-25	-							
	15W-xx	-20	-							
	20W-xx	-15	-							
<b>Low temperature pumping viscosity</b> (ASTM D4684), mPa.s, max.(no yield stress)	0W-xx	-	60000 (-40°C)	60000 (-40°C)	60000 (-40°C)	60000 (-40°C)	60000 (-40°C)	60000 (-40°C)	60000 (-40°C)	60000 (-40°C)
	5W-xx	-	60000 (-35°C)	60000 (-35°C)	60000 (-35°C)	60000 (-35°C)	60000 (-35°C)	60000 (-35°C)	60000 (-35°C)	60000 (-35°C)
	10W-xx	-	60000 (-30°C)	60000 (-30°C)	60000 (-30°C)	60000 (-30°C)	30000 (-25°C)	60000 (-30°C)	60000 (-30°C)	60000 (-30°C)
	15W-xx	-	60000 (-25°C)	60000 (-25°C)	60000 (-25°C)	60000 (-25°C)	60000 (-25°C)	60000 (-25°C)	60000 (-25°C)	60000 (-25°C)
	20W-xx	-	60000 (-20°C)	60000 (-20°C)	60000 (-20°C)	60000 (-20°C)	60000 (-20°C)	60000 (-20°C)	60000 (-20°C)	60000 (-20°C)

**GB 11121 - 2006 <sup>(#)</sup> - Passenger car gasoline engine oil**  
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PERFORMANCE CATEGORY	SE	SF	SG	SH	SJ	SL	GF-1 <sup>(2)</sup>	GF-2 <sup>(2)</sup>	GF-3 <sup>(2)</sup>
	Viscosity grades <sup>(1)</sup>		0W-20, 0W-30, 5W-20, 5W-30, 5W-40, 5W-50, 10W-30, 10W-40, 10W-50, 15W-30, 15W-40, 15W-50, 20W-40, 20W-50, 30, 40, 50						
<b>High temperature high shear viscosity, (ASTM D4741), mPa.s, min.</b>	xW-20  0W-30, 5W-30, 5W-40, 10W-30, 10W-40, 15W-30  5W-50, 10W-50, 15W-40, 15W-50, 20W-40, 20W-50	-  -				2.6  2.9  3.7			
<b>Water (ASTM D95), %, max.</b>						Trace (0.03)			
<b>Mechanical impurities (ASTM D2273), wt%, max.</b>						0.01			
<b>Flash point (COC), (ASTM D92), °C, min.</b>	0W-xx, 5W-xx  10W-xx  15W-xx, 20W-xx  30, 40, 50					200  205  215  220(30), 225(40), 230(50)			
<b>TBN (ASTM D2896), Sulphated ash (ASTM D874), Sulfur (ASTM D4951), Nitrogen (ASTM D5762) <sup>(4)</sup></b>						Report			
<b>Engine test and laboratory tests corresponding API requirements (including their footnotes) <sup>(5)</sup></b>						Yes			

**Notes:**

- (1) Note that all P&C and bench tests are treated as critical limits by China authorities who sample finished oils from the market for quality check (although ASTM D4485 is included in 'Reference Documents'). Delivery inspections<sup>1</sup> are required. Batch inspections: KV, VI, CCS, PP, Impurities, water, FP, foaming, high temp, foaming, ash, TBN, Nitrogen and Phosphorus. Periodic inspections (every 6 months): volatility, borderline pumping temperature; MRV; HTHS and sulfur. Periodic inspections (once a year): gelation index, high temp, deposit, homogeneity and miscibility, filterability, L-39 or Seq. VIII.  
For the latest API oil categories or other oil categories not listed in GB 11121: Lubricant manufacturers' 'Enterprise Standard' is allowed with following conditions: 'Enterprise Standard' is more stringent than GB 11121; Get approval from and keep record in local authorities.  
(1) Early version of SAE J3000 fresh oil properties are listed within respective category: SAE J3000-1987 (corresponding to GB/T 14906-94) for SE and SF, SAE J3000-1999 for other categories.  
(2) GF-x specifications are obsolete under ILSAC (only the latest version is in use at any time) but adopted by GB without reference to ILSAC because there is no Energy Conserving or Resource Conserving listed in GB.  
(3) Corresponding ASTM test methods are listed instead of original Chinese methods (i.e.: GB/T or SH/T) if applicable (e.g.: GB/T 265 is corresponding to ASTM D445; SH/T 260 is modified in relation to ISO 3733:1999, which is corresponding to ASTM D95).  
(4) At the time of ex-factory of each batch of products, the producer shall report the actual measured value of this item to the users and dealers, if any disputes, the result of engine test shall prevail. 'Report' of phosphorus (ASTM D5185) is also required for SE & SF.  
(5) The original specification tests and limits are listed but replacement tests and limits for older categories can be used. Additional requirements: Volatility for SF, use API SH/SG limits; Foaming (ASTM D892) for SE and SF: 25/0, 150/0, 25/0.

# GB 11122 - 2006 <sup>(#)</sup> - Heavy duty diesel engine oil

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PERFORMANCE CATEGORY	Viscosity grades <sup>(1)</sup>	CC	CD	CF	CF-4	CH-4	CI-4 <sup>(2)</sup>
Viscosity at 100°C (ASTM D445) <sup>(3)</sup> , mm <sup>2</sup> /s			0W-20, 0W-30, 0W-40, 5W-20, 5W-30, 5W-40, 5W-50, 10W-30, 10W-40, 10W-50, 15W-30, 15W-40, 15W-50, 20W-40, 20W-50, 20W-60, 30, 40, 50, 60	SAE J300 <sup>(1)</sup>			
Low temperature cranking (ASTM D5293), mPa.s, max.	0W-xx 5W-xx 10W-xx 15W-xx 20W-xx	3250 (-30°C) 3500 (-25°C) 3500 (-20°C) 3500 (-15°C) 4500 (-10°C)			6200 (-35°C) 6600 (-30°C) 7000 (-25°C) 7000 (-20°C) 9000 (-15°C)		
Viscosity index (ASTM D2270), min.	xW-xx 30 40, 50			- 75 80			
Pour point (ASTM D97), °C, max.	0W-xx 5W-xx 10W-xx 15W-xx 20W-xx 30 40 50, 60		-40 -35 -30 -23 -18 -15 -10 -5			-40 -35 -30 -25 -20 -15 -10 -5	
Pumping temperature (ASTM D3829), °C, max.	0W-xx 5W-xx 10W-xx 15W-xx 20W-xx	-35 -30 -25 -20 -15	-35 -30 -25 -20 -15	- - - - -	- - - - -	- - - - -	- - - - -
Low temperature pumping viscosity (ASTM D4684), mPa.s, max.(no yield stress)	0W-xx 5W-xx 10W-xx 15W-xx 20W-xx		- - - - -			60000 (-40°C) 60000 (-35°C) 60000 (-30°C) 60000 (-25°C) 60000 (-20°C)	

# GB 11122 - 2006 <sup>(#)</sup> - Heavy duty diesel engine oil

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PERFORMANCE CATEGORY	Viscosity grades <sup>(3)</sup>	SE	SF	SG	SH	SJ	SL
			0W-20, 0W-30, 0W-40, 5W-20, 5W-30, 5W-40, 5W-50, 10W-30, 10W-40, 10W-50, 15W-30, 15W-40, 15W-50, 20W-40, 20W-50, 20W-60, 30, 40, 50, 60				
<b>High temperature high shear viscosity,</b> (ASTM D4741), mPa.s, min.	xW-20  OW-30, 5W-30, 5W-40, 10W-30, 10W-40, 15W-30  5W-50, 10W-50, 15W-40, 15W-50, 20W-40, 20W-50, 20W-60	-  -  -	2.6  2.9  3.7	2.6  2.9  3.7	2.6  2.9  3.7	2.6  2.9  3.7	3.5  3.5  3.7
<b>Water</b> (ASTM D95), %, max.				Trace (0.03)			
<b>Mechanical impurities</b> (ASTM D2273), wt%, max.				0.01			
<b>Flash point</b> (COC), (ASTM D92), °C, min.	0W-xx, 5W-xx  10W-xx  15W-xx, 20W-xx  30, 40, 50, 60			200  205  215  220 (30), 225 (40), 230 (50), 240 (60)			
<b>TBN</b> (ASTM D2896), <b>Sulphated ash</b> (ASTM D874), <b>Sulfur</b> (ASTM D4951), <b>Phosphorus</b> (ASTM D5185), <b>Nitrogen</b> (ASTM D5762) <sup>(4)</sup>				Report			
<b>Engine test and laboratory tests corresponding API requirements (including their footnotes)</b> <sup>(5)</sup>				Yes			

**Notes:**

(4) Note that all P&C and bench tests are treated as critical specifications by China authorities who sample finished oils from the market for quality check (although ASTM D4485 is included in 'Reference Documents'). Delivery inspections<sup>1</sup> are required. Batch inspections: KV, VI, CCS, PR; Impurities, water, FP, foaming, ash, TBN, Nitrogen and Phosphorus. Periodic Inspections (every 6 months): volatility, borderline pumping temperature; MRV; HTHS and sulfur. Periodict inspections (once a year): corrosion, high temp. corrosion, KV after shearing, L-38 or Seq. VIII.

For the latest API oil categories or other oil categories not listed in GB 11122: Lubricant manufacturers' 'Enterprise Standard' is allowed with following conditions: 'Enterprise Standard' is more stringent than GB 11122; Get approval from and keep record in local authorities.

(1) Early version of SAE J300 fresh oil properties are listed within respective category: SAE J300-1987 (corresponding to GB/T 14906-94) for CC and CD, SAE J300-1999 for other categories.

(2) There is no CI-4+ in GB.

(3) Corresponding ASTM test methods are listed instead of original Chinese methods (i.e.: GB/T or SH/T) if applicable (e.g.: GB/T 265 is corresponding to ASTM D445; SH/T 260 is modified in relation to ISO 3733:1999, which is corresponding to ASTM D95).

(4) At the time of ex-factory of each batch of products, the producer shall report the actual measured value of this item to the users and dealers, if any disputes, the result of engine test shall prevail.

(5) The original specification tests and limits are listed but replacement tests and limits for older categories can be used. Additional foaming (ASTM D892) requirements: For CF and CF-4: 20/0, 50/0, 20/0; For CD and CC: 25/0, 150/0, 25/0.

# GLOBAL DHD-1 specification

- 1 -



Laboratory tests	Limits
<b>Foaming tendency w/o option A</b> (ASTM D892), ml, max.	
Sequence I	10 / 0 <sup>(1)</sup>
Sequence II	50 / 0 <sup>(1)</sup>
Sequence III	10 / 0 <sup>(1)</sup>
<b>High temperature foaming</b> (ASTM D6082), ml, max.	100 / 0 <sup>(1)</sup>
<b>Sulfated ash</b> (ASTM D874), % m/m, max.	2.0
<b>Base number</b> (ASTM D4739), mg KOH/g, min.	10
<b>HTCBT at 135°C</b> (ASTM D6594), ppm increase, max.	
Copper	20
Lead	120
Tin	50
<b>Copper strip rating</b> (acc. to ASTM D130), max.	3.5
<b>Kinematic viscosity at 100°C</b> (ASTM D445), mm <sup>2</sup> /s.	SAE J300
<b>Low temperature cranking viscosity</b> (ASTM D5293), mPa.s at -xx°C	SAE J300
<b>Pumpability</b> (ASTM D4684), 60.000 mPa.s max. at -xx°C	SAE J300
<b>NOACK volatility</b> , ASTM D5800 or CEC L-40-93, % loss, max.	15
<b>Shear stability</b> , ASTM D3945 or CEC L-14-A-93	
Kin. Visc. at 100°C after 30 cycle Bosch shearing, mm <sup>2</sup> /s, min.	Stay in grade
<b>Oxidation induction time</b> , PDSC, CEC-L-085-99, Min, min.	35
<b>Elastomer compatibility</b> , CEC-L-039-96 <sup>(2)</sup>	Pass

**Notes:**

(1) After 1 min. settling.

(2) Please refer to chapter "Elastomer Compatibility" for limits.

# GLOBAL DHD-1 specification

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Engine tests	Limits
Run number	1 / 2 / 3
<b>Aeration, EOAT (ASTM RR D02-1379)</b> Oil Aeration at 20 h., %, max.	8.0
<b>OM 441 LA (CEC L-52-T-97)</b> Bore polishing, average, %, max. Piston cleanliness, average, merit, min. Boost pressure loss, 400 h, %, max. Specific oil consumption, kg/test, max.	2.0 25.0 4 40
<b>Mack T-9 (ASTM D6483)</b> Average liner wear at 1.75% soot, $\mu\text{m}$ , max. Top ring weight loss, mg, max. Used oil lead increase, ppm, max. TAN increase at EOT, max.	25.4 / 26.6 / 27.1 120 / 136 / 144 15 <sup>(3)</sup> 2.0
<b>Cummins M11 (300 h extended test) (ASTM RR:D02-1440)</b> Rocker pad total weight loss at 4.5% soot, mg, max. Engine sludge at 200 h, CRC merit, min. Oil filter AP at 200 h, kPa, max.	6.5 / 7.5 / 8.0 8.7 / 8.6 / 8.5 79 / 93 / 100
<b>Caterpillar 1R (ASTM D6923) <sup>(4)</sup></b> Weighted total demerit, max. Top groove carbon fill, %, max. Top land carbon, %, max. Average initial oil consumption, 0-252 h, g/h, max. Average final oil consumption, 432-504 h, g/h, max. Piston ring sticking and liner scuffing	397 / 416 / 440 40 / 42 / 44 37 / 42 / 46 13.1 1.5X Initial None
<b>Sequence IIIF (ASTM D6984) <sup>(5)</sup></b> Viscosity increase at 40°C at 60 h (unadjusted), %, max.	200
<b>Mack T-8E (300 h extended test) (ASTM D5967)</b> Relative viscosity at 4.8% soot TGA, max.	2.1 / 2.2 / 2.3
<b>Mitsubishi Fuso 4D34T4 Valve train wear test (JASO M 354:1999)</b> Avg.cam diameter loss, $\mu\text{m}$ , max. <sup>(6)</sup>	95
<b>Roller Follower Wear Test (ASTM D5966)</b> Pin wear, $\mu\text{m}$ , max.	7.6 / 8.4 / 9.1

**Notes:**

(3) Lead max. 25 ppm, if fresh oil has TBN (ASTM D4739) greater than 10.

(4) The Caterpillar 1R requirements may be satisfied with a passing API CH-4 test result in the Caterpillar 1P.

(5) The Sequence IIIF oxidation requirements may be satisfied with a passing API CH-4 test result in the Sequence IIIE.

(6) Normalized at 4.5 mass % carbon residue increase.

# JASO DH-1, DH-2, DH-2F, DL-0, DL-1 specification - Laboratory test

- 1 -



Specifications	DH-1-05	DH-1-14 DH-1-15 DH-1-17	DH-2-08	DH-2-14 DH-2-15 DH-2-17 DH-2F-17	DL-0-17	DL-1-08	DL-1-14 DL-1-15 DL-1-17
SAE Viscosity grades	-	-	-	-	-	xW-20, xW-30	xW-20, xW-30
Laboratory tests	Limits						
Kinematic viscosity at 100°C (ASTM D445), mm <sup>2</sup> /s.	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
HHTS viscosity (ASTM D4683), mPa.s, min.	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
Low temperature cranking viscosity (ASTM D5293), mPa.s at -xx°C	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
Pumpability (ASTM D4684), 60.000 mPa.s max. at -xx°C	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300	SAE J300
Hot surface deposit control at 280°C (JPI-5S-55-99), merit, min.	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Foaming tendency w/o option A (ASTM D892), ml, max.							
Sequence I	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
Sequence II	50 / 0	50 / 0	50 / 0	50 / 0	50 / 0	50 / 0	50 / 0
Sequence III	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
High temperature foaming (ASTM D6082), ml, max.	-	-	-	-	100 / 0	100 / 0	100 / 0
NOACK volatility (ASTM D5800), % loss at 250°C, max.	18.0	18.0	18.0	18.0	15	15	15
HTCBT at 135°C (ASTM D6594), ppm increase, max.							
Copper	20	20	20	20	20	20	20
Lead	120	120	100	100	120	120	120
Tin	50	50	50	50	50	50	50
Copper strip rating (acc. to ASTM D130), max.	3	3	3	3	3	3	3
Shear stability (ASTM D6278) Kin. Visc. at 100°C after 30 cycle Bosch shearing, mm <sup>2</sup> /s, min.	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	Stay in grade <sup>(1)</sup>	xW-30; 8.6 xW-20; Stay in grade <sup>(1)</sup>	xW-30; 8.6 xW-20; Stay in grade <sup>(1)</sup>
Sulfated ash (ASTM D874), % m/m, max.	Report	Report	1.0 3 0.1	1.0 3 0.1	1.6	0.6	0.6
Base number (ASTM D4739), mg KOH/g, min.	10.0 <sup>(2)</sup>	10.0 <sup>(2)</sup>	-	-	-	Report <sup>(2)</sup>	Report <sup>(2)</sup>
Base number (JIS K2501:2003 8.), mg KOH/g, min.	10.0 <sup>(2)</sup>	10.0 <sup>(2)</sup>	5.5	5.5	-	Report <sup>(2)</sup>	Report <sup>(2)</sup>
Base number (ASTM D2896 or JIS K2501:2003 9.), mg KOH/g, min.	-	-	-	-	8.0	-	-

**JASO DH-1, DH-2, DH-2F, DL-0, DL-1 specification - Laboratory test**  
**- 2 -**



Specifications	DH-1-05	DH-1-14 DH-1-15 DH-1-17	DH-2-08	DH-2-14 DH-2-15 DH-2-17 DH-2F-17	DL-0-17	DL-1-08	DL-1-14 DL-1-15 DL-1-17
SAE Viscosity grades	-	-	-	-	-	xW-20, xW-30	xW-20, xW-30
Laboratory tests	Limits						
Phosphorus (ASTM D5185), % m/m, max.	Report	Report	0.12	0.12	Report	0.1	0.1
Sulfur (ASTM D5185), % m/m, max.	Report	Report	0.5	0.5	Report	0.5	0.5
Chlorine (ASTM D6443), ppm, max.	Report	Report	150	150	Report	150	150
Elastomer compatibility (CEC L-39-T-96) <sup>(3)</sup> or Elastomer compatibility (ASTM D7216) <sup>(3)</sup>	Pass -	Pass Pass	Pass -	Pass Pass	Pass Pass	Pass -	Pass Pass

**Notes:**

- (1) Only for multi grade oils.
- (2) Only one of Base number has to be run.
- (3) Only one of Elastomer compatibility has to be run. Please refer to chapter "Elastomer Compatibility" for limits.

# JASO DH-1, DH-2, DH-2F, DL-0, DL-1 specification - Engine test

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Specifications	DH-1-05 DH-2-08	DL-1-08	DH-1-14 DH-2-14	DL-1-14	DH-1-15 DH-2-15	DL-1-15	DH-1-17 DH-2-17 DL-0-17	DH-2F	DL-1-17
First date when classification indication is allowed	-		October 1, 2014		October 1, 2015			October 1, 2017	
Last date when a new reporting is accepted	March 31, 2016		March 31, 2017		March 31, 2018			-	
On-file termination date	September 30, 2019		September 30, 2020		September 30, 2021			-	
Engine tests									
Limits									
<b>Nissan Diesel TD25 Piston detergency test (JASO M 336:1998)<sup>(1)</sup></b>									
Top groove fill, %, max.	60.0	60.0	-	-	-	-	-	-	-
Deposits on ring lands, merit	Report	Report	-	-	-	-	-	-	-
Piston ring sticking	All free	All free	-	-	-	-	-	-	-
<b>Hino N04C Piston detergency test (JASO M 336:2014)</b>									
Weighted Total Demerit, max.	-	-	740	740	740	740	740	740	740
Top groove fill, %, max.	-	-	Report	Report	Report	Report	Report	Report	Report
Deposits on ring lands, merit	-	-	Report	Report	Report	Report	Report	Report	Report
Piston ring sticking	-	-	All free	All free	All free	All free	All free	All free	All free
<b>Mitsubishi Fuso 4D34T4 Valve train wear test (JASO M 354:2006)</b>									
Avg.cam diameter loss, µm, max. <sup>(2)</sup>	95.0	95.0	95.0	95.0	-	-	-	-	-
Max.cam diameter loss, µm, max. <sup>(2)</sup>	210	210	210	210	-	-	-	-	-
Cam surface wear	No pitting	No pitting	No pitting	No pitting	-	-	-	-	-
<b>Hino N04C Valve train wear test (JASO M 354:2015)</b>									
Tappet Wear, µm, max.	-	-	-	-	11.3	11.3	11.3	11.3	11.3
<b>Mack T-8A (ASTM D5967) <sup>(3)</sup></b>									
Viscosity increase (100 to 150 h.) at 100°C, mm <sup>2</sup> /s/h., max.	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
<b>or Mack T-8E (ASTM D5967) <sup>(3)</sup></b>									
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Relative viscosity at 100°C at 4.8% soot, max.	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3	2.1 - 2.2 - 2.3

# JASO DH-1, DH-2, DH-2F, DL-0, DL-1 specification - Engine test

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Specifications	DH-1-05 DH-2-08	DL-1-08	DH-1-14 DH-2-14	DL-1-14	DH-1-15 DH-2-15	DL-1-15	DH-1-17 DH-2-17 DL-0-17	DH-2F	DL-1-17
First date when classification indication is allowed	-		October 1, 2014		October 1, 2015			October 1, 2017	
Last date when a new reporting is accepted	March 31, 2016		March 31, 2017		March 31, 2018			-	
On-file termination date	September 30, 2019		September 30, 2020		September 30, 2021			-	
Engine tests									
Limits									
<b>or Mack T-11 (ASTM D7156)<sup>(3)</sup></b>									
Run number	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3	1 - 2 - 3
Minimum % TGA Soot at 4.0 cSt increase at 100°C	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3	3.5 - 3.4 - 3.3
Minimum % TGA Soot at 12.0 cSt increase at 100°C	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9	6.0 - 5.9 - 5.9
Minimum % TGA Soot at 15.0 cSt increase at 100°C	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5	6.7 - 6.6 - 6.5
<b>SEQUENCE IIIE (ASTM D5533), or SEQUENCE IIIF (ASTM D6984), or SEQUENCE IIIG (ASTM D7320)<sup>(4)</sup></b>	IIIE, or IIIF, or IIIG	IIIF, or IIIG	IIIE, or IIIF, or IIIG	IIIF, or IIIG	IIIE, or IIIF, or IIIG	IIIF, or IIIG	IIIE, or IIIF, or IIIG	IIIE, or IIIF, or IIIG	IIIF, or IIIG
Viscosity increase at 40°C, increase after 64 h, %, max. (IIIE)	200	-	200	-	200	-	200	200	-
Viscosity increase at 40°C, increase after 60 h, %, max. (IIIF)	295	275 (after 80 h.)	295	275 (after 80 h.)	295	275 (after 80 h.)	295	295	275 (after 80 h.)
Viscosity increase at 40°C, increase after 100 h, %, max. (IIIG)	150	150	150	150	150	150	150	150	150
<b>Hino N04C Fuel economy test (JASO M 362:2017)</b>									
Average fuel economy improvement (fresh oils), %, min.	-	-	-	-	-	-	-	3.7	-
Sum of average fuel economy improvement (fresh + aged oils), %, min. <sup>(5)</sup>	-	-	-	-	-	-	-	6.8	-
<b>M111 Fuel economy test (CEC L-54-T-96)<sup>(6)</sup></b>									
Fuel economy improvement, %, min.	-	2.5	-	2.5	-	2.5	-	-	2.5

**Notes:**

(1) TD25 engine is no longer supplied since March 2009.

Alternative detergency tests for DH-1-05 and DH-2-08 are: Caterpillar 1K (ASTM D6750), Caterpillar 1N (ASTM D6750), Caterpillar 1P (ASTM D6681), Caterpillar 1R (ASTM D6923), Caterpillar C13 (ASTM D7549) according to the limits of API CH-4, CI-4 and CJ-4.

Alternative detergency test for DL-1-08 is: VWTD12 (CEC-L-78-T-99) according to the limits of ACEA C2-08.

(2) Normalized at 4.5 mass % carbon residue increase.

(3) Only one of the Mack tests has to be run.

(4) Only one of the Sequence III tests has to be run.

(5) Aged oil after 200 h operation, which was obtained according to the JASO M 336 or JASO M 354, shall be used.

(6) Not required for 10W-30.

# MIL-PRF-2104H specification <sup>(2)</sup>

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Laboratory tests	Limits		
SAE Viscosity grades	40	15W-40	5W-40
<b>Foaming tendency w/o option A</b> (ASTM D892), ml, max.			
Sequence I	10 / 0 <sup>(1)</sup>	10 / 0 <sup>(1)</sup>	10 / 0 <sup>(1)</sup>
Sequence II	50 / 0 <sup>(1)</sup>	50 / 0 <sup>(1)</sup>	50 / 0 <sup>(1)</sup>
Sequence III	10 / 0 <sup>(1)</sup>	10 / 0 <sup>(1)</sup>	10 / 0 <sup>(1)</sup>
<b>Sulfated ash</b> (ASTM D874), % m/m, max.	1.5	1.5	1.5
<b>HTCBT at 135°C</b> (ASTM D6594), ppm increase, max.			
Copper	20	20	20
Lead	120	120	120
Tin	50	50	50
Copper strip rating (acc. to ASTM D130), max.	3	3	3
<b>HTHS viscosity</b> (ASTM D4683), mPa.s, min.	-	3.7	3.7
<b>Kinematic viscosity at 100°C</b> (ASTM D445), mm <sup>2</sup> /s.	SAE J300	SAE J300	SAE J300
<b>Low temperature cranking viscosity</b> (ASTM D5293), mPa.s at -xx°C	-	SAE J300	SAE J300
<b>Pumpability</b> (ASTM D4684), 60.000 mPa.s max. at -xx°C	-	SAE J300	SAE J300
<b>NOACK volatility</b> , ASTM D5800 or CEC L-40-93, % loss, max.	-	15	15
<b>Shear Stability KV100</b> , CEC L-014-93 or ASTM D3945, Kin. Viscosity, mm <sup>2</sup> /s	-	Stay in grade	Stay in grade
<b>Flash Point</b> , ASTM D92, °C, min.	225	215	210
<b>Pour point</b> , ASTM D97 or D5950, °C, max.	-15	-25	-40
<b>Allison C-4 Elastomer compatibility</b> (GMN10055) <sup>(2)</sup>	Pass	Pass	Pass
<b>Allison C-4 Graphite and paper friction</b>	$\geq$ qualified batch sample mean mid-point friction coefficient minus 0.012 $\leq$ max. acceptable slip time criteria		
Mid-point dynamic friction			
Slip time			
<b>Caterpillar TO-4/TO-4M</b> (SEQ1220)			
Avg.dynamic coefficient, %	90.0-140.0		
Avg.static coefficient, %	91.0-127.0		
Disc wear, mm, max.	0.04		
Energy limit, m/s, min.	25		

## MIL-PRF-2104H specification <sup>(2)</sup>

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Laboratory tests	Limits		
SAE Viscosity grades	40	15W-40	5W-40
<b>Caterpillar TO-4/TO-4M (SEQFRRET)</b>			
Avg.dynamic coefficient, %			
at 3000 cycles	85.0-130.0		
at 8000 cycles	90.0-125.0		
at 15000 cycles	90.0-125.0		
at 25000 cycles	95.0-125.0		
<b>Caterpillar TO-4M, EHD Film-Forming</b>			
% of Elastohydrodynamic (EHD) reference film thickness at 2 m/s			
at 70 °C	-	≥90	
at 100 °C	-	≥96	
at 130 °C	-	≥98	
<b>Homogeneity and miscibility (ASTM D6922)</b>	Pass <sup>(3)</sup>	Pass <sup>(3)</sup>	Pass <sup>(3)</sup>

**Notes:**

(1) After 1 min. settling.

(2) Specification covers engine oils suitable for lubrication of reciprocating compression-ignition internal combustion engines and for power transmission fluid applications.

(3) Shall remain homogenous and, when mixed with ASTM reference oils, shall remain miscible.

**MIL-PRF-2104H specification <sup>(2)</sup>**  
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Engine tests	Limits
SAE Viscosity grades	All
Aeration, EOAT (ASTM RR D02-1379)	
Oil Aeration at 20 h., %, max.	8.0
Caterpillar 1K (ASTM D6750) <sup>(4)</sup>	Run number
Weighted total demerit, max.	1 / 2 / 3 332 / 347 / 353
Top groove carbon fill, %, max.	24 / 27 / 29
Top land heavy carbon, %, max.	4 / 5 / 5
Oil consumption, g/kWh, max.	0.5 g/hph
Piston ring sticking and liner scuffing	None
Caterpillar 1P (ASTM D6681)	Run number
Weighted total demerit	1 / 2 / 3 350 / 378 / 390
Top groove carbon fill, %	36 / 39 / 41
Top land heavy carbon, %	40 / 46 / 49
Average oil consumption, 0-360 h, g/h	12.4
Final oil consumption, 336-360 h, g/h	14.6
Piston ring and liner scuffing	Report
Final oil cons., g/h, max., 312-360h	14.6
Cummins M11 EGR (ASTM D6975)	Run number
Crosshead total weight loss at 4.6% average soot, mg, max.	1 - 2 - 3 20.0 - 21.8 - 22.6
Oil filter ΔP at 250 h, kPa, max.	275 - 320 - 341
Engine sludge at end-of-test, CRC merit, min.	7.8 - 7.6 - 7.5
Top ring weight loss, mg, max.	175 - 186 - 191
Mack T-8E (300 h extended test) (ASTM D5967)	Run number
Relative viscosity at 4.8% soot TGA, max.	1 - 2 - 3 1.8 - 1.9 - 2.0
Mack T-10 (ASTM D6987)	
Merit rating, min.	1000
Used oil pumpability at 75 h., MRV at -20°C, mPa.s, max. <sup>(5)</sup>	25.000 (NYS)

## MIL-PRF-2104H specification <sup>(2)</sup>

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Engine tests	Limits
SAE Viscosity grades	All
<b>DETROIT DIESEL DD6V 92TA (ASTM D5862) <sup>(1)</sup></b>	
Broken rings.	1 - 2 - 3
Liner distress, avg. % area, max.	none
Piston rings face distr.fire ring, demerit, max.	60.0 - 63.5 - 65.0
Piston rings face distr., avg. 2 <sup>nd</sup> +3 <sup>rd</sup> ring, demerit, max.	0.33 - 0.34 - 0.36
Cylinder liner port plugging area, avg., %, max.	0.28 - 0.29 - 0.30
Cylinder liner port plugging area, single cylinder, %, max.	2 - 2 - 2
<b>ROLLER FOLLOWER WEAR TEST (RFWT) (ASTM D5966)</b>	
Average Pin Wear, ( $\mu\text{m}$ ) max	5 - 5 - 5
<b>Sequence IIIF (ASTM D6984)</b>	
Viscosity (at 40°C), increase from 10 min sample, % max (IIIF)	1 - 2 - 3
	7.6 - 8.4 - 9.1
	275 (MTAC)

**Notes:**

(1) Per ASTM D5862, with the exception that ratings from any five of the six cylinders shall be averaged.

(2) Specification covers engine oils suitable for lubrication of reciprocating compression-ignition internal combustion engines and for power transmission fluid applications.

(3) If yieldstress is detected, modified ASTM D4684 can be used.

**OEM  
requirements  
for Gasoline  
and Diesel  
engine oils**



## BMW Long Life specification overview

- 1 -



BMW Specifications	LL-01	LL-01 FE	LL-04	LL-12 FE	LL-14 FE+	LL-17 FE+
Application	Minimum level for Gasoline from MY2002	All Gasoline engines from MY 2005	Mandatory for DPF Diesels	Standard BMW Diesels from MY 2013 onwards. (Not backward compatible)	ONLY for EU and USA	Backward compatible with LL-14 FE+
	Minimum level for non-DPF Diesels from MY2003	OK for older Gasoline engines with Valvetronic	OK for non-DPF Diesels	NOT allowed for high power Diesels. Check manual for details. (Rule of thumb: Multiple turbos)	Allowed for Gasoline from MY 2013 with N20 and "Baukasten" engines	ONLY for EU, NAFTA, China
	OK for older engines	Not allowed for Diesel Engines	OK for gasoline from MY 2002 in Europe only	OK for gasoline from MY 2002 in Europe only	NOT allowed for other engines	Mandatory for engines with Gasoline Particulate Filters (GPF's)
	Not allowed for M engines in general, only for new S55- and S63-M-engines	Not allowed for M engines in general, only for new S55- and S63-M-engines	Not allowed for M engines in general, only for new S55- and S63-M-engines	Not allowed for M engines in general, only for new S55- and S63-M-engines	Not allowed for M engines in general, only for new S55- and S63-M-engines	OK for Gasoline from MY 2013 with N20 and "Baukasten" engines NOT allowed for other engines Not allowed for M engines in general, only for new S55- and S63-M-engines
ACEA basis	A3/B4 <sup>-16</sup>	A5/B5 <sup>-16</sup>	C3 <sup>-16</sup> excl. P limit	C2 <sup>-16</sup>	C5 <sup>-16</sup> excl. S. Ash limit	C5 <sup>-16</sup>
SAE Viscosity grade	0/5W-30/40	xW-30	0/5W-30/40	xW-30	xW-20	xW-20
HTHS viscosity (CEC L-036-90), mPa.s, min.	3.5	3.0	3.5	2.9	2.6	2.6
Kin. viscosity at 100 °C, mm <sup>2</sup> /s	SAE J300	≥ 10.0	SAE J300	≥ 8.8	≥ 7.8 & < 9.3	≥ 7.8 & < 9.3
Noack (ASTM D5800), %	ACEA	ACEA	ACEA	ACEA	ACEA	ACEA
TBN (ASTM D2896), mg KOH/g, min.	10.0	10.0	6.0	6.0	9.5	6.0
Sulfated ash (ASTM D874), % m/m	≤ 1.0 & ≤ 1.6	≤ 1.6	≤ 0.8	≤ 0.8	≤ 1.3	≤ 0.8
Pour Point (ASTM D97), °C, max.	-42 for 0W-xx, TBD for 5W-xx	-42	-42			

## BMW Long Life specification overview

- 2 -



BMW Specifications	LL-01	LL-01 FE	LL-04	LL-12 FE	LL-14 FE+	LL-17 FE+
<b>Required BMW laboratory tests:</b>						
FZG Wear test A10/16.6R/130 (CEC L-84-02), failure load stage, min.	8	8	8	8	8	8
<b>Required BMW engine tests:</b>						
<b>N20 Performance</b>						
Piston cleanliness (average 4 pistons), merit, min.	44.0	44.0	44.0	44.0	44.0	44.0
Engine sludge avg., merit, min.	9.1	9.1	9.1	9.1	9.1	9.1
Average weighted turbo deposits, merit, max.	2.2	2.2	2.2	2.2	2.2	2.2
Viscosity increase at 40°C, %, max.	20	20	20	20	20	20
Viscosity increase at 100°C, %, max.	20	20	20	20	20	20
Fe-content, ppm, max.	130	130	130	130	130	130
<b>N20 Aeration</b>						
Fresh oil, part 1 (Avg. run 3, 4, 5 at 6500 rpm), %, max.	4.0	4.0	4.0	4.0	4.0	4.0
Fresh oil, part 2 at 3125 ml, %, max.	15.0	15.0	15.0	15.0	15.0	15.0
Used oil (70h), part 1 (Avg. run 3, 4, 5 at 6500 rpm), %, max.	8.0	8.0	8.0	8.0	8.0	8.0
Used oil, part 2 at 3125 ml, %, max.	15.0	15.0	15.0	15.0	15.0	15.0
<b>N42 Valvetronic RNT , ratio: candidate/reference, max</b>	44.0	44.0	44.0	44.0	44.0	44.0
<b>B48 Gasoline fuel economy NEDC/WLTP/CAFE</b>	-	Pass <sup>(1)</sup>	-	Pass <sup>(1)</sup>	Pass <sup>(2)</sup>	Pass <sup>(2)</sup>
<b>B47 Diesel fuel economy WLTP</b>	-	-	-	Pass <sup>(3)</sup>	-	Pass <sup>(4)</sup>
<b>B47 Aeration</b>	-	-	Comparable or better than reference oil	Comparable or better than reference oil	-	Comparable or better than reference oil
<b>B47 Diesel turbo charger deposits test, merit, max</b>	-	-	1.6	1.6	-	1.6

**Notes:**

(1) Limit  $\geq -0.5\%$  vs OW-20 ref oil on NEDC and WLTP,  $\geq -0.4\%$  for CAFE

(2) Limit  $\geq 0.0\%$  vs OW-20 ref oil for NEDC, WLTP and CAFE

(3) Limit  $\geq -0.0\%$  vs OW-30 ref oil for WLTP

(4) Limit  $\geq -0.5\%$  vs OW-30 ref oil on WLTP

# CATERPILLAR Engine Crankcase Fluid (ECF) recommendations

- 1 -



	Model year 2007 <sup>(1)</sup>	Pre-model year 2007 <sup>(1)</sup>
Viscosity grades (SAE J300)		10W-30, 15W-40
Preferred	Cat DEO-ULS  Cat DEO and Cat DEO-ULS require in addition to the tests required for Cat ECF classifications, pass results in a number of Cat Proprietary multi-cylinder tests, field tests and a variety of quality assurance tests.	Cat DEO-ULS Cat DEO
Commercial lubricants	Cat ECF-3 / API CJ-4 <sup>(2)</sup>	Cat ECF-3 / API CJ-4 Cat ECF-2 Cat ECF-1-a

**Notes:**

- (1) The oils are listed in order of preference
- (2) Cat ECF-2 oils of ≤ 1 percent ash content are also allowed

Caterpillar specification	Application	Caterpillar ECF specifications requirements
Cat ECF-3	Caterpillar 2007 model year on-highway diesel engines. Also highly recommended for other Caterpillar engines in on-highway applications. Cat 3500 series and smaller machine and commercial diesel engines.	API CJ-4
Cat ECF-2	All 2006 model year and older Caterpillar on-highway diesel engines and Cat 3500 Series and smaller commercial and machine diesel engines. <u>Not applicable to Cat engines equipped with Diesel Particulate Filters (DPF)</u>	API CI-4 / CI-4 PLUS  Cat C13 500h. engine test as defined in the API CJ-4 oil category requirements and 2- Oils of sulfated ash >1.50 wt% are not allowed. Sulfated ash ≤ 1.50wt%  API oil categories older than API CI-4 may not claim to meet the Cat ECF-2 specification.
Cat ECF-1-a	All 2006 model year and older Cat on-highway diesel engines and Cat 3500 series and smaller commercial and machine diesel engines. Not applicable to Cat model year 2007 and newer on-highway engine models. Not applicable to Cat engines equipped with Diesel Particulate Filters (DPF).	API CH-4  Cat IP SCOTE <sup>(1)</sup> test (ASTM D6681). Sulfated ash ≤ 1.30wt%  If 1.30 < sulfated ash ≤ 1.50wt%, two passing Cat IP test (ASTM D4485) at the single pass limits API oil categories older than API CI-4 may not claim to meet Cat ECF-1-a specification.

**Notes:**

- (1) SCOTE Single Cylinder Oil Test Engine.

## CATERPILLAR Engine Crankcase Fluid (ECF) recommendations

- 2 -



Fuel sulfur level (ppm)	Cat engine oils	TBN of commercial engine oils (mg KOH/g)
≤ 500	Cat DEO-ULS, Cat DEO	≥ 7
> 500 - 1000	Cat DEO-ULS, Cat DEO	≥ 7
> 1000	Cat DEO	≥ 10

## CHRYSLER GROUP LLC requirements - MS-6395 specification



Specification	MS-6395
Bench test requirements and limits	According to ILSAC GF-5
Engine test requirements and limits	According to ILSAC GF-5
Chrysler field test	
Chrysler vehicles for 100000 miles in taxicabs in Las Vegas over two summers and one winter	Pass

# CUMMINS Engineering Standards (CES)

- 1 -



CES Number	20076	20077	20078	20081	20086 / 20087
API, ACEA, JASO performance level	API CH-4/SJ, ACEA E5, JASO DH-1	API CH-4/SJ, ACEA E5, JASO DH-1	API CI-4, ACEA E7	API CJ-4, ACEA E9, JASO DH-2	API CK-4 / FA-4
Viscosity grades (SAE J300)	xW-30, xW-40	10W-30, 10W-40, 15W-40	xW-30, xW-40	xW-30, xW-40	xW-30, xW-40 / xW-30
<b>Laboratory tests <sup>(1)</sup></b>					
Viscosity at 40°C (ASTM D445), mm <sup>2</sup> /s at 100°C	Report Per SAE J300	Report Per SAE J300	Report Report	Report Report	Report Report
Shear stability (ASTM D3945, D6278, D7109, CEC L-14-A-96)				D7109 (90 cycles)	D7109 (90 cycles)
Kinematic viscosity at 100°C (ASTM D445), mm <sup>2</sup> /s, min.	xW-30: 9.5, xW-40: 12.5	Stay in grade	xW-30: 9.3, xW-40: 12.5	xW-30: 9.3, xW-40: 12.5	xW-30: 9.3; 0W-40: 12.5; xW-40: 12.8
Low temperature cranking and pumping viscosity					
CCS (ASTM D5293), mPa.s, max.	Per SAE J300	Per SAE J300	Report	Report	Report
MRV (ASTM D4684), mPa.s, max.	Per SAE J300	Per SAE J300	Report	Report	Report
HTHS viscosity (ASTM D4683, CEC L-36-90), mPa.s, min.	3.7	Per SAE J300	3.5	3.5	3.5 / 2.9 - 3.2
Gelation index (ASTM D5133), max.	12	-	12	12	12
Evaporative loss (Noack) (ASTM D5800), %, max. (CEC L-40-A-93), %, max.	xW-30: 20, xW-40: 18	- 12	15 -	xW-30: 15, xW-40: 13 -	13 -
TBN (ASTM D2896), mg KOH/g, min. (ASTM D4739), mg KOH/g, min.	Report -	Report -	- 10.0	Report Report	Report Report
TAN (ASTM D664), mg KOH/g	Report	Report	Report	Report	Report
Sulfated ash (ASTM D874), % m/m, max.	Run number 1.85	1.85	1.85	1.00 / 1.02 / 1.03	1.0 / 1.0 / 1.0
Ba, Bo, Ca, Cu, Mg, Mo, Si, Na, Zn (ICP)	Report	Report	Report	Report	Report
Phosphorus (ASTM D4951), % m/m, max.	Report	Report	Report	0.12	0.12
Sulfur (ASTM 4951), % m/m, max.	Report	Report	Report	0.4	0.4
Nitrogen (ASTM D4629 / D5762), % m/m	Report	Report	Report	Report	Report
Infrared spectrum (CES 60005)	Report	Report	Report	Report	Report
Oxidation induction time (PDSC) (CEC-L-85-T-99), min.	-	35	-	-	-

# CUMMINS Engineering Standards (CES)

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CES Number	20076	20077	20078	20081	20086 / 20087
<b>Elastomer compatibility</b> (CEC L-39-96, ASTM D7216) <sup>(2)</sup>					
Nitrile (NBR)	Pass	Pass	Pass	Pass	Pass
Silicone (VMQ)	Pass	Pass	Pass	Pass	Pass
Polyacrylate (ACM)	Pass	Pass	Pass	Pass	Pass
Fluor elastomer (FKM)	Pass	Pass	Pass	Pass	Pass
Vamac G (AEM)	-	-	-	Pass	Pass
<b>Corrosion tendency</b> (HTCBT) (ASTM D5968 at 275°F, D6594 at 135°C)	D5968	D5968	D6594	D6594	D6594
Copper increase, ppm, max.	20	20	20	20	20
Lead increase, ppm, max.	120	100	120	120	120
Tin increase, ppm, max.	50	100	50	50	50
Copper strip rating (ASTM D130), max.	3	-	3	3	3
<b>Foaming tendency</b>					
Sequence I (24°C), II (94°C), III (24°C) (ASTM D892) (No option A), ml, max.	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0	10 / 0, 20 / 0, 10 / 0	10 / 0, 20 / 0, 10 / 0	10 / 0, 20 / 0, 10 / 0
Sequence IV (150°C) (ASTM D6082), ml, max.	-	200 / 50	-	-	-
<b>Low temperature pumping viscosity</b> (75 / 180 h T10(A) / T11(A)) (ASTM D4684)					
MRV viscosity at -20°C, mPa.s, max.	-	-	25000	25000	18000
MRV yield stress	-	-	No yield stress	No yield stress	No yield stress

# CUMMINS Engineering Standards (CES)

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CES Number	20076	20077	20078	20081	20086 / 20087
<b>Engine tests <sup>(1)</sup></b>					
<b>Caterpillar 1P (ASTM D6681)</b>					
Weighted total demerit	Report	-	-	-	-
Top groove carbon fill, %	Report	-	-	-	-
Top land heavy carbon, %	Report	-	-	-	-
Average oil consumption, 0-360 h, g/h	Report	-	-	-	-
Final oil consumption, 336-360 h, g/h	Report	-	-	-	-
Piston ring and liner scuffing	Report	-	-	-	-
<b>Caterpillar 1R (ASTM D6923)</b>					
Weighted total demerit, max.	-	-	382	-	-
Top groove carbon fill, %, max.	-	-	52	-	-
Top land carbon, %, max.	-	-	31	-	-
Average oil consumption - initial 0-252 h, g/h, max.	-	-	13.1	-	-
Average oil consumption - final 432-504 h, g/h, max.	-	-	Initial + 1.8	-	-
Piston ring sticking and liner scuffing	-	-	None	-	-
<b>Caterpillar 1K (ASTM D6750) <sup>(2)</sup></b>	Run number	1 / 2 / 3 332 / 347 / 353 24 / 27 / 29 4 / 5 / 5 0.5 g/bhp-h None	332 24 4 0.5 g/kW-h None	286.2 20 3 0.5 None	286.2 20 3 0.5 None
<b>Caterpillar 1N (ASTM D6750) <sup>(3)</sup></b>	Run number	- - - - -	286.2 20 3 0.5 None	286.2 20 3 0.5 None	1 / 2 / 3 286.2 / 311.7 / 323 20 / 23 / 25 3 / 4 / 5 0.5 None

# CUMMINS Engineering Standards (CES)

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CES Number		20076	20077	20078	20081	20086 / 20087
<b>Caterpillar C13 (ASTM D7549)</b>						
Merit rating, min.		-	-	-	Report	1000
Oil consumption delta , g/h, max.		-	-	-	Report	31
TLC, %, max.		-	-	-	Report	35
TGC, %, max.		-	-	-	Report	53
2 <sup>nd</sup> Ring top carbon, %, max.		-	-	-	Report	33
Hot stuck piston ring		-	-	-	Report	None
<b>Aeration volume</b>	Run number					1 / 2 / 3
Aeration volume (ASTM D6894), vol%, max.		8.0	-	8.0	8.0	
Average aeration (COAT) (ASTM D8047), vol%, max		-	-	-	-	11.8 / 11.8 / 11.8
<b>Cummins ISB (ASTM D7484)</b>	Run number				1 / 2 / 3	1 / 2 / 3
Slider tappet weight loss, avg., mg, max.		-	-	-	100 / 108 / 112	100 / 108 / 112
Cam shaft wear, avg., µm, max.		-	-	-	50 / 53 / 55	50 / 53 / 55
Crosshead weight loss, avg., mg		-	-	-	Report	Report
<b>Cummins ISM (ASTM D7468)</b>						
Merit rating, min.		-	-	-	1000	1000
Crosshead total weight loss, mg at 3.9% avg. soot, max.		-	-	-	7.1	7.1
Diff. pressure across oil filter after 150 h, kPa, max.		-	-	-	19	19
Adjusting screw weight loss, mg, max.		-	-	-	45	45
Avg. engine sludge CRC merits at EOT, min.		-	-	-	8.7	8.7
<b>Cummins M11 (300 h extended test) (ASTM D6838)</b>	Run number	1 / 2 / 3	1 / 2 / 3			
Rocker pad total weight loss at 4.5% soot, mg, max.		-	-	-	-	-
Crosshead wear weight loss at 6.5% soot, avg., mg, max.		12.0	12.0	-	-	-
Engine sludge at 200 h, CRC merit, min.		8.7 / 8.6 / 8.5	8.7 / 8.6 / 8.5	-	-	-
Oil filter ΔP at 200 h, kPa, max.		79 / 93 / 100	79 / 93 / 100	-	-	-
<b>Cummins M11 EGR (ASTM D6975)</b>						
Crosshead total weight loss at 4.6% avg. soot, mg, max.		-	-	20.0	-	-
Top ring weight loss, mg, max.		-	-	175.0	-	-
Engine sludge at end-of-test, CRC merit, min.		-	-	7.80	-	-
Oil filter ΔP at 250 h, kPa, max.		-	-	275.0	-	-

# CUMMINS Engineering Standards (CES)

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CES Number	Run number	20076	20077	20078	20081	20086 / 20087
<b>Mack T-8 (250 h) (ASTM D5967)</b>						
Viscosity increase at 3.8% soot, mm <sup>2</sup> /s, max.		-	-	-	-	-
Oil filter ΔP, kPa, max.		-	-	-	-	-
Oil consumption, g/kWh, max.		-	-	-	-	-
<b>Mack T-8E (300 h extended test) (ASTM D5967)</b>	Run number	1 / 2 / 3 1.8 / 1.9 / 2.0 11.5 / 12.5 / 13.0	1 / 2 / 3 1.8 / 1.9 / 2.0 11.5 / 12.5 / 13.0	1.8 Report	-	-
Relative viscosity at 4.8% soot TGA, max.						
Viscosity increase at 100°C at 3.8% soot, mm <sup>2</sup> /s, max.						
Oil filter ΔP, kPa, max.		-	138	-	-	-
Oil consumption, g/kWh, max.		-	0.304	-	-	-
<b>Mack T-9 (ASTM D6483)</b>	Run number	1 / 2 / 3 25.4 / 26.6 / 27.1 120 / 136 / 144 20 / 27 / 31	1 / 2 / 3 25.4 / 26.6 / 27.1 120 / 136 / 144 25 / 32 / 36	-	-	-
Average liner wear at 1.75% soot, µm, max.						
Top ring weight loss, mg, max.						
Used oil lead increase, ppm, max.						
Lead increase from 400 to 500 h, ppm, max.		10	-	-	-	-
<b>Mack T-10 (ASTM D6987)</b>						
Merit rating, min.		-	-	1000	-	-
Average liner wear, µm, max.		-	-	32	-	-
Average top ring weight loss, mg, max.		-	-	158	-	-
Lead increase from 0 to 300 h, ppm, max.		-	-	35	-	-
Lead increase from 250 to 300 h, ppm, max.		-	-	14	-	-
Oil consumption, avg., g/h, max.		-	-	65	-	-
<b>Mack T-11 (ASTM D7156)</b>	Run number					1 / 2 / 3 3.5 / 3.4 / 3.3 6.0 / 5.9 / 5.9 6.7 / 6.6 / 6.5
Minimum % TGA Soot at 4.0 mm <sup>2</sup> /s increase at 100°C		-	-	-	3.5	
Minimum % TGA Soot at 12.0 mm <sup>2</sup> /s increase at 100°C		-	-	-	6.0	
Minimum % TGA Soot at 15.0 mm <sup>2</sup> /s increase at 100°C		-	-	-	6.7	
<b>Mack T-12 (ASTM D7422)</b>						1 / 2 / 3
Merit rating, min.		-	-	-	1300	-
Liner wear, avg., µm, max.		-	-	-	20	21 / 22 / 23
Top ring weight loss, avg., mg, max.		-	-	-	105	105
EOT used oil lead / new oil lead content, ppm, max.		-	-	-	30	Report
Lead increase from 250 h to 300 h, mg/kg, max.		-	-	-	12	Report
Oil consumption, avg., g/h, max.		-	-	-	80	Report

# CUMMINS Engineering Standards (CES)

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CES Number		20076	20077	20078	20081	20086 / 20087
<b>Roller follower wear test (ASTM D5966)</b>	Run number	1 / 2 / 3 0.30 / 0.33 / 0.36 7.6 / 8.4 / 9.1	-	-	-	1 / 2 / 3 0.30 / 0.33 / 0.36 7.6 / 8.4 / 9.1
Pin wear, mils max.						
μm, max.						
<b>Mitsubishi 4D34T (JASO M354-1999)</b>				95.0	-	-
Cam lobe wear, μm, max.		-	-			
<b>Sequence IIIE (ASTM D5533)</b>		100	-	-	-	-
Viscosity increase at 64 h at 40°C from 10 min sample, %, max.						
<b>Sequence IIIF (ASTM D6984) / Sequence IIIG (ASTM D7320)</b>				IIIF 20.0	IIIF (IIIG) 275 (150)	-
Cam and tappet wear, μm, max.		-	-		-	-
Viscosity increase at EOT at 40°C, %, max.		-	-	275	275 (150)	-
Oil consumption, l, max.		-	-	5.2	-	-
<b>OM 441 LA (CEC L-52-T-97)</b>						
Bore polishing, avg., %, max.		-	2	-	-	-
Piston cleanliness, avg., merit, min.		-	25	-	-	-
Boost pressure loss at 400 h, %, max.		-	4	-	-	-
Oil consumption, kg/test, max		-	40	-	-	-
<b>OM 602A (CEC L-51-A-97)</b>						
Viscosity increase at 40°C, %, max.		-	90	-	-	-
Cam wear, avg., μm, max.		-	45.0	-	-	-
Cylinder wear (avg. 4 cyl.), μm, max.		-	20.0	-	-	-
Bore polishing, %, max.		-	7.0	-	-	-
Oil consumption, kg/test, max.		-	10	-	-	-
Piston cleanliness, avg., merit, min.		-	Report	-	-	-
Engine sludge, avg., merit		-	Report	-	-	-
<b>Volvo T-13 (ASTM WK50204) <sup>(4)</sup></b>	Run number					1 / 2 / 3 80 / 80 / 80 50 / 50 / 50 Report
IR peak height at EOT, A/cm, max		-	-	-	-	
Kinematic viscosity at 40°C, %, max		-	-	-	-	
Average oil consumption 48-192 h, max		-	-	-	-	

**Notes:**

(1) Unless a Cummins limit is more stringent, all applicable tiered limits shall be consistent with requirements of ASTM D4485 or relevant ASTM body.

(2) Please refer to chapter "Elastomer Compatibility" and ACEA Sequence E for limits.

(3) For CES 20078, oil shall pass either Caterpillar IK or Caterpillar IN.

(4) Candidate base oil saturates shall be no less than the reproducibility of ASTM D2007-11 (currently 4.0 mass%) from the base oil saturates of the T-13 tested oil.

# DETROIT Fluids Specification (DFS)

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Specifications	93K214	93K215	93K218	93K222 / 93K223
API performance level	API CI-4 PLUS	API CH-4	API CJ-4	API CK-4 / API FA-4
Description	Cooled EGR-equipped engines without after treatment devices or any engine operating on Low Sulfur Fuel. These engines meet 2002 to 2006 model year emission requirements.	Non-EGR-equipped engines, operating on fuel below 5000 ppm sulfur fuel.	Recommended for all four-cycle Detroit™ engines including with and without an after treatment system, EPA07/10/GHG14/ GHG17 and older (including legacy engines), operating on ULSD fuel.	
SAE J300 viscosity grades	-	-	xW-30, xW-40	xW-30, xW-40 / xW-30 (x ≥ 5)
<b>Laboratory tests</b>				
Sulphated ash (ASTM D874), % m/m, max.	2.0	2.0	1.0	1.0
Phosphorus (ASTM D4951, ASTM D5185), % m/m, max.	-	-	0.12	0.12
Sulphur (ASTM D4951, ASTM D2622), % m/m, max.	-	-	0.4	0.4
HTHS viscosity at 150°C (ASTM D4683), mPa.s, min.	4.2	3.5	xW-30: 3.5; xW-40: Report	xW-30: 3.5; xW-40: Report / 2.9-3.2
Shear stability (ASTM D6278 / D7109)				
Viscosity at 100°C after 30 cycles shear (ASTM D445), mm²/s, min.	-	12.5	-	-
Viscosity at 100°C after 90 cycles shear (ASTM D445), mm²/s, min.	12.5	-	xW-30: 9.3; xW-40: 12.5	xW-30: 9.3; xW-40: 12.8 / 9.3
HTHS viscosity after 90 cycles shear (ASTM D4683), mPa.s, min.	3.9	-	xW-30: Report; xW-40: 3.9	xW-30: 3.4; xW-40: 3.9 / 2.8
Low temperature pumpability (ASTM D4684 or D6896)				
MRV viscosity TP-1 at -20°C, mPa.s	-	-	-	Report
Yield stress, Pa, max.	-	-	-	35
Evaporative loss (Noack) (ASTM D5800), % loss, max. (ASTM D5480), % loss, max.	13	18	13	13
Pour point (ASTM D97), °C, max.	-25	-25	-27	-27
Foaming tendency (ASTM D892)	No option A 10 / 0, 20 / 0, 10 / 0	No option A 10 / 0, 20 / 0, 10 / 0	Option A allowed 10 / 0, 20 / 0, 10 / 0 <sup>(4)</sup>	Option A allowed 10 / 0, 20 / 0, 10 / 0 <sup>(4)</sup>
Corrosion tendency (HTCBT) (ASTM D6594)				
Copper increase, ppm, max.	20	20	20	20
Lead increase, ppm, max.	120	120	120	120
Tin increase, ppm, max.	50	50	-	-
Copper strip rating (ASTM D130), max.	3	3	3	3

# DETROIT Fluids Specification (DFS)

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Specifications	93K214	93K215	93K218	93K222 / 93K223
<b>Elastomer compatibility (ASTM D7216 / CEC L-39-96) <sup>(1)</sup></b>				
Nitrile (NBR)	Pass <sup>(2)</sup>	Pass <sup>(3)</sup>	Pass <sup>(2)</sup>	Pass <sup>(2)</sup>
Silicone (VMQ)	Pass <sup>(2)</sup>	-	Pass <sup>(2)</sup>	Pass <sup>(2)</sup>
Polyacrylate (ACM)	Pass <sup>(2)</sup>	Pass <sup>(3)</sup>	Pass <sup>(2)</sup>	Pass <sup>(2)</sup>
Fluor elastomer (FKM)	Pass <sup>(2)</sup>	Pass <sup>(3)</sup>	Pass <sup>(2)</sup>	Pass <sup>(2)</sup>
Vamac G	Rate & report <sup>(3)</sup>	Pass <sup>(3)</sup>	Pass <sup>(2)</sup>	Pass <sup>(2)</sup>
<b>Engine tests</b>				
<b>Low temperature pumpability of sooted oil (ASTM D4684 / D7110)</b>				
MRV viscosity at -20°C of 75 h oil from Mack T-10, T-10A or T-11 test at 5% soot, mPa.s, max.	25000	-	-	-
MRV viscosity at -20°C of 180 h oil from Mack T-11 or T-11A test, mPa.s, max.	-	-	18000	18000
Yield stress, Pa, max.	35	-	35	35
<b>Sequence IIIF (ASTM D6984)</b>				
Viscosity increase at 80 h at 40°C, %, max.	275	295	275 (MTAC) <sup>(5)</sup>	-
Oil consumption, l, max.	5.2	-	-	-
<b>Sequence IIIG (ASTM D7320) (Alternative to IIIF)</b>				
EOT viscosity increase at 40°C, %, max.			150 (MTAC) <sup>(5)</sup>	-
<b>Roller follower wear test (ASTM D5966)</b>	Run number			
Average pin wear, mils, max. or µm, max.	0.30 7.6	1 / 2 / 3 0.30 / 0.33 / 0.36 7.6 / 8.4 / 9.1	1 / 2 / 3 0.30 / 0.33 / 0.36 7.6 / 8.4 / 9.1	1 / 2 / 3 0.30 / 0.33 / 0.36 7.6 / 8.4 / 9.1
<b>Engine oil aeration test</b>	Run number			
EOAT (ASTM D6994), aeration, vol %, max.	-	8.0	8.0 (MTAC)	-
COAT (ASTM D8047), avg. aeration, 40 h to 50 h, %	-	-	-	11.8 / 11.8 / 11.8
<b>Mitsubishi 4D34T4 (JASO M 354)</b>				
Valve train wear, cam lobe wear, µm, max.	-	95	-	-
<b>OM 441 LA (CEC L-52-T-97) <sup>(6)</sup></b>				
Bore polishing, avg., %, max.	2.0	2.0	2.0	-
Piston deposits, avg., merit, min.	25.0	25.0	25.0	-
Boost pressure loss at 400 h, %, max.	4	4	4	-
Specific oil consumption, kg/test, max.	40	40	40	-

# DETROIT Fluids Specification (DFS)

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Specifications	93K214	93K215	93K218	93K222 / 93K223
<b>OM 501 LA (CEC L-101-09) <sup>(7), (8)</sup></b>				
Piston cleanliness avg., merit, min.	-	-	19.0	20.0
Ring sticking 2 <sup>nd</sup> ring, ASF, max.	-	-	1.0	1.0
Engine sludge avg., merit, min.	-	-	9.0	9.0
General engine deposits avg., demerit, max.	-	-	2.0	2.0
Wear rating (visual) avg., demerit, max.	-	-	3.0	3.0
Bore polishing avg., %, max.	-	-	2.0	2.0
Cylinder wear avg., mm, max.	-	-	0.008	0.008
Turbocharger deposits, demerit, max.	-	-	2.0	2.0
TBN (ASTM D4739) at end of test, mg KOH/g	-	-	Rate & report	Rate & report
TAN (ASTM D664) at end of test, mg KOH/g	-	-	Rate & report	Rate & report
Specific oil consumption, g/h, max.	-	-	30.0	30.0
<b>OM 646 DE22LA Wear test (CEC L-99-08) <sup>(7)</sup></b>				
Cam wear inlet / outlet valve (avg. max. wear 8 cams), µm, max.	-	-	100 / 130	100 / 130
Cylinder wear (avg. 4 cylinders), µm, max.	-	-	5.0	5.0
Bore polishing (13 mm), %, max. value of 4 cylinders	-	-	3.5	3.5
Piston cleanliness (avg. 4 pistons), merit, min.	-	-	12.0	14.0
Engine sludge avg., merit, min.	-	-	8.8	8.8
Ring sticking	-	-	No	No
Tappet wear inlet (avg. max. wear 8 cams), µm	-	-	Rate & report	Rate & report
Tappet wear outlet (avg. max. wear 8 cams), µm	-	-	Rate & report	Rate & report
Bearing wear main / con rod bearing, µm, max. <sup>(9)</sup>	-	-	2.1 / 2.1	2.1 / 2.1
Piston ring wear axial at ring 1 / ring 2 / ring 3, µm, max. <sup>(9)</sup>	-	-	10.4 / 6.0 / 5.0	10.4 / 6.0 / 5.0
Piston ring wear radial at ring 1 / ring 2 / ring 3, µm, max. <sup>(9)</sup>	-	-	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0
Timing chain wear (elongation), %, max.	-	-	0.4	0.4
Oil consumption, g/test, max.	-	-	7000	7000
Soot, %, max.	-	-	4.0 - 7.0	3.0 - 6.0
Viscosity increase at 100°C, %, max.	-	-	100	100

# DETROIT Fluids Specification (DFS)

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Specifications		93K214	93K215	93K218	93K222 / 93K223
<b>Caterpillar 1K or 1N (ASTM D6750)</b>	Run number	1K (1N) <sup>(10)</sup>	1K 1 / 2 / 3	1N 1 / 2 / 3	1N 1 / 2 / 3
Weighted total demerits (WDN), max.		332 (286)	332 / 347 / 353	286.2 / 311.7 / 323.0	286.2 / 311.7 / 323.0
Top groove fill (TGF), %, max.		24 (20)	24 / 27 / 29	20 / 23 / 25	20 / 23 / 25
Top land heavy carbon (TLHC), %, max.		4 (3)	4 / 5 / 5	3 / 4 / 5	3 / 4 / 5
Oil consumption, 0-252 h, avg., g/kW-h, max.		0.5 (0.5)	0.5 / 0.5 / 0.5	0.5	0.55 / 0.54 / 0.54
Oil consumption, 0-252 h, g/MJ, max.		-	-	-	0.15 / 0.15 / 0.15
Piston ring sticking and liner scuffing		None (None)	None	None	None
<b>Caterpillar 1R (ASTM D6923), 1P (ASTM D6681)</b>	Run number	1R	1P 1 / 2 / 3	-	-
Weighted total demerits (WDR), max.		382	350 / 378 / 390	-	-
Top groove carbon fill (TGC), %, max.		52	36 / 39 / 41	-	-
Top land carbon (TLC), %, max.		31	40 / 46 / 49	-	-
Average oil consumption, g/h, max.		-	14.4 / 14.6 / 14.6	-	-
Initial, 0-252 h, g/h, max.		13.1	-	-	-
Final, 432-504 h, g/h, max.		Initial + 1.8	-	-	-
Piston ring and liner scuffing		None	None	-	-
<b>Caterpillar C13 (ASTM D7549)</b>	Run number				1 / 2 / 3
Merit rating, min.		-	-	1000	1000 / 1000 / 1000
Hot stuck piston rings		-	-	None	None
Top land carbon (TLC)		-	-	Rate & report	Rate & report
Top groove carbon (TGC)		-	-	Rate & report	Rate & report
<b>Cummins M11 EGR (ASTM D6975) <sup>(11)</sup></b>	Run number	20.0	-	-	-
Crosshead total weight loss at 4.6% avg. soot, mg, max.		175	-	-	-
Top ring weight loss, mg, max.		275	-	-	-
Oil filter ΔP at 250 h, kPa, max.		7.80	-	-	-
Engine sludge, avg., CRC merits, min.					
<b>Cummins M11 (ASTM RR: DO2 1439)</b>	Run number		1 / 2 / 3		
Crosshead weight loss, mg, max.		-	6.5 / 7.5 / 8.0	-	-
Oil filter ΔP at end-of-test, kPa, max.		-	79 / 93 / 100	-	-
Sludge rating, merits, min.		-	8.7 / 8.6 / 8.5	-	-

# DETROIT Fluids Specification (DFS)

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Specifications		93K214	93K215	93K218	93K222 / 93K223
Cummins ISM (ASTM D7468)	Run number			1 / 2 / 3 1000	1 / 2 / 3 1000
Merit rating, min.		-	-		
Top ring weight loss, mg, max.		-	-	100 / 100 / 100	100 / 100 / 100
Crosshead weight loss, avg., mg		-	-	Rate & report	Rate & report
Cummins ISB (ASTM D7484)	Run number			1 / 2 / 3 100 / 108 / 112	1 / 2 / 3 100 / 108 / 112
Slider tappet weight loss, mg , avg., max.		-	-		
Cam lobe wear, µm, avg., max.		-	-	55 / 59 / 61	55 / 59 / 61
Crosshead weight loss, avg., mg		-	-	Rate & report	Rate & report
Mack T-8E (ASTM D5967)	Run number		1 / 2 / 3 2.1 / 2.2 / 2.3 11.5 / 12.5 / 13	-	-
Relative viscosity at 100°C at 4.8% soot, max.		-			
Viscosity increase at 100°C at 3.8% soot, mm²/s, max.		-		-	-
Mack T-10 (ASTM D6987)	Run number		1 / 2 / 3 1000 32 158 35 14 65	- 1000 32 / 34 / 35 150 / 159 / 163 50 / 56 / 59 - - 65	- - - - - - -
Soot at 12.0 mm²/s increase at 100°C from 90 pass sheared (ASTM D6278 mod.) new oil as interpolated from 2 data points, %, min.		6.00	-	-	1 / 2 / 3 - - - - - - -
TGA soot at 4.0 mm²/s increase at 100°C, %, min.		-	-	3.5 / 3.4 / 3.3	3.5 / 3.4 / 3.3
TGA soot at 12.0 mm²/s increase at 100°C, %, min.		-	-	6.0 / 5.9 / 5.9	6.0 / 5.9 / 5.9
TGA soot at 15.0 mm²/s increase at 100°C, %, min.		-	-	6.7 / 6.6 / 6.5	6.7 / 6.6 / 6.5

# DETROIT Fluids Specification (DFS)

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Specifications		93K214	93K215	93K218	93K222 / 93K223
Mack T-12 (ASTM D7422)	Run number	-	-	1000	1 / 2 / 3
Merit rating, min.					-
Top ring mass loss, mg, max.					105 / 105 / 105
Cylinder liner wear, $\mu\text{m}$ , max.					24.0 / 24.0 / 24.0
Mack T-13 (ASTM WK50204)	Run number	-	-	-	1 / 2 / 3
IR peak at EOT, Abs., $\text{cm}^{-1}$		-	-		80 / 80 / 80
Kinematic viscosity increase at 40°C, %, max.		-	-		50 / 50 / 50
Average oil consumption, 48 h - 192 h, g/h, max.		-	-		Report
DD13 Scuffing test (WK53775)		-	-	-	31
Hours-to-Scuff, h, min.					

**Notes:**

- (1) Please refer to chapter "Elastomer Compatibility" for limits.
- (2) According to ASTM D7216.
- (3) According to CEC L-39-96.
- (4) Option A is allowed.
- (5) Either the Sequence IIIF or Sequence IIIG requirement shall be met.
- (6) Requirement can be satisfied by submitting MB 228.3 approval documentation and information relating the candidate formulation and that tested.
- (7) Requirements for the OM 501 LA and/or the OM 646DE22L engine tests may be satisfied by a MB trading approval for MB 228.31 or 228.51 on the candidate formulation.
- (8) Only for xW-30 or OW-40: Evaluation of bearing wear in an OM 501 LA engine with new crankshaft and premeasured bearings is required. Rerating by Daimler at TP/PHC.
- (9) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.
- (10) Requirement can be satisfied with passing result from either Caterpillar 1K or IN test.
- (11) M11 EGR tests ending after March 1, 2003 may not be used to satisfy this requirement. The Mack T10 (ASTM D6981) Top Ring Weight Loss max. limit of 140 mg then applies.

## DEUTZ lubricating oil Quality Classes (DQC)

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**DQC I-02:** Minimum oil quality, some shorter oil change intervals.

**DQC II-18:** Engine oil, usually used in engines with open crankcase ventilation.

**DQC III-18:** Standard quality, high performance diesel engine oils, for use in engines with closed crankcase ventilation and/or with high thermal loads.

**DQC IV-18:** Ultra high performance diesel engine oils for engines with the highest levels of output, with closed crankcase ventilation and/or with the highest thermal loads and the highest requirement for piston cleanliness (suitable for TTCD steel piston engines).

**DQC II-18 LA:** Low ash engine oil, usually used in engines with open crankcase ventilation.

**DQC III-18 LA:** Low ash high performance diesel and gas engine oil, standard quality, for use in engines with closed crankcase ventilation and/or with high thermal loads.

**DQC IV-18 LA:** Low ash ultra high performance diesel and gas engine oil for engines with the highest levels of output, with closed crankcase ventilation and/or with the highest thermal loads and very high requirements for piston cleanliness (suitable for TTCD steel piston engines) and extended oil change intervals.

Specifications	DQC I-02	DQC II-18	DQC II-18 LA	DQC III-18	DQC III-18 LA	DQC IV-18	DQC IV-18 LA
ACEA performance level	ACEA E2-96, API CF, or CF-4	CEA E3-96, E4-16, E5-02, E7-16, API CG-4, CH-4, CI-4, CI-4 PLUS, or DHD-1	ACEA E6-16, E9-16, or API CJ-4	ACEA E7-16 <sup>(1)</sup>	ACEA E9-16 <sup>(1)</sup>	ACEA E4-16, E7-16 <sup>(1)</sup>	ACEA E6-16, E9-16 <sup>(1)</sup>
Viscosity grades (SAE J300)	xW-30, xW-40, 15W-50, 20W-50 (x = 0, 5, 10, 15)			xW-30, xW-40 (x = 0, 5, 10, 15)		xW-30, xW-40 (x = 0, 5, 10)	
<b>Laboratory Tests</b>							
<b>Density at 15°C</b> (DIN ISO EN 12185, DIN 51757, ASTM D4052)		Report		Report		Report	
<b>Viscosity at 40°C</b> (DIN EN ISO 3104, DIN 51562-1, ASTM D445), mm <sup>2</sup> /s at 100°C		Report Report		Report Report		Report Report	
<b>HHTS viscosity at 150°C</b> (CEC L-36-90), mPa.s, min. at 100°C		3.5 Report		3.5 Report		3.5 Report	
<b>Viscosity index (VI)</b> (DIN ISO 2209, ASTM D2270)		Report		Report		Report	

## DEUTZ lubricating oil Quality Classes (DQC)

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Specifications	DQC I-02	DQC II-18	DQC II-18 LA	DQC III-18	DQC III-18 LA	DQC IV-18	DQC IV-18 LA
<b>Shear stability</b> (CEC L-14-93, ASTM D6278, D7109)		Stay in grade		Stay in grade		Stay in grade	
Viscosity at 100°C after 30 cycles shear (ASTM D445), mm <sup>2</sup> /s		Stay in grade		Stay in grade		Stay in grade	
Viscosity at 100°C after 90 cycles shear (ASTM D445), mm <sup>2</sup> /s		Stay in grade		Stay in grade		Stay in grade	
<b>Low temperature pumping viscosity</b> (ASTM D4684, CEC L-105-12), mPa.s, max.		according to SAE J300		according to SAE J300		according to SAE J300	
<b>Low temperature cranking viscosity</b> (DIN 51377, ASTM D5293), mPa.s		Report		Report		Report	
<b>Evaporative loss</b> (Noack) (CEC L-40-93, DIN 51581-13), %, max.		as ACEA or API		12		11	
<b>TAN</b> (DIN EN 12634, ASTM D664), mg/KOH/g		Report		Report		Report	
<b>TBN</b> (DIN ISO 3771, ASTM D2896), mg KOH/g, min.		as ACEA or API	9	7	12	7	
<b>Sulfated ash</b> (DIN 51575, ASTM D874), % m/m, max.		as ACEA or API; DQC II-18 LA: ≤ 1.0	2.0	1.0	2.0	1.0	
<b>Ca, Mg, Zn, Mo, Bo, Na, Si, K</b> (DIN 51391-2, -3, 51399-1, -2, 51443-2 (Bo), ASTM D4951)		Report		Report		Report	
<b>Chlorine</b> (DIN ISO 15597, ASTM D6443), % m/m, max.		0.015		0.015		0.015	
<b>Phosphorus</b> (DIN 51399-1, -2, ASTM D4951), % m/m, max.		Report		Report	0.12	Report	0.08
<b>Sulfur</b> (DIN 51399-1, -2, DIN EN ISO 14596, 16591, ASTM D4951), % m/m, max.		Report		Report	0.4	Report	0.3
<b>Flash point</b> (COC) (DIN EN ISO 2592, ASTM D92), °C, min.		Report		Report		Report	
<b>Pourpoint</b> (DIN ISO 3016, ASTM D97), °C, max.		Report		Report		Report	
<b>Oxidation induction time</b> (PDSC) (CEC L-85-99), min, min.		as ACEA or API	70	70	70 <sup>(2)</sup> / 110 <sup>(3)</sup>		70
<b>Oil oxidation with biodiesel</b> , CEC L-109-14		-	120	90	90		80
Oxidation increase after 168 h, A/cm, max.		-	300	150	130		130
Kinematic viscosity increase at 100°C after 168 h, %, max.							
<b>Corrosion</b> (HTCBT) (ASTM D6594)							
Copper, ppm increase, max.		as ACEA or API		20		20	
Lead, ppm increase, max.		as ACEA or API		90		70	
Copper strip rating (ASTM D130), max.		as ACEA or API		3		3	
<b>Elastomer compatibility</b> (CEC-L-116-16) <sup>(2)</sup>		according to ACEA		according to ACEA		according to ACEA	
<b>Foaming tendency</b> (ASTM D892) (No option A), ml, max.		as ACEA or API		according to ACEA		according to ACEA	
<b>High temp foaming tendency</b> (ASTM D6082), ml, max.		as ACEA or API		according to ACEA		according to ACEA	
<b>Turbocharger deposits</b> (DIN 51535), mg, max.		-		110		90 <sup>(5)</sup>	

## DEUTZ lubricating oil Quality Classes (DQC)

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Specifications	DQC III-10	DQC III-10 LA	DQC IV-10	DQC IV-10 LA
<b>Engine Tests</b>				
<b>OM 646 LA (CEC-L-99-A-08)</b>				
Cam wear outlet, average, µm, max.	140		120	
Cam wear inlet, average, µm, max.	110		100	
Cylinder wear, average, µm, max.	5.0		5.0	
Bore polishing, %, max.	3.5		3.0	
Tappet wear, inlet	Rate & report		Rate & report	
Tappet wear, outlet	Rate & report		Rate & report	
Viscosity increase at 100°C, %, max.	100		100	
Oil consumption, target value, kg/test, max.	7		7	
<b>Mack T-8E (ASTM D5967)</b>	Run number	1 / 2 / 3 2.1 / 2.2 / 2.3		1 / 2 / 3 2.1 / 2.2 / 2.3
Relative viscosity at 4.8% soot (300 h), %, max.				
<b>Mack T-11 (ASTM D7156), alternative to Mack T-8E</b>				
Minimum TGA soot at 4.0 mm²/s increase at 100°C, %, max.	-	3.5 / 3.4 / 3.3		-
Minimum TGA soot at 12.0 mm²/s increase at 100°C, %, max.	6.0 / 5.9 / 5.9	6.0 / 5.9 / 5.9		6.0 / 5.9 / 5.9
Minimum TGA soot at 15.0 mm²/s increase at 100°C, %, max.	-	6.7 / 6.6 / 6.5		-
<b>OM 501 LA (CEC L-101-08)</b>				
Bore polishing, avg., %, max.	2.0		1.0	
Piston cleanliness, avg., merit, min.	17		30	
Turbocharger deposits, demerit, max.	Rate & report		Rate & report	
Oil consumption, kg/test, max.	9		9	
Sludge, avg., merit, min.	Rate & report		Rate & report	
Wear (visual), avg., demerit, max.	Rate & report		Rate & report	
Total deposits, avg., demerit, max.	Rate & report		Rate & report	
Cylinder wear, µm, max.	Rate & report		Rate & report	
Ring sticking piston ring 2, ASF, max.	Rate & report		Rate & report	
<b>Cummins ISM (ASTM D7468)</b>				
Rocker pad weight loss at 3.9% soot, avg., mg, max.	7.5	7.1	7.5	7.1
Oil filter ΔP at 150 h, kPa, max.	55	19	55	19
Engine sludge, avg., merit, min.	8.1	8.7	8.1	8.7
Adjusting screw weight loss, mg, max.	-	49	-	49

## DEUTZ lubricating oil Quality Classes (DQC)

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Specifications	DQC III-18	DQC III-18 LA	DQC IV-18	DQC IV-18 LA
<b>Mack T-12</b> (ASTM D7422), alternative to Volvo T-13 for DQC III-18 LA				
Merit rating, min.	1150 <sup>(6)</sup>	1150 <sup>(6)</sup> / 1200 <sup>(7)</sup>	1300 <sup>(6)</sup>	Volvo T-13 mandatory
Liner wear, avg., µm, max.	26	26	24	
Top ring weight loss, avg., mg, max.	117	105	117	
Lead end-of-test, mg/kg, max.	42	35	42	
Δ lead 250-300 h, mg/kg, max.	18	15	18	
Oil consumption (phase II), g/h, max.	95	85	95	
<b>Volvo T-13</b> (ASTM D8048), alternative to Mack T-12 for DQC III-18 and DQC IV-18				
FTIR Oxidation peak height at EoT, abs., max.	125	125	125	80
Viscosity increase at 40°C (300-360 h), %, max.	75	75	75	50
Nitration	Rate & report	Rate & report	Rate & report	Rate & report
Δ lead	Rate & report	Rate & report	Rate & report	Rate & report
Oil consumption, avg. 48-192 h, g/h, max.	40	40	40	40
<b>OM 646 LA Bio</b> (CEC L-104-16)				
Piston cleanliness, avg., merit, min.	-	RL255 + 2	-	RL255 + 4
Ring sticking, ASF	-	Rate & report	-	Rate & report
Sludge, avg.	-	Rate & report	-	Rate & report

**Notes:**

- (1) DEUTZ requirements may be higher than the ACEA specification.
- (2) If Mack T-12 engine test is used.
- (3) If Volvo T-13 engine test is used instead of Mack T-12 engine test.
- (4) Alternative CEC L-39-T-96 (Use either the most recent complete Daimler requirements +RE3, or complete requirements + Daimler requirements for AEM).
- (5) Variation of DIN 51535: Calibration with RL 206 and FES T-XH5-12.
- (6) Merit calculation as per API CI-4.
- (7) Merit calculation as per API CJ-4.

# FIAT service fill engine oil specifications, conventional SAPS



FIAT 9.55535 Specifications		G1	G2	M2	N1	N2	Z2
<b>Chrysler equivalent</b>		MS-50081	-	MS-12991	-	MS-12991 (only for spark ignition engines)	MS-12991 (only SAE 5W-40 for NAFTA)
<b>Application</b>		Service fill engine oil - Long Life - Low HTHS	Service fill engine oil - Long Life - Low HTHS	Service fill engine oil - Long Life - High HTHS	Service fill engine oil - Low HTHS	Service fill engine oil - Long Life - High HTHS	Service fill engine oil - High HTHS
<b>Description</b>		Energy saving oils for spark ignition engines and ethanol blended gasoline	Standard oils for spark ignition engines and ethanol blended gasoline	"Long drain" oils for spark ignition engines	Energy saving oil for Diesel engines	"Long drain" oils for spark ignition and Diesel engines	"Long drain" oils for spark ignition and Diesel engines with high features turbochargers
<b>Fuel type</b>		Gasoline & Ethanol	Gasoline & Ethanol	Gasoline (& Diesel)	Diesel	Diesel & Gasoline	Diesel & Gasoline
<b>Main region</b>		Latin America	Latin America (Brazil)	Worldwide, minimum requirement	-	India	Europe & North America
<b>ACEA, API, or ILSAC required level</b>		A1/B1 <sup>(1)</sup>	A3/B4 <sup>(1)</sup>	A3/B4 <sup>(1)</sup>	A5/B5 <sup>(1)</sup>	A3/B4 <sup>(1)</sup>	A3/B4 <sup>(1)</sup>
<b>Acceptable SAE Grades</b>		5W-30	5W-40	0W/5W-40	5W-30	0/5W-40	0/5W-40
<b>Laboratory tests (on fresh oil)</b>							
HTHS viscosity (CEC L-036-A-90), mPa.s		≥ 2.9	≥ 3.5	≥ 3.5	≥ 2.9 and ≤ 3.5	≥ 3.5	≥ 3.5
Noack (CEC L-40-A-93), % (m/m), max.		11.5	11.5	11.5	11.5	11.5	8.0
TBN (ASTM D2896), mg KOH/g, min.		9.0	9.0	10.0	10.0	10.0	10.0
Sulfur (DIN 51 400), % (m/m), max.		0.50	0.50	0.50	0.50	0.50	0.50
Sulfated ash (ASTM D874), % (m/m), max.		1.2	1.2	1.2	1.2	1.2	1.2
Molybdenum (ASTM D4951), ppm		150-300	150-300	-	-	-	50-150
Oxidation stability (PDSC), (CEC L-085-99), min.		≥ 80	≥ 80	-	-	-	≥ 120
Oil-elastomers compatibility		According to latest ACEA oil sequence above	According to latest ACEA oil sequence above	According to latest ACEA oil sequence above	According to latest ACEA oil sequence above	According to latest ACEA oil sequence above	According to latest ACEA oil sequence above
<b>Physical and chemical data (FPT MEC031)</b>		Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report
<b>FIAT engine tests</b>							
<b>Aeration test (LP.MEC100) (2015)</b>		-	-	-	M756 - 1.3 M-JET2 4V E5 95hp	M756 - 1.3 M-JET2 4V E5 95hp	M758 - 1.3 M-JET 4V E6b 95hp
Air content <sup>(1)</sup> , %, max.		-	-	-	10.0	10.0	10.0
<b>Turbocharger test (LP.DUR114) (2017)</b>		-	-	-	M756 - 1.3 M-JET2 4V E5 95hp	M756 - 1.3 M-JET2 4V E5 95hp	M758 - 1.3 M-JET 4V E6b 95hp
Air temperature variation, %, max.		-	-	-	5	5	5
Total deposit, g, max.		-	-	-	1	1	1

**Notes:**

(1) After oil temperature stabilization at 130°C and 4500 rpm.

# FIAT service fill engine oil specifications, mid-SAPS

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FIAT 9.55535 Specifications	S1	S2	S3	S4	T2	DS1	DSX	DM1	D3	GH2	GS1	GSX	CR1
<b>Other requirements</b>	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	MS-90047 Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)	Standard FPT 07988 (1)
<b>Application</b>	Service Fill Engine Oil - Mid SAPS - Low HTHS	Service Fill Engine Oil - Mid SAPS - High HTHS	Service Fill Engine Oil - Mid SAPS - High HTHS	Service Fill Engine Oil - Low SAPS - High HTHS	Service fill engine oil - Mid SAPS - High HTHS - High TBN	Service fill engine oil - Mid SAPS - Low HTHS	Service fill engine oil - Mid SAPS - Low HTHS	Service fill engine oil - Mid SAPS - Very Low HTHS	Service fill engine oil - Mid SAPS - High HTHS - High TBN	Service fill engine oil - Long Life - High HTHS	Service fill engine oil - Mid SAPS - Low HTHS	Service fill engine oil - Mid SAPS - Low HTHS	Service fill engine oil - Low HTHS
<b>Description</b>	Energy saving "Mid-SAPS" oils for Diesel engines Specific for high features turbochargers	"Mid-SAPS" oils for spark ignition engines	"Mid-SAPS" oils for spark ignition and Diesel engines	"Low-SAPS" oils for Diesel engines	"Mid-SAPS" - High performance oils for spark ignition and CNG-LPG engines	Energy saving "Mid-SAPS" oils specific for EURO 6 Diesel with high features turbo	Very High energy saving "Mid-SAPS" oils specific for EURO 6 Diesel with high features turbo	Very High energy saving "Mid-SAPS" oils specific for EURO 6 Diesel with high features turbo	"Mid-SAPS" oils for Heavy Diesel and Light Trucks with DPF	"Mid-SAPS" high perform / "long drain" oils for spark ignition engines	Energy saving "Mid-SAPS" oils for EURO 6 spark ignition engines	Very high energy saving oils for EURO 6 spark ignition engines	Energy saving oils for spark ignition engines
<b>Fuel type</b>	Diesel	Gasoline	Diesel & Gasoline	Diesel	CNG & LPG	Diesel	Diesel	Diesel	Diesel	Gasoline	Gasoline	Gasoline	Gasoline
<b>Main region</b>	Europe (Euro 5) India & Brazil (Euro 4)	Europe	Europe	Europe	Europe	Europe	Europe	Europe	Europe	Europe	Europe	Europe	North America
<b>ACEA, API, or ILSAC required level</b>	C1 or C2 <sup>12</sup>	C3 <sup>12</sup>	C3 <sup>12</sup>	C4 <sup>12</sup>	C3 <sup>12</sup>	C2 <sup>12</sup>	C5 <sup>16</sup>	C5 <sup>16</sup>	API CJ-4 / SM	C3 <sup>12</sup>	C2 <sup>12</sup>	API SN and ILSAC GF-5	API SN and ILSAC GF-5
<b>Other requirements</b>	-	-	Chrysler MS-II106	RN 0720	-	-	-	-	Chrysler MS-10902	-	-	-	Chrysler MS-6395
<b>Acceptable SAE grades</b>	5W-30	0W/5W-40	5W-30	5W-30	0W/5W-40	0W-30	0W-20	0W-20	5W-40	5W-40 / 10W-50	0W-30	0W-20	0W/5W-10W/20/30
<b>Laboratory tests (on fresh oil)</b>													
<b>HTHS viscosity (CEC L-036-A-90), mPa.s</b>	≥ 2.9 and ≤ 3.5	≥ 3.5	≥ 3.5	≥ 3.5	≥ 3.5	≥ 2.9 and < 3.5	≥ 2.8 and ≤ 2.9	≥ 2.6 and ≤ 2.9	-	≥ 3.5	≥ 2.9 and ≤ 3.5	≥ 2.6 and ≤ 2.9	-
<b>HTHS viscosity (ASTM D4683), mPa.s</b>	-	-	-	-	-	-	-	-	≥ 3.5	-	-	-	-
<b>HTHS after shear (30 pass) (ASTM D6278), mPa.s</b>	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>Borderline pumping viscosity (ASTM D4684A), mPa.s</b>	-	-	-	-	-	-	-	-	-	-	-	-	≤ 40000 at -40°C for 0W-xx ≤ 40000 at -35°C for 5W-xx ≤ 50000 at -30°C for 10W-xx
<b>Noack (CEC L-40-A-93), % (m/m), max.</b>	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	13.0	8.0	11.0	11.0	-
<b>TBN (ASTM D2896), mg KOH/g, min.</b>	6.0	6.0	6.0	7.0	9.5	7.0	7.0	7.0	10.0	7.0	7.0	7.0	-
<b>Sulfur (DIN 51 400), % (m/m), max.</b>	-	-	-	-	-	-	-	-	-	0.30	-	-	-
<b>Sulfur (ASTM D5185), % (m/m), max.</b>	0.30	0.30	0.30	0.20	0.30	0.30	0.30	0.30	0.40	-	0.30	0.50	-

# FIAT service fill engine oil specifications, mid-SAPS

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FIAT 9.55535 Specifications	S1	S2	S3	S4	T2	DS1	DSX	DM1	D3	GH2	GS1	GSX	CR1
Phosphorus (ASTM D5185), % (m/m), max.	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	-	0.090	0.090	0.080	-
Sulfated ash (ASTM D874), % (m/m), max.	0.8	0.8	0.8	0.5	0.8	0.8	1.0	1.0	1.0	0.8	0.8	1.0	-
Molybdenum (ASTM D4951), ppm	-	-	-	-	-	-	-	450-550	-	-	-	150-300	-
Oxidation stability (PDSC), (CEC L-085-99), min.	-	-	-	-	120	100	100	100	-	120	100	100	-
Flash point (ASTM D92A), °C	-	-	-	-	-	-	-	-	-	-	-	-	200
Oil-elastomers compatibility	According to latest ACEA oil sequence above	According to API CJ-4 / SM and MS-10902	According to latest ACEA oil sequence above	According to MS-6395									
Physical and chemical data (FPT MEC031)	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report						
<b>FIAT engine tests</b>													
Aeration test (LP.MEC100) (2015)	M756 - 1.3 M-JET2 4V E5 95hp	-	M756 - 1.3 M-JET2 4V E5 95hp	-	-	M758 - 1.3 M-JET 4V E6b 95hp	M758 - 1.3 M-JET 4V E6b 95hp	M758 - 1.3 M-JET 4V E6b 95hp	-	-	M062 - 1.0 Twinair NA 65hp	M062 - 1.0 Twinair NA 65hp	-
Air content <sup>(2)</sup> , %, max	10.0	-	10.0	-	-	10.0	10.0	10.0	-	-	≤ 10.0	≤ 10.0	-
Turbocharger test (LP.DURII4) (2017)	M756 - 1.3 M-JET2 4V E5 95hp	-	M756 - 1.3 M-JET2 4V E5 95hp	-	-	M758 - 1.3 M-JET 4V E6b 95hp	M758 - 1.3 M-JET 4V E6b 95hp	M758 - 1.3 M-JET 4V E6b 95hp	-	-	-	-	-
Air temperature variation, %, max	5	-	5	-	-	5 <sup>(3)</sup>	5 <sup>(3)</sup>	5 <sup>(3)</sup>	-	-	-	-	-
Total deposit at 300h, g	1	-	1	-	-	1.0	1.0	1.0	-	-	-	-	-
Accelerated DPF test (FPT DUR017)	-	-	-	-	-	M735 - 1.6 M-Jet2 4V E5 120hp	M735 - 1.6 M-Jet2 4V E5 120hp	M735 - 1.6 M-Jet2 4V E5 120hp	-	-	-	-	-
Total oil consumption, kg/test	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-
Engine oil analysis:	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-
Soot (DIN 51452), wt%	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-
TBN (ASTM D664), mg KOH/g	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-
Viscosity increase at 40°C (ASTM D445), %	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-
Fe content (suitable method to be declared), ppm	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-
Pb content (suitable method to be declared), ppm	-	-	-	-	-	Rate & Report	Rate & Report	Rate & Report	-	-	-	-	-

## FIAT service fill engine oil specifications, mid-SAPS

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FIAT 9.55535 Specifications	S1	S2	S3	S4	T2	DS1	DSX	DM1	D3	GH2	GS1	GSX	CR1
Engine wear:	-	-	-	-	-	≤ 6	≤ 6	≤ 6	-	-	-	-	-
Rod bearing loss average top, µm	-	-	-	-	-	≤ 4	≤ 4	≤ 4	-	-	-	-	-
Main bearing loss average bottom, µm	-	-	-	-	-	≤ 20	≤ 20	≤ 20	-	-	-	-	-
Cam profile max wear (h max), µm	-	-	-	-	-	≤ 5	≤ 5	≤ 5	-	-	-	-	-
Cam profile maw wear (base radius), µm	-	-	-	-	-	≤ 7	≤ 7	≤ 7	-	-	-	-	-
Camshaft max wear, µm	-	-	-	-	-	-	-	-	-	-	-	-	-
Engine cleanliness rate (CEC M-02-A-78):	-	-	-	-	-	≥ 8.5	≥ 8.5	≥ 8.5	-	-	-	-	-
Ring sticking, merit	-	-	-	-	-	≥ 3.0	≥ 3.0	≥ 3.0	-	-	-	-	-
Varnish average, merit	-	-	-	-	-	-	-	-	-	-	-	-	-
<b>NEDC simulation (CAL006)</b>	-	-	-	-	-	M735 - 1.6 M-Jet2 4V E5 120hp	M735 - 1.6 M-Jet2 4V E5 120hp	-	-	-	-	-	-
FC reduction vs. Ref 5W-30 (TD6200510), %, min	-	-	-	-	-	1.0 (tbc)	1.0 (tbc)	-	-	-	-	-	-
<b>Fuel economy test (FPWVEE017)</b>	-	-	-	-	-	-	-	M735 - 1.6 M-Jet2 4V E5 120hp	-	-	-	-	-
Fuel consumption reduction vs Ref 0W-30, %, min.	-	-	-	-	-	-	-	1.8	-	-	-	-	-

**Notes:**

- (1) For FDR on first application complete qualification procedure is needed ( Standard FPT 07988).
- (2) After oil temperature stabilization at 130°C and 4500 rpm.
- (3) Engine intake air temperature 20°C +/- 2°C.

## FPT Engine Oil Requirements



Engine family		Recommended Engine Oil Quality					Oil Drain Interval
		ACEA C2	ACEA E4	ACEA E7	ACEA E6	ACEA E9	
Family 1 (Daily)	Euro 5, IV, V	5W-30,	-	-	-	-	Light + medium duty: 40000 km, 2 yrs, 800 h Heavy duty: 20000 km, 1 yr
	Euro 5, VI	0W-30	-	-	-	-	
Tector (Eurocargo)	Euro IV, V	-	5W-30	15W-40	-	-	Light duty: 80000 km; Medium duty: 60000 km Heavy duty: 40000 km, 1 yr (1), 800 h
	Euro VI	-	-	-	5W-30	10W-40	
CURSOR 8 (Stralis)	Euro IV, V	-	5W-30	15W-40	-	-	ACEA E4: 100000 km, 1 yr ACEA E7: 80000 km
CURSOR 9 (Stralis)	Euro VI	-	-	-	5W-30	10W-40	ACEA E6: 100000 km, 1 yr, 2000 h ACEA E9: 80000 km
CURSOR 10, 13 (Stralis)	Euro IV, V	-	5W-30	15W-40	-	-	ACEA E4: 150000 km, 1 yr ACEA E7: 100000 km
CURSOR 11, 13 (Stralis)	Euro VI	-	-	-	5W-30, 0W-20 <sup>(2)</sup>	10W-40	ACEA E6: 150000 km, 1.5 yr ACEA E9: 100000 km, 1 yr

**Notes:**

(1) ACEA E6: 1.5 yr.

(2) Exclusively PLI Urania SAE 0W-20.

# FORD MOTOR COMPANY active Ford engine oil specifications

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WSS FORD Specifications	M2C950-A	M2C948-B	M2C913-D	M2C913-C	M2C925-B	M2C917-A	M2C929-A (5W-30) M2C930-A (5W-20)	M2C945-A (5W-20) M2C946-A (5W-30) M2C947-A (0W-20)	M2C171-E
Fill type	Initial / Service	Service <sup>(1)</sup>	Initial for Diesels / Service	Service	Initial / Service	Service	929 = Service / 930 = Initial	Initial / Service	Initial / Service
<b>Application</b>	New MY 2015 Transit, Mondeo and Focus with new 2.0 Diesel engine	Gasoline world- wide excl. North America	All Diesels World- wide (except where M2C950-A is specified) Allowed for Gasoline in some markets	All Diesels World- wide where fuel Sulfur level is ≤ 300 ppm. <sup>(1)</sup> Allowed for Gasoline in some markets	Gasoline (Fuel Economy)	Ford Ka, Consult Ford for requirements	Gasoline	Gasoline	Diesel
<b>Fuel type</b>	Diesel & Gasoline	Gasoline	Diesel & Gasoline	Diesel & gasoline (max 300 ppm S)	Gasoline	Diesel & Gasoline	Gasoline	Gasoline	Diesel
<b>Main region</b>	Worldwide, excl. North America	Worldwide, excl. North America	Worldwide, excl. North America	Worldwide, excl. North America	Scheduled to be phased out	Europe	Scheduled to be phased out	US + Mexico + Latin Amerika + China	US
<b>ILSAC or API and ACEA required level</b>	C2 -12 without M111FE	C2-12 without M111FE	A5/B5 <sup>-10</sup>	A5/B5 <sup>-08</sup>	A5/B5 <sup>-08</sup> <sup>(2)</sup>	C3 <sup>-08</sup>	GF-4	GF-5	API CJ-4
<b>Acceptable SAE Grades</b>	0W-30	5W-20	5W-30	5W-30	5W-20	5W-40	5W-30 / 5W-20	5W-30 / 5W-20	According API CJ-4
<b>HTHS viscosity (CEC L-036-90), mPa.s</b>	≥ 2.9 & < 3.5	≥ 2.6 & < 2.9	≥ 2.9 & < 3.5	≥ 2.9 & < 3.5	≥ 2.9 & < 3.5	-	-	According SAE J300	-
<b>HTHS viscosity (CEC L-036-90 after CEC L-014-88 or ASTM D6278), mPa.s, min.</b>	2.6	2.6	2.9	2.9	2.6	-	-	-	-
<b>Shear stability (CEC L-014-93 or ASTM D6278), kin. viscosity, mm<sup>2</sup>/s</b>	Stay in grade	≥ 6.8 - < 9.3	9.3 - <12.5	9.3 - <12.5	≥ 6.8 - < 9.3	-	-	-	-
<b>Noack, (ASTM D5800), %, max.</b>	13	13	13	13	13	-	15	15	-
<b>Sulfated ash (ASTM D874), % m/m, max.</b>	0.8	0.8	1.3	1.3	1.3	-	-	-	-
<b>Phosphorus (ASTM D4951), % m/m</b>	≥ 0.06 & ≤ 0.09	≥ 0.06 & ≤ 0.08	≤ 0.1	≤ 0.1	≤ 0.1	-	≤ 0.08	≥ 0.06 & ≤ 0.08	-
<b>Sulfur (ASTM D4951, or ASTM D5453), max.</b>	0.3	0.3	Rate & report	Rate & report	Rate & report	-	0.50	0.50	-
<b>TBN (ASTM D2896), mg KOH/g, min.</b>	7.0	7.5	10.0	8.0	8.5	-	-	-	-
<b>Copper corrosion (ASTM D130), rating, max.</b>	1b	1b	1b	1b	1b	-	1b	1b	-
<b>Gelation index (ASTM D5133), max.</b>	12	12	12	12	12	-	12	12	-

# FORD MOTOR COMPANY active Ford engine oil specifications

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WSS FORD Specifications	M2C950-A	M2C948-B	M2C913-D	M2C913-C	M2C925-B	M2C917-A	M2C929-A (5W-30) M2C930-A (5W-20)	M2C945-A (5W-20) M2C946-A (5W-30) M2C947-A (0W-20)	M2C171-E
Fill type	Initial / Service	Service <sup>(1)</sup>	Initial for Diesels / Service	Service	Initial / Service	Service	929 = Service / 930 = Initial	Initial / Service	Initial / Service
TEOST MHT4 (ASTM D7097), high temp. dep., mg, max.	35	35	35	35	35	-	30	35	-
Ball rust test (ASTM D6557), average grey value, min.	100	100	100	100	100	-	100	100	-
Daimler biodiesel oxidation test, average of 3 runs, A/cm, max.	35	-	50	-	-	-	-	-	-
Aged oil low temp viscosity, Seq. IIIGA or ROBO (ASTM D7528 or D7320), mPa.s	≤ 60000	≤ 60000	EOT Sample must show no yield stress. D4684 below SAE J300. If CCS used ≤ CCS grade then run MRV TP-1 at original grade if CCS used ≥ max original grade then run MRV TP-1 at next higher grade.	-	-	-	-	-	-
Ford timing belt compatibility (CEC-L-039-96 procedure)	Pass <sup>(4)</sup>	Pass <sup>(4)</sup>	Pass <sup>(4)</sup>	-	-	-	-	-	-
MI11 fuel economy (CEC L-054- 96), average of 3 tests, %	-	-	≥ 3.0	≥ 3.0	≥ 3.3	-	-	-	-
Ford gasoline fuel economy test at ISP, %	> 0.6% vs 5W-20 WSS M2C925-B Ref Oil	> 0.7% vs 5W-20 WSS M2C925-B Ref Oil	-	-	-	-	-	-	-
Ford diesel fuel economy test at ISP, %	> 0.75% vs 5W-30 WSS M2C913-D Ref Oil	-	-	-	-	-	-	-	-
Ford gasoline durability test at ISP	-	-	-	-	-	-	-	-	-
Ford diesel test for chain wear at ISP	Pass	-	Pass	-	-	-	-	-	-

**Notes:**

(1) Can be used in regions with higher S fuel levels up to 3000 ppm, but with reduced drain interval.

(2) ACEA A5/B5 quality, but in 5W-20 viscosity grade.

(3) For initial fill M2C948-A is used. This spec has the Seq. VID added.

(4) Please refer to chapter " Elastomer Compatibility" for limits.

# GM engine oil specifications

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Specifications	dexos1™	dexos1™ 2015	dexos2™
<b>Application</b>	Service Fill: Gasoline excluding European region	Factory Fill: Gasoline worldwide (incl. E85, CNG, LPG) Service Fill: Gasoline excluding European region	Factory Fill: Diesel worldwide Service Fill: Diesel worldwide and Gasoline in European region
<b>Laboratory tests</b>			
SAE viscosity grade, Service Fill, SAE J300	0/5W-20/30	0/5W-16/20/30	0/5W-30/40
SAE viscosity grade, Factory Fill, SAE J300	0/5W-20/30	0/5W-16/20/30	5W-30, 0W-40
HTHS viscosity (CEC L-36-A-90 or ASTM D4741), mPa*s, min.	xW-20: 2.6 / xW-30: 2.9	xW-16: 2.3 / xW-20: 2.6 / xW-30: 2.9	3.5
Low temperature cranking viscosity (ASTM D5293)	Standard per SAE J300	Standard per SAE J300	Standard per SAE J300
Low temperature pumping viscosity (ASTM D4684)			
At -40°C, ASTM D4684, mPa*s, no yield stress, max.	-	0W-xx: 40000 / 5W-xx: Report	-
At -35°C, ASTM D4684, mPa*s, no yield stress, max.	-	0W-xx: Report / 5W-xx: 40000	-
At -30°C, ASTM D5133, mPa*s, no yield stress, max.	-	Rate & Report	-
At -25°C, ASTM D5133, mPa*s, no yield stress, max.	-	Rate & Report	-
At -20°C, ASTM D5133, mPa*s, no yield stress, max.	-	Rate & Report	-
At -15°C, ASTM D5133, mPa*s, no yield stress, max.	-	Rate & Report	-
Gelation index (ASTM D5133), mPa*s, max.	-	12	-
Kinematic viscosity (DIN ISO 3104 / ASTM D445), mm²/s			
At 40°C	Rate & Report	Rate & Report	-
At 100°C	-	xW-16: ≥ 6.1 & < 8.2	Rate & Report
At 100°C	xW-20: ≥ 6.9 & < 9.3	xW-20: ≥ 6.9 & < 9.3	-
At 100°C	xW-30: ≥ 9.3 & < 12.5	xW-30: ≥ 9.3 & < 12.5	-
Shear stability (CEC L-14-A-93)			xW-30: ≥ 9.3 & < 12.5 / xW-40 ≥ 12.5 & < 15.0
Kinematic viscosity at 100°C, mm²/s, range	-	Stay within GM fresh oil limits	
HTHS at 150°C, mPa*s, min.	-	xW-16: 2.1 / xW-20: 2.4 / xW-30: 2.7	-
Noack volatility (CEC L-40-A-93 / ASTM D5800), % loss (A method), max.	13.0%	Avg of 3 consecutive runs: 13.0%	-
Sulfated ash, (DIN 51 575 / ASTM D874), % m/m, max	1.0	1.0	13.0%
TBN (ASTM D2896), mg KOH/g, min.	6.0	6.0	0.8
Chlorine (ISO 15597), mg/kg, max.	150	150	6.0
Phosphorus (DIN 51363-3/-2 or ASTM D4951), mg/kg, max.	850	850	150
Sulfur (DIN ISO 14596 or ASTM D2622), mg/kg, max.	4500	4500	≥ 700 & ≤ 900
Corrosion performance (GMW16073), max.	0 (no corrosion) <sup>(1)</sup>	-	3500

## GM engine oil specifications

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Specifications	dexos1™	dexos1™ 2015	dexos2™
<b>Foaming tendency option A (ASTM D892), ml, max., foaming / settling</b>			
Sequence I	10 / 0	10 / 0	10 / 0
Sequence II	50 / 0	50 / 0	50 / 0
Sequence III	10 / 0	10 / 0	10 / 0
<b>High temperature foaming (ASTM D6082), max.</b>	100 / 0	100 / 0	100 / 0
<b>Ball rust test (ASTM D6557), average grey value, min.</b>	100	100	100
<b>Elastomer compatibility</b>	Elastomer type:	Elastomer type:	Elastomer type:
ACEA: CEC L-39-T-96	RE-1, RE-4	RE-1, RE-5	RE-1, RE-4
ACEA: VDA 675301	AEM	AEM	AEM
SAE: ASTM D7216	SAE J2643: ACM-1, HNBR-1, VMQ-1	SAE J2643: ACM-1, HNBR-1, VMQ-2	SAE J2643: ACM-1, HNBR-1, VMQ-1
<b>Engine tests, ACEA</b>			
High temperature deposits, ring sticking, oil thickening TU5JP-L4, (CEC-L-088-02) <sup>(2)</sup>			
Ring sticking (each part), merit, min.	9.0	9.0	9.0
Piston varnish (6 elements, average of 4 pistons), merit, min.	RL 216	RL 216	RL 216
Absolute viscosity increase at 40°C between min and max values during test, mm <sup>2</sup> /s, max.	0.8 x RL 216	0.8 x RL 216	0.8 x RL 216
Oil consumption, kg/test	Rate & Report	Rate & Report	Rate & Report
<b>Low temperature sludge, Sequence VG (ASTM D6593-00)<sup>(2)</sup></b>			
Average engine sludge, merit, min.	8.3	8.3	8.3
Rocker cover sludge, merit, min.	8.5	8.5	8.5
Average piston skirt varnish, merit, min.	7.5	7.5	7.5
Average engine varnish, merit, min.	8.9	8.9	8.9
Comp. ring (hot stuck)	none	none	none
Oil screen clogging, %, max.	10	10	10
<b>Valve train scuffing wear, TU3M (CEC-L-038-94)<sup>(2)</sup></b>			
Cam wear, average, mm., max.	10	10	10
Cam wear, max., mm, max.	15	15	15
Pad merit (average of 8 pads), merit, min.	7.5	7.5	7.5

## GM engine oil specifications

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Specifications	dexos1™	dexos1™ 2015	dexos2™
<b>Black sludge, M271 (MB method) <sup>(3)</sup></b>	RL140 + 4Σ	RL140 + 0.4	RL140 + 4Σ
Engine sludge, average, merit, min.	-	-	2%
<b>Fuel economy, M111 (CEC-L-054-96)</b>	-	-	0.9 x RL 248 result
Fuel economy improvement vs.reference oil RL 191 (15W40), %, min.	-	-	Rate & Report
<b>Medium temperature dispersivity, DV6 (CEC-L-106)</b>	-	-	120
Absolute viscosity increase at 100°C and 5.5% soot, mm²/s, max.	-	-	100
Piston merit	-	-	5.0
<b>Wear, OM646LA (CEC-L-099-08)</b>	-	-	3
Cam wear outlet (average max.wear 8 cams), mm, max.	-	-	Rate & Report
Cam wear inlet (average max.8 cams, µm, max.	-	-	Rate & Report
Cylinder wear (average 4 cyl.), µm, max.	-	-	Rate & Report
Bore polishing (13mm) (max of 4 cyl.), %, max.	-	-	Rate & Report
Tappet wear inlet (average max.wear 8 cams) , mm.	-	-	Rate & Report
Tappet outlet wear (average max.wear 8 cams), mm.	-	-	Rate & Report
Piston cleanliness (average 4 pistons), merit.	-	-	Rate & Report
Oil consumption, kg/test	-	-	Rate & Report
Engine sludge avg., merit.	-	-	Rate & Report
<b>DI diesel piston cleanliness &amp; ring sticking, VW TDI (CEC-L-078-99)</b>	-	-	> RL 206 + Std Dev
Piston deposits, merit, min.	-	-	1.0
Ring sticking, average 1 <sup>st</sup> gr, ASF, max.	-	-	1 / 0
Ring sticking, max. 1 <sup>st</sup> / 2 <sup>nd</sup> gr, ASF, max.	-	-	Rate & report
End of test TBN, DIN 51639-1, mgKOH/g, min.	-	-	Rate & report
End of test TAN, ASTM D664, max.	-	-	

## GM engine oil specifications

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Specifications	dexos1™	dexos1™ 2015	dexos2™
<b>Engine tests, API and GM</b>			
High temperature deposits, ring sticking, oil thickening, Seq. IIIG / IIIGA (ASTM D7320) <sup>(4)</sup>	150 4.5 None 60 Rate & Report Pass equal or next higher grade	- - - - -	150 4.5 None 60 Rate & Report Pass equal or next higher grade
Viscosity increase at 40°C, %, max.			
Weighted piston deposits, merit, min.			
Ring sticking (hot stuck)			
Average cam + lifter wear, µm, max.			
Oil consumption, l.			
Aged oil low temperature pumping viscosity (ASTM D4684), mPa*s			
Bearing corrosion, Sequence VIII (ASTM D6709)	26 Stay in grade	26 Stay in grade	26 Stay in grade
Bearing weight loss, mg, max.			
10 h stripped viscosity, mm²/s			
<b>NEDC fuel economy gasoline</b> (ISP T0384-2014)	-	xW-30: 0.5%, xW-20: 0.8%, xW-16: Report	-
Fuel economy improvement vs.reference oil, %, min.			
<b>Fuel economy</b> , Sequence VID (ASTM D7589) <sup>(5)</sup>	0W-20 1.2 2.6	0W-30 0.9 1.9	0W-20 1.2 2.6 0W-30 0.9 1.9
FEI 2, %, min.			
Sum of FEI, %, min.			
<b>GM oxidation and deposit test</b> (GMW17043)			
Viscosity increase at 100 h, %, max.	-	100	-
Average weighted piston deposits, merit, min.	-	5.2	-
Average groove 3 Deposits, merit, min.	-	9.0	-
Average piston skirt varnish thrust side, merit, min.	-	9.0	-
Average pistonskirt varnish anti-thrust side, merit, min.	-	9.0	-
Hot stuck rings	-	none	-
Oil consumption, l.	-	Rate & Report	-
CCS viscosity (ASTM D5293), mPa*s	-	0W-xx: Report at -35°C, 5W-xx: Report at -30°C	-
Low temperature pumping viscosity (ASTM D4684), mPa*s	-	Meet requirement of original grade or next higher grade depending CCS results	-
Phosphorus retention, %, min.	-	79	-
<b>GM aeration test</b> (GMW17295), % Aeration			
0.5 h to 1 h aeration	-	Rate & Report	-
4 h to 5 h aeration	-	Rate & Report	-
19 h to 20 h aeration	-	Rate & Report	-
28 h to 29 h aeration	-	< GM Aeration reference oil 1	-
Maximum micro motion aeration	-	Rate & Report	-

# GM engine oil specifications

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Specifications	dexos1™	dexos1™ 2015	dexos2™
<b>GM pre-ignition test (GMW17244)</b>			
Number of pre-ignition events in 5 runs, counts	-	≥ 3 of 5 consecutive tests with 0 peak pressure events, no tests with more than 2 peak pressure events	-
<b>GM turbo charger deposit test (GMW17299)</b>			
Turbo coolant out temperature increase, %, below	-	13	-
Average weighted turbo deposits, merit	-	Rate & Report	-
<b>GM valve-train wear test (GMPTE-T DUR021, RNT method)</b>			
Cam wear max., nm/h, max.	5	5	5
Tappet wear max., nm/h, max.	2	2	2
<b>GM aeration test (GMPTE-T MEC024)</b>			
Aeration rate of Candidate vs. Ref.Oil	Candidate < Ref.Oil	-	Candidate < Ref.Oil
Max .difference in aeration of aged Candidate vs. Ref.Oil	EOT candidate oil - Fresh Ref.Oil < +2	-	EOT candidate oil - Fresh Ref.Oil < +2
<b>Oil release test (gasoline), OP1 (GMPTE-T DUR020) (6)</b>			
Function test, oil pressure, bar	Pass	Pass	Pass
Run-in oil consumption, g/h	15 - 39	15 - 39	15 - 39
Viscosity increase at 40°C (DIN ISO 3104), %, max.	130	130	130
TAN at EOT (ASTM D664), mg KOH/g, max.	8.0	8.0	8.0
Nitration at EOT (DIN 51 453), A/cm, max.	30	30	30
<b>Oil release test (diesel) (GMPTE-T DUR019)</b>			
Piston ring clearance 1 <sup>st</sup> ring (avg.), mm, max.	-	-	0.05
Piston ring clearance 2 <sup>nd</sup> ring (avg.), mm, max.	-	-	0.15
Piston ring clearance 3 <sup>rd</sup> ring (avg.), mm, max.	-	-	0.08
Connecting rod bearing wear, µm, max.	-	-	3
Main bearing wear (avg.), µm, max.	-	-	3
Camshaft wear (avg.) µm, max.	-	-	10
Timing chain elongation, mm, max.	-	-	0.8
Duplex chain elongation, mm, max.	-	-	0.7
Balancer chain elongation, mm, max.	-	-	1.5
Piston cleanliness, merit	-	-	Rate & Report
Oil consumption, g/h, max.	-	-	15
Blow-by (max.), l/min., max.	-	-	50
Viscosity increase at 100°C and 2.5 wt% soot, mm <sup>2</sup> /s, max.	-	-	6.0

**Notes:**

- (1) For factory fill only.
- (2) TU5JP, Seq. VG, TU3M, M271 to be run as long as available.
- (3) M271 Sludge to be replaced by M271EVO when available.

(4) GM does NOT accept the ROBO test as replacement for the oil aging phase for the Sequence IIIGA test.

(5) Seq VID to be replaced by Seq VIE when available.

(6) OP1 test to be replaced by OP2 when available.

## Jaguar Land Rover Limited engine oil specifications



Oronite

JLR specifications - please contact JLR for information

## MAN works standards

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Specifications	M 3275-1 / 2	M 3277 <sup>(1)</sup>	M 3377	M 3477	M 3575	M 3677	M 3777
ACEA / API performance level	ACEA E7- <sup>08</sup> (Issue 2)	ACEA E4- <sup>08</sup> (Issue 2)	ACEA E4- <sup>12</sup>	ACEA E6- <sup>12</sup>	ACEA E9- <sup>08</sup> and API CJ-4	ACEA E6- <sup>12</sup>	ACEA E6- <sup>16</sup> , API CK-4
Viscosity grades (SAE J300)	M 3275-1: 5W-x, 10W-x, 15W-x M 3275-2: 30, 40, 50	0W-x, 5W-x, 10W-x	0W-x, 5W-x, 10W-x	0W-x, 5W-x, 10W-x	xW-30, xW-40	0W-30, 5W-30, 10W-30	0W-30, 5W-30, 10W-30
<b>Laboratory tests</b>							
Density at 15°C (DIN 51757), g/ml	Report	Report	Report	Report	Report	Report	Report
Viscosity at 40°C (DIN 51562-1) at 100°C	Report	Report	Report	Report	Report	Report	Report
Viscosity index (DIN ISO 2909)	In acc. with DIN 51511	In acc. with DIN 51511	In acc. with DIN 51511	In acc. with DIN 51511	In acc. with DIN 51511	In acc. with DIN 51511	In acc. with DIN 51511
HTHS viscosity (CEC L-36-A-90), mPa.s, min.	-	Report	Report	Report	Report	Report	Report
Shear stability (DIN EN ISO 20844)	xW-30: 9, xW-40: 12						
Viscosity at 100°C after 90 cycles shear (DIN 51562-1), mm <sup>2</sup> /s, min.	30, 40, 50: Stay in grade	xW-30: 9, xW-40: 12	xW-30: 9, xW-40: 12	xW-30: 9, xW-40: 12	xW-30: 9, xW-40: 12	Stay in grade	Stay in grade
Evaporative loss (NOACK) (DIN 51581-1), %, max.	13	12	12	12	13	12	12
Flash point (COC) (DIN EN ISO 2592), °C, min.	215	215	215	215	215	215	215
Pour point (DIN ISO 3016), °C, max.	5W-x:-40; 10W-x:-30; 15W-x:-27	0W-x, 5W-x:-40;	0W-x, 5W-x:-40;	0W-x, 5W-x:-40;	xW-30:-27;	10W-30:-30;	10W-30:-30;
TBN (DIN ISO 3771), mg KOH/g, min.	30, 40, 50: -	10W-x:-30	10W-x:-30	10W-x:-30	xW-40:-30	0W-30, 5W-30:-40	0W-30, 5W-30:-40
TAN (ASTM D664), mg KOH/g, min.	Report	Report	Report	Report	Report	Report	Report
Metallic constituents (Calcium, magnesium, others) (DIN 51399-1)	Report	Report	Report	Report	Report	Report	Report
Zinc (DIN 51399-1), % m/m, min.	0.08	Report	Report	Report	Report	Report	Report
Phosphorus (DIN 51399-1), % m/m, max.	Report	Report	0.11	0.08	0.12	0.08	0.08
Boron (DIN 51399-1), % m/m	Report	Report	-	Report	Report	Report	Report
Nitrogen (additive) (calculated), % m/m	Report	Report	Report	Report	Report	Report	Report
Sulfated ash (DIN 51575), % m/m, max.	2.0	2.0	1.2 - 1.5	1.0	1.0	1.0	1.0
Sulfur in finished oil (DIN EN ISO 14596) (as additive only), % m/m, max.	-	-	0.3	0.3	0.4	0.3	0.3
Ethylen glycol (DIN 51375-2), % m/m, max.	0.05	0.05	0.05	Report	0.05	Report	Report
Turbocharger and intercooler deposits (MTV 5040) (DIN 51535), mg, max.	Report	120	120	100	Report	100	100
Oxidation stability (PDSC) (CEC L-85-99), min, min.	-	-	100	100	-	100	100

## MAN works standards

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Specifications	M 3275-1 / 2	M 3277 <sup>(1)</sup>	M 3377	M 3477	M 3575	M 3677	M 3777
<b>Foaming tendency (ASTM D892) (No option A)</b>	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0	10 / 0, 50 / 0, 10 / 0
Sequence I, II, III, ml, max.							
<b>Elastomer compatibility (VDA 675 301, M 3273)<sup>(2)</sup></b>	Pass						
<b>Base oil blend analysis (M3353)</b>	Pass						
<b>Engine tests</b>							
<b>OM 501 LA (CEC L-101-08)</b>							
Piston merit, average, merit, min.	17.0	26.0	26.0	26.0	17.0	26.0	28.0
Wear rating (visual), average, demerit, max.	3.0	2.0	2.0	-	3.0	2.0	2.0
Bore polishing, average, %, max.	2.0	1.0	1.0	1.0	2.0	1.0	1.0
General engine deposits, average, demerit, max.	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Cylinder wear, average, mm, max.	0.008	0.008	0.008	-	0.008	0.008	0.008
Ring sticking, piston ring 2, ASF, max.	1.0	1.0	1.0	-	1.0	1.0	1.0
Turbocharger deposits, demerit, max.	2.0	2.0	2.0	-	2.0	2.0	2.0
Engine sludge, average, merit, min.	9.0	9.4	9.4	Rate & report	9.0	9.4	9.4
Specific oil consumption, kg/test, max.	9	9	9		9	9	9
TBN at end-of-test, mg KOH/g	Rate & report	Rate & report	Rate & report	-	Rate & report	Rate & report	Rate & report
TAN at end-of-test, mg KOH/g	Rate & report	Rate & report	Rate & report	-	Rate & report	Rate & report	Rate & report
<b>OM 646 LA (CEC L-099-08)</b>							
Cam wear inlet (average max. 8 cams), µm, max.	110	100	100	-	110	100	100
Cam wear outlet (average max. wear 8 cams), µm, max.	140	120	120	140	140	120	120
Cylinder wear (average 4 cyl.), µm, max.	5.0	5.0	5.0	-	5.0	5.0	5.0
Bore polishing (13 mm) (max of 4 cyl.), %, max.	3.5	3.0	3.0	-	3.5	3.0	3.0
Tappet wear inlet (average max. wear 8 cams), µm, max.	Rate & report	Rate & report	Rate & report	-	Rate & report	Rate & report	Rate & report
Tappet outlet wear (average max.wear 8 cams), µm, max.	Rate & report	Rate & report	Rate & report	-	Rate & report	Rate & report	Rate & report
Viscosity increase at 100°C, %, max.	100	90	90	-	100	90	90
Oil consumption, kg/test, target value, max.	7	7	7	-	7	7	7

## MAN works standards

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Specifications	M 3275-1 / 2	M 3277 <sup>(1)</sup>	M 3377	M 3477	M 3575	M 3677	M 3777
<b>Mack T-13 (ASTM D8048)</b>							
IR Oxidation peak height at 360 h, A/cm, max.	-	-	-	-	-	-	80
KV40 increase (300 - 360 h), %, max.	-	-	-	-	-	-	50
<b>Field test (M 3554)</b>							
Field test with three MAN trucks	-	-	-	-	-	Pass	Pass

**Notes:**

- (1) Approval of engine oils and additive packages will be dependent on the results in the test engines OM501LA and OM646LA. Alternatively, these two CEC tests may be replaced with the 400 h test in the MAN D2876 LF04 engine.
- (2) Please refer to chapter "Elastomer Compatibility" for limits.
- (3) Test fuel in accordance with EN 590, but with a sulphur content <10 mg/kg and without addition of FAME.

# MERCEDES-BENZ specifications for passenger car (service fill) V2017.1

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
Mono-/multigrade viscosities	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi
Viscosity grades (SAE J300)	OW-, 5W-30, OW-, SW-, 10W-40	OW-, 5W-30, OW-, 5W-40	OW-, 5W-30, 10W-X	OW-, 5W-30, 10W-X	OW-, 5W-30, 10W-X	OW-, 5W-30, 10W-X	OW-, 5W-X	OW-, 5W-30	OW-, 5W-30	OW-, 5W-20
SAE xW-30 and OW-40	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Only OW-/ 5W-30	Only OW-/ 5W-30	No
<b>DBL, Read Across guidelines, ACEA, API, DDC</b>										
Related Daimler Liefervorschrift (DBL)	6615	6615	6615	6615	6615	6615	6615	6615	6615	6615
MB read across <sup>(5)</sup>	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Package pass <sup>(5)</sup>	No	No	No	No	No	No	No	No	No	No
ACEA Oil Sequences required	If any ACEA Ax, Bx, Cx, Ex or Fx oil sequence is claimed all tests within this oil sequence are mandatory.									
RN oil specification level, RN certificate is mandatory, validity acc. to RN certificate	RN0710	RN0720	-	-	-	-	-	-	-	-
<b>Laboratory tests</b>										
Sulphated ash (DIN 51575 or ASTM D874), % m/m, max	≥ 0.7 & < 1.5	0.5	> 0.9 & ≤ 1.5	0.8	> 1.0 & ≤ 1.6	0.8	0.8	> 1.0 & ≤ 1.6	≤ 0.8	≤ 0.8
TBN (ASTM D2896), fresh oil, mg KOH/g, min.	8.0	6.0	7.0	6.0	10.0	6.0	6.0	8.0	7.5	7.5
TBN (ASTM D4739), fresh oil, mg KOH/g	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
TAN (ASTM D664), fresh oil, mg KOH/g	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Density at 15°C (DIN 51757), kg/m <sup>3</sup>	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Flash point (DIN EN ISO 2592, ASTM D92), °C	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Pour point (ISO 3016 or ASTM D97), °C, max.	Rate & report	Rate & report	-27	-27	-27	-27	-36	-36	-39	-39
Evaporative loss (Noack) (CEC L-40-93, ASTM 5800), %, max.	12	11	13	12	10	10	10	10	10	11
Kinematic viscosity (ASTM D445, DIN 51562-1), mm <sup>2</sup> /s	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
KV at 40°C	-	-	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300
KV at 100°C	-	-	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	≥ 7.8
Viscosity at High Temperature and High Shear (CEC L-36-90), mPa.s, min	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
HHTS at 100°C	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
HHTS at 150°C	≥ 3.5	≥ 3.5	≥ 3.5	≥ 3.5	≥ 3.5	≥ 3.5	≥ 3.5	≥ 2.9 & < 3.2	≥ 2.9 & < 3.2	≥ 2.6 & < 2.9

**MERCEDES-BENZ specifications for passenger car (service fill) V2017.1**  
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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
<b>Shear stability (CEC L-14-93, ASTM D6278, 30 cycles / ASTM D7109, 90 cycles)</b>	at 30 cycles	at 30 cycles	at 30 cycles	at 30 cycles	at 90 cycles					
Kin. viscosity at 100°C after 30 / 90 cycles shearing, mm <sup>2</sup> /s	Stay in grade									
<b>Chemical elements</b>										
Zinc (DIN 51399 -1/2, ASTM D4951, ASTM D5185), % m/m, min.	Rate & report	Rate & report	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulphur (DIN 51399 -1/2, ASTM D4951, ASTM D5185), % m/m, max.	Rate & report	0.2	0.5	0.3	0.5	0.3	0.3	0.5	0.3	0.3
Phosphorus (DIN 51399 -1/2, ASTM D4951, ASTM D5185), % m/m, max.	Rate & report	0.9	0.05 - 0.11	0.05 - 0.09	0.05 - 0.11	0.05 - 0.09	0.05 - 0.09	0.07 - 0.11	0.07 - 0.09	0.07 - 0.09
Chlorine (DIN 51399-2, ASTM D6443), % m/m, max.	Rate & report	Rate & report	0.015	0.015	0.015	0.015	0.010	0.010	0.010	0.010
Calcium (DIN 51399-1/2, ASTM D4951, ASTM D5185)	-	-	0.4	0.3	0.4	0.3	0.3	0.4	0.3	0.3
Magnesium (DIN 51399-1/2, ASTM D4951)	-	-	0.4	0.3	0.4	0.3	0.3	0.4	0.3	0.3
Elements B, Ba, Mo, N, Si, % m/m	-	-	Rate & report							
Dielectric constant $\delta r$ of fresh oil										
Temic oil sensor (DAI) test method at 20°C - 100°C, % m/m	-	-	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5
<b>Daimler oxidation test - fresh oil at 160°C (Daimler oxidation test procedure)</b>										
Kin. viscosity at 100°C, EOT 168 h, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Oxidation DIN 51453 at EOT 168 h, A/cm, max.	-	-	60	60	25	25	20	20	20	20
$\Delta$ kin. viscosity at 100°C, absolute, mm <sup>2</sup> /s, max.	-	-	Rate & report							
A kin. viscosity at 100°C, relative, %, max.	-	-	80	80	70	70	50	50	50	50

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
Daimler oxidation test - with fuel dilution 5% B100 at 160°C (FAME from OM 646 Biodiesel test)										
Kin. viscosity at 100°C, EOT 168 h, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Oxidation at EOT 168 h, A/cm, max. (DIN 51453)	-	-	100	100	80	80	40	40	40	40
Δ kin. viscosity at 100°C, absolute, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Δ kin. viscosity at 100°C, relative, %, max.	-	-	120	80	70	70	50	50	50	50
Oxidation test - with fuel dilution 7% B100 at 150°C (CEC L-109) (FAME from OM 646 Biodiesel test)										
Kin. viscosity at 100°C, EOT 168 h, avg. 2 runs, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Kin. viscosity at 100°C, EOT 216 h, avg. 2 runs, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Oxidation at EOT 168 h, avg. 2 runs, A/cm, max. (DIN 51453)	-	-	120	100	100	80	50	100	50	50
Oxidation at EOT 216 h, avg. 2 runs, A/cm, max. (DIN 51453)	-	-	150	120	120	100	80	120	80	80
Δ kin. viscosity 168 h, avg. of 2 runs, absolute, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Δ kin. viscosity 168 h, avg. of 2 runs, relative, %, max.	-	-	150	60	60	60	50	60	50	50
Δ kin. viscosity 216 h, avg. of 2 runs, absolute, mm <sup>2</sup> /s, max.	-	-	Rate & report							
Δ kin. viscosity 216 h, avg. of 2 runs, relative, mm <sup>2</sup> /s, max.	-	-	350	150	150	150	100	150	100	100
TOC oxidation test (D55 3099)										
TAN, mg KOH/g	R&R at 80 h	R&R at 96 h	-	-	-	-	-	-	-	-
PAI CO, max.	400 at 80 h	400 at 96 h	-	-	-	-	-	-	-	-
Variation of viscosity at 40°C, %, max.	200 at 80 h	200 at 96 h	-	-	-	-	-	-	-	-
Variation of viscosity at 100°C, %	R&R at 80 h	R&R at 96 h	-	-	-	-	-	-	-	-
MCT cokefaction test (GFC Lu 27), merit, min.	7.0	7.0	-	-	-	-	-	-	-	-

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71	
SRV (Schwing Reib Verschleiß) tTest, PC ring / liner (MBN10474, SRV version 4 to be applied) <sup>(2)</sup>											
Load carrying capacity, fresh oil, avg. 5 runs, N, min.	-	-	100	-	150	100	100	100	100	100	
Coefficient of friction, fresh oil, avg. of 5 runs, µr, max.	-	-	Rate & report	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	
Load carrying capacity, aged oil, avg. 5 runs, N, min.	-	-	Rate & report	-	60	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	
Coefficient of friction, aged oil, avg. of 5 runs, µr, max.	-	-	Rate & report	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	
CCS (according to SAE J300, fresh oil)											
At SAE J300 fresh oil temperatures, mPa.s, max.			Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300					
MRV (according to SAE J300, fresh oil)											
MRV at SAE J300 fresh oil temperature, mPa.s, max.	-	-	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	30000	30000	30000	30000	
Yield stress, Pa	-	-	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300					
CEC Low temperature pumping test (CEC L-105) <sup>(2)</sup>											
MRV at SAE J300 fresh oil temperature, mPa.s, max.	-	-					According to SAE J300 for fresh oil				
Yield stress, Pa, max.	-	-	No	No	No	No	No	No	No	No	
High Temperature Corrosion Bench Test (HTCBT) (modified ASTM D6594 at 135 °C)											
Cu increase, without / with 10% B100*, ppm, max.	-	-	20 / 200	20 / 200	20 / 150	20 / 150	20 / 150	20 / 150	20 / 150	20 / 150	
Pb increase (only fresh oil), ppm, max.	-	-	100	100	100	100	100	100	100	100	
Copper strip rating, without / with 10% B100*, max.	-	-	3 / 4a	3 / 4a	3 / 4a	3 / 4a					
* Reference fuel B100 (80/20 RME/SME from OM 646 TDG-L-104)											

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
<b>Foaming tendency (ASTM D892)</b>										
Sequence I (24°C) (ASTM D892 w/o option A), ml, max.	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
Sequence II (94°C) (ASTM D892 w/o option A), ml, max.	50 / 0	50 / 0	20 / 0	20 / 0	20 / 0	20 / 0	20 / 0	20 / 0	20 / 0	20 / 0
Sequence III (24°C) (ASTM D892 w/o option A), ml, max.	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
Sequence IV (150°C) (ASTM D6082 after 1 min settling period), ml, max.	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0
<b>Elastomer compatibility</b>										
According ACEA (CEC L-112-16)	A3/B3	C4	A3/B3	C3	A3/B4	C3	C3	A5/B5	C2	C5
<b>Infrared spectrum</b> (window material KBr, ZnSe, NaCl, cell thickness 100-125 µm)	Rate & report									
<b>Brand name / Type / Content of .....</b>										
Base oil acc. ATIEL	Report									
Additive package	Report									
Any additional additive component (e.g. PPD, VII, anti foam additive)	Report									

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
<b>Engine tests</b>										
<b>M 271 sludge test</b> (M 271 classic sludge DL, until M 271 EVO, CEC L-107, is ready at CEC) <sup>(2)</sup> Engine sludge, avg., merit, min.	RL140 + 4σ	RL140 + 4σ	8.8	8.8	9.1	9.1	9.1	9.1	9.1	9.1
<b>M 271 EVO sludge</b> (CEC L-107 when ready at CEC, as alternative to M 271 Sludge Test) <sup>(2)</sup> Engine sludge, avg., merit, min.	-	-	RL261 + 4xRSD							
<b>M 271 wear test</b> (MB DL, wear 250 h) <sup>(2)</sup> Cam wear inlet / outlet valve, avg. max. wear 8 $\mu\text{m}$ , max. Piston ring wear radial ring 1 / 2, avg., $\mu\text{m}$ , max. <sup>(4)</sup> Piston ring wear axial ring 1 / groove 1, avg., $\mu\text{m}$ , max. <sup>(4)</sup> Ring sticking Main bearing wear, avg., $\mu\text{m}$ , max. Conrod bearing wear, avg., $\mu\text{m}$ , max. Timing chain wear (elongation), %, max. Timing chain wear (single chain link), %, max.	-	-	5.0 / 5.0	5.0 / 5.0	5.0 / 5.0	5.0 / 5.0	5.0 / 5.0	5.0 / 5.0	5.0 / 5.0	5.0 / 5.0
Fuel economy improvement vs. RL252 (15W-40), %, min. (for xW-30) (C3)	1.0	1.0	1.0	1.0	xW-30: 2.0	xW-30: 2.0	xW-30: 2.2	2.5	2.5	3.0
	(for xW-30) (C3)									
	xW-40: 1.7									
	xW-40: 1.7									

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
<b>NEDC MB fuel economy tests - (FE benefit in NEDC, PC chassis dynamometer Test) for 0W-30/-40 and 5W-30/-40 vs. MB RL001 Otto &amp; MB RL002 Diesel<sup>(3)</sup></b>						xW-30: 0.5	xW-30: 1.2	-	1.4	1.7
FE in W204 C250 CDI / engine: OM651 vs. MB RL002, %, min.	-	-	-	-	-	xW-40: R & R	xW-40: 0	-		
FE in W204 C320 CDI / engine: OM642 vs. MB RL002, %, min.	-	-	-	-	-	xW-30: 0.7	xW-30: 1.2	-	1.8	2.7
FE in W204 C200 K / engine: M271 ML 18 vs. MB RL001, %, min.	-	-	-	-	xW-30: 0	xW-40: R & R	xW-40: 0	-	0.5	1.0
FE in W204 C350 CGI / engine: M271 DE35 vs. MB RL001, %, min.	-	-	-	-	xW-40: R & R	xW-40: R & R	xW-40: R & R	-	0.4	0.8
<b>OM 646 DE22LA wear test (CEC L-99-08)<sup>(2)</sup></b>										
Cam wear inlet / outlet valve (avg. max. wear 8 cams), µm, max.	100 / 120	100 / 120	100 / 130	100 / 130	90 / 110	90 / 110	90 / 110	90 / 110	90 / 110	90 / 110
Cylinder wear (avg. 4 cylinders), µm, max.	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Bore polishing (13 mm), value of 4 cylinders, %, max.	3.0	3.0	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0
Piston cleanliness (avg. 4 pistons), merit, min.	Rate & report	Rate & report	12.0	14.0	14.0	16.0	16.0	14.0	16.0	16.0
Engine sludge avg., merit, min.	Rate & report	Rate & report	8.8	8.8	9.1	9.1	9.1	9.1	9.1	9.1
Ring sticking	Rate & report	Rate & report	No							
Tappet wear inlet (avg. wear 8 cams), µm	Rate & report									
Tappet wear outlet (avg. wear 8 cams), µm	Rate & report									
Bearing wear main / con rod bearing, µm, max. <sup>(4)</sup>	Rate & report	Rate & report	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1
Piston ring wear axial ring 1 / 2 / 3, µm, max. <sup>(4)</sup>	Rate & report	Rate & report	10.4/6.0/5.0	10.4/6.0/5.0	8.7/4.0/3.0	8.7/4.0/3.0	8.7/4.0/3.0	8.7/4.0/3.0	8.7/4.0/3.0	8.7/4.0/3.0
Piston ring wear radial ring 1 / 2 / 3, µm, max. <sup>(4)</sup>	Rate & report	Rate & report	10.0/12.0/8.0	10.0/12.0/8.0	10.0/12.0/8.0	10.0/12.0/8.0	10.0/12.0/8.0	10.0/12.0/8.0	10.0/12.0/8.0	10.0/12.0/8.0
Timing chain wear (elongation), %, max.	Rate & report	Rate & report	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Oil consumption, g/test, max.	Rate & report	Rate & report	7000	7000	7000	7000	7000	7000	7000	7000
Soot, %, max.	Rate & report	Rate & report	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0
Viscosity increase at 100°C, %, max.	Rate & report	Rate & report	100	100	90	90	90	90	90	90

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MB Sheet No. <sup>(1)</sup>	226.5	226.51	229.3	229.31	229.5	229.51	229.52	229.6	229.61	229.71
<b>OM 646 DE22LA biodiesel test (CEC L-104) <sup>(2)</sup></b>										
Piston cleanliness, avg. 4 pistons, merit, min.	-	-	20.0	20.0	25.0	25.0	25.0	25.0	25.0	25.0
Engine sludge, avg., merit, min.	-	-	8.8	8.8	9.0	9.0	9.2	9.2	9.2	9.2
Ring sticking	-	-	No	No	No	No	No	No	No	No
TBN at EoT (ASTM D4739), mg KOH/g, min.	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
TAN at EoT (ASTM D664), mg/KOH/g, max.	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Oil consumption, g/test, max.	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Soot, %, max.	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Viscosity increase at 100°C, %, max.	-	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
<b>Daimler OM 646 DE22LA aeration test (Daimler inhouse test)</b>										
Gas content in engine oil - high reference oil, after 5 h, vol.%	-	-	-	-	-	-	-	-	Rate & report	Rate & report
Gas content in engine oil - candidate oil, after 5 h, vol.%	-	-	-	-	-	-	-	-	Rate & report	Rate & report
Gas content in engine oil - high reference oil, after 20 h, vol.%	-	-	-	-	-	-	-	-	Rate & report	Rate & report
Gas content in engine oil - candidate oil, after 20 h, vol.%	-	-	-	-	-	-	-	-	Rate & report	Rate & report
Ratio candidate oil after 5 h / high reference oil after 5 h, max.	-	-	-	-	-	-	-	-	1.2	1.2
<b>Daimler LSPI engine test (Daimler inhouse test) <sup>(3)</sup></b>										
Ratio of Preignition events (candidate oil / reference oil MBRLO10), max.	-	-	-	-	0.5	0.5	0.5	0.5	0.5	0.5
<b>VW TDI (CEC L-79-99)</b>	-	-	-	-	-	-	-	-	-	-
Piston cleanliness, avg., merit, min.	RL 206 A5/B5	RL 206 C4	RL 206 A3/B4	RL 206 C3	RL 206 A3/B4	RL 206 C3	RL 206 C3	RL 206 A5/B5	RL 206 C2	RL 206 C5
All other requirements as listed in ACEA 2012										
<b>VW T4 (VW PV 1449)</b>										
All test parameters from VW 502.00	-	-	Yes	-	Yes	-	-	-	-	-
<b>LLR Renault in-house test</b>										
PAI CO at end of test, max.	-	200	-	-	-	-	-	-	-	-
Viscosity increase at 40°C at end of test, %, max.	-	100	-	-	-	-	-	-	-	-
Oil consumption, g/h,	-	Report	-	-	-	-	-	-	-	-
Piston deposits, merit, min.	-	5	-	-	-	-	-	-	-	-
Ring sticking (all rings)	-	No	-	-	-	-	-	-	-	-

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## Notes:

- (1) Complete test reports for each test have to be submitted. All required data have to be measured, calculated values are not accepted.
- (2) For MB Engine Tests: Rerating at RD/PDI for all related engine parts is required.
- (3) Only for xW-30 or OW-40: Evaluation of bearing wear in a OM 501 LA engine with new crankshaft and premeasured bearings. Rerating by Daimler at TP/PEH.
- (4): The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.
- (5) Read Across only according to MB Read Across Guidelines for engine tests (based on the latest ATC and ATIEL Code of Practice). MB Package Pass only for Mineral Oils (SN, ATIEL Grp. I and II) and for SAE 15W-40, 20W-40, 15W-50, 20W-50.
- (6) Corresponding ACEA Sequences or DDC specification level is indicated. Since the performance level of these specifications is different to MB specification they cannot be used alternatively to MB specification.
- (7) Detailed rating for Mack T-12, Cummins ISM and Caterpillar C13 according to API CJ-4 Merit Systems; 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 for MB-Approval 228.3.
- (8) Introduced on 01.11.2018 according to BEAM message from 07/2018.

## Conditions for approvals and the use of performance claims (MB sheets) against MB oil specifications

MB requires that any claims for oil performance to meet the mentioned MB specifications, must be based on credible data and controlled tests in accredited test laboratories. All engine performance testing used to support a claim of compliance with these MB oil specifications must be generated according to the MB Read Across Guidelines and the European Engine Lubricants Quality Management System (EELQMS).

An MB Approval for each new oil formulation is valid for 5 years.

The validity period of rebrands and reblands is limited by the runtime of the original and therefore limited to max. 5 years.

From the introduction date of a new version of the MB Specification the previous version is still valid one year. During this period of time both specification versions are valid for approvals.

Package Pass approvals: For every treat rate a trading approval is required. The trading approvals are handled like approvals for new oil formulations.

As a consequence the following timeline is valid from now on:

MB Specification - Issue (version with year spec. no.)	First allowable use	New approvals by at the latest
MB Specification V2009.1	16.03.2009	21.03.2013
MB Specification V2012.1	21.03.2012	substituted by MB Specification V2012.2 on 01.10.2012
MB Specification V2012.2	01.10.2012	31.05.2017
MB Specification V2016.1	31.05.2016	31.05.2018
MB Specification V2017.1	01.06.2017	substituted by MB Specification V2019.1 on 15/01/2019
MB Specification V2019.1	15.01.2019	

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

New approvals by means that from this date all approvals for new oil formulations must be according to the latest MB specification release.

# MERCEDES-BENZ specifications for heavy duty (service fill) V2017.1

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
Mono-/multigrade viscosities	Mono / multi	Multi	Multi	Multi	Multi	Multi
Viscosity grades (SAE J300)	acc. ACEA	acc. ACEA	acc. ACEA	acc. ACEA	acc. ACEA	xW-30
SAE xW-30 and OW-40	Yes <sup>(3)</sup>	Yes <sup>(3)</sup>	Yes <sup>(3)</sup>	Yes <sup>(3)</sup>	Yes <sup>(3)</sup>	Only xW-30 <sup>(3)</sup>
<b>DBL, Read Across guidelines, ACEA, API, DDC</b>						
Related Daimler Lieferforschrift (DBL)	6610	6610	6610	6610	6610	6610
MB read across <sup>(5)</sup>	Yes	Yes	Yes	Yes	Yes	yes
Package pass <sup>(5)</sup>	Yes	Yes	No	No	No	No
Corresponding ACEA Oil Sequences level <sup>(6)</sup>	E7	E9	E4	E6	E6	F8
ACEA Oil Sequences required	If any ACEA Ax, Bx, Cx, Ex or Fx oil sequence is claimed all tests within this oil sequence are mandatory.					
API Oil Categories required	-	API CJ-4	-	-	-	API FA-4
Corresponding DDC Oil Specification level <sup>(6)</sup>	-	93K218	-	-	-	93K223
<b>Laboratory tests</b>						
<b>Sulphated ash</b> (DIN 51575 or ASTM D874A), % m/m, max	> 1.0 & ≤ 2.0	1.0	> 1.0 & ≤ 2.0	1.0	1.0	1.0
TBN (ASTM D2896), fresh oil, mg KOH/g, min.	8.0	7.0	12.0	7.0	7.0	7.0
TBN (ASTM D4739), fresh oil, mg KOH/g	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
TAN (ASTM D664), fresh oil, mg KOH/g	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Density at 15°C (DIN 51577), kg/m³	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Flash point (DIN EN ISO 2592, ASTM D92), °C	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Pour point (ISO 3016 or ASTM D97), °C, max.	R & R / -27	-27	-27	-27	-27	-27
Evaporative loss (Noack) (CEC L-40-93, ASTM 5800), %, max.	13	13	13	12	12	12
<b>Kinematic viscosity</b> (ASTM D445, DIN 51562-1), mm²/s						
KV at 40°C	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
KV at 100°C	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300
<b>Viscosity at High Temperature and High Shear</b> (CEC L-36-90), mPa.s, min						
HTHS at 100°C	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
HTHS at 150°C	3.5	3.5	3.5	3.5	3.5	≥ 2.9 & ≤ 3.2
<b>Shear stability</b> (CEC L-14-93, ASTM D6278, 30 cycles / ASTM D7109, 90 cycles)	at 30 cycles	at 90 cycles	at 90 cycles	at 90 cycles	at 90 cycles	at 90 cycles
Kin. viscosity at 100°C after 30 / 90 cycles shearing, mm²/s	Stay in grade	Stay in grade	Stay in grade	Stay in grade	Stay in grade	Stay in grade

# MERCEDES-BENZ specifications for heavy duty (service fill) V2017.1

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
<b>Chemical elements</b>						
Zinc (DIN 51399 -1/2, ASTM D4951, ASTM D5185), % m/m, min.	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Sulphur (DIN 51399 -1/2, ASTM D4951, ASTM D5185), % m/m, max.	Rate & report	0.4	Rate & report	0.3	0.3	0.4
Phosphorus (DIN 51399 -1/2, ASTM D4951, ASTM D5185), % m/m, max.	Rate & report	0.12	Rate & report	0.08	0.08	0.12
Chlorine (DIN 51399-2, ASTM D6443), % m/m, max.	Rate & report	Rate & report	Rate & report	0.015	0.015	0.015
Calcium (DIN 51399-1/2, ASTM D4951, ASTM D5185), % m/m, max.	Rate & report	Rate & report	Rate & report	Rate & report	0.15	Rate & report
Magnesium (DIN 51399-1/2, ASTM D4951), % m/m, max.	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Elements B, Ba, Mo, N, Si, % m/m	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
Dielectric constant $\epsilon_r$ of fresh oil						
Temic oil sensor (DAI) test method at 20°C - 100°C, % m/m	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5	2.0 - 2.5
<b>Daimler oxidation test - fresh oil at 160°C</b> (Daimler oxidation test procedure)						
Kin. viscosity at 100°C, EOT 168 h, avg. of 3 runs, mm <sup>2</sup> /s, max.	Rate & report 80 100	Rate & report 80 100	Rate & report 25 80	Rate & report 25 80	Rate & report 25 80	Rate & report 25 80
Oxidation DIN 51453 at EOT 168 h, avg. 3 runs, A/cm, max.						
Delta kin. viscosity at 100°C, avg. of 3 runs, absolute, mm <sup>2</sup> /s, max.						
Delta kin. viscosity at 100°C, avg. of 3 runs, relative, %, max.						
<b>Daimler oxidation test - with fuel dilution 5% B100 at 160°C</b> (FAME from OM 646 Biobiodiesel test) (Daimler ox. test procedure)						
Kin. viscosity at 100°C, EOT 168 h, max.	Rate & report 120 300	Rate & report 120 150	Rate & report 90 130	Rate & report 80 100	Rate & report 80 100	Rate & report 80 100
Oxidation at EOT 168 h, max. (DIN 51453)						
Delta kin. viscosity at 100°C, absolute, mm <sup>2</sup> /s, max.						
Delta kin. viscosity at 100°C, relative, %, max.						
<b>Oxidation test - with fuel dilution 7% B100 at 150°C</b> (CEC L-109) (FAME from OM 646 Biobiodiesel test)						
Kin. viscosity at 100°C, EOT 168 h, avg. 2 runs, mm <sup>2</sup> /s, max.	Rate & report - 120 -	Rate & report - 90 -	Rate & report Rate & report Rate & report	Rate & report 80 80	Rate & report 80 80	Rate & report 80 80
Kin. viscosity at 100°C, EOT 216 h, avg. 2 runs, mm <sup>2</sup> /s, max.						
Oxidation at EOT 168 h, avg. 2 runs, A/cm, max. (DIN 51453)						
Oxidation at EOT 216 h, avg. 2 runs, A/cm, max. (DIN 51453)						
Delta kin. viscosity 168 h, avg. of 2 runs, absolute, mm <sup>2</sup> /s, max.	Rate & report 300	Rate & report 150	Rate & report 130	Rate & report 130	Rate & report 130	Rate & report 130
Delta kin. viscosity 168 h, avg. of 2 runs, relative, %, max.						
Delta kin. viscosity 216 h, avg. of 2 runs, absolute, mm <sup>2</sup> /s, max.						
Delta kin. viscosity 216 h, avg. of 2 runs, relative, mm <sup>2</sup> /s, max.						
<b>CCS</b> (according to SAE J300, fresh oil)						
At SAE J300 fresh oil temperatures, mPa.s, max.	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300	Acc. SAE J300

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
<b>MRV</b> (according to SAE J300, fresh oil)						
MRV at SAE J300 fresh oil temperature, mPa.s	Acc. SAE J300					
Yield stress, Pa	Acc. SAE J300					
<b>CEC low temperature pumping test (CEC L-105)</b>						
MRV at SAE J300 fresh oil temperature, mPa.s						
Yield stress, Pa						
<b>Deposit test</b> (MTU, DIN 51535), mg, min.	No	No	No	No	No	No
<b>Sooted oil MRV (T-II/T-IIA) (ASTM D6896)</b>	Rate & report	Rate & report	130	130	130	130
180 hour sample T-II/T-IIA drain MRV, mPa.s, max.	-	18000	-	-	-	25000
Yield stress, Pa, max.	-	35	-	-	-	35
<b>High Temperature Corrosion Bench Test (HTCBT) (modified ASTM D6594 at 135 °C)</b>						
Cu increase, without / with 10% B100*, ppm, max.	20 / 200	20 / 200	20 / 200	20 / 200	20 / 200	20 / 200
Pb increase (only fresh oil), ppm, max.	100	100	100	100	100	100
Copper strip rating, without / with 10% B100*, max.	3 / 4a					
* Reference fuel B100 (80/20 RME/SME from OM 646 TDG-L-104)						
<b>Foaming tendency</b> (ASTM D892)						
Sequence I (24°C) (ASTM D892 w/o option A), ml, max.	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
Sequence II (94°C) (ASTM D892 w/o option A), ml, max.	20 / 0	20 / 0	20 / 0	20 / 0	20 / 0	20 / 0
Sequence III (24°C) (ASTM D892 w/o option A), ml, max.	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
Sequence IV (150°C) (ASTM D6082 after 1 min settling period), ml	200 / 50	200 / 50	200 / 50	200 / 50	200 / 50	200 / 50
<b>Elastomer compatibility</b>						
ACEA (CEC L-112- $\times$ )	ACEA E7	ACEA E9	ACEA E4	ACEA E6	ACEA E6	ACEA F8
API (ASTM D7216)	-	API CJ-4	-	-	-	API FA-4
<b>Infrared spectrum</b> (window material KBr, ZnSe, NaCl, cell thickness 100-125 $\mu\text{m}$ )	Rate & report					
<b>Brand name / Type / Content of .....</b>						
Base oil acc. ATIEL	Report	Report	Report	Report	Report	Report
Additive package	Report	Report	Report	Report	Report	Report
Any additional additive component (e.g. PPD, VII, anti foam additive)	Report	Report	Report	Report	Report	Report

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
<b>Engine tests</b>						
OM 646 DE22LA wear test (CEC L-99-08) <sup>(2)</sup>						
Cam wear inlet / outlet valve (avg. max. wear 8 cams), µm, max.	100 / 130	100 / 130	90 / 110	90 / 110	90 / 110	90 / 110
Cylinder wear (avg. 4 cylinders), µm, max.	5.0	5.0	5.0	5.0	5.0	5.0
Bore polishing (13 mm), value of 4 cylinders, %, max.	3.5	3.5	3.0	3.0	3.0	3.0
Piston cleanliness (avg. 4 pistons), merit, min.	14.0	14.0	16.0	16.0	16.0	16.0
Engine sludge avg., merit, min.	8.8	8.8	9.1	9.1	9.1	9.1
Ring sticking	No	No	No	No	No	No
Tappet wear inlet (avg. wear 8 cams), µm	Rate & report					
Tappet wear outlet (avg. wear 8 cams), µm	Rate & report					
Bearing wear main / con rod bearing, µm, max. <sup>(4)</sup>	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1	2.1 / 2.1
Piston ring wear axial ring 1 / 2 / 3, µm, max. <sup>(4)</sup>	10.4 / 6.0 / 5.0	10.4 / 6.0 / 5.0	8.7 / 4.0 / 3.0	8.7 / 4.0 / 3.0	8.7 / 4.0 / 3.0	8.7 / 4.0 / 3.0
Piston ring wear radial ring 1 / 2 / 3, µm, max. <sup>(4)</sup>	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0
Timing chain wear (elongation), %, max.	0.4	0.4	0.4	0.4	0.4	0.4
Oil consumption, g/test, max.	7000	7000	7000	7000	7000	7000
Soot, %, max.	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0	3.0 - 6.0
Viscosity increase at 100°C, %, max.	100	100	90	90	90	90
OM 646 DE22LA biodiesel test (CEC L-104) (when ready) <sup>(2)</sup>						
Piston cleanliness, avg. 4 pistons, merit, min.	Rate & report	20.0	25.0	25.0	25.0	25.0
Engine sludge, avg., merit, min.	Rate & report					
Ring sticking	Rate & report					
TBN at EoT (ASTM D4739), mg KOH/g, min.	Rate & report					
TAN at EoT (ASTM D664), mg/KOH/g, max.	Rate & report					
Oil consumption, g/test, max.	Rate & report					
Soot, %, max.	Rate & report					
Viscosity increase at 100°C, %, max.	Rate & report					

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
OM 501 LA Euro 5 (CEC L-101-09) <sup>(2), (3)</sup>						
Piston cleanliness, avg., merit, min.	20.0	20.0	30.0	30.0	30.0	30.0
Ring sticking, 2 <sup>nd</sup> rings, ASF, max.	1.0	1.0	1.0	1.0	1.0	1.0
Engine sludge, avg., merit, min.	9.0	9.0	9.4	9.4	9.4	9.4
General engine deposits, avg., demerit, max.	2.0	2.0	2.0	2.0	2.0	2.0
Wear rating (visual), avg., demerit, max.	3.0	3.0	2.0	2.0	2.0	2.0
Bore polishing, avg., %, max.	2.0	2.0	1.0	1.0	1.0	1.0
Cylinder wear, avg., mm, max.	0.008	0.008	0.008	0.008	0.008	0.008
Turbocharger deposits, demerit, max.	2.0	2.0	2.0	2.0	2.0	2.0
Specific oil consumption, g/h, max.	30.0	30.0	30.0	30.0	30.0	30.0
TBN at EoT, mg KOH/g (ASTM D4739)	Rate & report					
TAN at EoT, mg KOH/g (ASTM D664)	Rate & report					
Daimler OM 471.999 (Daimler inhouse test, 400 h) (when ready as alternative to OM 501)						
Piston cleanliness, avg., %, min.	70	70	75	75	75	75
Ring sticking, 2 <sup>nd</sup> rings, %, min.	70	70	75	75	75	75
Engine sludge, avg., %, min.	70	70	75	75	75	75
General engine deposits, avg., %, min.	70	70	75	75	75	75
Wear rating (visual), avg., %, min.	70	70	75	75	75	75
Bore polishing, avg., %, min.	70	70	75	75	75	75
Cylinder wear, avg., %, min.	70	70	75	75	75	75
Turbocharger deposits, %, min.	70	70	75	75	75	75
Ease of movement of turbocharger (Freigängigkeit), %, min.	70	70	75	75	75	75
Specific oil consumption, g/h, max.	25	25	25	25	25	25
Kinematic viscosity at 40°C EoT (ASTM D445, DIN 51562-1), mm <sup>2</sup> /s	Rate & report					
Oxidation at EoT, A/cm (IR)	Rate & report					
Nitration at EoT, A/cm (IR)	Rate & report					
TBN at EoT (ASTM D4739), mg KOH/g	Rate & report					
TAN at EoT (ASTM D664), mg KOH/g	Rate & report					
OM 501 LA Euro 5 fuel economy test (Daimler inhouse test, WHTC, FE vs. MB RL003 or RL012, 10W-40 <sup>(2)</sup> )						
FE benefit vs. MB RL003, only required for xW-30, %, min.	0.3	0.3	0.6	0.6	0.6	0.8
FE benefit vs. MB RL012, only required for xW-30, %, min.	0.5	0.5	0.8	0.8	0.8	1.0

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
<b>DD13 scuffing test</b>						
Hours-to-Scuff, min.	-	31	31	31	31	31
Change in mass fraction of Fe at Hours-to-Scuff, mg/kg	-	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
<b>Mack T-11 (ASTM D7156)</b>						
TGA soot at 4.0 mm <sup>2</sup> /s increase at 100°C, %, min.	-	3.5 / 3.4 / 3.3	-	-	-	3.5 / 3.4 / 3.3
TGA soot at 12.0 mm <sup>2</sup> /s increase at 100°C, %, min.	-	6.0 / 5.9 / 5.9	-	-	-	6.0 / 5.9 / 5.9
TGA soot at 15.0 mm <sup>2</sup> /s increase at 100°C, %, min.	-	6.7 / 6.6 / 6.5	-	-	-	6.7 / 6.6 / 6.5
<b>Mack T-12 EGR (ASTM D7422)<sup>(7)</sup></b>						
Mack merit rating, min.	-	1000	-	-	-	-
<b>Mack T-12 EGR (ASTM D7422)</b>						
Top ring mass loss, mg, max.	-	-	-	-	-	105 / 105 / 105
Cylinder liner wear, µm, max.	-	-	-	-	-	24.0 / 24.0 / 24.0
<b>Volvo T-13 oxidation test (ASTM D8048)</b>						
IR peak at EoT, abs, A/cm, max.	-	-	-	125 / 130 / 133	125 / 130 / 133	125 / 130 / 133
Kinematic viscosity increase at 40°C EoT, relative, %, max.	-	-	-	75 / 85 / 90	75 / 85 / 90	75 / 85 / 90
Average oil consumption, 48 h to 192 h, g/h, max.	-	-	-	Report	Report	Report
<b>Cummins ISM EGR (ASTM D7468)<sup>(7)</sup></b>						
Cummins merit rating, min.	-	1000	-	-	-	1000
Top ring weight loss, mg, max.	-	100 / 100 / 100	-	-	-	100 / 100 / 100
<b>Cummins ISB EGR (ASTM D7484)</b>						
Slider tappet weight loss, avg., mg, max.	-	100 / 108 / 112	-	-	-	100 / 108 / 112
Cam lobe wear, µm, max. 55	-	55 / 59 / 61	-	-	-	55 / 59 / 61
Crosshead weight loss, mg	-	Rate & report	-	-	-	Rate & report
<b>Caterpillar C13 (ASTM D7549)<sup>(7)</sup></b>						
CAT merit rating, min.	-	1000	-	-	-	1000 / 1000 / 1000
Hot-stuck piston ring	-	None	-	-	-	-

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MB Sheet No.(1)	228.2 / 3	228.31	228.5	228.51	228.52	228.61
<b>Caterpillar 1N (ASTM D6750)</b>	-		-	-	-	
Weighted demerits, max.	-	286.2 / 311.7 / 323.0	-	-	-	286.2 / 311.7 / 323.0
Top groove fill, %, max.	-	20 / 23 / 25	-	-	-	20 / 23 / 25
Top land heavy carbon, %, max.	-	3 / 4 / 5	-	-	-	3 / 4 / 5
Oil consumption (0-252 h), g/kWh, max.	-	0.5	-	-	-	0.54 / 0.54 / 0.54
Oil consumption (0-252 h), g/MJ, max.	-	-	-	-	-	0.15 / 0.15 / 0.15
Piston / ring / liner scuffing	-	None	-	-	-	None
Piston ring sticking	-	None	-	-	-	None
<b>Roller followerwear test (ASTM D5596)</b>	-		-	-	-	
Pin wear, avg., mils, max.	-	0.30/0.33/0.36	-	-	-	0.30/0.33/0.36
or µm, max.	-	7.6/8.4/9.1	-	-	-	7.6/8.4/9.1
<b>Engine oil aeration test (ASTM D6894)</b>	-		-	-	-	-
Oil aeration volume (MTAC), %, max.	-	8.0	-	-	-	-
<b>Caterpillar C13 COAT (ASTM D8047)</b>	-	-	-	11.8/11.8/11.8	11.8/11.8/11.8	11.8/11.8/11.8
Average aeration, 40 h to 50 h, %, max.	-					

**Notes:**

- (1) Complete test reports for each test have to be submitted. All required data have to be measured, calculated values are not accepted.
- (2) For MB Engine Tests: Rerating at RD/PDI for all related engine parts is required.
- (3) Only for xW-30 or 0W-40: Evaluation of bearing wear in a OM 501 LA engine with new crankshaft and premeasured bearings. Rerating by Daimler at TP/PEH
- (4) The worst result (outlier result) will be replaced by the second worst to calculate the average to control outliers.
- (5) Read Across only according to MB Read Across Guidelines for engine tests (based on the latest ATC and ATIEL Code of Practice). MB Package Pass only for Mineral Oils (SN, ATIEL Grp. I and II) and for SAE 15W-40, 20W-40, 15W-50, 20W-50; for 228.31 additionally: Base Oils (SN, ATIEL Grp. II & III <30%) and only for SAE 10W-30.
- (6) Corresponding ACEA Sequences or DDC specification level is indicated. Since the performance level of these specifications is different to MB specification they cannot be used alternatively to MB specification.
- (7) Detailed rating for Mack T-12, Cummins ISM and Caterpillar C13 according to API CJ-4 Merit Systems: 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 for MB-Approval 228.31.

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### Conditions for approvals and the use of performance claims (MB sheets) against MB oil specifications

MB requires that any claims for oil performance to meet the mentioned MB specifications, must be based on credible data and controlled tests in accredited test laboratories.

All engine performance testing used to support a claim of compliance with these MB oil specifications must be generated according to the MB Read Across Guidelines and the European Engine Lubricants Quality Management System (EELQMS).

An MB Approval for each new oil formulation is valid for 5 years.

The validity period of rebrands and reblands is limited by the runtime of the original and therefore limited to max. 5 years.

From the introduction date of a new version of the MB Specification the previous version is still valid one year. During this period of time both specification versions are valid for approvals.

Package Pass approvals: For every treat rate a trading approval is required. The trading approvals are handled like approvals for new oil formulations.

MB Specification - Issue (version with year spec. no.)	First allowable use	New approvals by at the latest
MB Specification V2009.1	16.03.2009	21.03.2013
MB Specification V2012.1	21.03.2012	substituted by MB Specification V2012.2 on 01.10.2012
MB Specification V2012.2	01.10.2012	31.05.2017
MB Specification V2016.1	31.05.2016	31.05.2018
MB Specification V2017.1	01.06.2017	substituted by MB Specification V2019.1 on 15.01.2019
MB Specification V2019.1	15.01.2019	

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

**New approvals by** means that from this date all approvals for new oil formulations must be according to the latest MB specification release.

## MTU diesel engine oil specifications - MTL5044

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- Oil category 1: Normal quality (generally corresponds to API-CF, CG-4, CH-4, or ACEA E2-96).
- Oil category 2: Higher quality level (corresponds to SHPD = Super High Performance Diesel, or ACEA E7-08).
- Oil category 2.1: Higher quality with low ash-forming additive content (low SAPS) (API CJ-4, ACEA E9-08).
- Oil category 3: High performance diesel engine oil (quality level above ACEA E4-08).
- Oil category 3.1: High performance diesel engine oil with low ash-forming additive content (low SAPS) (ACEA E6-08).

Oil category	-	-	1, 2, 2.1, 3	3.1
Viscosity grades (SAE J300)	30	40	5W-30, 10W-30	5W-40, 10W-40, 15W-40
<b>Laboratory tests</b>				
Density at 15°C (DIN51757, ASTM D1298), g/ml	Report	Report	Report	Report
Viscosity at 40°C (DIN 51562-1, ASTM D445), mm²/s at 100°C	Report 9.3 - 12.5	Report 12.5 - 16.3	Report 9.3 - 12.5	Report 12.5 - 16.3
HTHS viscosity (CEC L-036-90), mPa.s, min.	-			3.5
Shear stability (DIN 51382, CEC L-014-93, ASTM D6278, D7109)				
Viscosity after 30 cycles shear (DIN 51562-1, ASTM D445), mm²/s	-		Oil cat. 1, 2: Stay in grade	
Viscosity after 90 cycles shear (DIN 51562-1, ASTM D445), mm²/s	-		Oil cat. 2.1, 3, 3.1: Stay in grade	
Viscosity index (VI) (DIN ISO 2209, ASTM D2270)	Report		Report	
Pour point (DIN ISO 3016, ASTM D97), °C	Report		Report	
<b>Flash point</b>				
COC (DIN EN ISO 2592, ASTM D92), °C, min.	215		215	
PM (DIN EN ISO 2719), °C	Report		Report	
Evaporative loss (Noack) (DIN 51581, CEC L-040-93), %, max.	10	13		12
TBN (ISO 3771, ASTM D2896), mg KOH/g, min.	8.0	Oil cat. 1, 2: 8.0 Oil cat. 2.1: 7.0 Oil cat. 3: 12.0		7.0
TAN (ASTM D664), mg KOH/g	Report		Report	
Sulfated ash (DIN 51575, ASTM D874), % m/m, max.	1.0 - 2.0	Oil cat. 1, 2, 3: 1.0 - 2.0 Oil cat. 2.1: 1.0		1
Mg, Ca, Bo, Mo, Na, K (DIN 51391-3)	Report		Report	

## MTU diesel engine oil specifications - MTL5044

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Oil category	-	-	1, 2, 2.1, 3	3.1
Viscosity grades (SAE J300)	30	40	5W-30, 10W-30, 5W-40, 10W-40, 15W-40	5W-30, 10W-40
<b>Chlorine</b> (DIN 15597), mg/kg, max.		150		150
<b>Phosphorus</b> (DIN 51363-2/-3), % m/m, max.		Report	Oil cat. 1, 2, 3: Report Oil cat. 2.1: 0.12	0.08
<b>Sulfur</b> (DIN 51400-1, DIN EN ISO 14596), % m/m, max.		Report	Oil cat. 1, 2, 3: Report Oil cat. 2.1: 0.4	0.3
<b>Zinc</b> (DIN 51391-3), % m/m, min.	0.035			0.035
<b>Nitrogen</b> (ASTM D3228, D5762), % m/m		Report	Report	
<b>Further additive elements</b> >0.01 % m/m		Report	Report	
<b>Elastomer compatibility</b> (DIN 53521), SRE NBR 28, FPM AK6 <sup>(1)</sup>		Pass		Pass
<b>FZG gear rig</b> (DIN 51354-2, CEC L-07-A-95), damage force stage, min.	11			11
<b>Foaming tendency</b> (ASTM D6082), ml, max.	200 - 50			200 - 50
<b>Turbocharger deposits</b> (MTV 5040) (DIN 51535), mg, max.	-			120
<b>PDSC oxidation test</b> (CEC L-85-99), min		Report		Report

## MTU diesel engine oil specifications - MTL5044

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Oil category	1	2. 2.1	3. 3.1
<b>Laboratory tests</b>			
<b>OM 441 LA (CEC L-52-T-97)</b>			
Bore polishing, average, %, max.	3.0	-	-
Piston cleanliness, average, merit, min.	22	-	-
Cylinder wear, average, µm, max.	8.0	-	-
Engine sludge, average, merit, min.	9.0	-	-
Specific oil consumption, g/h, max.	100	-	-
Viscosity increase at 40°C, %, max.	-	-	-
Wear rating, demerit, max.	2.5	-	-
General engine deposits, demerit, max.	3.0	-	-
Oil drain interval, h	200	-	-
<b>OM 501 LA (CEC L-101-09)</b>			
Piston cleanliness, average, merit, min.	16.0	19.0	28.0
Ring sticking piston ring 2, ASF, max.	1.0	1.0	1.0
Engine sludge, average, merit, min.	9.0	9.0	9.4
General engine deposits, average, demerit, max.	3.0	2.0	2.0
Wear rating, average, demerit, max.	3.0	3.0	2.0
Bore polishing, average, %, max.	3.0	2.0	1.0
Cylinder wear, average, µm, max.	8	8	8
Turbocharger deposits, demerit, max.	3.0	2.0	2.0
TBN (ASTM D4739) at end of test, mg KOH/g	Report	Report	Report
TAN (ASTM D6664) at end of test, mg KOH/g	Report	Report	Report
Oil consumption, g/h, max.	50.0	30.0	30.0
<b>OM 611 (Mercedes-Benz 300 h test)</b>			
Bore polishing, max. value of 4 cylinders	4.0	-	-
Piston cleanliness, average, merit, min.	23	-	-
Cylinder wear, average, µm, max.	7.0	-	-
Cam wear inlet / outlet valve, average, µm, max.	140 / 155	-	-
Engine sludge, average, merit, min.	8.0	-	-
Oil consumption, g/test, max.	6000	-	-
Viscosity increase at 40°C, %, max.	100	-	-

# MTU diesel engine oil specifications - MTL5044

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Oil category		1	2. 2.1	3. 3.1
<b>OM 646 DE22LA (CEC L-099-08)</b>				
Cam wear inlet / outlet valve, average, µm, max.		120 / 155	100 / 130	90 / 110
Cylinder wear, average, µm, max.		5	5	5
Bore polishing (13 mm), max. value of 4 cylinders		4.0	3.5	3.0
Piston cleanliness, average, merit, min.		10.0	12.0	14.0
Engine sludge, average, merit, min.		8.6	8.8	9.1
Ring sticking, yes/no		No	No	No
Tappet wear inlet / outlet, average, µm, max.		Rate & report	Rate & report	Rate & report
Bearing wear main / con rod bearing, µm, max.		2.1 / 21	2.1 / 21	2.1 / 21
Piston ring wear axial at ring 1 / ring 2 / ring 3, µm, max.		10.4 / 6.0 / 5.0	10.4 / 6.0 / 5.0	8.7 / 4.0 / 3.0
Piston ring wear radial at ring 1 / ring 2 / ring 3, µm, max.		10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0	10.0 / 12.0 / 8.0
Timing chain wear (elongation), %, max.		0.4	0.4	0.4
Oil consumption, g/test, max.		7000	7000	7000
Soot, %, max.		4.0 - 7.0	4.0 - 7.0	4.0 - 7.0
Viscosity increase at 100°C, %, max.		100	100	90
<b>Mack T-8E (ASTM D5967) (Not for oil category 2.1)</b>	Run number	1 / 2 / 3	1 / 2 / 3	1 / 2 / 3
Relative viscosity at 100°C at 4.8% soot, max.		-	2.1 / 2.2 / 2.3	2.1 / 2.2 / 2.3
<b>Mack T-11 (ASTM D7156) (Oil category 2.1)</b>	Run number		1 / 2 / 3	
TGA soot at 4.0 mm <sup>2</sup> /s increase at 100°C, %, min.		-	3.5 / 3.4 / 3.3	-
TGA soot at 12.0 mm <sup>2</sup> /s increase at 100°C, %, min.		-	6.0 / 5.9 / 5.9	-
TGA soot at 15.0 mm <sup>2</sup> /s increase at 100°C, %, min.		-	6.7 / 6.6 / 6.5	-

**Notes:**

(1) Please refer to chapter "Elastomer Compatibility" for limits.

## PACCAR DAF engine oil requirements and oil drain intervals



Engine	Engine Oil Recommendation	Oil Drain Interval
<b>Euro V / EEV</b>		
Paccar PR	ACEA E6, xW-40	Standard drain: 75000 km Extended drain <sup>(1)</sup> : 100000 km
Paccar MX	ACEA E6, E9, xW-30, xW-40	Standard drain: 90000 km Extended drain <sup>(1)</sup> : 150000 km only with ACEA E6
<b>Euro VI</b>		
Paccar PX-4, PX-5, PX-7	ACEA E9 + CES 20081, 10W-30	Standard drain: 60000 km
Paccar MX-11 (MY2013-2016)	ACEA E6, E9, xW-30, xW-40	Standard drain: 75000 km Extended drain <sup>(1)</sup> : 150000 km with ACEA E6
Paccar MX-11 (MY2017)	ACEA E6, E9, xW-30, xW-40	Standard drain: 100000 km Extended drain <sup>(1)</sup> : 150000 km with ACEA E6
Paccar MX-13 (MY2013-2016)	ACEA E6, E9, xW-30, xW-40	Standard drain: 90000 km Extended drain <sup>(1)</sup> : 180000 km with ACEA E6
Paccar MX-13 (MY2017)	ACEA E6, E9, xW-30, xW-40	Standard drain: 100000 km Extended drain <sup>(1)</sup> : 200000 km with ACEA E6
<b>EPA 2010</b>		
Paccar MX-11 <sup>(7)</sup> , MX-13 <sup>(2)</sup> (MY2013-2016)	API CJ-4, CK-4, xW-30, xW-40	Severe duty, Vocational <sup>(3)</sup> : 30.000 miles Normal duty, Long haul <sup>(4)</sup> : 40.000 / 60.000 <sup>(5)</sup> miles
Paccar MX-11, MX-13 <sup>(2)</sup> (MY2017)	API CJ-4, CK-4, xW-30, xW-40	Severe duty, Vocational <sup>(3)</sup> : 30.000 miles Long haul <sup>(4)</sup> : 50.000 <sup>(5)</sup> / 75.000 <sup>(6)</sup> miles

### Notes:

(1) DAF Service Rapido system: double fuel filter and centrifugal oil filter; MX-13 engine has 6 L larger sump.

(2) Standard with extended oil drain package.

(3) Fuel consumption: <2.5 km/L (<6 MPG); Gross vehicle weight: >36.300 kg (>80.000 lb).

(4) Fuel consumption: >2.5 km/L (>6 MPG); Gross vehicle weight: <36.300 kg (<80.000 lb).

(5) Only if idle time is <20%.

(6) Only for MY2017 MX-11 and MX-13 engines, used oil analysis program recommended for extended ODI's greater than 60.000 miles.

(7) MX-11 engine available as from 2015.

## PORSCHE engine oil requirements



Specifications	Porsche A40	Porsche C40	Porsche C30	Porsche C20
<b>Performance requirements:</b>				
HTHS (CEC L-36-A-90), mPa.s, min.	3.5	3.5	3.5	2.6
ACEA level	A3/B3 <sup>-16</sup> , A3/B4 <sup>-16</sup>	C3 <sup>-16</sup>	C3 <sup>-16</sup>	C5 <sup>-16</sup>
Volkswagen approval	-	-	VW 504.00 / 507.00	VW 508.00 / 509.00
VW T4 (PV 1449)			Included in VW Specification	Included in VW Specification
Viscosity at 40°C at end of test, mm <sup>2</sup> /s, max.	200 +/- test stand severity	200 +/- test stand severity		
Viscosity increase at 40°C, %, max.	130 +/- test stand severity	130 +/- test stand severity		
TBN end of test, DIN 51639-1, mg KOH/g, min.	Ref Oil of test stand +1 (typical =4)	≥ 5 mg(KOH)/g + TBN Fresh Oil Std Dev		
TAN increase end of test, TAN points, max.	4	4		
Piston merit, 5 parts, min.	1.0	1.0		
Ring sticking, ASF, max.	none	none		
VW Fuel economy (PV 1496 Audi EA888)	-	0.0	Included in VW Specification	Included in VW Specification
FE vs. RL 5W-30, %, min.	-	0.0	Included in VW Specification	Included in VW Specification
<b>Porsche durability (9A1, 3.6L, 360 kW B6 engine, 163.7 h cycling test):</b>				
Sludge rating, merit, min.	Pass	Pass	-	-
Turbo deposits, merit, min.	9.5	9.5	-	-
Turbo feed pipe deposits, merit, min.	6.0	6.0	-	-
Turbo charger sealing ring sticking	7.4	7.4	-	-
Piston ring groove fill % max. (Porsche method)	none	none	-	-
Piston ring sticking	100	100	-	-
Cylinder liner wear: washboard	none	none	-	-
Cam wear, µm, average, max.	8 -10	8 -10	-	-
Cam wear, µm, max.	9 -12	9 -12	-	-
Tappet wear, µm, average	3 - 10	3 - 10	-	-
Tappet wear, µm, max.	5 - 13	5 - 13	-	-
Thrust curve	as Ref. Oil or better	as Ref. Oil or better	-	-
VW W12 TSI PZD (PV xxxx)		Pass		
HPDSC (CEC L-85-99 / ASTM D6186)				
Porsche profile run at 210°C	Rate & Report	Rate & Report	Rate & Report	Rate & Report
Oxidation stability (CEC L-109)				
With Porsche poor fuel specification (POSK)	Rate & Report	Rate & Report	Rate & Report	Rate & Report
With NMA (N-Methyl Aniline)	Rate & Report	Rate & Report	Rate & Report	Rate & Report

# PSA-PEUGEOT-CITROEN engine oil specifications

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Specifications	B71 2300	B71 2296	B71 2290	B71 2297	B71 2302	B71 2312	B71 2010
<b>Expiration date</b>	04-mai-20	04-mai-20	17-mai-20	27-avr-20	17-mai-20	20-janv-19	16-nov-20
<b>Application</b>	Service fill engine oil ACEA A3/B4. Applicable worldwide, except China	Service fill engine oil ACEA A3/B4. Applicable worldwide	Service fill engine oil ACEA Cx, except C5 Applicable in Europe only	Service fill gasoline engine oil ACEA Cx, except C5. Applicable in warm countries	Factory- and service fill gasoline engine oil ACEA C2 or C3. Applicable outside Europe (Brazil & China)	Service fill engine oil ACEA C2 or C3. Applicable in Europe only	Service fill engine oil ACEA C5. Applicable in Europe only
<b>Fuel type</b>	Gasoline & Diesel	Gasoline & Diesel	Gasoline & Diesel	Gasoline & Diesel	Gasoline & Diesel	Gasoline & Diesel	Gasoline & Diesel
<b>Allowed SAE Viscosity grade(s)</b>	10W-40	5W-40	5W-30	5W-30 (restricted)	0W-30	0W-30	0W-20
<b>ACEA basis <sup>(1)</sup></b>	A3/B4 <sup>-12</sup>	A3/B4 <sup>-12</sup>	Cx <sup>16</sup> except C5 <sup>16</sup>	Cx <sup>16</sup> except C5 <sup>16</sup>	C2 <sup>-12</sup> or C3 <sup>-12</sup>	C2 <sup>-16</sup> or C3 <sup>-16</sup>	C5 <sup>-16</sup>
<b>Physical characteristics</b>							
<b>Kinematic viscosity (ISO 3104 or ASTM D445)</b>							
at 145°C (KV145), mm <sup>2</sup> /s	Report	Report	Report	Report	Report	Report	Report
at 100°C (KV100), mm <sup>2</sup> /s	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	≥ 11	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above
at 40°C (KV40), mm <sup>2</sup> /s	Report	Report	Report	≥ 65	Report	Report	Report
<b>Viscosity index (ISO 2909 or ASTM STP43C)</b>	Report	Report	Report	Report	Report	Report	Report
<b>Shear stability after 30 cycles (CEC L-14-A-93 or ASTM D6278)</b>							
at 145°C (KV145), mm <sup>2</sup> /s	Report	Report	-	-	Report	Report	≥ 3.8
at 100°C (KV100), mm <sup>2</sup> /s	According to ACEA level above	According to ACEA level above	According to ACEA level above	-0.7 mm <sup>2</sup> /s max compared to KV100	According to ACEA level above	According to ACEA level above	According to ACEA level above
at 40°C (KV40), mm <sup>2</sup> /s	Report	Report	Report	Report	Report	Report	Report
<b>Low temperature viscosity (CCS) (ASTM D5293), cP</b>	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above
<b>Pumpability limit temperature (MRV) (ASTM D4684), cP</b>	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above
<b>Dynamic viscosity HTHS (CEC L-39-A-90 or ASTM D4683), cP</b>	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above	≥ 3.2	Within SAE J300 grade above	Within SAE J300 grade above	Within SAE J300 grade above
<b>Density at 15°C (ISO 12185 or ASTM D4052), kg/m<sup>3</sup></b>	Report	Report	Report	Report	Report	Report	Report
<b>Flash point (ISO 2592 or ASTM D92), °C, min.</b>	210	210	210	210	210	210	210
<b>Pour point (ISO 3016 or ASTM D97), °C</b>	Report	≤ -35	≤ -35	≤ -35	≤ -35	≤ -35	≤ -35
<b>Aeration / Air release at 40°C &amp; 80°C (ISO 9120 mod. or ASTM D3427), min.</b>	Superior or equivalent performance to reference oil; provide curves	Superior or equivalent performance to reference oil; provide curves	30 max at 40°C 4 max at 80°C; provide curves	15 max at 40°C 4 max at 80°C; provide curves	30 max at 40°C 4 max at 80°C; provide curves	Superior or equivalent performance to reference oil; provide curves	15 max at 40°C 4 max 80°C; provide curves

# PSA-PEUGEOT-CITROEN engine oil specifications

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Specifications	B71 2300	B71 2296	B71 2290	B71 2297	B71 2302	B71 2312	B71 2010
<b>Foaming tendency and stability</b>							
at 24°C (ISO 6247 or ASTM D892), ml / ml	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
at 93°C (ISO 6247 or ASTM D892), ml / ml	50 / 0	50 / 0	50 / 0	50 / 0	50 / 0	50 / 0	50 / 0
at 24°C after 93°C (ISO 6247 or ASTM D892), ml / ml	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0	10 / 0
at 150°C, (ASTM D6082), ml / ml	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0
<b>High temperature volatility (Noack)</b> (CEC L-40-A-93 or ASTM D5800), wt%	According to ACEA level above	≤ 11	According to ACEA level above	≤ 9	According to ACEA level above	According to ACEA level above	According to ACEA level above
<b>Chemical characteristics</b>							
<b>Total acid number (TAN)</b> (ISO 6619 or ASTM D664), mgKOH/g	Report	≤ 3.0	≤ 3.0	≤ 3.0	≤ 3.0	≤ 3.0	≤ 3.0
<b>Total base number (TBN)</b> , mgKOH/g							
ISO 3771 or ASTM D2896, min.	10.0	10.0	6.0	6.0	6.0	6.0	6.0
ASTM D4739	Report	Report	Report	Report	Report	Report	Report
<b>Infrared spectrum</b>	Report	Report	Report	Report	Report	Report	Report
<b>HPDSC (CEC L-85-99)</b>						HPDSC after ageing (acc PSA procedure)	HPDSC after ageing (acc PSA procedure)
Oxidation induction time (OIT)	Report	Report	Report	Report	Report	Report	Report
Onset ignition temperature	Report	Report	≥ 205	≥ 205	≥ 205	≥ 205 *	≥ 205 *
<b>Steel corrosion</b>	-	-	Light rusting 2; light rusting	Light rusting 2; light rusting			
<b>Copper corrosion</b> (ISO 2160 or ASTM D130)			Report	Report	Report	Report	Report

# PSA-PEUGEOT-CITROEN engine oil specifications

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Specifications	B71 2300	B71 2296	B71 2290	B71 2297	B71 2302	B71 2312	B71 2010
<b>Elementary analysis (ASTM D5185 or ASTM D6443)</b>							
Sulphur (S) content, ppm	According to ACEA level above						
Phosphorus (P) content, ppm	According to ACEA level above	According to ACEA level above	≤ 800	≤ 800	≤ 800	≤ 800	≤ 800
Lithium (Li), Lead (Pb), Sodium (Na) and Potassium (K) global content, ppm	Traces	Traces	Traces	≤ 25	Traces	Traces	Traces
Other elements (Ca, Mg, Zn, B, Mo, Si, Ba, N ...) content, ppm	Report	Report	Report	-	Report	Report	Report
Chlorine (Cl) content, ppm	Report	Report	≤ 25	≤ 25	≤ 25	≤ 25	≤ 25
Nitrogen (N) content, ppm	-	-	Report	Report	-	-	Report
Calcium (Ca) content, ppm	-	-	≤ 1400	≤ 1400	≤ 1400	≤ 1400	≤ 1400
Calcium (Ca) & magnesium (Mg) global content, ppm	-	-	≤ 1700	≤ 1700	≤ 1700	≤ 1700	≤ 1700
<b>Sulphated ash content (ISO 3987 or ASTM D874), % m/m</b>	According to ACEA level above						
<b>Laboratory mechanical tests</b>							
4-Ball machine - wear test (ISO 20623)							
Average imprint diameter at 40kg, 60min, 1500rpm, mm	≤ 0.50	≤ 0.50	≤ 0.50	≤ 0.50	≤ 0.50	≤ 0.50	≤ 0.50
4-Ball machine - extreme pressure test (ISO 20623)							
Seizure load, kg	Report; target = 100	Report; target = 100	≥ 100	≥ 100	≥ 100	≥ 100	≥ 100
Imprint diameter at 100kg, mm	Report; target = 0.55	Report; target = 0.55	≤ 0.55	≤ 0.55	≤ 0.55	≤ 0.55	≤ 0.55
<b>PSA specific laboratory tests</b>							
Resistance to water (D57 5046)	No gelation						
PCT Coking test at 288°C (GFC Lu-29-T-97 v.5), merit	≥ 8.0	≥ 8.0	≥ 8.0	≥ 8.0	≥ 8.0	≥ 8.0	≥ 8.0
PCT Coking test at 305°C (PSA SOP 01563_10_00802), merit	Report	Report	Report; Target = 8.0				

## PSA-PEUGEOT-CITROEN engine oil specifications

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Specifications	B71 2300	B71 2296	B71 2290	B71 2297	B71 2302	B71 2312	B71 2010
<b>TOC Oxidation stability at 170°C (ATO3)</b> (PSA SOP 01563_11_00047)	test duration = 120h  Report  KV100 at 0, 72, 96, 120h & 144h, mm <sup>2</sup> /s	test duration = 144h  Report  RKV (relative KV100 change compared to fresh oil) at 72 & 96h, %	test duration = 144h  Report  RKV (relative KV100 change compared to fresh oil) at 72, 96 & 120h, %	test duration = 144h  Report  RKV at end of test (compared to fresh oil), %	test duration = 144h  Report  RKV at 120h - RKV at 96h) / 24, %/h	test duration = 144h  Report  PAI at 72, 96 & 120h	test duration = 144h  Report  Insoluble content at 120h, wt%
KV100 at 0, 72, 96, 120h & 144h, mm <sup>2</sup> /s	Report  ≥ -20 (target) and ≤ +20	-	-	-	-	-	-
RKV (relative KV100 change compared to fresh oil) at 72 & 96h, %	-	≥ -20 (target) and ≤ +20	≥ -20 (target) and ≤ +20	≥ -20 (target) and ≤ +20	≥ -20 (target) and ≤ +20	≥ -20 (target) and ≤ +20	≥ -20 (target) and ≤ +20
RKV (relative KV100 change compared to fresh oil) at 72, 96 & 120h, %	≤ +200	≤ +200	≤ +200	≤ +200	≤ +200	≤ +200	≤ +200
RKV at end of test (compared to fresh oil), %	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5
(RKV at 120h - RKV at 96h) / 24, %/h	-	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5	≤ 1.5
(RKV at 144h - RKV at 120h) / 24, %/h	-	-	-	-	-	-	-
PAI at 72, 96 & 120h	Report	Report	Report	Report	Report	Report	Report
Insoluble content at 120h, wt%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
<b>TOC Oxidation stability with 8% added E10 (ATOE3)</b> (Ethanol fuel)	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min
<b>TOC Oxidation stability with 1% added EHN1</b> (Nitration)	Pass same limits as standard TOC test	Pass same limits as standard TOC test	Pass same limits as standard TOC test	Pass same limits as standard TOC test	Pass same limits as standard TOC test	Pass same limits as standard TOC test	Pass same limits as standard TOC test
<b>TOC Oxidation stability with 8% added E22</b> (Brasil ethanol fuel)	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min
<b>TOC Oxidation stability with 8% added E10S</b> (China ethanol fuel)	-	-	-	-	-	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	
<b>TOC Oxidation stability with 5% added BVRP2</b> (Malaysia gasoline)	-	-	-	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	-	-
<b>TOC Oxidation stability with 8% added M15</b> (China methanol fuel)	-	-	-	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	-	-
<b>TOC Oxidation stability with 8% added E100</b> (Brasil ethanol fuel)	-	-	-	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	Same limits as standard TOC test PCT at 288°C; merit 7.0 min	-

# PSA-PEUGEOT-CITROEN engine oil specifications

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Specifications	B71 2300	B71 2296	B71 2290	B71 2297	B71 2302	B71 2312	B71 2010
TOC Oxidation stability with 10% added B10 (ATOB3) (B10_LUB)	test duration = 120h Report $\geq -30$ (target) and $\leq +20$	test duration = 144h Report -	test duration = 144h Report -	test duration = 144h Report -	test duration = 144h Report -	test duration = 144h Report -	test duration = 144h Report -
KV100 at 0, 72, 96, 120h & 144h, mm <sup>2</sup> /s							
RKV (relative KV100 change compared to fresh oil) at 72 & 96h, %							
RKV (relative KV100 change compared to fresh oil) at 72, 96 & 120h, %	-	$\geq -30$ (target) and $\leq +20$	$\geq -30$ (target) and $\leq +20$	$\geq -30$ (target) and $\leq +20$	$\geq -30$ (target) and $\leq +20$	$\geq -30$ (target) and $\leq +20$	$\geq -30$ (target) and $\leq +20$
RKV at end of test (compared to fresh oil), %	$\leq +200$	$\leq +200$	$\leq +200$	$\leq +200$	$\leq +200$	$\leq +200$	$\leq +200$
(RKV at 120h - RKV at 96h) / 24, %/h	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$
(RKV at 144h - RKV at 120h) / 24, %/h	-	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$	$\leq 1.5$
PAI at 72, 96 & 120h	Report	Report	Report	Report	Report	Report	Report
Insoluble content at 120h, wt%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Compatibility with elastomers							
Compatibility with ACEA elastomers (CFC L-112-16) <sup>(1)</sup>	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above
Compatibility with PSA elastomers (PSA S22 5106)	-	-	Please refer to chapter "Elastomer Compatibility" for limits (available at Freudenberg, France)	Please refer to chapter "Elastomer Compatibility" for limits (available at Freudenberg, France)	Better or same performances than PSA reference (available at Freudenberg, France)	Better or same performances than PSA reference (available at Freudenberg, France)	Better or same performances than PSA reference (available at Freudenberg, France)

# PSA-PEUGEOT-CITROEN engine oil specifications

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Specifications	B71 2300	B71 2296	B71 2290	B71 2297	B71 2302	B71 2312	B71 2010
<b>Engine test requirements</b>							
ACEA engine tests	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above	According to ACEA level above
DW10C Engine endurance test at FEV	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA
DW10B Engine lash adjuster wear test at APL	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA	Acceptability by PSA
EP6CDT Engine endurance test at ISP	Acceptability by PSA	Acceptability by PSA	-	Test to be run with sulphur-containing E10 Acceptability by PSA	To be run with China E10 fuel, Acceptability by PSA	Acceptability by PSA	Acceptability by PSA
EC5 endurance test at (lab to be defined)	-	-	Once available; acceptability by PSA	Once available; acceptability by PSA	Once available; acceptability by PSA	Once available; acceptability by PSA	Once available; acceptability by PSA
EP6CDT LSPI (Rumble) test at ISP	-	-	Only if HPDSC onset temp or calcium content limits are not met	Only if HPDSC onset temp or calcium content limits are not met	Only if HPDSC onset temp or calcium content limits are not met	Only if HPDSC onset temp or calcium content limits are not met	Only if HPDSC onset temp or calcium content limits are not met
EB2DT fuel economy test at ISP	-	-	-	Report	-	-	Better or equal to Ref oil (Total MA7)

**Notes:**

(1) Please refer to chapter "Elastomer Compatibility" for limits of ACEA 2016.

# RENAULT passenger car engine oil requirements

- 1 -



Specifications	B71 2300	B71 2296	B71 2290
Application	Gasoline engines	Turbocharger gasoline & diesel engines without DPF	Diesels with DPF
<b>ACEA basis <sup>(1)</sup></b>	A3/B4 <sup>-08</sup> or A5/B5 <sup>-08</sup>	A3/B4 <sup>-08</sup>	C4 <sup>-08</sup>
<b>SAE viscosity grade</b>	0/5W-30 & 0/5/10W-40	0/5W-30 & 0/5/10W-40	0/5W-30 & 0/5W-40
<b>HTHS (CEC L-36-A-90), mPa.s, min.</b>	2.9	3.5	3.5
<b>Noack volatility (CEC L-40-A-93, loss (B method)), max.</b>	13.0	12.0	11.0
<b>Sulfated ash (ASTM D874), % m/m</b>	> 0.7 & ≤ 1.5	> 0.7 & ≤ 1.5	< 0.50
<b>Phosphorus (ASTM D5185), % m/m, max.</b>	Rate & report	Rate & report	0.09
<b>Sulfur (ASTM D4951, or ASTM D5453), % m/m, max.</b>	Rate & report	Rate & report	0.2
<b>TBN (ASTM D2896), mg KOH/g, min.</b>	8	8	6
<b>TAN (ASTM D664), mg KOH/g, max.</b>	Rate & report	Rate & report	Rate & report
<b>Low temperature pumpability viscosity (ASTM D4684), mPa.s</b>	According SAE J300	According SAE J300	According SAE J300
<b>Density (ISO 12185/NFT 601172), kg/m<sup>3</sup></b>	Rate & report	Rate & report	Rate & report
<b>Flash point (ISO 2592), °C, min.</b>	200	200	200
<b>Pour point (ISO 3016), °C</b>	Rate & report	Rate & report	Rate & report
<b>Copper corrosion (3 hrs at 150 °C) (ISO 2160), rating</b>	1a	1a	1a
<b>Anti-wear properties (60 min - 40daN, Avg. Diameter) (ISO 20623), mm, max.</b>	0.5	0.5	0.5
<b>De-airing at 40 °C (ISO 9120), minutes, max.</b>	35	35	35
<b>Water content (GFC TR-40-A-14), %, max.</b>	0.05	0.05	0.05
<b>Oxidation test TOC (D55 3099), Big tube (150g), 170°C, 360 mg/kg of iron, 10/l/h air. Samples at 0, 8, 80, 96, 140 h. (TAN, PAI CO, viscosity)</b>	report at 80 h 400 at 80 h 200% at 80 h report at 80 h	report at 80 h 400 at 80 h 200% at 80 h report at 80 h	report at 96 h 400 at 96 h 200% at 96 h report at 96 h
<b>TAN (ASTM D664), mg KOH/g, max.</b>	6.0	7.0	7.0
<b>PAI CO, max.</b>	See spec for details	See spec for details	See spec for details
<b>Variation of viscosity at 40°C, %, max.</b>			
<b>Variation of viscosity at 100°C, %, max.</b>			
<b>MCT (cokefaction test), (GFC Lu 27), merit, min.</b>			
<b>Storage stability test <sup>(2)</sup> (Renault in-house test method)</b>			

## RENAULT passenger car engine oil requirements

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Specifications	B71 2300	B71 2296	B71 2290
Compatibility test First Fill oils <sup>(2)</sup> (Renault in-house test method)	See spec for details	See spec for details	See spec for details
Compatibility with plastics <sup>(2)</sup> (Renault in-house test method)	See spec for details	See spec for details	See spec for details
Particular contamination <sup>(2)</sup> (ISO 4426)	16 / 13	16 / 13	16 / 13
Filterability <sup>(2)</sup> (ME 64120 A 014/--B), ΔP (bar) with KN filter			
After 5 minutes, bar, max.	0.05	0.05	0.05
After 50 minutes, bar, max.	0.2	0.2	0.2
FMA, micron, max.	12	12	12
LLR durability, Renault engine durability test at IFP (Renault in-house test method)			
Viscosity increase at 40°C (PAI CO), %, max.	-	-	100
Oil consumption, g/h, max.	-	-	Rate & report
Piston deposit, merit, min.	-	-	5
Ring sticking, max.	-	-	None (for all rings)

**Notes:**

(1) Renault does not require official ACEA approval, only tests mentioned in their specs. These are based on ACEA 2008 tests and limits.

(2) For Factory Fill only.

## RENAULT passenger car engine oil requirements

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Specifications	RN17	RN17FE	RN17RSA
<b>Application</b>	All gasoline engines except for sport applications (see RN17RSA). New Euro 6 diesel engines starting mid-2018 and all diesel engines without DPF	Some gasoline engines (see owner's manual). New 1.5l Euro 6 diesel engines starting mid-2018 (see owner's manual)	Renault Sport and Alpine engines
ACEA basis <sup>(1)</sup>	C3 <sup>-16</sup>	C5 <sup>-16</sup>	C3 <sup>-16</sup>
<b>SAE viscosity grade</b>	5W-30	0W-20	0W-40
HTHS (CEC L-36-A-90), mPa.s, min.	3.5	2.6	4.1
Noack volatility (CEC L-40-A-93, loss (B method)), max.	11.0	11.0	11.0
Sulfated ash (ASTM D874), % m/m	≤ 0.8	≤ 0.8	≤ 0.8
Phosphorus (ASTM D5185), % m/m, max.	0.09	0.09	0.09
Sulfur (ASTM D4951, or ASTM D5453), % m/m, max.	0.3	0.3	0.3
TBN (ASTM D2896), mg KOH/g, min.	7.5	7.5	7.5
TAN (ASTM D664), mg KOH/g, max.	Rate & report	Rate & report	Rate & report
Low temperature pumpability viscosity (ASTM D4684), mPa.s	According SAE J300	According SAE J300	According SAE J300
Density (ISO 12185/NFT 601172), kg/m <sup>3</sup>	Rate & report	Rate & report	Rate & report
Flash point (ISO 2592), °C , min.	200	200	200
Pour point (ISO 3016), °C	Rate & report	Rate & report	Rate & report
Copper corrosion (3 hrs at 150 °C) (ISO 2160), rating	Rate & report	Rate & report	Rate & report
<b>HTCBT at 135°C (ASTM D6594). ppm increase, max.</b>			
Copper	20	20	20
Bronze strip rating	1	1	1
Copper strip rating (acc. to ASTM D130), max.	1b	1b	1b
<b>Ball rust test (ASTM D6557), avg. grey value, min.</b>	Rate & report	Rate & report	Rate & report
<b>De-airing at 40 °C (ISO 9120), minutes, max.</b>	35	35	35
<b>Water content (GFC TR-40-A-14), %, max.</b>	0.05	0.05	0.05

## RENAULT passenger car engine oil requirements

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Specifications	RN17	RN17FE	RN17RSA
<b>Oxidation test TOC</b> (D55 3099), Big tube (150g), 170°C, 360 mg/kg of iron, 10l/h air. Samples at 0, 24, 120, 136, 168 h. (TAN, PAI CO, viscosity)	report at 120 h 400 at 120 h 200% at 120 h report at 120 h	report at 120 h 400 at 120 h 200% at 120 h report at 120 h	report at 120 h 400 at 120 h 200% at 120 h report at 120 h
TAN (ASTM D664), mg KOH/g, max.			
PAI CO, max.			
Variation of viscosity at 40°C, %, max.			
Variation of viscosity at 100°C, %, max.			
<b>MCT (cokefaction test)</b> , (GFC Lu 27), merit, min.	7.0	7.0	7.0
<b>LLR durability</b> , Renault engine durability test at IFP (Renault in-house test method)			
Viscosity increase at 40°C, %, max.	100	-	-
PAI CO, max.	200	-	-
Piston deposit, merit, min.	3.5	-	-
Ring sticking, max.	9	-	-
<b>Fuel Economy on NEDC cycle</b> , Renault Fuel Economy test (test engine: K9K636) <sup>(2)</sup>			
Fuel economy vs Ref oil (Renault supply, ACEA C4, SAE 5W-30, HTHS 3.2), %, min.	-	≥ 0.0	-

**Notes:**

(1) Renault does not require official ACEA approval, only tests mentioned in their specs. These are based on ACEA 2016 tests and limits.

(2) Performed by CERTAM.

## **SCANIA Long Drain Field (LDF) test requirements**



- Scania has the following specifications: LDF, LDF-2, LDF-3, Low Ash, LDF-4, LDF-3 FS and LDF-5.
- The Scania specifications are no longer public information, so we are not able to publish these.

# VOLVO CAR CORPORATION engine oil specifications

- 1 -



Volvo Car Specifications	VCC RBS0-2AE OW-20	95200356	95200377
Latest version date	Sept 10 <sup>th</sup> 2014	Sept 10 <sup>th</sup> 2014	Sept 10 <sup>th</sup> 2014
Application	Volvo Car OW-20 low ash, long drain, high fuel economy oil. Suitable only for HTHS 2.6 capable Volvo engines starting with the Volvo Engine Architecture (VEA) diesel and gasoline engine platform. Not backward compatible.	Volvo Car high ash standard service fill oil suitable for all gasoline and diesel engines.	Volvo Car high ash, fuel economy, service fill oil suitable for all gasoline and diesel engines.
Main region	Europe and US	China	Worldwide
ACEA level	C2 <sup>-12</sup> Unless otherwise stated per test	A3/B4 <sup>-12</sup>	A5/B5 <sup>-12</sup>
Acceptable SAE grades	OW-20	OW-30	OW-30
Viscosity (ASTM D445) at 150°C, mm <sup>2</sup> /s	3.6	Rate & report	Rate & report
Viscosity (ASTM D445) at 100°C, mm <sup>2</sup> /s	≥ 7.0 & ≤ 9.3	≥ 11.5 & ≤ 12.5	≥ 9.3 & ≤ 12.6
Shear stability KV100 (CEC L-014-93 or ASTM D6278), Kin. Viscosity, mm <sup>2</sup> /s	≥ 7.0 & ≤ 9.3	≥ 9.3 & ≤ 12.5	≥ 9.3 & ≤ 12.6
HTHS viscosity (CEC L-036-90), mPa.s, min.	2.75	3.5	≥ 2.9 & < 3.5
Shear stability HTHS (CEC L-014-93 or ASTM D6278), mPa.s, min.	2.75	3.5	≥ 2.9 & < 3.5
Noack (ASTM D5800), %, max.	13	13	13
Sulfated ash (ASTM D874), % m/m, max.	0.9	≥ 1.0 & ≤ 1.6	≤ 1.6
Phosphorus (ASTM D5185), % m/m	≥ 0.07 & ≤ 0.09	Rate & report	Rate & report
Sulfur (ASTM D4951, or ASTM D5453), max.	0.3	Rate & report	Rate & report
TBN (ASTM D2896), mg KOH/g, min.	7.5	10.0	8.0
Pour point (ASTM D97), °C, max.	-48	Rate & report	-
Copper corrosion (ASTM D130 or ISO2160), rating, max.	1b	1b	1b
Gelation index (ASTM D5133), max.	8.5	-	-
Flash Point (ASTM D93), °C, min.	185	Rate & report	230
Foaming high temperature (ASTM D6082), ml, max.	100/0	100/0	50/0
M111 fuel economy (CEC L-054-96), %, min.	3.4% (avg. of 3 tests)	-	2.5%

# VOLVO CAR CORPORATION engine oil specifications

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Volvo Car Specifications	VCC RBS0-2AE 0W-20	95200356	95200377
VW TDI (PV 1452)			
Piston deposits, merit, min.	> RL 206 + Std Dev	RL 206 + Std Dev	> RL 206 + Std Dev
Ring sticking, average 1 <sup>st</sup> gr, ASF, max.	1.0	1.0	1.0
Ring sticking, Max. 1 <sup>st</sup> / 2 <sup>nd</sup> gr, ASF, max.	1 / 0	1 / 0	1 / 0
End of test TBN (DIN 51639-1), mgKOH/g, min.	4.0	4.0	4.0
End of test TAN (ASTM D664), max.	Rate & report	Rate & report	Rate & report
OM 646 DE22LA wear (CEC L-099-08)			
Cam wear inlet / outlet valve (average wear 8 cams), µm, max.	100 / 120	100 / 120	100 / 120
Cylinder wear (average 4 cylinders), µm, max.	5.0	5.0	5.0
Bore polishing (13 cm), max value of 4 cylinders, %, max.	3.0	3.0	3.0
Tappet wear inlet/oulet (average wear 8 cams), µm	Rate & report	Rate & report	Rate & report
Piston cleanliness (average 4 pistons), merit, min.	Rate & report	Rate & report	Rate & report
Engine sludge average, merit, min.	Rate & report	Rate & report	Rate & report

# VOLVO VDS, MACK EO and RENAULT RLD standards

- 1 -



Specifications	Volvo VDS-3, Mack EO-N, Renault RLD-2 STD 417-0002	Volvo VDS-4, Mack EO-O PP, Renault RLD-3 STD 417-0001	Volvo VDS-4.5, Mack EOS-4.5, Renault RLD-3 STD 417-0003
ACEA / API performance level	ACEA E7 and/or API CI-4	ACEA E9 and/or API CJ-4	ACEA E6, E9, API CJ-4 or CK-4
Viscosity grades (SAE J300)	xW-30, xW-40 (x = 0, 5, 10, 15)	xW-30, xW-40 (x = 0, 5, 10, 15)	xW-30, xW-40 (x = 0, 5, 10, 15)
<b>Laboratory tests</b>			
Density (ASTM D1298), kg/m <sup>3</sup>	Report	Report	Report
Flash point COC (ASTM D92), °C	Report	Report	Report
Pour point (ASTM D97), °C	Report	Report	Report
Viscosity (ASTM D445) at 40°C, mm <sup>2</sup> /s at 100°C, mm <sup>2</sup> /s	Report xW-30: 9.3 - 12.5; xW-40: 12.5 - 16.3	Report xW-30: 9.3 - 12.5; xW-40: 12.5 - 16.3	Report xW-30: 9.3 - 12.5; xW-40: 12.5 - 16.3
HTHS viscosity (ASTM D4683 or CEC L-36-97), mPa.s	Report	Report	Report
Shear stability (ASTM D7109)			
Viscosity at 100°C after 90 cycles shear (ASTM D445), mm <sup>2</sup> /s, min.	xW-30: 9.3; xW-40: 12.5	xW-30: 9.3; xW-40: 12.5	xW-30: 9.3; xW-40: 12.5
HTHS viscosity after 90 cycles shear (ASTM D4683 or CEC L-36-90), mPa.s, min.	xW-30: 3.4; xW-40: 3.7	xW-30: 3.4; xW-40: 3.9	xW-30: 3.4; xW-40: 3.9
Low temperature cranking viscosity (CCS) (ASTM D5293), mPa.s, max.	Acc. to SAE J300	Acc. to SAE J300	Acc. to SAE J300
Low temperature pumping viscosity (MRV) (ASTM D4684), mPa.s, max.	Acc. to SAE J300	Acc. to SAE J300	Acc. to SAE J300
Base oil viscosity at 100°C (ASTM D445), mm <sup>2</sup> /s, min. <sup>(1)</sup>	Report	Report	Report
Evaporative loss (Noack) (ASTM D5800 or CEC L-40-93), %, max.	13	13	13
Sulfated ash (ASTM D874), % m/m, max.	-	1.0	1.0
Phosphorus (ASTM D4951), % m/m, max.	-	0.12	0.12
Sulfur (ASTM D4951), % m/m, max.	-	0.4	0.3
Foaming tendency (ASTM D892)	Run number	1 / 2 / 3 10 / 0, 20 / 0, 10 / 0	1 / 2 / 3 10 / 0, 20 / 0, 10 / 0
Sequence I, II, III, ml, max.			10 / 0, 20 / 0, 10 / 0
Corrosion (ASTM D6594)			
Copper increase, ppm, max.	20	20	20
Lead increase, ppm, max.	120	120	120
Copper strip rating (ASTM D130), max.	3	3	3

# VOLVO VDS, MACK EO and RENAULT RLD standards

- 2 -



Specifications	Volvo VDS-3, Mack EO-N, Renault RLD-2 STD 417-0002	Volvo VDS-4, Mack EO-O PP, Renault RLD-3 STD 417-0001	Volvo VDS-4.5, Mack EOS-4.5, Renault RLD-3 STD 417-0003
<b>Hot surface oxidation (PDSC) (CEC L-85-99)</b>			
Oxidation induction time, min., min.	65	-	-
<b>Low temperature pumpability (CEC L-105-12)</b>			
MRV <sup>(3)</sup> , mPa.s, max.	According to SAE J300	According to SAE J300	According to SAE J300
Yield stress, Pa, max.	According to SAE J300	According to SAE J300	According to SAE J300
<b>Oxidation stability (CEC L-109-14)</b>			
Viscosity increase, %, max.	300	150	130
Oxidation, A/cm, max.	120	90	80
<b>Seal compatibility <sup>(4)</sup></b>			
Nitrile, Silicone, Polyacrylate, FKM, Vamac G (ASTM D7216)	Pass	Pass	Pass
<b>Engine tests</b>			
<b>Cummins ISM (ASTM D7468)</b>	Run number		
Merit rating, min.	-	1000	1000
Crosshead weight loss at 3.9% soot, mg, max.	7.5 / 7.8 / 7.9	7.1	7.1
Oil filter delta p at 150 h, kPa, max.	55 / 67 / 74	19	19
Engine sludge, average, merit, min.	8.1 / 8.0 / 8.0	8.7	8.7
VAS weight loss at 3.9% soot, average, mg, max.	-	45	45
<b>Cummins ISB EGR (ASTM D7484)</b>	Run number		
Slider tappet weight loss, average, max.	-	100 / 108 / 112	100 / 108 / 112
Cam lobe wear, average, max.	-	50 / 53 / 55	50 / 53 / 55
Crosshead weight loss, average, mg	-	Report	Report

# VOLVO VDS, MACK EO and RENAULT RLD standards

- 3 -



Specifications		Volvo VDS-3, Mack EO-N, Renault RLD-2 STD 417-0002	Volvo VDS-4, Mack EO-O PP, Renault RLD-3 STD 417-0001	Volvo VDS-4.5, Mack EOS-4.5, Renault RLD-3 STD 417-0003
<b>Mack T-8E</b> (ASTM D5967) <sup>(5)</sup>	Run number	1 / 2 / 3 1.8 / 1.9 / 2.0 0.75	- -	- -
Relative viscosity at 4.8% soot, max.				
Slope at 275 h or 5.8% soot (if reached before 275 h), max. <sup>(6)</sup>				
<b>Mack T-10</b> (ASTM D6987) / <b>Mack T-12</b> (ASTM D7422)		<b>T-10 / T-12</b> <sup>(7, 8)</sup> 1250 / 1250 32 / 26 158 / 117 35 / 42 14 / 18 65 / 95	<b>T-12</b> <sup>(8)</sup> 1300 21 105 30 12 80	<b>T-12</b> <sup>(8)</sup> 1300 21 105 30 12 80
Merit rating, min.				
Cylinder liner wear, µm, max.				
Top ring weight loss, mg, max.				
Δ lead 0 - 300 h, ppm, max.				
Δ lead 250 - 300 h, ppm, max.				
Oil consumption, g/h, max.				
<b>Mack T-11 or T-11A used oil MRV TP-1</b> (ASTM D6896) <sup>(2)</sup>				
180 h drain MRV viscosity, mPa.s, max		25000	18000	18000
MRV yield stress, Pa, max.		35	35	35
<b>Mack T-11</b> (ASTM D7156)	Run number		1 / 2 / 3 3.5 / 3.4 / 3.3 6.0 / 5.9 / 5.9	1 / 2 / 3 3.5 / 3.4 / 3.3 6.0 / 5.9 / 5.9
TGA soot at 4.0 mm <sup>2</sup> /s increase, %, min.		-		
TGA soot at 12.0 mm <sup>2</sup> /s increase, %, min.		-		
<b>Mack T-12</b> (ASTM D7422)				
Cylinder liner wear, µm, max.		-	-	21.0
Top ring weight loss, mg, max.		-	-	105
Δ lead 0 - 300 h, ppm, max.		-	-	Report
Δ lead 250 - 300 h, ppm, max.		-	-	Report
Oil consumption, g/h		-	-	Report
<b>Mack T-13</b> (ASTM Dxxxx)				
KV40 increase (300 - 360 h), %, max.		-	-	50
Oxidation peak height, A/cm, max.		-	-	80
Nitration, A/cm		-	-	Report
Δ lead, ppm, max.		-	-	Report
Average oil consumption (ag. 48 - 192 h), g/h, max.		-	-	40

# VOLVO VDS, MACK EO and RENAULT RLD standards

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Specifications		Volvo VDS-3, Mack EO-N, Renault RLD-2 STD 417-0002	Volvo VDS-4, Mack EO-O PP, Renault RLD-3 STD 417-0001	Volvo VDS-4.5, Mack EOS-4.5, Renault RLD-3 STD 417-0003
<b>OM 501 LA (CEC L-101-08)</b>				
Piston deposits, average, merit, min.		17	-	-
Bore polish, average, %, max.		2	-	-
Oil consumption, kg/test, max.		9	-	-
Engine sludge, average, merit		Report	-	-
<b>Sequence IIIF (ASTM D6984)</b>				
KV40 increase at 80 h, %, max.		275	-	-
<b>Sequence IIIG (ASTM D7320)</b>				
EOT KV40 increase (adjusted), %, max.		-	150	-
KV40 increase at 100 h (unadjusted), % [B]		-	Report	-
KV40 increase at 80 h (unadjusted), % [C]		-	Report	-
KV40 increase at 60 h (unadjusted), % [D]		-	Report	-
EOT Ratio [(B-C)/(C-D)], max.		-	Report	-
<b>CAT Oil Aeration Test (COAT) (WK 51937)</b>	Run number		1 / 2 / 3	1 / 2 / 3
Average aeration 40 to 50 h, % vol., max.		-	11.6 / 11.7 / 11.8	11.8 / 11.8 / 11.8
<b>Volvo D12D460 (TC 415) <sup>(9)</sup></b>				
Piston deposits, merit, min.		40	40	40
Ring riding, %, max.		50	50	50
Bore polish, cm <sup>2</sup> , max.		150	150	150
Oil consumption (400 h), g/h, max.		35	35	35
Oil consumption (final 100 h), g/h, max.		35	35	35
<b>Fuel economy (D12D460) <sup>(10)</sup></b>				
Fuel economy , ESC 13 mode (Flat and Hilly) <sup>(11)</sup> , g/kWh, min.		-	xW-30: p/n 8715091	-
<b>Environmental aspects <sup>(10)</sup></b>		STD 900-0008	STD 900-0008	STD 900-0008

**Notes:**

(1) The base oil viscosity of the finished oil must always be higher or equal to the base oil viscosity of all test formulations used in the Mack T-12, Cummins ISB and Cummins ISM tests.

(2) Results from T-10 (or T-12A if established and accepted by ASTM) can be used as an alternative to T-11A results. Limits as for API CI-4 or CI-4 PLUS apply.

(3) SSV shall be measured at the temperature required for respective W-grade in accordance with SAE J300.

(4) Additional requirements may apply for factory-fill and Volvo Group-branded products. These are the unadjusted specification limits. Candidate oils need to conform to adjusted limits. Seal results shall be presented along with adjusted specification limits.

(5) The results for Mack T-11 (ASTM D7156) obtained as part of API CI-4, CI-4 PLUS or CJ-4 approval programs can be used.

(6) Slope is calculated using derivative of a 3<sup>rd</sup> order polynomial regression fit of Soot vs Relative Viscosity using the last seven data points (150-300 h).

(7) The results for Mack T-10 or Mack T-12 can be used.

(8) If passing results in Volvo T-13 are obtained, only CLW and TRWL data at the listed limits are required.

(9) Test code: Volvo Powertrain Corporation.

(10) Applies only to factory-fill and Volvo Group-branded products.

(11) According to Volvo Powertrain Corp. weighting factors.

# VOLKSWAGEN engine oil specifications

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Specifications	VW 504.00/507.00	VW 508.00/509.00	VW 508.88/509.99	VW 502.00/505.00	VW 501.01/505.00	VW 505.01	VW First Fill ex. EU
<b>First Fill</b>	TL 521.95	TL 525.77	TL 525.53 (5W-40 only)		-		TL 521.67
<b>Last version date</b>	Dec 2004 / Dec 2004	1-Aug-2017	Apr-13	Dec-14	Mar 2005 / May 2010	Jan-15	March 2005
<b>Service Fill</b>	VW low ash, universal service Fill oil, fully backward compatible and in Europe used for extended drain. Mandatory for diesels with DPF. Only allowed in ultra low sulfur fuel regions.	VW 0W-20 low ash, long drain, high fuel economy oil. Suitable only for HTHS 2.6 capable VW engines in EU and US. Not backward compatible. Not allowed outside EU and USA.	VW high ash oil for outside Europe with different quality fuel than in EU. Normal drain. Not allowed for diesels with DPF. Currently allowed only in Brazil.	VW normal ash service fill oil for gasoline engines under server duty and pump injector diesels WITHOUT DPF.	VW normal ash standard service fill oil. Not allowed for Pump injector diesels. Not allowed for modern day VW engines.	No New Approvals! Existing approvals can requalify as long as no changes. VW mid SAPS stand alone service fill oil for diesel engines at severe duty and pump injector diesels for non DPF diesels	No New Approvals! Existing approvals can requalify as long as no changes. VW mid SAPS factory fill for gasoline engines under severe duty and pump injector diesels without DPF.
<b>ACEA basis</b>	A3/B4-16 (VW DPF test drives to C3)	C5-16	A3/B4 -16	A3/B4 -16	A3/B3 -16	C3-16	C3 -16
<b>SAE viscosity grade</b>	0/5W-30	0W-20	0/5/10W-30/40	0/5W-30/40	0..20W-30..60	0/5W-30/40	5W-40
<b>HTHS (CEC L-36-A-90), mPa.s, min.</b>	3.5	2.6	3.5	3.5	3.5	3.5	3.5
<b>KV 100 (DIN 51562-1), mm<sup>2</sup>/s</b>	According SAE J300	≥ 7.8 & ≤ 9.3	According SAE J300	According SAE J300	According SAE J300	According SAE J300	According SAE J300
<b>Shear stability (CEC L-14-A-93), 30 cycles</b>							
KV 100 (DIN 51562-1), mm <sup>2</sup> /s, % loss after shear, max.	15%	15%	15%	15%	15%	15%	15%
KV 100 (DIN 51562-1), mm <sup>2</sup> /s, after shear, min.	Stay in grade	6.9	Stay in grade	Stay in grade	Stay in grade	Stay in grade	Stay in grade
<b>Noack volatility (CEC L-40-A-93), loss, B method, max.</b>	11%	11%	13%	13%	13%	13%	13%
<b>TBN (DIN 51639-1), mg KOH/g, min.</b>	6.0	6.0	11.0	10.0	8.0	7.0	7.0
<b>Sulfated ash (DIN 51575), % m/m.</b>	≤ 1.5 & Pass VW DPF test	≤ 1.0 & Pass VW DPF test	≥ 1.0 & ≤ 1.5	≥ 1.0 & ≤ 1.5	≤ 1.5	≤ 0.8	≤ 0.8
<b>Chlorine (DIN ISO 15597), % m/m, max.</b>	-	0.0050	-	-	-	-	-
<b>Phosphorus (DIN 51363-3), % m/m.</b>	Rate & Report	Rate & Report	≥ 0.08 & ≤ 0.15	≥ 0.09 <sup>(1)</sup>	≥ 0.08 <sup>(1)</sup>	≥ 0.07 <sup>(1)</sup>	Rate & Report
<b>Sulfur (DIN EN ISO 14596), % m/m, max.</b>	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report	Rate & Report
<b>Zirkonium content (PV1497), % m/m</b>	-	0.0025	-	-	-	-	-
<b>Color. (no norm)</b>	-	Green	-	-	-	-	-

## VOLKSWAGEN engine oil specifications

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Specifications	VW 504.00/507.00	VW 508.00/509.00	VW 508.88/509.99	VW 502.00/505.00	VW 501.01/505.00	VW 505.01	VW First Fill ex. EU
PAH value (VW 50550 and PV 1448), % m/m <sup>(6)</sup>	Rate & Report	Rate & Report	Rate & Report	-	-	-	Rate & Report
Sum PAH 1 till 12, mg/kg, max.	10	10	10	-	-	-	10
Ben(a)pyren, mg/kg, max.	1	1	1	-	-	-	1
Impurities by particles (ISO 4406) <sup>(6)</sup>	Class 23/22/18 for 4/6/14 µm, Class 23/18 for 5/15 µm	Class 23/22/18 for 4/6/14 µm, Class 23/18 for 5/15 µm	Class 23/22/18 for 4/6/14 µm, Class 23/18 for 5/15 µm	-	-	-	Class 23/22/18 for 4/6/14 µm, Class 23/18 for 5/15 µm
Emulsion stability (ASTM D7563)							
0°C and 24h.	-	-	No phase separation	-	-	-	-
25°C and 24h.	-	-	No phase separation	-	-	-	-
Oxidation stability (CEC L-109)							
Oil oxidation at 216 h, A/cm, max.	55	55	-	-	-	-	-
Viscosity increase, relative at 216 h, %, max.	50	50	-	-	-	-	-
Corrosion test (PV 1401), corrosion grade, max. <sup>(6)</sup>	1	1	1	-	-	-	1
Corrosion test (PV 1425) <sup>(6)</sup>							
Steel, grade, max.	1	1	1	-	-	-	1
Copper, grade, max.	2	2	2	-	-	-	2
Weight loss, % m/m, max.	0.5	0.5	0.5	-	-	-	0.5
Corrosion test (PV 1492), corrosion grade, max.	-	-	1	-	-	-	-
Foaming tendency option A (ASTM D892), ml, max., foaming / settling							
Sequence I	10/0	10/0	10/0	10/0	10/0	10/0	10/0
Sequence II	30 / 0	30 / 0	30 / 0	30 / 0	30 / 0	30 / 0	30 / 0
Sequence III	10/0	10/0	10/0	10/0	10/0	10/0	10/0
High temperature foaming (ASTM D6082), max.	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0	100 / 0
VW oil/seal compat. (PV 3344) <sup>(2)</sup>							
AEM1/AEM2	500 h	500 h	168 h	168 h	168 h	168 h	168 h
ACM1	500 h	500 h	168 h	168 h	168 h	168 h	168 h
AK6/1	168 h	168 h	3 x 94 h	3 x 94 h	3 x 94 h	3 x 94 h	3 x 94 h

## VOLKSWAGEN engine oil specifications

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Specifications	VW 504.00/507.00	VW 508.00/509.00	VW 508.88/509.99	VW 502.00/505.00	VW 501.01/505.00	VW 505.01	VW First Fill ex. EU
<b>M271 Sludge test (MB procedure)</b> Engine sludge average, merit, min.	9.1	9.1	9.1	9.1	RL140 + 4Σ	9.1	9.1
<b>OM 646 DE22LA Wear</b> (CEC L-099-08) Cam wear inlet / outlet valve (average wear 8 cams), µm, max.	100 / 120	50 / 60 Report	90 / 110 -	100 / 120 -	110 / 140 -	100 / 120 -	100 / 120 -
Tappet wear inlet / outlet valve (average wear 8 tappets ), µm, max.	-	5.0	5.0	5.0	5.0	5.0	5.0
Cylinder wear (average 4 cylinders), µm, max.	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Bore polishing (13 cm), max value of 4 cylinders, %, max.	3.0	3.0	3.0	3.0	3.5	3.0	3.0
Bore polishing (13 cm), avg. value of 4 cylinders, %.	-	Report	-	-	-	-	-
<b>VW T4 (PV 1449)</b>							
Viscosity at 40°C at end of test, mm <sup>2</sup> /s, max.	200 - VW correction	200 - VW correction	200 - VW correction	200 - VW correction	-	-	200 - VW correction
Vis. increase at 40°C, %, max.	130 - VW correction	130 - VW correction	130 - VW correction	130 - VW correction	-	-	130 - VW correction
TBN end of test, DIN 51639-1, mg KOH/g, min.	Ref Oil (typical 5) - VW correction	Ref Oil (typical 5) - VW correction	Ref Oil + 3 (typical 8) - VW correction	Ref Oil +1 (typical 6) - VW correction			Ref Oil (typical 5) - VW correction
TAN increase end of test, TAN points, max.	4	4	3	4			4
Piston merit, 5 parts, min.	1	1	1	1	-	-	1
Ring sticking, ASF, max.	none	none	none	none	-	-	none
<b>VW Fuel economy (PV 1451)</b>							
FE vs. RL 191 (15W-40), %, min.	0W-30: 2.5% / 5W-30: 2.0%	4.0% <sup>(4)</sup>	-	-	-	-	-
<b>VW Fuel economy (PV 1496 Audi EA888)</b>							
FE vs. RL 5W-30, %, min.	only PV 1451 allowed	1.5% <sup>(4)</sup>	-	-	-	-	-

## VOLKSWAGEN engine oil specifications

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Specifications	VW 504.00/507.00	VW 508.00/509.00	VW 508.88/509.99	VW 502.00/505.00	VW 501.01/505.00	VW 505.01	VW First Fill ex. EU
<b>VW TDI (PV 1452)</b>							
Piston deposits, merit, min.	> RL 206 + Std Dev	RL 206 + Std Dev	RL 206 + Std Dev + 2	> RL 206 + Std Dev	> RL 206 + Std Dev - 4	RL 206 + Std Dev	> RL 206 + Std Dev
Ring sticking, average 1 <sup>st</sup> gr, ASF, max.	1.0	1.0	0.0	1.0	1.2	1.0	1.0
Ring sticking, Max. 1 <sup>st</sup> / 2 <sup>nd</sup> gr, ASF, max.	1 / 0	1 / 0	0 / 0	1 / 0	2.5 / 0	1 / 0	1 / 0
End of test TBN (DIN 51639-1), mgKOH/g, min.	Rate & report	Rate & report	6.0	6.0	4.0	Rate & report	Rate & report
End of test TAN (ASTM D664), max.	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report	Rate & report
<b>VW 1.4 L FSI (PV 1481)</b>							
Inlet valve deposits, max.	Ref Oil FSI 5510 - 38.18%	Ref Oil FSI 5510 - 38.18%	Ref Oil FSI 5510 - 38.18%	-	-	-	-
<b>VW DPF 1.9 L TDI (PV 1485)</b>							
Backpressure increase / oil consumption, mbar / kg, max.	6.0	6.0	-	-	-	-	-
<b>VW bio-diesel sludge test (PV 1800)</b>							
Oil sump sludge, merit, min.	Avg low ref oil +/- test stand severity + 40% (high ref minus low ref)	Avg low ref oil +/- test stand severity + 40% (high ref minus low ref)	-	-	-	-	-
Ring sticking, ASF, max.	-	0	-	-	-	-	-
<b>VW RNT wear test</b>	Full test (650 h)	-	-	-	-	250 h test	250 h test
<b>Baumuster Prufung<sup>(3)</sup></b>	Complete Program	VW508.00/509.00 Program	-	-	-	Short program	Short program

**Notes:**

- (1) If the phosphorus content is < 0.10 % m/m, functional and/or in-vehicle tests may be required for release. Type and scope of these tests shall be coordinated with VW prior to approval.
- (2) Please refer to chapter "Elastomer Compatibility" for limits.
- (3) Consult VW for actual baumuster requirements.
- (4) For VW508.00/509.00 Fuel Economy performance either PV 1451 or PV 1496, Audi EA888 can be used.
- (5) Control parameter. For information only.
- (6) Factory Fill only.

**ACC, API,  
ATC and  
ATIEL codes  
of practice  
(CoP)**



## API and ATIEL base stock categories



	Saturates <sup>(1)</sup> wt%		Sulfur <sup>(2)</sup> wt%		Viscosity Index <sup>(3)</sup>
Group I	< 90	and/or	> 0.03	and	80 ≤ VI < 120
Group II	≥ 90	and	≤ 0.03	and	80 ≤ VI < 120
Group III	≥ 90	and	≤ 0.03	and	≥ 120
Group IV			Polyalphaolefins (PAO)		
Group V			All other base stocks not included in Group I, II, III, or IV.		

**Notes:**

(1) ASTM D2007 / IP129 for Group I or II / IP 129 for Goup II or III or IV.

(2) ASTM D2622 / ASTM D4294 / ASTM D4927 / ASTM D3120 may be used.

(3) ASTM D2270.

## API EOLCS definitions for Base Oil Interchangeability guidelines



Acc. To Appendix	A	is / are
E.1.2.1	Base stock	<p>A lubricant component that</p> <ul style="list-style-type: none"> <li>- is produced by a single manufacturer to the same specifications (independent of feed source or manufacturer's location),</li> <li>- meets the same manufacturer's specification,</li> <li>- is identified by a unique formula, product identification number, or both,</li> <li>- may be manufactured using a variety of different processes including but not limited to distillation, solvent refining, hydrogen processing, oligomerization, esterification, and rerefining.</li> </ul> <p>Rerefined stock shall be substantially free from materials introduced through manufacturing, contamination, or previous use."</p>
E.1.2.2	Base stock slate	A product line of base stocks that have different viscosities but are in the same base stock grouping and from the same manufacturer.
E.1.2.3	Base oil	The base stock or blend of base stocks used in an API-licensed oil.

## ATIEL Code of Practice definitions for base stock interchange guidelines



Acc. To Appendix	A	is / are
A.1	Base oil	The base stock or blend of base stocks which, when mixed with performance additives, is used in an engine lubricant marketed as conforming to ACEA Oil Sequences
A.1	Base stock	<p>A base oil component that:</p> <ul style="list-style-type: none"> <li>- is produced and used in accordance with the ATIEL Base Oil Quality Assurance (Appendix B) and Interchange Guidelines given in Appendix A of the ATIEL Code of Practice issue 20</li> <li>- is produced by a single manufacturer or partner group to the same specification, independently of feed source or manufacturer's location,</li> <li>- meets the same manufacturer's or partner group's specification and is identified by a unique formula, product identification number or both,</li> <li>- may be manufactured using a variety of different processes including but not limited to distillation, solvent refining, hydrogen processing, oligomerization, esterification, and re-refining,</li> <li>- is substantially free from materials introduced through manufacturing, contamination, or previous use.</li> </ul>
2.1	Base stock manufacturer	A company which produces, at one or more manufacturing sites, base stock(s) for use in lubricants for which compliance with ACEA Oil Sequences is claimed.
A.1	Feedstock	<p>The starting material such as crude oil, refinery intermediate or used lubricating oil from which base stocks are produced at a manufacturing site.</p> <p>A particular feedstock may originate from a single source or multiple sources.</p>
A.1	Base stock slate	<p>A product line of base stocks that:</p> <ul style="list-style-type: none"> <li>- is produced by the same manufacturer,</li> <li>- meets the ATIEL definition of base stock,</li> <li>- is in the same ATIEL Base Stock Group (I to IV)</li> <li>- may have different specified viscosities and other properties,</li> <li>- has been demonstrated, in lubricants for which compliance with ACEA Oil Sequences is claimed, to be technically substitutable by other appropriate base stocks on the same slate.</li> </ul>
A.1	Linked slates	Base stock slates that the lubricant manufacturer or base stock manufacturer or partner group concerned has demonstrated are interchangeable without the need for further engine testing for the tests for which linking has been demonstrated
A.1	Partner group	<p>A voluntary grouping of two or more base stock manufacturers who have:</p> <ul style="list-style-type: none"> <li>- base stock slates complying with the ATIEL definition of base stock slate,</li> <li>- linked base stock slates on the basis of a written agreement.</li> </ul>
A.1	Base oil interchange	The process of substituting base stock(s) from alternative base stock slates in engine lubricants validated as complying with ACEA Oil Sequence(s).

## ATIEL base stock interchange guidelines

### Use of alternative base stocks in validated formulations



<b>Same slate or linked base stock slate #6.5.1</b>	Base stocks can differ in their physical properties and chemical composition, which may result in differences in the performance of formulated engine lubricants in engine tests and in service. The ATIEL BOI guidelines define the minimum engine test necessary to ensure that the standard of engine lubricant performance defined by the ACEA Oil Sequences will be maintained when one base stock is substituted by another in validated formulations. These guidelines are given in Appendix A. Base stocks having the same quality control specifications are assumed to be interchangeable only if they belong to the same slate or to linked slates and so substitution of a base stock by another base stock within the same base stock slate, or within linked slates is permitted. In all other cases, the base oil interchange guidelines apply.
<b>Guidelines for Base Oil Interchange (BOI) App. A, A4 #6.5.2</b>	<p>Base Oil Interchange Tables (Appendix A - A4) identify which engine tests can be waived ("not required") and which shall be passed ("required") to permit interchange base stocks in an originally-tested engine lubricant formulation with those from a different base stock slate.</p> <p>Passing results are required only for those engine tests that are a requirement of the ACEA categories for which support is being established. Complete ACEA Performance Data Set documentation is required for the original formulation.</p> <p>When applying the guidelines, the performance additive package and its concentration, the viscosity modifier (VM) (possible concentration adjustment shall be less than 15% mass fraction relative) and the viscosity grade of the formulations shall remain the same. BOI test work shall be carried out separately from any possible Viscosity Modifier Interchange or other performance additive package modification.</p> <p>Where base stocks from more than one base stock group are interchanged simultaneously, cumulative base stock substitutions shall not exceed 10% or 30% by mass, as given in the BOI tables in Appendix A.</p>

# ACC and ATC guidelines for minor formulation modifications

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	ACC (*) Appendix H of the ACC Code of Practice		Appendix #	ATC (**) Section h of the ATC Code of Practice	Section #
Performance additive package minor formulation modifications	Level 1	Level 2		Modifications within an ATC data set or programme	
Decrease in treatment level of either the entire performance additive package or its individual components	Not allowed except for ZnDTP or detergent rebalance			Not allowed except for permissible rebalances	h.1
Performance additive package treatment level increase	≤ 20% <sup>(4)</sup>	> 20 to ≤ 30%	H 1	Allowed	h.2
Single component of performance additive package increase - present at > 1.0% in finished oil - present at ≤ 1.0% in finished oil • ≤ 0.3% • > 0.3% to ≤ 0.6% • > 0.6 % to ≤ 1%	≤ 20% <sup>(4)</sup>  ≤ 100 % <sup>(4)</sup> ≤ 50 % <sup>(4)</sup> ≤ 30 % <sup>(4)</sup>	> 20 to ≤ 30%  > 100% to 200% (max 0.6% in formulation to be tested) > 50% to 100% > 30% to 100% (max 1.3% in formulation to be tested)	H 2  H 3.a H 3.b H 3.c	Allowed	h.2
New component addition (Only one Permitted)	Not allowed	≤ 10% of total final performance additive package	H 4	≤ 10% by mass of final Performance Additive Package.	h.3
Rebalance of ZnDTP (Only one permitted)	Not allowed	Allowed while maintaining constant Phosphorus level, this may include introduction of a new ZnDTP	H 5.a	Allowed whilst maintaining constant formulation Phosphorus level.  This may include introduction of a new ZnDTP; only one new ZnDTP introduction is allowed	h.4
Increase in ZnDTP treatment level	Allowed except VIB/VID/VIE/VIF <sup>(1)</sup>	Required for Seq VIB/VID for 0.04% ≤ Phosphorus ≤ 0.12% increase <sup>(1)</sup>  Required for all engine tests for increases above 0.12% Phosphorus <sup>(1)</sup>	H 5.b		h.4
Rebalance of metallic detergents (Only one permitted) <sup>(2)</sup>	Not allowed	Permitted if sulfated ash remains constant Overall soap must not be decreased Soap increase ≤ 30 % per individual soap type <sup>(2)</sup>	H 6	Acceptable provided overall soap level is not decreased, only one new metallic detergent introduction is allowed	h.5

# ACC and ATC guidelines for minor formulation modifications

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	ACC (*) Appendix H of the ACC Code of Practice		Appendix #	ATC (**) Section h of the ATC Code of Practice	Section #
Performance additive package minor formulation modifications	Level 1	Level 2		Modifications within an ATC data set or programme	
Other limitations		Performance additive package minor modifications $\leq 3$ or 4 <sup>(3)</sup> The sum of all modifications shall not result in an increase in treatment level of any major component $> 30\%$	H 7	No	
Any metallic detergent modification for Seq IX	Not allowed	All modifications which involve a metallic detergent (e.g. performance additive package treat rate increase, metallic detergent increase, metallic detergent rebalance, or new metallic detergent introduction) requires Level 2 support for the Sequence IX	H 11	No	

**Notes:**

The performance additive package commercialized must include all permitted minor modifications. ACC Appendix H 10, ATC Section h.6.

(\*) From ACC CoP Code Bulletin CS7 with effective date December 3, 2017. Applies only to sequence IIIF, IIIG, IIIH, IVA, VG, VIB, VID, VIE, VIF, VIII, and IX engine tests.

(\*\*) From ATC CoP Section H, Feb. 2017.

(1) H.5.b) original language: An increase in treatment level of zinc dithiophosphate (ZnDTP), in a formulation where the phosphorus level from ZnDTP is greater than 0.04%, up to a maximum of 0.12 % phosphorus from ZnDTP is acceptable with Level 2 support for the Sequence VIB and/or VID and Level 1 support for all other engine tests. For increases above 0.12% P from ZnDTP, Level 2 support is required for all engine tests. Alternatively, Guideline H2 or H3 could be used if applicable.

(2) The detergent rebalance may be effected simultaneously with the addition of a new metallic detergent component in line with the requirements of Guideline 4. In the specific instance where the soap and metal type of the new component are already present in the formulation, the rebalance counts as one modification. In other cases, the simultaneous rebalance/ addition counts as two minor modifications.

(3) Matrix Core approach allows 4 minor modifications; non-matrix Core approach only allows 3 minor modifications.

(4) See guideline 11 for the Sequence IX test.

## ACC and ATC guidelines for minor formulation modifications

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Base stocks and other constituents minor formulation modifications	ACC (*) Appendix H of the ACC Code of Practice	Appendix #	ATC (**) Section h of the ATC Code of Practice						Section #
Base stock ratio change: Same slate	Acceptable with Level 1 support: ≤15% absolute on a normalized to 100 % base stock ratio.	H 8.a	Unrestricted <sup>(4)</sup> Follow the principles given in h.7 (also covers new base stock addition) No change in Gp V permitted						h.8d
Different slate									
New base stock addition Same slate	Acceptable with Level 1 support: ≤ 15% of base oil (base stock blend)	H 8.a	Within same base stock slate Group I to Group I, Group II to Group II, Group III to Group III, Group IV to Group IV is unrestricted.						h.7.1
Different slate	≤ 10 % in finished oil  (Limit to Group I, II, III or IV only)	H 8.b	Interchange Base Stock <sup>(1),(4)</sup>						h.7.1
			Base stock in original formulation	Group I	Group II	Group III	Group IV	Group V	
			Group I	Note 7	≤10% <sup>(8)</sup>	≤30% >30% <sup>(2)</sup>	≤30% >30% <sup>(2)</sup>	≤10 <sup>(2)</sup>	
			Group II	≤10% <sup>(8)</sup>	≤10% <sup>(8)</sup>	≤30% >30% <sup>(2)</sup>	≤30% >30% <sup>(2)</sup>	≤10 <sup>(2)</sup>	
			Group III	None <sup>(8)</sup>	None <sup>(8)</sup>	≤10% <sup>(6)(8)</sup>	≤30	≤10 <sup>(2)</sup>	
			Group IV	None <sup>(8)</sup>	None <sup>(8)</sup>	None	Note 3	≤10 <sup>(2)</sup>	
			Group V	None	None	None	None	None	
Matrix approach	Use the API base oil interchangeability guidelines		Tests which are not deemed to be sensitive to base stock changes may be run in any applicable base stock (as per the ATIEL Code base oil interchange principles)						h.7.2

## ACC and ATC guidelines for minor formulation modifications

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Base stocks and other constituents minor formulation modifications	ACC (*) Appendix H of the ACC Code of Practice	Appendix #	ATC (**) Section h of the ATC Code of Practice	Section #
Viscosity modifier treat level change	≤ 15% relative within Level 1	H 8.c	≤ 15% relative allowed without further support >15 % relative is allowed if in alignment with ATIEL Viscosity Grade Read Across Guidelines	h.8a
Pour point depressant treat level or type change	Acceptable with Level 1	H 9	Acceptable	h.8b
Antifoam treat level or type change	Acceptable with Level 1 except COAT <sup>(5)</sup>	H 9	Acceptable	h.8c

**Notes:**

The performance additive package commercialized must include all permitted minor modifications. (ACC Appendix H 10, ATC Section h.9).

(\*) From ACC CoP Code Bulletin C57 with effective date December 3, 2017. Applies only to sequence IIIF, IIIG, IIIH, IVA, VG, VIB, VID, VIE, VIF, VIII, and IX engine tests.

(\*\*) From ATC CoP Section H, Feb. 2017: Cumulative substitutions must not exceed 10% or 30% by mass, as relevant and as defined above, from any initial/intermediate candidate for which test data are to be retained in support of the final candidate without specific engine test data.

With specific engine test data, replacement of Gp I or II with Gp III or IV is unlimited.

Where changes such as above are introduced as the result of failing engine test data, and to pass an engine test, the reverse substitution may not be made subsequently, even if apparently allowed under the rules above, without the relevant engine test having been re-done at a point where a system is representative of the final base stock mix to be promoted.

(1) All percentages are % on the finished oil.

(2) Allowed with specific engine test data.

(3) Substitution of Gp IV by another manufacturer's Gp IV is allowed as defined by the ATIEL Code of Practice Issue Number20 (Appendix A, Base Stock Interchange Guidelines).

(4) Base stock groupings are as defined by the ATIEL Code of Practice Issue Number 20, Appendix A, Section A1.

(5) Published in Code Bulletin C-48 effective April 22, 2016: When changing foam inhibitor type or treatment level in the Caterpillar Oil Aeration Test (COAT), Level 1 support alone is not adequate; fundamental formulation knowledge support must exist to ensure performance is not deteriorated in this test.

(6) For the TUSJP, follow ATIEL Code of Practice Issue Number 19, Appendix B, Table B.3. For other engine tests, follow the table above.

(7) Follow ATIEL Code of Practice Issue Number 20, Appendix A, Table A.4.2 BOI Tables for engine tests listed there. For the TUSJP and DV43E follow ATIEL Code of Practice Issue Number 19, Appendix B.

(8) For the M111FE, follow the requirements of the ATIEL Code of Practice Issue Number 20, Appendix A, Table BOI.3. For other engine tests, follow the table above.

## ACC guidelines for program guidelines



	ACC (*) Appendix I of the ACC Code of Practice		Appendix #
	Level 1	Level 2	
Program guidelines built on existing Core Data sets developed under the ACC code			
Uptreat of Performance additive package treatment level	$\leq 20\%$ except for Seq IX	$\leq 20\%$ for Seq IX	I 1 a)
Uptreat of additives already present or additives which were not present in the original tested formulation	Not allowed	Any amount	I 1 b)
New component addition	Not allowed	Any amount	I 1
Change in viscosity modifier shear stability within the same chemical type <sup>(i)</sup> and manufacturer	Not allowed	Allowed	I 3
Addition of dispersant for monograde or other grade with a lower dispersant viscosity modifier treatment level compared to what was used in a multigrade program will be defined by Seq VG	Not allowed	Required for all Sequence engine tests except VG	I 4
Substitution of Group III or Group IV base stock for Group I, Group II, and/or Group III base stock is allowed with Level 2 support.	Not allowed	Allowed	I 5
Substitution of API Group V base stock for up to 10% of the base stock for PCMOs and diesel engine oils	Not allowed	Allowed	I 6

**Notes:**

The performance additive package commercialized must include all permitted minor modifications. ACC Appendix H 10, ATC Section h.6.

(\*) From ACC CoP Code Bulletin C57 with effective date December 3, 2017.

(i) Chemical type means chemical family, such as, but not limited to, styrene ester, polymethacrylate, styrene butadiene, styrene isoprene, polyisoprene, olefin copolymer, and polyisobutene.

# ACC and ATC guidelines data required for candidate data packages

- 1 -



ACC	<b>Level 1</b> ACC CoP Appendix E 2	<b>INITIAL &amp; MODIFIED FORMULATIONS</b> <ul style="list-style-type: none"> <li>• Analytical Testing               <ul style="list-style-type: none"> <li>- All additive elements known to be present</li> <li>- TBN (ASTM D2896)</li> </ul> </li> </ul> <b>FINAL FORMULATION</b> <ul style="list-style-type: none"> <li>• Analytical Testing               <ul style="list-style-type: none"> <li>- All additive elements known to be present</li> <li>- TBN (ASTM D2896)</li> <li>- IR (Infrared trace)</li> </ul> </li> </ul> <li>• Base Stock Analysis               <ul style="list-style-type: none"> <li>- Saturates (ASTM D2007)</li> <li>- Sulfur (ASTM D1552/ D2622/ D3120/ D4294/ D4297)</li> <li>- Viscosity Index (ASTM D2270)</li> </ul> </li>	<ul style="list-style-type: none"> <li>• Rheological Testing               <ul style="list-style-type: none"> <li>- Viscosity at 100°C (ASTM D445)</li> <li>- CCS (if W grade) (ASTM D5293)</li> <li>- HTHS at 150°C (ASTM D4683, D4624, or D4741)</li> </ul> </li> </ul> <ul style="list-style-type: none"> <li>• Rheological Testing               <ul style="list-style-type: none"> <li>- Viscosity at 100°C (ASTM D445)</li> <li>- Viscosity at 40°C (ASTM D445)</li> <li>- CCS (if W grade) (ASTM D5293)</li> <li>- MRV (if W grade) (ASTM D4684)</li> <li>- HTHS at 150°C (ASTM D4683, D4624, or D4741)</li> </ul> </li> </ul>
	<b>Level 2</b> <b>= Level 1+</b>  ACC CoP Appendix E 3 and definition of Level 2 support in Glossary of Terms Tab 1	<ul style="list-style-type: none"> <li>• Engine Tests / Final Formulation               <ul style="list-style-type: none"> <li>- Full length ASTM operationally valid engine tests on oils containing performance additive package(s) representative of the chemistry in the final formulation.</li> <li>- ASTM calibrated test stands to be used in all cases.</li> <li>- Tests limited to the following:                   <ul style="list-style-type: none"> <li>- statistically designed engine test matrices, or</li> <li>- complete engine test programs, or</li> <li>- partial set of tests from same technology family</li> </ul> </li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Demonstrate No Harm</li> </ul>

## ACC and ATC guidelines data required for candidate data packages

- 2 -



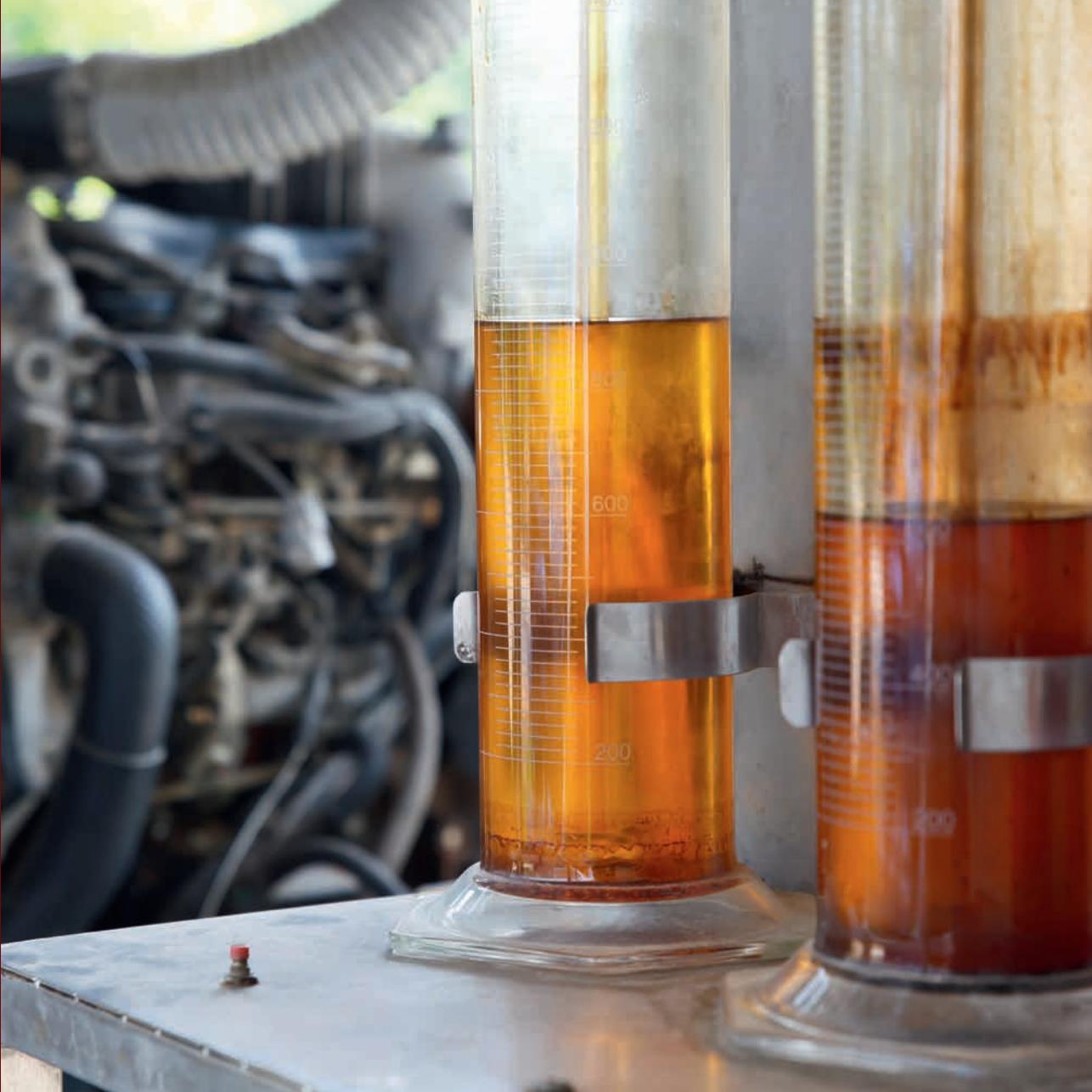
ACC	ATC CoP Section G.g.4	<b>FOR ALL SUPPORTING AND FINAL FORMULATIONS:</b> <ul style="list-style-type: none"> <li>• <b>Analytical Testing</b> <ul style="list-style-type: none"> <li>- Finished oil metals where present</li> <li>- Finished oil S, N, Si, P, Cl <sup>(1)</sup></li> <li>- TBN (ASTM D2896)</li> <li>- Sulfated ash (ASTM D874)</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Rheological Testing</b> <ul style="list-style-type: none"> <li>- Viscosity at 100°C (ASTM D445)</li> <li>- CCS (if W grade) (ASTM D5293)</li> </ul> </li> <li>• <b>Treatment level in finished oil of</b> <ul style="list-style-type: none"> <li>- Performance additive package</li> <li>- Base stocks</li> <li>- Viscosity Modifier</li> <li>- Other constituents</li> </ul> </li> </ul>
	ATC CoP Section G.2	<ul style="list-style-type: none"> <li>• <b>Base Stock Analysis</b> <ul style="list-style-type: none"> <li>- Saturates (ASTM D2007 or IP129)</li> <li>- Sulfur (ASTM D2622 or ASTM D4294 or ASTM D4927 or ASTM D3120)</li> <li>- Viscosity Index (ASTM D2270)</li> </ul> </li> </ul>	

**Notes:**

(1) Cl determination is only required on the final formulation and where an ACEA A/B or C claim is being made.

**API  
guidelines for:**

- Viscosity grade  
read-cross (VGRA)
- Base oil  
interchange (BOI)



# API 1509 engine oil licensing and certification system guidelines: viscosity grades read across requirements for formulations containing Group I, II, III and IV base stocks



F1.3

Tables F-2 through F-12 on following pages indicate when a viscosity grade read-across is allowed (X) and not allowed (-).

For viscosity grades not included in those tables, read across is allowed for certain tests if the viscosity grades meet all the applicable technical principles described in Table F-1.

Read-across for viscosity grades not covered by Table F-1 through F-13 is not allowed until API's BOI/VGRA Task Force reviews the justification and data supporting a change to the tables and recommends the change to the API Lubricants Committee and the Lubricants Committee approves the change.

Engine manufacturers may not recommend all of the viscosity grades shown in Tables F-2 through F-13 for a particular engine type.

Check marks in Table F-1 indicate which technical principles apply to a specific test.

**Table F-1**

Passenger car motor oils	Sequence									
	IID	L-38/ VIII	IIIE/IIIF/IIIG	IIIGA <sup>(2)</sup>	IIIGB/IIIB	IIIH	IVA	VE	VG	VIA/VIB/VID
Detergent (dispersant)-inhibitor (DI) content of the read-across viscosity grade shall be equal to, or higher than, that of the original viscosity grade. The increase in DI is limited to the maximum allowed by the ACC Code of Practice	ffl	ffl	ffl	ffl	ffl	ffl	ffl	ffl	ffl	(3)
Base stock blend kinematic viscosity at 100°C of the read-across viscosity grade must be equal to or higher than that of the original viscosity grade, considering the precision of the test method	NA	NA	ffl	ffl	NA	ffl	ffl	ffl	NA	(3)
The viscosity modifier (VM) content of the read-across viscosity grade must be equal to or lower than that of the original viscosity grade	NA	NA	(4)	(4)	NA	(4)	ffl	ffl or (5)	ffl or (5)	(3)

Diesel engine oils		1M-PC
Detergent (dispersant)-inhibitor (DI) content of the read-across viscosity grade shall be equal to or higher than that of the original viscosity grade. The increase in DI is limited to the maximum allowed by the ACC Code of Practice		ffl
Base stock blend kinematic viscosity at 100°C of the read-across viscosity grade must be equal to or higher than that of the original viscosity grade, considering the precision of the test method		ffl
The viscosity modifier (VM) content of the read-across viscosity grade must be equal to or lower than that of the original viscosity grade		ffl
Finished oil volatility of the read-across viscosity grade must be equal to or lower than that of the original viscosity grade		ffl

**Notes:**

(1) ffl = principle is applicable; NA = not applicable.

(2) Technical principles for the Sequence IIIGA are limited to 0W, 5W, and 10W multigrades.

(3) New viscosity grades and associated read-across can only be added after review by the API BOI/VGRA Task Force and approval by the API Lubricants Committee.

(4) Viscosity modifier content must be no more than 1.5 times higher than the viscosity modifier content in the oil on which the test was run.

(5) For dispersant-type VM, the VM content of the read-across viscosity grade must be equal to or higher than the original viscosity grade.

(6) Read-across viscosity grades must contain an equal amount of the same group V base stock (e.g., ester) in the finished oil blend if a Group V base stock is used in the original viscosity grade.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



L-38/Sequence VIII tests - Table F-2

Test Run on	Can Be "Read-Across" to:												
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	X	X	X	X	X	X	X	X	X	X	X
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	X
10W	—	—	NA	—	—	—	—	X	—	—	X	X	X
10W-30	—	—	X	NA	X	X	X	X	X	X	X	X	X
10W-40	—	—	X	X	NA	X	X	X	X	X	X	X	X
15W-40	—	—	—	X	X	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	X	X	NA	X	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	X	X	NA	X	X	X	X
20W-50	—	—	—	—	—	—	X	X	X	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

**Notes:**

(1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.

(2) A dash (—) means that read-across is not permitted; NA = not applicable.

(3) New viscosity grades and associated read-across are allowed if the requirements described in F1.3 are met.

(4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

(5) The read-across in this table applies only to bearing weight loss and piston varnish. All multigrade oils must stay-in-grade for 10 hours in the L-38/Seq. VIII tests (see ILSAC GF-1, GF-2, GF-3 and GF-4).

Data to support stay-in-grade "read-across" shall be provided by the licensee for API Service Categories SM, SL, SJ, SH, and CG-4 and ILSAC GF-1, GF-2, and GF-3 oils (OW-XX, 5W-XX, 10W-XX).

(6) The guidelines in this table apply only to bearing weight loss. All multigrade oils must stay in grade for 10 hours. Data to support stay-in-grade read across shall be provided by the licensee for active API Service Categories and ILSAC Standards.

ASTM D6278 (30 passes) may be used to support stay-in-grade requirements, where the following limits must be met at 100 °C: SAE XW-20 5.6 cSt minimum, XW-30 8.5 cSt minimum, XW-40 11.5 cSt minimum, and XW-50 15.0 cSt minimum.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence IID - Table F-3

Test Run on	Can Be "Read-Across" to:													
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50	
5W-20	NA	X	X	X	X	X	X	X	X	X	X	X	—	
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	—	
10W	—	—	NA	—	—	—	—	X	—	—	X	X	—	
10W-30	—	—	X	NA	X	X	X	X	X	X	X	X	—	
10W-40	—	—	X	X	NA	X	X	X	X	X	X	X	—	
15W-40	—	—	—	X	X	NA	X	X	X	X	X	X	X	
15W-50	—	—	—	—	X	X	NA	X	X	X	X	X	X	
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X	
20W-40	—	—	—	—	X	X	X	X	NA	X	X	X	X	
20W-50	—	—	—	—	—	X	X	X	X	NA	X	X	X	
30	—	—	—	—	—	—	—	X	—	—	NA	X	X	
40	—	—	—	—	—	—	—	—	—	—	X	NA	X	
50	—	—	—	—	—	—	—	—	—	—	—	—	NA	

- Notes:**
- (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.
  - (2) A dash (—) means that read-across is not permitted; NA = not applicable.
  - (3) New viscosity grades and associated read-across are allowed if the requirements described in F1.3 are met.
  - (4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence IIIE/IIIF/IIIG/IIIGB tests - Table F-4

Test Run on	Can Be "Read-Across" to:												
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	—	X	X	—	—	—	X	X	X	X	X	X
5W-30	X <sup>a</sup>	NA	X	X	X	X	X	X	X	X	X	X	X
10W	—	—	NA	—	—	—	—	X	—	—	X	X	X
10W-30	—	—	X	NA	X	X	X	X	X	X	X	X	X
10W-40	—	—	X	X	NA	X	X	X	X	X	X	X	X
15W-40	—	—	—	X	X	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	—	X	NA	—	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	—	—	X	NA	X	X	X	X
20W-50	—	—	—	—	—	—	—	—	X	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

- Notes:**
- (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee. Viscosity modifier content must be no more than 1.5 times higher than the viscosity modifier content in the oil on which the test was run.
- (2) A dash (—) means that read-across is not permitted; NA = not applicable.
- (3) New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.
- (4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.
- (a) The read from 5W-30 to 5W-20 applies to Sequence IIIF/IIIG only.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence IIIGA and ROBO tests - Table F-5

Test Run on	Can Be "Read-Across" to:				
	5W-20	5W-30	10W	10W-30	10W-40
5W-20	NA	—	X	X	—
5W-30	X	NA	X	X	X
10W-30	—	—	X	NA	X
10W-40	—	—	X	X	NA

**Notes:**

- (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.
- Viscosity modifier content must be no more than 1.5 times higher than the viscosity modifier content in the oil on which the test was run.
- (2) A dash (—) means that read-across is not permitted; NA = not applicable.
- (3) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence IVA Test - Table F-6

Test Run on	Can Be "Read-Across" to:												
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	—	X	X	—	—	—	X	Xa	Xa	X	X	X
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	X
10W	—	—	NA	—	—	—	—	X	—	—	X	X	X
10W-30	—	—	—	NA	—	X	—	X	X	X	X	X	X
10W-40	—	—	—	X	NA	X	X	X	X	X	X	X	X
15W-40	—	—	—	X	—	NA	X	X	X	X	X	X	X
15W-50	—	—	—	—	—	—	NA	—	X	X	X	X	X
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	—	—	NA	X	X	X	X
20W-50	—	—	—	—	—	—	—	—	—	NA	X	X	X
30	—	—	—	—	—	—	—	—	—	—	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

- Notes:**
- (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.
- (2) A dash (—) means that read-across is not permitted; NA = not applicable.
- (3) New viscosity grades and associated read-across are allowed if the requirements described in F1.3 are met.
- (4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.
- (a) Read-across permitted if requirements in F1.3 are met.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence VE/VG test nondispersant viscosity modifier - Table F-7

Test Run on	Can Be "Read-Across" to:													
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50	
5W-20	NA	—	X	X	—	—	—	X	—	—	X	X	—	
5W-30	X	NA	X	X	X	X	X	X	X	X	X	X	—	
10W	—	—	NA	—	—	—	—	X	—	—	X	X	—	
10W-30	—	—	—	NA	—	X	—	X	X	X	X	X	—	
10W-40	—	—	—	X	NA	X	X	X	X	X	X	X	—	
15W-40	—	—	—	X	—	NA	X	X	X	X	X	X	X	
15W-50	—	—	—	—	—	—	NA	—	X	X	X	X	X	
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X	
20W-40	—	—	—	—	—	X	—	—	NA	X	X	X	X	
20W-50	—	—	—	—	—	—	—	—	—	NA	X	X	X	
30	—	—	—	—	—	—	—	—	—	—	NA	X	X	
40	—	—	—	—	—	—	—	—	—	—	—	NA	X	
50	—	—	—	—	—	—	—	—	—	—	—	—	NA	

- Notes:**
- (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.
  - (2) A dash (—) means that read-across is not permitted; NA = not applicable.
  - (3) New viscosity grades and associated read-across are allowed if the requirements described in F1.3 are met.
  - (4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence VE/VG test dispersant viscosity modifier <sup>(a)</sup> - Table F-8

Test Run on	Can Be "Read-Across" to:												
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	—	X	X	X	X	—	X	X	—	—	—
5W-30	—	NA	—	X <sup>b</sup>	X	X	X	—	X	X	—	—	—
10W	—	—	NA	—	—	—	—	X	—	—	X	X	—
10W-30	—	—	—	NA	X	X	X	—	X	X	—	—	—
10W-40	—	—	—	X	NA	X	X	—	X	X	—	—	—
15W-40	—	—	—	X	X	NA	X	—	X	X	—	—	—
15W-50	—	—	—	—	—	—	NA	—	X	X	—	—	—
20W	—	—	—	—	—	—	—	NA	—	—	X	X	X
20W-40	—	—	—	—	—	X	X	—	NA	X	—	—	—
20W-50	—	—	—	—	—	—	X	—	—	NA	—	—	—
30	—	—	—	—	—	X	X	—	X	X	NA	X	X
40	—	—	—	—	—	—	—	—	—	—	—	NA	X
50	—	—	—	—	—	—	—	—	—	—	—	—	NA

**Notes:**

(1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.

(2) A dash (—) means that read-across is not permitted; NA = not applicable.

(3) New viscosity grades and associated read-across are allowed if the requirements described in F.1.3 are met.

(4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

(a) Read-across is allowed to formulations with an equal or higher concentration of dispersant viscosity modifier.

(b) 10W-30 read-across is permitted at a lower concentration of dispersant viscosity modifier than the 5W-30 provided that a passing SAE 30 is also obtained on the formulation where the DI treat remains unchanged.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence VIA test - Table F-9

Test Run on	Can Be "Read-Across" to:							
	0W-20	5W-20	0W-30	5W-30	0W-40	5W-40	10W-30	10W-40
0W-20	NA	—	—	—	—	—	—	—
5W-20	X1	NA	—	—	—	—	—	—
0W-30	X1	—	NA	—	—	—	—	—
5W-30	X1	X1	X2	NA	—	—	X4	—
0W-40	X1	—	X2	—	NA	—	—	—
5W-40	X1	X1	X2	X2	—	NA	—	—
10W-30	—	X1	X2	X2	—	—	NA	—
10W-40	—	—	—	X2	—	X2	X3	NA

- Notes:**  
 (1) X1 = read-across allowed at 1.4% FEI or greater.  
 (2) X2 = read-across allowed at 1.1% FEI or greater.  
 (3) X3 = read-across allowed at 0.5% FEI or greater.  
 (4) X4 = read-across allowed if the 5W-30 meets 1.1% FEI and the HTHS of the 10W-30 is no more than 0.2cP higher than the 5W-30. This read-across is currently applicable to Group I base stocks only.  
 (5) The data required to establish the Sequence VIA viscosity grade read-across table had the following range of (Group I and Group II) base oil parameters:

- Viscosity Index: Min. 93 – Max. 116
- Saturates: Min. 71.5% – Max. 100%
- Aromatics: Min. 0.0% – Max. 27%
- Sulfur: Min. 0.0% – Max. 0.4% wt.

This information is for reference. It does not restrict application of the guidelines by the marketer who is responsible for ensuring that each licensed engine oil satisfies all engine and bench test performance requirements.

(6) A dash (—) means that the read-across is not permitted; NA = not applicable.

(7) New viscosity grades and associated read-across can only be added by requests to the API BOI/VGRA Task Force.

(8) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence VIB test - Table F-10

Test Run on	Can Be "Read-Across" to:							
	0W-20	5W-20	0W-30	5W-30	0W-40	5W-40	10W-30	10W-40
0W-20	NA	—	—	—	—	—	—	—
5W-20	X1	NA	—	—	—	—	—	—
0W-30	X1	—	NA	—	—	—	—	—
5W-30	X1	X1	X1	NA	—	—	X3	—
0W-40	X1	—	X1	—	NA	—	—	—
5W-40	X1	X1	X1	X1	—	NA	—	—
10W-30	X1	X1	X1	X1	—	—	NA	—
10W-40	X1	X1	X1	X1	X2	X2	X2	NA

**Notes:**

(1) X1 = VGRA allowed if result on the tested oil meets requirements for the read-across grade.

(2) X2 = read-across allowed.

(3) X3 = read-across allowed provided the Noack volatility of the 10W-30 is less than or equal to the Noack of the 5W-30 and the HTHS of the 10W-30 is no more than 0.1 cP higher than the HTHS of the 5W-30, within the precision of the tests, and the delta between the CCS of the 10W-30 oil and the maximum CCS limit is greater than or equal to the delta between the CCS of the 5W-30 oil and the maximum CCS limit at the appropriate temperatures.

(4) A dash (—) means that the read-across is not permitted; NA = not applicable.

(5) New viscosity grades and associated read-across can only be added by requests to the API BOI/VGRA Task Force.

(6) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



Sequence VID test - Table F-11

Test Run on	Can Be "Read-Across" to:							
	0W-20	5W-20	0W-30	5W-30	10W-30	0W-40	5W-40	10W-40
0W-20	NA	X1	—	—	—	—	—	—
5W-20	X1	NA	—	—	—	—	—	—
0W-30	X2	X2	NA	X1	X1	—	—	—
5W-30	X2	X2	X1	NA	X1	—	—	—
10W-30	X2	X2	X2	X2	NA	X1	X1	X1
0W-40	—	—	—	—	X1	NA	X1	X1
5W-40	—	—	—	—	X1	X1	NA	X1
10W-40	—	—	—	—	X1	X1	X1	NA

**Notes:**

X1 = VGRA is allowed if HTHS@100°C (D6616) of the candidate oil is less than or equal to the original tested oil OR if HTHS@100°C (D6616) of the candidate oil meets the conditions of Equations F.1.O.  
X2 = VGRA is allowed if the original tested oil meets the FEI Sum and FEI2 limit requirements for the read-across viscosity grade and the HTHS@100°C (D6616) of the candidate oil is less than or equal to the original tested oil.

**Equations F.1.O**

Testing is not required if both equations are true:

$$\begin{aligned} \text{HCandidate} &\leq \text{HOriginal} + (\text{FEIsumLimit} - \text{FEIsumOriginal}) / -0.485 + (\text{HOriginal} * R) \\ \text{HCandidate} &\leq \text{HOriginal} + (\text{FEI2Limit} - \text{FEI2Original}) / -0.227 + (\text{HOriginal} * R) \end{aligned}$$

Where:

HCandidate is the HTHS@100°C of the candidate oil as measured by ASTM D6616  
HOriginal is the HTHS@100°C of the original tested oil as measured by ASTM D6616  
FEIsumLimit is the FEI sum passing limit for the original tested viscosity grade  
FEIsumOriginal is the FEI sum (FEI1Original + FEI2Original) result of the original tested oil  
-0.485 is the FEIsum coefficient from the Seq. VID industry matrix model  
FEI2Limit is the FEI2 passing limit for the original tested viscosity grade  
FEI2Original is the FEI2 result of the original tested oil  
-0.227 is the FEI2 coefficient from the Seq. VID industry matrix model

R is the reproducibility as reported in the most recent version of ASTM D6616. The current R = 0.035 (3.5%) for ASTM D6616-07.

The range of the HTHS@100°C used to develop the Seq. VID industry matrix model was 5.44 to 7.68 cP (5.25 to 7.95 cP when allowance is made for D6616 reproducibility).

This information is for reference. It does not restrict application of the guidelines by the marketer who is responsible for ensuring that each licensed engine oil satisfies all engine and bench test performance requirements.

# API 1509 engine oil licensing and certification system guidelines: viscosity grades read across requirements for formulations containing Group II, III and IV base stocks



## Sequence IX tests - Table F-\*\*

For viscosity grades not listed in the table below, bracketing two passing formulations for a given technology may be used to waive additional testing. VGRA is allowed if the candidate's base oil viscosity at 100°C falls within the range of the base oil viscosity at 100°C of the 2 passing formulations.

Additionally, the viscosity modifier content must be no more than 1.5 times higher than the highest viscosity modifier content in the oils used to support the VGRA bracket. (This approach applies to formulations with base stock Group II, Group III and Group IV.)

Can Be "Read-Across" <sup>(3)</sup> to:						
Test Run on	0W-16	0W-20	0W-30	5W-20	5W-30	10W-30
0W-16	NA	X	X	X	X	X
0W-20	X	NA	X	X	X	X
0W-30	X	X	NA	X	X	X
5W-20	X	X	X	NA	X	X
5W-30	X	X	X	X	NA	X
10W-30	X	X	X	X	X	NA

## Notes:

(1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.

(2) A dash (—) means that read-across is not permitted; NA = not applicable.

(3) Tested formulations containing Group I and/or Group V stocks must contain an equal amount of the same base stock in the finished oil blend for application of viscosity grade read-across.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



**F.4 VGRA for bench tests**

**F.4.1 HOMOGENEITY AND MISCELLIBILITY (H & M) (ASTM D6922) and EOFT (ASTM D6795)**

These tests are required in the core data set (see ACC Code of Practice for definition of core data set), and then read-across is allowed to all other viscosity grades within the same base stock slate.

**F.4.2 EOWTT (ASTM D6794)**

This test must be run on the formulation with the highest additive (DI/VI) combination.

Results are then read-across results to all other base oil/viscosity grade formulations using same or lower concentration of the identical additive (DI/VI) combination.

Each different (DI/VI) combination must be tested.

**F.4.3 BALL RUST TEST (BRT) (ASTM D6557)**

If there is one passing Ball Rust Test (BRT) (ASTM D6557) in the core data set as defined by the ACC Code of Practice, read-across is allowed to all other viscosity grades and base oil slates.

**F.4.4 EMULSION RETENTION (ASTM D7563)**

For oils formulated with Group II and/or Group III base stocks, the Emulsion Retention ASTM D7563 is required only for the highest additive (DI/VI) concentration.

Read across is allowed to all other Group II, Group III and combinations of Group II and Group III base oil/viscosity grade formulations using the same or lower concentration of the identical additive (DI/VI) combination. If the PPD type is changed for the DI/VI combination, testing is required.

**F.4.5 HIGH TEMPERATURE CORROSION BENCH TEST (ASTM D6594)**

If there is one passing HTCCT (ASTM D6594) in the core data set as defined by the ACC Code of Practice, read-across is allowed to all other viscosity grades and base oil slates.

TEOST Test (Method 33) - Table F-12

Test Run on	Can Be "Read-Across" to:							
	5W-20	5W-30	10W-30	10W-40	15W-40	20W-40	20W-50	Mono- Grade
5W-20	NA	X	—	—	—	—	—	—
5W-30	X	NA	X	X	X	X	X	X
10W-30	—	—	NA	X	X	X	X	X
10W-40	—	—	X	NA	X	X	X	X
15W-40	—	—	—	—	NA	X	X	X
20W-40	—	—	—	—	—	NA	X	X
20W-50	—	—	—	—	—	X	NA	X

**Notes:**

(1) X = read-across is permitted for viscosity grades identified based on data and some application of technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.

(2) Monogrades are defined as SAE 10W, SAE 20W, SAE 30, SAE 40, and SAE 50.

(3) A dash (—) means that read-across is not permitted; NA = not applicable.

(4) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

(5) New viscosity grades and associated read-across are allowed if requirements described in F.1.3 are met.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



TEOST MHT-4 - Table F-13

Test Run on	Can Be "Read-Across" to:												
	5W-20	5W-30	10W	10W-30	10W-40	15W-40	15W-50	20W	20W-40	20W-50	30	40	50
5W-20	NA	X	—	X	X	—	—	—	—	—	—	—	—
5W-30	X	NA	—	x	X	—	—	—	—	—	—	—	—
10W	—	—	NA	—	—	—	—	—	—	—	—	—	—
10W-30	X	X	—	NA	X	X	X	—	—	—	—	—	—
10W-40	X	X	—	X	NA	X	X	—	—	—	—	—	—
15W-40	—	—	—	X	X	NA	X	—	—	—	—	—	—
15W-50	—	—	—	X	X	X	NA	—	—	—	—	—	—
20W	—	—	X	—	—	—	—	NA	—	—	—	—	—
20W-40	—	—	—	X	X	X	X	—	NA	X	—	—	—
20W-50	—	—	—	X	X	X	X	—	X	NA	—	—	—
30	—	—	X	—	—	—	—	X	—	—	NA	—	—
40	—	—	X	—	—	—	—	X	—	—	X	NA	—
50	—	—	X	—	—	—	—	X	—	—	X	X	NA

- Notes:**
- (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.
- (2) A dash (—) means that read-across is not permitted; NA = not applicable.
- (3) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.
- (4) If the viscosity grade of interest is not in the table, then the TEOST MHT-4 must be run.
- (5) The principles behind this table are that higher base oil viscosity tends to give poorer performance and that VM level is not necessarily detrimental.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



**GF-5 Elastomer compatibility test (ASTM D7216 Annex 2A) - Table F-14**

For viscosity grades not listed in the table below, bracketing two passing formulations for a given technology may be used to waive additional testing. VGRA is allowed if the candidate's base oil viscosity at 100°C falls within the range of the base oil viscosity at 100°C of the 2 passing formulations.

Test Run on	Can Be "Read-Across" <sup>(3)</sup> to:					
	0W-20	0W-30	5W-20	5W-30	10W-30	10W-40
0W-20	NA	X	X	X	X	X
0W-30	X	NA	X	X	X	X
5W-20	X	X	NA	X	X	X
5W-30	X	X	X	NA	X	X
10W-30	X	X	X	X	NA	X
10W-40	X	X	X	X	X	NA

- Notes:**  
 (1) X = read-across is permitted for the viscosity grades identified based on data and some applications of the technical principles approved by API BOI/VGRA Task Force and API Lubricants Committee.  
 (2) A dash (--) means that read-across is not permitted; NA = not applicable.  
 (3) Tested formulations containing Group I and/or Group V stocks must contain an equal amount of the same base stock in the finished oil blend for application of viscosity grade read-across.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



**Table F-15**

Read-across for viscosity grades not covered explicitly by this table are not allowed unless permitted by table F-1.

Performance test	From SAE	To SAE
Caterpillar 1K	10W-40 15W-40 30 40	10W-30, 15W-40, 15W-50 10W-30, 20W-40, 20W-50 10W, 20W, 40, 10W-30, 15W-40, 20W-50 10W, 20W, 30, 10W-30, 15W-40, 20W-50
Caterpillar 1M-PC <sup>(a)</sup>	5W-30 10W-30 10W-40 20W-20 <sup>(b)</sup> 30 40 50 10W 15W-40 15W-50 20W-40 20W-50	All single grades and 5W-20, 10W-30, 10W-40, 15W-40, 15W-50, 20W-40, 20W-50 All single grades and 15W-40, 15W-50, 20W-40, 20W-50 All single grades and 10W-30, 15W-40, 15W-50, 20W-40, 20W-50 All single grades except 10W All single grades except 10W All single grades except 10W All single grades except 10W All single grades All single grades and 20W-40, 20W-50 All single grades and 15W-40, 20W-40, 20W-50 All single grades except 10W and 20W-50 All single grades except 10W and 20W-40
Caterpillar 1N	15W-40 20W-20 <sup>(b)</sup> 30 40 50	10W-30, 20W-40, 20W-50 10W 10W, 20W-20 <sup>(b)</sup> , 30 10W, 20W-20 <sup>(b)</sup> , 30, 40
Caterpillar 1P	10W-30 10W-40 15W-40 15W-50	15W-40, 20W-40, 20W-50 10W-30, 15W-40, 15W-50, 20W-40, 20W-50 20W-40, 20W-50 15W-40, 20W-40, 20W-50
Caterpillar 1R	10W-30 10W-40	15W-40 10W-30, 15W-40, 15W-50
Caterpillar C13	10W-30 10W-40 15W-50	15W-40 10W-30, 15W-40 15W-40

**Notes:**

(1) This table originally became effective January 1, 1992. Engine manufacturers may not recommend all of the viscosity grades shown in the table for a particular engine type.

(2) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

(a) No 0W and 5W single grades were considered for this table. 1M-PC read-across guidelines effective December 1, 2002.

(b) These read across also apply to SAE 20 and SAE 20W monograde oils.

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



**Table F-15**

Read-across for viscosity grades not covered explicitly by this table are not allowed unless permitted by table F-1.

Performance test	From SAE	To SAE
Corrosion Bench Test (CBT)	10W-30	15W-40
COAT	15W-40 10W-40	10W-30, 10W-40 10W-30
Elastomer Compatibility	10W-30 15W-40	15W-40 10W-30
High Temperature Corrosion Bench Test (HT-CBT)	See F-4.5	
Mack M11HST	10W-30 15W-40	10W-40, 15W-40, 15W-50 10W-40, 15W-50
Mack M11EGR	10W-30 15W-40	10W-40, 15W-40, 15W-50 10W-40, 15W-50
Cummins ISB	10W-30 15W-40	10W-40, 15W-40, 15W-50 10W-40, 15W-50
Cummins ISM	10W-30 15W-40	10W-40, 15W-40, 15W-50 10W-40, 15W-50
Cummins NTC-400	15W-40 20W-50 30 40	10W-30, 20W-50 <sup>(c)</sup> 10W-30, 15W-40 10W, 20W, 10W-30, 15W-40, 20W-50 10W, 20W, 30, 10W-30, 15W-40, 20W-50
Detroit Diesel 6V 92TA	10W-XX <sup>(d)</sup> 10W-30 15W-XX <sup>(d)</sup> 15W-40 20W-XX <sup>(d)</sup> 30 40	15W-XX <sup>(d)</sup> , 20W-XX <sup>(d)</sup> , 30, 40, 50 15W-40, 20W-50, 30, 40, 50 20W-XX <sup>(d)</sup> , 30, 40, 50 20W-50, 30, 40, 50 30, 40, 50 40, 50 50
Navistar Engine Oil Aeration Test (EOAT)	10W 10W-30 15W-40 15W-50 40	10W-30, 15W-40, 15W-50 10W, 15W-40, 15W-50 10W, 10W-30, 15W-50 10W, 10W-30, 15W-40 10W, 30, 10W-30, 15W-40, 15W-50
Roller Follower Wear Test	10W-30 15W-40	10W-40, 15W-40, 15W-50, 20W-40, 20W-50, 30, 40, 50 15W-50, 20W-40, 20W-50, 40, 50

**Notes:**

(1) This table originally became effective January 1, 1992. Engine manufacturers may not recommend all of the viscosity grades shown in the table for a particular engine type.

(2) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

(c) 20W-50 must contain no more bright stock than the 15W-40.

(d) Provided the XX for "Grade Tested" is less than or equal to XX of the multigrade oil for "Read Across to."

**API 1509 engine oil licensing and certification system guidelines:  
viscosity grades read across requirements for formulations containing  
Group I, II, III and IV base stocks**



**Table F-15**

Read-across for viscosity grades not covered explicitly by this table are not allowed unless permitted by table F-1.

Performance test	From SAE	To SAE
Mack T-6 <sup>(e)</sup>	10W-30 15W-40 20W-50 30	15W-40, 20W-50 10W-30, 20W-50 10W-30, 15W-40 10W, 20W, 40, 10W-30, 15W-40, 20W-50
Mack T-7 <sup>(f)</sup>	10W-30 15W-40 20W-50 30	15W-40, 20W-50 10W-30, 20W-50 10W-30, 15W-40 10W, 20W, 40, 10W-30, 15W-40, 20W-50
Mack T-8, Mack T-8A and Mack T-8E <sup>(f)</sup>	15W-40	10W-30, 10W-40, 15W-50
Mack T-9 <sup>(e)</sup>	10W-30 15W-40	10W-40, 15W-40, 15W-50, 20W-40 <sup>(h)</sup> , 20W-50 <sup>(h)</sup> 15W-50, 20W-40 <sup>(h)</sup> , 20W-50 <sup>(h)</sup>
Mack T-10	10W-30 15W-40	10W-40, 15W-40, 15W-50, 20W-40 <sup>(h)</sup> , 20W-50 <sup>(h)</sup> 15W-50, 20W-40 <sup>(h)</sup> , 20W-50 <sup>(h)</sup>
Mack T-10A	15W-40	OW-XX, 5W-XX, 10W-XX
Mack T11 <sup>(g)</sup>	10W-30 10W-40 15W-40 15W-50 20W-40 20W-50	10W-40 10W-30 10W-30, 10W-40, 15W-50 10W-30, 10W-40, 15W-40 10W-30, 10W-40, 15W-40, 15W-50, 20W-50 10W-30, 10W-40, 15W-40, 15W-50, 20W-40
Mack T-11A	15W-40	OW-XX, 5W-XX, 10W-XX
Mack T-12	10W-30 15W-40	10W-40, 15W-40, 15W-50, 20W-40 <sup>(h)</sup> , 20W-50 <sup>(h)</sup> 15W-50, 20W-40 <sup>(h)</sup> , 20W-50 <sup>(h)</sup>
Mack T-12A	15W-40	OW-XX, 5W-XX, 10W-XX
Mack T-13	10W-30 10W-40 15W-40	10W-40, 15W-40 10W-30, 15W-40 10W-30, 10W-40

**Notes:**

(1) This table originally became effective January 1, 1992. Engine manufacturers may not recommend all of the viscosity grades shown in the table for a particular engine type.

(2) Tested formulations containing Group V stocks must contain an equal amount of the same Group V base stock (e.g., ester) in the finished oil blend for application of viscosity grade read-across.

(e) ACF-4 test program with T-9 data to validate engine wear performance must use the T-6 viscosity grade read across guidelines.

(f) A CF-4 test program with T-8A or T-8E data to validate soot handling performance must use the T-7 viscosity grade read across guidelines.

(g) Base oil saturates in the test and final formulations must comply with the guidelines in E.3.1.9, and in cases where a dispersant viscosity modifier (DVM) is used, the DVM level in the final formulation must be equal to or greater than the level in the test oil.

(h) Provided the saturates level in the new candidate oil is equal to or greater than the original candidate oil and the sulfur level is equal to or less than that of the original candidate oil within the precision of the tests.

# API 1509 engine oil licensing and certification system guidelines: API base oil interchangeability guidelines for passenger car motor oils



Interchange for passenger car motor oils - Appendix E.2

## E.2.1 GUIDELINES

- E.2.1.1** Based on existing engine test data submitted to API, the passing engine tests specified in Section E.2 are required for interchanging the base stock in an original API-Licensed PCMO.
- E.2.1.2** In any case where base stocks of more than one group are interchanged simultaneously, the most severe testing requirement applies.
- E.2.1.3** Engine testing is not required when a single interchange base stock that meets the definition of Group I, Group II, Group III, or Group IV is used at less than or equal to 10 mass percent of the blended PCMO formulation. In some cases, higher percentages of Group III or Group IV may be substituted without further engine testing as specified in Appendix E, or in the ACC Code (Appendix I, Guideline 5). The ACC Code should be followed for Group V.
- E.2.1.4** The PCMO blended with the interchange base stock shall meet all physical and chemical specifications and bench test requirements for the appropriate API Service Category and/or ILSAC specification.
- E.2.1.5** Base stocks approved under the provisions of these Guidelines may be commingled without further testing, consistent with provisions of Appendix F.
- E.2.1.6** Acceptable test methods for base stock and base oil blend properties are listed in Table E-1.  
It is understood that when comparing properties, the precision of the methods is taken into consideration.  
In the following tables, BOBV refers to the Base Oil Blend Viscosity measured by ASTM D445.
- E.2.1.7** For engine oils licensed by API against the ILSAC GF-5 standard, the licensee shall ensure that the ROBO or IIIGA data supporting the final formulation was produced in a formulation containing the pour point depressant and base stock(s) used in the licensed formulation.
- E.2.2.1** API recognizes the importance of the Multiple Test Evaluation Procedures. Engine testing to support base oil interchangeability shall be in accordance with Appendix N.  
These Guidelines shall be used in conjunction with the ACC Code.
- E.2.2.2** Complete performance documentation is required for the original Passenger Car Motor Oils (PCMO).  
The detergent inhibitor (DI) and/or viscosity modifier (VM) remain unchanged when interchange base oils are tested, except as provided by the ACC Code.  
A base oil interchange obtained under these guidelines applies to a single PCMO formulation.  
In the event of a change in the DI and/or VM outside the ACC Code, these Guidelines shall be reapplied.

Interchange for passenger car motor oils - Appendix E.2

Property	Test Method
Saturates	ASTM D2007
Viscosity Index	ASTM D2270
Sulfur (use one listed method)	ASTM D1552 ASTM D2622 ASTM D3120 ASTM D4294 ASTM D4927

**Notes:**

The most recent version of each of the listed standards shall be used.

## API 1509 engine oil licensing and certification system guidelines: API base oil interchangeability guidelines for passenger car motor oils



**E.2.2.3** For the passenger car tests listed in Table E-2, these Guidelines may allow some testing relief.  
Check the Guidelines for each specific test before establishing the test program requirements for a specific oil formulation.

Table E-2 - Tests for API S category base oil interchange

Test Name	ASTM	Appendix E Reference	SH	SJ	SL	SM	SN	Energy Conserving	Resource Conserving	ILSAC GF-5
Sequence IID	D5244	E.4.6	X	X						
Sequence IIIE	D5533	E.2.2.4.1	X	X						
Sequence IIIF	D6984	E.2.2.4.1	X	X	X					
Sequence IIIG/IIIGA/IIIGB	D7320	E.2.2.4.1			X	X	X		X	X
Sequence IVA	D6891	E.2.2.4.2	X	X	X	X	X			X
Sequence VE	D5302	E.2.2.4.3	X	X	X					
Sequence VG	D6593	E.2.2.4.3	X	X	X	X	X			X
Sequence VIA	D6202	E.2.2.4.4							X	
Sequence VIB	D6837	E.2.2.4.4							X	
Sequence VID	D7589	E.2.2.4.5							X	X
CRC L-38	D5119	E.2.2.4.6	X	X						
Sequence VIII	D6709	E.2.2.4.6	X	X	X	X	X			X
Ball Rust Test	D6557	E.4.6	X	X	X	X	X			X
EOFST	D6795	E.4.4	X	X	X	X	X			X
Filterability - EOWTT	D6794	E.4.5		X	X	X	X			X
Homogeneity & Miscibility	D6922	E.4.4	X	X	X	X	X			X
TEOST 33/33C	D6335	E.4.2		X						X
TEOST MHT	D7097	E.4.3			X	X	X			X
Aged Oil Low Temp. Vis. ROBO	D7528	E.2.1.7					X			X
Elastomer Compatibility Std. Ref. Elastomers	D7216	E.4.13							X	X

**Notes:**

X = Test methods where BOI is defined. Testing requirements can be found in API 1509 Appendices G and Q and/or ASTM D4485.

**E.2.2.4** Passenger car engine test required for interchanging the base stock given in E.2.2.4.1 through E.2.2.4.5.

The BOI Guidelines vary according to the API base oil group and amount of the base stocks used in the original test oil and the candidate oil formulations. All percentages are mass percent of the total formulation unless otherwise noted. The data set used to establish the BOI Guidelines involving Group III base oils is based on a base oil VI range up to 126 VI, within the precision of the test.

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E.2.2.4.1 Sequence IIIE / IIIF / IIIFHD / IIIG and IIIGA tests required for interchanging the base stock<sup>(2)</sup> - Table E-3

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Required	Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	≤30% Not Required, >30% Required	Required
Group IV	Required	Required	≤30% Not Required, >30% Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

(2) Single Technology Matrix (STM) is an alternate approach to BOI for Sequence IIIF, IIIFHD, IIIG and IIIGA (see appendix R).

Additionally, once five passing IIIGB tests have been demonstrated on a unique technology (A Unique Technology is a single package (DI) at a constant treat rate), then no additional Sequence IIIGB testing is required for that unique technology.

E.2.2.4.2 Sequence IVA tests required for interchanging the base stock - Table E-4

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if BOBV at 100°C ≥ original	Not Required if BOBV at 100°C ≥ original	≤30% Not Required, >30% Not Required if BOBV at 100°C ≥ original	≤30% Not Required, >30% and ≤50% Not Required if BOBV at 100°C ≥ original, >50% Required	Required
Group II	Not Required if BOBV at 100°C ≥ original	Not Required if BOBV at 100°C ≥ original	≤30% Not Required, >30% Not Required if BOBV at 100°C ≥ original	≤30% Not Required, >30% and ≤50% Not Required if BOBV at 100°C ≥ original, >50% Required	Required
Group III	Not Required if BOBV at 100°C ≥ original	Not Required if BOBV at 100°C ≥ original	Not Required if BOBV at 100°C ≥ original	≤30% Not Required if BOBV at 100°C ≥ original, >30% Required	Required
Group IV	Required	Required	≤30% Not Required, >30% Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

BOBV refers to the base oil blend viscosity measured by ASTM D445.

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties

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E.2.2.4.3 Sequence VE / VG tests required for interchanging the base stock - Table E-5

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ original	Not Required	Not Required	≤50% Not Required, >50% Required	Required
Group II	Required	Not Required if saturates ≥ original	Not Required	≤50% Not Required, >50% Required	Required
Group III	Required	Required	Not Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

E.2.2.4.4 Sequence VIA / VIB tests required for interchanging the base stock - Table E-6

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if CCS & HTHS ≤ original	Not Required if CCS & HTHS ≤ original	Required	Required	Required
Group II	Not Required if CCS & HTHS ≤ original	Not Required if CCS & HTHS ≤ original	Required	Required	Required
Group III	Not Required if CCS & HTHS ≤ original	Not Required if CCS & HTHS ≤ original	Not Required if CCS & HTHS & base oil VI ≤ original	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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E.2.2.4.5 Sequence VID tests required for interchanging the base stock - Table E-7

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required if HTHS at 100°C(D6616) ≤ original. If HTHS at 100°C > the original, see Equations E.1.0			Required
Group III	Required			Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Equation E.1.0**

If HTHS at 100°C of the candidate oil is > the HTHS at 100°C of the original passing oil, testing is not required if both equations are true:

$$HCandidate \leq HOriginal + ((FEIsumLimit - FEIsumOriginal) / -0.485) + (HOriginal * R)$$

$$HCandidate \leq HOriginal + ((FEI2Limit - FEI2Original) / -0.227) + (HOriginal * R)$$

Where:

HCandidate is the HTHS at 100°C of the candidate oil as measured by ASTM D6616

HOriginal is the HTHS at 100°C of the original tested oil as measured by ASTM D6616

FEIsumLimit is the FEI sum passing limit for the original tested viscosity grade

FEIsumOriginal is the FEIsum (FEI1Original + FEI2Original) result of the original tested oil

-0.485 is the FEIsum coefficient from the Seq. VID industry matrix model

FEI2Limit is the FEI2 passing limit for the original tested viscosity grade

FEI2Original is the FEI2 result of the original tested oil

-0.227 is the FEI2 coefficient from the Seq. VID industry matrix model

R is the reproducibility as reported in the most recent version of ASTM D6616

R = 0.035 (3.5%) for ASTM D6616-07

The range of HTHS at 100°C used to develop the Seq. VID industry matrix model was 5.44 to 7.68 cP.

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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E.2.2.4.6 Sequence VIII / CRC L-38 tests required for interchanging the base stock(2) - Table E-8

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Not Required	Not Required	Required
Group II	Not Required	Not Required	Not Required	Not Required	Required
Group III	Not Required	Not Required	Not Required	≤30% Not Required, >30% Required	Required
Group IV	Required	Required	≤30% Not Required, >30% Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

(2) These BOI Guidelines apply only to bearing weight loss.

Sequence IX tests required for interchanging the base stock - Table E-xx

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required	Required
Group II	Required	Not Required	Not Required	Not Required	Required
Group III	Required	Not Required	Not Required	Not Required	Required
Group IV	Required	Not Required	Not Required	Not Required	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) The guideline in this table were developed from data generated on oil with Viscosity Grades from SAE 0W-16 to SAE 10W-30. It does not restrict application of the guidelines by the marketer that is responsible for ensuring that each licensed engine oil satisfies all engine and bench test performance requirements.

# API 1509 engine oil licensing and certification system guidelines: API base oil interchangeability guidelines for diesel engine oils



Interchange for diesel engine oils - Appendix E.3

## E.3.1 GUIDELINES

**E.3.1.1** Based on existing engine test data submitted to API, passing engine tests specified in Section E.3 are required for interchanging the base stock in an original API-Licensed Heavy Duty Engine Oil (HDEO).

**E.3.1.2** In any case where base stocks of more than one group are interchanged simultaneously, the most severe testing requirement applies.

**E.3.1.3** Engine testing is not required when a single interchange base stock that meets the definition of Group I, Group II, Group III, or Group IV is used at less than or equal to 10 mass percent of the blended HDEO formulation. In some cases, higher percentages of Group III or Group IV may be substituted without further engine testing as specified in Appendix E or in the ACC Code (Appendix I, Guideline 5). The ACC Code should be followed for Group V.

**E.3.1.4** The HDEO blended with the interchange base oil shall meet all physical and chemical specifications required for the appropriate API Service Category.

**E.3.1.5** Base stocks approved under the provisions of these Guidelines may be commingled without further testing, consistent with Appendix F.

**E.3.1.6** Acceptable test methods for base stock and base oil blend properties are listed in Table E-1. It is understood that when comparing properties, the precision of the methods is taken into consideration. In the following tables, BOBV refers to the Base Oil Blend Viscosity measured by ASTM D445.

**E.3.2.1** API recognizes the importance of the Multiple Test Evaluation Procedures. Engine testing to support base oil interchangeability shall be in accordance with Appendix N. These Guidelines shall be used in conjunction with the ACC Code.

**E.3.2.2** Complete performance documentation is required for the original HDEO's. The detergent inhibitor (DI) and/or viscosity modifier (VM) remain unchanged when interchange base oils are tested, except as provided by the ACC Code. A base oil interchange obtained under these guidelines applies to a single HDEO formulation. In the event of a change in the DI and/or VM outside the ACC Code, these Guidelines shall be reapplied.

**E.3.2.3** When a base stock or slate of base stocks is to be changed in a number of different viscosity grades containing a single HDEO formulation, these Guidelines shall be used in conjunction with appendix F, except when the recommended grade for testing contains less than or equal to 10 mass percent of the interchange base stock in the formulation. In this case, the next higher viscosity grade shall be tested.

**E.3.2.5** Heavy Duty engine tests required for interchanging the base stock given in E.3.2.5.1 through E.3.2.5.16. The BOI Guidelines vary according to the API base oil group and amount of the base stocks used in the original test oil and the candidate oil formulations. All percentages are mass percent of the total formulation unless otherwise noted. The data set used to establish the BOI Guidelines involving Group III base oils is based on a base oil VI range up to 126 VI, within the precision of the test.

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**E.3.2.4** For the HDEO tests listed in Table E-8, the BOI Guidelines may allow some testing relief.

Check the Guidelines for each specific test before establishing the test program requirements for a specific oil formulation.

**Table E-9 - Tests for API C category base oil interchange**

Test Name	ASTM	Appendix E Reference	CF	CF-2	CG-4	CH-4	CI-4	CI-4 w/ CI-4 PLUS	CJ-4
Sequence IIIF / IIIFHD	D6984	E.2.2.4.1			X	X	X	X	X
Sequence IIIG	D7320	E.2.2.4.1			X	X	X	X	X
CRC L-38	D5119	E.2.2.4.5	X	X	X				
Sequence VIII	D6709	E.2.2.4.5	X	X	X				
Caterpillar 1M-PC	D6618	E.3.2.5.1	X	X					
Caterpillar CI3	D7549	E.3.2.5.16							X
Caterpillar 1K	D6750 (1K)	E.3.2.5.3				X	X	X	
Caterpillar 1N	D6750 (1N)	E.3.2.5.4			X		X	X	X
Caterpillar 1P	D6681	E.3.2.5.6				X	X	X	
Caterpillar 1R	D6923	E.3.2.5.5					X	X	
Engine Oil Aeration Test	D6894	E.3.2.5.11			X	X	X	X	X
Cummins ISM	D7468	E.3.2.5.13					X	X	X
Cummins ISB	D7484	E.3.2.5.13							X
Cummins M11	D6838	E.3.2.5.12				X			
Cummins M11 EGR	D6975	E.3.2.5.12					X	X	
Detroit Diesel 6V92TA	D5862	E.3.2.5.2		X					
Mack T-8	D5967	E.3.2.5.8			X				
Mack T-8E	D5967	E.3.2.5.8				X	X	X	
Mack T-9	D6483	E.3.2.5.7				X			
Mack T-10	D6987/M	E.3.2.5.9				X	X	X	
Mack T-10A	75h used oil in D4684	E.4.7					X	X	
Mack T-11	D7156	E.3.2.5.15						X	X
Mack T11A	D6896	E.4.10						X	X
Mack T-12	D7422	E.3.2.5.14					X	X	X
Roller Follower Wear Test	D5966	E.3.2.5.10			X	X	X	X	X
Cummins HTCBT	D6594	E.4.11				X	X	X	
Elastomer Compatibility CI-4	D7216	E.4.8					X	X	
Elastomer Compatibility CJ-4	D7216	E.4.9							X

**Notes:**

X = Test methods where BOI is defined. Testing requirements can be found in API 1509 Appendixes G and Q and/or ASTM D4485.

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E.3.2.5.1 Caterpillar 1M-PC tests required for interchanging the base stock - Table E-10

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Required	Required	Required	Required, ≤30% Not Required for API CF if candidate oil also meets API SJ	Required
Group II	Not Required	Not Required	Required	Required, ≤30% Not Required for API CF if candidate oil also meets API SJ	Required
Group III	Required	Required	Not Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

E.3.2.5.2 Detroit Diesel 6V92TA tests required for interchanging the base stock - Table E-11

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if BOBV at 100°C ≥ original	Not Required if BOBV at 100°C ≥ original	Required	Required	Required
Group II	Not Required if BOBV at 100°C ≥ original	Not Required if BOBV at 100°C ≥ original	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties AND the BOBV @ 100°C is ≥ the BOBV in the originally approved formulation.

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E.3.2.5.3 Caterpillar 1K tests required for interchanging the base stock - Table E-12

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Not Required	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

E.3.2.5.4 Caterpillar IN tests required for interchanging the base stock - Table E-13

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Required	Required	Required
Group II	Not Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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E.3.2.5.5 Caterpillar 1R tests required for interchanging the base stock - Table E-14

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Required	Required	Required
Group II	Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

E.3.2.5.6 Caterpillar 1P tests required for interchanging the base stock - Table E-15

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Required in only one Group II base stock for CH-4, Not Required for CI-4	Required	Required	Required
Group II	Not Required	Not Required	Required	Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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E.3.2.5.7 Mack T-9 tests required for interchanging the base stock - Table E-16

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ original	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Required	Not Required if saturates ≥ original	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

E.3.2.5.8 Mack T-8 / T-8E tests required for interchanging the base stock - Table E-17

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if either of the following is met: 1. Saturates of original is ≥ 80% and interchange base oil saturates is ≥ original 2. Saturates of original is < 80% and interchange base oil saturates is ≥ original at 95% confidence level	Not Required	Not Required	Not Required	Required
Group II	Required	Not Required if saturates ≥ original	Not Required	Not Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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E.3.2.5.9 Mack T-10 tests required for interchanging the base stock - Table E-18

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ AND saturates ≥ AND BOBV at 100°C ≥ original	Not Required if saturates ≥ AND BOBV at 100°C ≥ original	≤30% Not Required if saturates ≥ AND BOBV at 100°C ≥ original, >30% Required	≤30% Not Required if saturates ≥ AND BOBV at 100°C ≥ original, >30% Required	Required
Group II	Required	Not Required if saturates ≥ AND BOBV at 100°C ≥ original	≤30% Not Required if saturates ≥ AND BOBV at 100°C ≥ original, >30% Required	≤30% Not Required if saturates ≥ AND BOBV at 100°C ≥ original, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

E.3.2.5.10 RFWTs tests required for interchanging the base stock - Table E-19

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Required in only one Group I base stock	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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E.3.2.5.11 EOATs tests required for interchanging the base stock - Table E-20

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Not Required	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties

E.3.2.5.12 Cummins M11 / M11 EGR tests required for interchanging the base stock - Table E-21

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ original	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Required	Not Required if saturates ≥ original	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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### E.3.2.5.13 Cummins ISM and ISB tests required for interchanging the base stock - Table E-22

If only one passing Cummins ISM or ISB test is available on a given technology, Table E-22 applies.

If more than one passing Cummins ISM or ISB test is available on a given technology, BOI is allowed if the candidate's base oil blend saturates level, sulfur content and BOBV at 100°C fall within the range of saturates, sulfur and BOBV at 100°C of the base oil blends in the original passing oils with a minimum of two tested/two passed and the Group III content of the candidate falls within the range of the Group III content covered by the original passing oils.

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ original	Not Required	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group II	Required	Not Required if saturates ≥ original	≤30% Not Required, >30% Required	≤30% Not Required, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

### E.3.2.14 Mack T-12 tests required for interchanging the base stock - Table E-23

If only one passing Mack T-12 test is available on a given technology, Table E-23 applies.

If more than one passing Mack T-12 test is available on a given technology, BOI is allowed if the candidate's base oil blend saturates level, sulfur content and BOBV at 100°C fall within the range of saturates, sulfur and BOBV at 100°C of the base oil blends in the original passing oils with a minimum of two tested/two passed and the Group III content of the candidate falls within the range of the Group III content covered by the original passing oils.

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≤ and saturates ≥ and BOBV at 100°C ≥ original	Not Required if saturates ≥ and BOBV at 100°C ≥ original	≤30% Not Required if saturates ≥ and BOBV at 100°C ≥ original, >30% Required	≤30% Not Required if saturates ≥ and BOBV at 100°C ≥ original, >30% Required	Required
Group II	Required	Not Required if saturates ≥ and BOBV at 100°C ≥ original	≤30% Not Required if saturates ≥ and BOBV at 100°C ≥ original, >30% Required	≤30% Not Required if saturates ≥ and BOBV at 100°C ≥ original, >30% Required	Required
Group III	Required	Required	Required	Required	Required
Group IV	Required	Required	Required	Not Required <sup>(1)</sup>	Required
Group V	Required	Required	Required	Required	Required

**Notes:**

(1) Not required provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.

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### E.3.2.5.15 Mack T-11 tests required for interchanging the base stock - Table E-24

Base Oil Interchange for all Mack T-11 engine tests associated with API CJ-4 and for Mack T-11 engine tests associated with API CI-4 and CI-4 PLUS started after April 28, 2006, may be determined using the method provided in Table E-24. Table E-24 defines the minimum saturates content of the candidate oil that can be interchanged from the original test oil.

**Table E-24 Mack T-11 BOI Saturates Requirements (within a range)**

Tested Oil	Candidate Oil
X ≤ 70.0	80.0 minimum
70.0 < X < 95.0	(0.6*X + 38) minimum
X ≥ 95.0	95.0 minimum

### E.3.2.5.16 Caterpillar C13 tests required for interchanging the base stock

If only one passing Caterpillar C13 test is available on a given technology and only Group II and/or Group III base stocks are present in the passing C13 oil and the candidate, then C13 BOI is allowed if the candidate's base oil blend viscosity index (VI) is equal to or less than the VI of the base oil blend of the passing C13 oil. If Group I base stock is present in either the passing C13 oil or the candidate, then C13 BOI is allowed if the base oil blend of the candidate has the same saturates level, the same or less sulfur and the same or lower VI than the base oil blend of the passing C13 oil. Additional guidelines apply when Group III base stock is present in the C13 passing oil:

- The candidate oil must have Group III content equal to or less than the passing oil.
- The typical VI of the Group III in the candidate must be no more than 6 units higher than the typical VI of the Group III in the passing C13 oil with no allowance for test precision.

Group IV base stocks can be interchanged provided the interchange Group IV meets the original manufacturer's specifications in all physical and chemical properties.  
When Group V base stocks are present , the C13 test must be run.

If more than one passing Caterpillar C13 test is available on a given technology, BOI is allowed if the candidate's base oil blend saturates level, sulfur content and viscosity index fall within the range of saturates level, sulfur, and VI of the base oil blends in the original passing oils (minimum two tested/two passed oils) and the Group III content of the candidate oil falls within the range of the Group III content covered by the original passing oils. Additionally, the typical VI of the Group III in the candidate oil must be no more than 6 units higher than the typical VI of the Group III in the passing C13 oil with no allowance for test precision.

## API 1509 engine oil licensing and certification system guidelines: API base oil interchangeability guidelines for diesel engine oils



Complete bench testing is required for interchanging a base stock in an API-licensed oil except where noted in the guidelines below.

E.4.2 TEOST 33 tests required for interchanging the base stock - Table E-26

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required	Not Required	Required	Required	Required
Group II	Not Required	Not Required	Not Required	Required	Required
Group III	Required	Not Required	Not Required	Required	Required
Group IV	Required	Required	Required	Required	Required
Group V	Required	Required	Required	Required	Required

E.4.3 TEOST MHT tests required for interchanging the base stock - Table E-27

Base stock in original test oil	Interchange base stock				
	Group I	Group II	Group III	Group IV	Group V
Group I	Not Required if sulfur ≥ and saturates ≤ original	Required	Required	Required	Required
Group II	Not Required	Not Required	Not Required	Required	Required
Group III	Required	Not Required	Required	Required	Required
Group IV	Required	Required	Required	Required	Required
Group V	Required	Required	Required	Required	Required

## API 1509 engine oil licensing and certification system guidelines: API base oil interchangeability guidelines for diesel engine oils



**E.4.4** Homogeneity and Miscibility (H&M) ASTM D6922 and Engine Oil Filterability (EOFT) ASTM D6795 [formerly known as GM 9099P Filterability (Standard Method)] tests are required in one viscosity grade represented in the core data set. Each base oil interchange requires only one H&M and one EOFT test. (See ACC Code for definition of core data set.) Core data sets are typically developed in SAE 5W-30, 10W-30, 10W-40 or 15W-40 viscosity grades.

**E.4.5** The Engine Oil Water Tolerance Test (EOWTT) ASTM D6794 [formerly GM 9099P Filterability (Modified Method for ILSAC GF-2/GF-3)] for each base oil interchange is required only in the viscosity grade with the highest additive (DI/VI) combination.

**E.4.6** If there is one passing Ball Rust Test (BRT) ASTM D 6557 in the core data set as defined by the ACC Code, read-across is allowed to all other viscosity grades and base oil slates.

**E.4.7** A Mack T-10A test is not required for base oil interchange if the saturates and sulfur content (within the precision of the two analytical tests) of the interchange base oil fall within the range of the saturates and sulfur content of the base oils in the original candidate oils (minimum two candidate oils), and fresh oil MRV-TP1 (ASTM D 4684) at -20°C of the interchange candidate is equal to or less than the BOI matrix limit.

The BOI matrix limit is defined as :

$$\text{BOI matrix limit} = 25000 - \text{margin of safety}$$

Margin of safety is defined as :

$$\text{Margin of safety} = \text{largest of } Y_1-X_1, Y_2-X_2, \text{ or } 0$$

where

X1 = fresh oil MRV-TP1 at -20°C for original candidate oil 1

X2 = fresh oil MRV-TP1 at -20°C for original candidate oil 2

Y1 = MRV-TP1 at -20°C of 75-hour T-10A sample for original candidate oil 1

Y2 = MRV-TP1 at -20°C of 75-hour T-10A sample for original candidate oil 2

**E.4.8** The CI-4 Elastomer Compatibility Test is not required if the saturates and sulfur content (within the precision of the tests) of the interchange base oil fall within the range of the saturates and sulfur content of the base oils in the original candidate oils (minimum two candidate oils) and the DI package is unchanged.

**E.4.9** The CJ-4 Elastomer Compatibility Test is not required if the saturates and sulfur content (within the precision of the tests) of the interchange base oil fall within the range of the saturates and sulfur content of the base oils in the original candidate oils (minimum two candidate oils) and the DI package is unchanged.

**E.4.10** In addition to the Mack T-11 BOI guidelines being met, for Base Oil Interchange in the Mack T-11A the fresh oil MRV-TP1 (ASTM D 4684) at -20°C of the interchange candidate must be less than or equal to 20000 cPs with no yield stress.

**E.4.11** If there is one passing High-Temperature Corrosion Bench Test (HTCBT) (ASTM D 6594) in the core data set as defined by the ACC Code, read-across is allowed to all other viscosity grades and base oil slates.

**E.4.12** For oils formulated with Group II and/or Group III base stocks, the Emulsion Retention ASTM D7563 is required only for the highest additive (DI/VI) concentration. Read across is allowed to all other Group II, Group III and combinations of Group II and Group III base oil/viscosity grade formulations using the same or lower concentration of the identical additive (DI/VI) combination. If the PPD type is changed for the DI/VI combination, testing is required.

**E.4.13** A passing GF-5 Elastomer Compatibility Test (ASTM D7216 Annex A2) in the core data set (as defined in the ACC Code) run in Group II or Group III or a mix of Group II and Group III, can be read across to formulations using other Group II or Group III or a mix of Group II and Group III base stocks.

Additionally, there is no viscosity grade restriction if the read across is limited to 0W-20, 0W-30, 5W-20, 5W-30, 10W-30 and 10W-40 viscosity grades.

When reading to a candidate using Group I base stocks, the GF-5 Elastomer Compatibility Test (ASTM D7216 Annex A2) is not required if the base oil saturates and base oil sulfur content (within the precision of the tests) of the interchange base oil fall within the range of the base oil saturates and base oil sulfur content of the base oils in the original candidate oils (minimum two candidate oils) and the DI package is unchanged.

**ATIEL**  
**guidelines for:**

- Viscosity grade  
read-across (VGRA)
- Base oil  
interchange (BOI)
- Viscosity modifier  
interchange (VMI)



## ATIEL viscosity grade read across guidelines

- 1 -



TU3M test		Can be read across (RA) to:															
Test run on:		↓	0W-20	0W-30	0W-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50
OW-20	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
OW-30		-	RA		RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
OW-40			-			RA	RA		RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-20		RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-30			RA		-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-40					-	RA			RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-50						-				RA	RA	RA		RA	RA	RA	RA
10W-30			RA			RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA
10W-40							RA		-	RA							
10W-50										-	RA		RA		RA		RA
10W-60											-						
15W-40							RA			RA	RA	-	RA	RA	RA	RA	RA
15W-50											RA		-			RA	
20W-40							RA			RA	RA		RA		-	RA	
20W-50										RA			RA				-

Stipulated requirement: the KV at 100°C of the finished oil of the read across grade must be greater than or equal to that of the tested grade.

TUSJP test		Can be read across (RA) to:															
Test run on:		↓	0W-20	0W-30	0W-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50
OW-20	-				RA	RA			RA	RA			RA	RA	RA	RA	RA
OW-30	RA	-		RA	RA	RA			RA	RA	RA		RA	RA	RA	RA	RA
OW-40	RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA						
5W-20			-						RA				RA		RA		RA
5W-30	RA			RA	-				RA	RA			RA	RA	RA	RA	RA
5W-40	RA	RA		RA	RA	-			RA	RA	RA		RA	RA	RA	RA	RA
5W-50	RA	RA	RA	RA	RA	RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA
10W-30					RA				-				RA		RA		RA
10W-40	RA				RA	RA				RA	-		RA	RA	RA	RA	RA
10W-50	RA	RA			RA	RA	RA			RA	RA	-	RA	RA	RA	RA	RA
10W-60	RA	RA	RA		RA	RA	RA	RA	RA	RA	RA	RA	-	RA	RA	RA	RA
15W-40						RA				RA			-		RA		RA
15W-50	RA				RA	RA				RA	RA			RA	-	RA	RA
20W-40									RA						-		
20W-50					RA				RA				RA		RA		-

Stipulated requirement: if the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

## ATIEL viscosity grade read across guidelines

- 2 -



**M111 Sludge or DV4TD test (non dispersant viscosity modifier)**

Test run on:		Can be read across (RA) to:														
↓	OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50	
OW-20	-			RA	RA			RA	RA			RA	RA	RA	RA	RA
OW-30	RA	-		RA	RA	RA		RA	RA	RA		RA	RA	RA	RA	RA
OW-40	RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-20				-				RA							RA	RA
5W-30	RA			RA	-			RA	RA			RA	RA	RA	RA	RA
5W-40	RA	RA		RA	RA	-		RA	RA	RA		RA	RA	RA	RA	RA
5W-50	RA	RA	RA	RA	RA	RA	-	RA	RA							
10W-30				RA				-							RA	RA
10W-40				RA	RA			RA	-			RA	RA	RA	RA	RA
10W-50	RA			RA	RA	RA		RA	RA	-		RA	RA	RA	RA	RA
10W-60	RA	RA		RA	RA	RA	RA	RA	RA	RA	-	RA	RA	RA	RA	RA
15W-40				RA				RA						-	RA	RA
15W-50				RA				RA	RA			RA	-	RA	RA	-
20W-40															-	
20W-50												RA	RA	RA	-	-

**Stipulated requirement:** if the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

## ATIEL viscosity grade read across guidelines

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**M111 Sludge or DV4TD test (dispersant viscosity modifier)**

Test run on:		Can be read across (RA) to:														
↓	OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50	
OW-20	-	RA			RA	RA			RA	RA			RA			
OW-30	-	RA			RA	RA			RA	RA						
OW-40		-				RA					RA					
5W-20	RA			-	RA			RA	RA			RA	RA			RA
5W-30	RA	RA			-	RA			RA	RA			RA			
5W-40		RA	RA			-	RA			RA	RA					
5W-50			RA				-				RA					
10W-30	RA			RA	RA			-	RA			RA	RA			RA
10W-40	RA	RA			RA	RA			-	RA	RA		RA			
10W-50		RA	RA			RA	RA			-	RA					
10W-60			RA				RA				-					
15W-40	RA			RA	RA			RA	RA			-	RA			RA
15W-50	RA	RA			RA	RA			RA	RA			-			RA
20W-40							RA					RA		-		RA
20W-50	RA				RA			RA	RA			RA	RA			-

**Stipulated requirement:** if the viscosity modifier concentration increase is larger than 20% mass fraction relative or decrease by more than -10% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

## ATIEL viscosity grade read across guidelines

- 4 -



DV6C or M271 Evo test (non dispersant viscosity modifier)

Test run on:		Can be read across (RA) to:														
↓	OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50	
OW-20	-			RA	RA			RA	RA			RA	RA	RA	RA	RA
OW-30	RA	-		RA	RA	RA		RA	RA	RA		RA	RA	RA	RA	RA
OW-40	RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-20				-				RA							RA	RA
5W-30	RA			RA	-			RA	RA			RA	RA	RA	RA	RA
5W-40	RA	RA		RA	RA	-		RA	RA	RA		RA	RA	RA	RA	RA
5W-50	RA	RA	RA	RA	RA	RA	-	RA	RA							
10W-30				RA				-						RA		RA
10W-40				RA	RA			RA	-			RA	RA	RA	RA	RA
10W-50	RA			RA	RA	RA		RA	RA	-		RA	RA	RA	RA	RA
10W-60	RA	RA		RA	RA	RA	RA	RA	RA	RA	-	RA	RA	RA	RA	RA
15W-40				RA				RA					-		RA	RA
15W-50				RA				RA	RA			RA	-	RA	RA	RA
20W-40														-		
20W-50												RA	RA	RA	-	

**Stipulated requirement:** if the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

## ATIEL viscosity grade read across guidelines

- 5 -



DV6C or M271 Evo test (dispersant viscosity modifier)

Test run on:		Can be read across (RA) to:														
↓	OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50	
OW-20	-	RA			RA	RA			RA	RA			RA			
OW-30	-	RA			RA	RA			RA	RA						
OW-40		-				RA					RA					
5W-20	RA			-	RA			RA	RA			RA	RA			RA
5W-30	RA	RA			-	RA			RA	RA			RA			
5W-40		RA	RA			-	RA			RA	RA					
5W-50			RA				-				RA					
10W-30	RA			RA	RA			-	RA			RA	RA			RA
10W-40	RA	RA			RA	RA			-	RA	RA		RA			
10W-50		RA	RA			RA	RA			-	RA					
10W-60			RA				RA				-					
15W-40	RA			RA	RA			RA	RA			-	RA			RA
15W-50	RA	RA			RA	RA			RA	RA			-			
20W-40								RA				RA			-	RA
20W-50	RA				RA			RA	RA			RA	RA			

**Stipulated requirement:** if the viscosity modifier concentration increase is larger than 20% mass fraction relative or decrease by more than -10% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

## ATIEL viscosity grade read across guidelines

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OM646LA wear test		Can be read across (RA) to:																
Test run on:		OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50	30	40
OW-20	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	
OW-30		-	RA		RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	
OW-40			-			RA	RA		RA	RA								
5W-20		RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	
5W-30			RA		-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	
5W-40					-	RA		RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	
5W-50						-			RA	RA			RA		RA		RA	
10W-30		RA			RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	
10W-40						RA		-	RA	RA								
10W-50									-	RA			RA		RA		RA	
10W-60										-					RA		RA	
15W-40						RA			RA	RA	-	RA	RA	RA	RA	RA	RA	
15W-50										RA		-		RA		RA	RA	
20W-40						RA			RA	RA		RA	-	RA	RA	RA	RA	
20W-50											RA			-			RA	
30																-	RA	
40																	-	

**Stipulated requirement:** VGRA is permitted for multigrade lubricants if the KV at 100°C in the read across viscosity grade is greater than or equal to that of the tested viscosity grade.

## ATIEL viscosity grade read across guidelines

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M111 fuel economy test		Can be read across (RA) to:														
Test run on:	↓	OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50
OW-20	-															
OW-30	RA	-														
OW-40	RA	RA	-	RA												
5W-20	RA			-												
5W-30	RA	RA		RA	-											
5W-40	RA	RA	RA	RA	RA	-										
5W-50	RA	RA	RA	RA	RA	RA	-	RA								
10W-30	RA	RA		RA	RA			-								
10W-40	RA	RA	RA	RA	RA	RA		RA	-							
10W-50	RA	RA	RA	RA	RA	RA	RA	RA	RA	-						
10W-60	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	-	RA		RA		
15W-40	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA		-				
15W-50	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA		RA		-		
20W-40	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA		RA		-		
20W-50	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA		RA	RA	RA	-	

**Stipulated requirement:**

The KV at 40°C of the finished oil of the read across grade must be lower than or equal to that of the tested grade.

The KV at 100°C of the finished oil of the read across grade must be lower than or equal to that of the tested grade.

The HTHS at 150°C viscosity of the finished oil of the read across grade must be lower than or equal to that of the tested grade.

## ATIEL viscosity grade read across guidelines

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VW TDI or OM646LA Bio or EP6CDT test (non-dispersant viscosity modifier)

Test run on:		Can be read across (RA) to:														
↓	OW-20	OW-30	OW-40	5W-20	5W-30	5W-40	5W-50	10W-30	10W-40	10W-50	10W-60	15W-40	15W-50	20W-40	20W-50	
OW-20	-			RA	RA			RA	RA			RA	RA	RA	RA	RA
OW-30	RA	-		RA	RA	RA		RA	RA	RA		RA	RA	RA	RA	RA
OW-40	RA	RA	-	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA
5W-20				-				RA				RA		RA		RA
5W-30	RA			RA	-			RA	RA			RA	RA	RA	RA	RA
5W-40	RA	RA		RA	RA	-		RA	RA	RA		RA	RA	RA	RA	RA
5W-50	RA	RA	RA	RA	RA	RA	-	RA	RA							
10W-30				RA				-				RA		RA		RA
10W-40	RA			RA	RA			RA	-			RA	RA	RA	RA	RA
10W-50	RA			RA	RA	RA		RA	RA	-		RA	RA	RA	RA	RA
10W-60	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	-	RA	RA	RA	RA	RA
15W-40				RA				RA				-		RA	RA	RA
15W-50				RA	RA			RA	RA			RA	-	RA	RA	RA
20W-40														-		
20W-50				RA				RA				RA		RA		-

**Stipulated requirement:** if the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

OM441LA & OM501LA Test (Non-dispersant viscosity modifier)

Test run on:		Can be read across (RA) to:													
↓	OW-30	5W-30	5W-40	5W-50	10W-30	10W-40	15W-40	15W-50	20W-40	20W-50	30	40			
OW-30	-														
5W-30		-				RA	RA	RA							
5W-40			-				RA	RA	RA						
5W-50				-					RA						
10W-30					-			RA							
10W-40						-	RA	RA							
15W-40							-								
15W-50								-							
20W-40									-						
20W-50										-					
30											-				
40												-			

**Stipulated requirement:** if the viscosity modifier concentration increase is larger than 15% mass fraction relative, VGRA can be permitted if technical support as defined in Section h.15 of the ATC Code of Practice is available to justify the read across.

## ATIEL viscosity grade read across guidelines

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Test run on:		Can be read across (RA) to:											
↓	0W-30	5W-30	5W-40	5W-50	10W-30	10W-40	15W-40	15W-50	20W-40	20W-50	30	40	
0W-30	-												
5W-30	RA	-	RA	RA									
5W-40	RA		-	RA									
5W-50	RA			-									
10W-30	RA	RA	RA	RA	-	RA							
10W-40	RA	RA	RA	RA		-							
15W-40	RA	RA	RA	RA	RA	RA	-	RA					
15W-50	RA	RA	RA	RA	RA	RA		-					
20W-40	RA	RA	RA	RA	RA	RA	RA	RA	-	RA			
20W-50	RA	RA	RA	RA	RA	RA	RA	RA		-			
30	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	-	RA	
40	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	RA	-	

**Notes:**

These read across table includes more viscosity grade read across than API 1509 to reflect the European market. However these read across guidelines have been produced only for test data to be used to support ACEA Oil Sequences claims. They cannot be used to support API claims where the relevant read across guidelines from API 1509 shall be followed.

## ATIEL base oil interchange guidelines for the M271Evo & M111SL



From original base stock	To interchange base stock (all % in mass of the formulated lubricant)							
	GROUP I		GROUP II		GROUP III		GROUP IV	
GROUP I	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required
	>10%	required	>10%	required <sup>(2)</sup>	>30%	required	>30%	required
GROUP II	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required
	>10%	required	>10%	required	>30%	required	>30%	required
GROUP III	≤10%	not required	≤10%	not required	≤10%	not required	≤10%	not required
	>10%	required	>10%	required	>10%	required	>10%	required
GROUP IV	≤10%	not required	≤10%	not required	≤10%	not required	conditions on PAO characteristics <sup>(1)</sup>	
	>10%	required	>10%	required	>10%	required		
GROUP V	required		required		required		required	

**Notes:**

(1) Group IV base stocks can be interchanged without additional qualification testing, providing that the interchange PAO meets the original PAO manufacturer's specifications for physical and chemical properties.  
The following key properties need to be met in the substituted stock:

- Kinematic viscosity at 100°C, 40°C and -40°C
- Viscosity Index
- Noack Volatility
- Pour Point
- Unsaturates

(2) Not required for M111SL

## ATIEL base oil interchange guidelines for the DV6C, DV4TD, TU3M



From original base stock	To interchange base stock (all % in mass of the formulated lubricant)							
	GROUP I		GROUP II		GROUP III		GROUP IV	
GROUP I	not required		≤10%	not required	≤30%	not required	≤30%	not required
			>10%	required	>30%	required	>30%	required
GROUP II	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required
	>10%	required	>10%	required	>30%	required	>30%	required
GROUP III	≤10%	not required	≤10%	not required	≤10%	not required	≤30%	not required
	>10%	required	>10%	required	>10%	required	>30%	required
GROUP IV	≤10%	not required	≤10%	not required	≤30%	not required	conditions on PAO characteristics <sup>(1)</sup>	
	>10%	required	>10%	required	>30%	required		
GROUP V	required		required		required		required	

**Notes:**  
<sup>(1)</sup> Group IV base stocks can be interchanged without additional qualification testing, providing that the interchange PAO meets the original PAO manufacturer's specifications for physical and chemical properties.

The following key properties need to be met in the substituted stock:

- Kinematic viscosity at 100°C, 40°C and -40°C
- Viscosity index
- Noack volatility
- Pour point
- Unsaturates

## ATIEL base oil interchange guidelines for the M111 FE test



From original base stock	To Interchange Base Stock (all % in mass of the formulated lubricant)								
	GROUP I		GROUP II		GROUP III		GROUP IV		GROUP V
GROUP I	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required	required
	>10%	HTHS, KV40 conditions <sup>(1)</sup>	10%-30%	HTHS, KV40 conditions <sup>(1)</sup>	>30%	required	>30%	required	
GROUP II	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required	required
	10%-30%	HTHS, KV40 conditions <sup>(1)</sup>	>10%	HTHS, KV40 conditions <sup>(1)</sup>	>30%	required	>30%	required	
	>30%	required							
GROUP III	≤10%	not required	≤10%	not required	≤10%	not required	≤30%	not required	required
	10%-30%	HTHS, KV40 conditions <sup>(1)</sup>	10%-30%	HTHS, KV40 conditions <sup>(1)</sup>	>10%	HTHS, KV40 conditions <sup>(1)</sup>	>30%	required	
	>30%	required	>30%	required					
GROUP IV	≤10%	not required	≤10%	not required	≤30%	not required	conditions on PAO characteristics <sup>(2)</sup>		required
	10%-30%	HTHS, KV40 conditions <sup>(1)</sup>	10%-30%	HTHS, KV40 conditions <sup>(1)</sup>	>30%	required			
	>30%	required	>30%	required					
GROUP V	required		required		required		required		required

**Notes:**

(1) No M111FE testing is required if the HTHS at 150°C and KV40 values of the interchange formulation are lower than or equal to that of the original formulation.

(2) Group IV base stocks can be interchanged without additional qualification testing, providing that the interchange PAO meets the original PAO manufacturer's specifications for physical and chemical properties.

The following key properties need to be met in the substituted stock:

- Kinematic viscosity at 100°C, 40°C and -40°C

- Viscosity index

- Noack volatility

- Pour point

- Unsaturates

## ATIEL base oil interchange guidelines for the OM646LA test



From original base stock	To Interchange Base Stock (all % in mass of the formulated lubricant)								
	GROUP I		GROUP II		GROUP III		GROUP IV		GROUP V
GROUP I	not required		≤10%	not required	not required		not required		required
			>10%	required					
GROUP II	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required	required
	>10%	required	>10%	required	>30%	required	>30%	required	
GROUP III	≤10%	not required	≤10%	not required	≤10%	not required	≤30%	not required	required
	>10%	required	>10%	required	>10%	required	>30%	required	
GROUP IV	≤10%	not required	≤10%	not required	≤30%	not required	conditions on PAO characteristics <sup>(1)</sup>		required
	>10%	required	>10%	required	>30%	required			
GROUP V	required		required		required		required		required

**Notes:**  
<sup>(1)</sup> Group IV base stocks can be interchanged without additional qualification testing, providing that the interchange PAO meets the original PAO manufacturer's specifications for physical and chemical properties.

The following key properties need to be met in the substituted stock:

- Kinematic viscosity at 100°C, 40°C and -40°C
- Viscosity index
- Noack volatility
- Pour point
- Unsaturates

**ATIEL base oil interchange guidelines for the  
VW TDI, OM646LA Bio, EP6CDT, TU5JP & OM501LA**



From Original base stock	To Interchange Base Stock (all % in mass of the formulated lubricant)								
	GROUP I		GROUP II		GROUP III		GROUP IV		GROUP V
GROUP I	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required	required
	>10%	required	>10%	required	>30%	required	>30%	required	
GROUP II	≤10%	not required	≤10%	not required	≤30%	not required	≤30%	not required	required
	>10%	required	>10%	required	>30%	required	>30%	required	
GROUP III	≤10%	not required	≤10%	not required	≤10%	not required	≤30%	not required	required
	>10%	required	>10%	required	>10%	required	>30%	required	
GROUP IV	≤10%	not required	≤10%	not required	≤30%	not required	conditions on PAO characteristics <sup>(1)</sup>		required
	>10%	required	>10%	required	>30%	required			
GROUP V	required		required		required		required		required

**Notes:**  
(1) Group IV base stocks can be interchanged without additional qualification testing, providing that the interchange PAO meets the original PAO manufacturer's specifications for physical and chemical properties.

The following key properties need to be met in the substituted stock:

- Kinematic viscosity at 100°C, 40°C and -40°C
- Viscosity index
- Noack volatility
- Pour point
- Unsaturates

## ATC viscosity modifier interchange guidelines

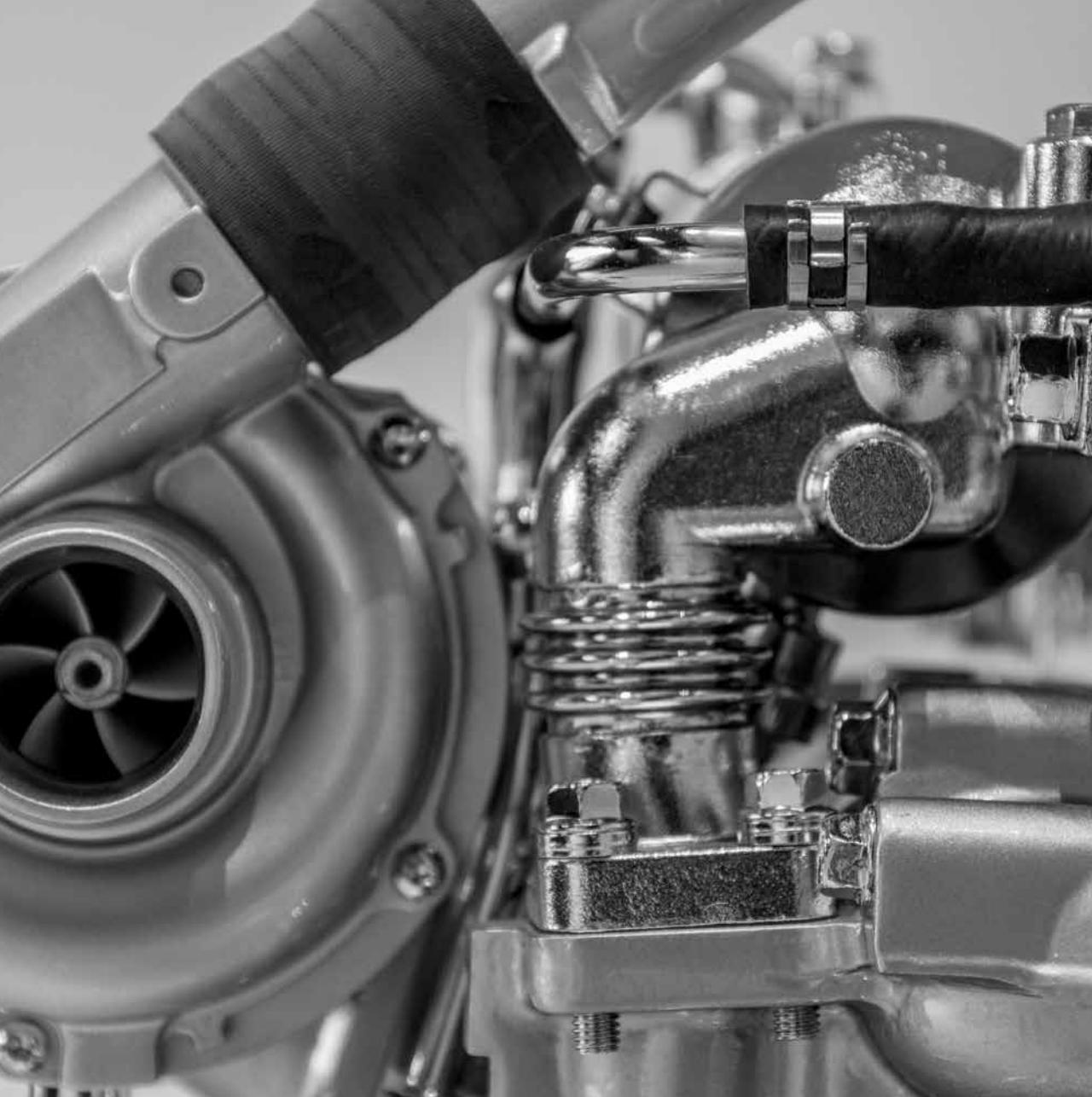


Performance Category	NDVM to NDVM (1,2,3,4,5,6)	DVM to DVM or NDVM to DVM (1,2,3,4,5,6,7)
Gasoline/Light Duty Diesel	TU572, EP6CDT M11ISL (8), M27IEVO (9) VW TDI M11I FE OM646LA Bio	TU572, EP6CDT M11ISL (8), M27IEVO (9) OM646LA, OM646LA Bio DV4E3 (10), DV6C (10) VW TDI M11I FE
Gasoline/Light Duty Diesel with After Treatment Devices	TU572, EP6CDT M11ISL (8), M27IEVO (9) VW DI M11I FE OM646LA Bio	TU572, EP6CDT M11ISL (8), M27IEVO (9) OM646LA, OM646LA Bio DV4E3 (10), DV6C (10) VW TDI M11I FE
Heavy Duty Diesel	Mack T8E or Mack T-11 (11, 12, 13) OM 441 LA, OM501LA Cummins ISM (14) OM646LA Bio	OM646LA, OM646LA bio Mack T-8E or Mack T-11 (12, 13) OM 441 LA or OM501LA Cummins ISM (14)

**Notes:**

- (1) Refer to Section d.2 for CEC test methods to be used.
- (2) Full testing is required for VMI not listed above.
- (3) Physical mixes of NDVM and DVM are treated DVM.
- (4) Only the tests included in the ACEA Oil Sequence/SAE grade for which read across is required have to be run.
- (5) Where alternative tests are listed, e.g., "T-8E or T-11", the alternative test cannot be run to document read-across if a failing result has already been obtained on the other test.
- (6) Cummins ISM (or M11HST or M11 EGR for ACEA E7-12) not required if the new lubricant formulation has the same or a greater HTHS value compared with the original tested formulation.
- (7) Service oil must be tested to CEC Code of Practice.
- (8) Or the M271 sludge test procedure as described by Daimler AG. This engine test is not documented in the ATC Code as it is not a CEC test method.
- (9) Until the next CEC test method L-107 is fully CEC-approved, the M271 sludge test procedure as described by Daimler AG must be run. Once the L-107 is fully approved, the L-107 may be used.
- (10) Only CEC approved parameters apply.
- (11) Mack T-8E requirement is waived if the replacement NDVM is within the same chemical type as the tested NDVM (chemical type means chemical family such as, but not limited to, styrene ester, polymethacrylate, styrene butadiene, styrene isoprene, polyisoprene, olefin copolymer and polyisobutylene).
- (12) For ACEA E9-12, Mack T-11 is required instead of the Mack T-8E.
- (13) Mack T-11 results obtained as part of an API CK-4, CI-4, CI-4+ or API CJ-4 or API FA-4 approval program can be used in place of Mack T-8E.
- (14) For ACEA E7-12, the Cummins M11HST or Cummins M11EGR test may be used in place of the Cummins ISM test.

# Tests and engines



## Engine test conditions

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Tests	Engine characteristics						Test conditions								Performance ratings								
	Procedure reference	Inject. type	Engine type	Aspiration	Engine displ., l	Max. output, kW/rpm	Fuel type: RON/Pb, g/l	Fuel type: % S, FAME %	Oil fill volume, l	Total test duration, h	Duration of each phase, h	Engine speed, rpm	Load, kW	Oil temp., °C	Deposit/ Piston cleanliness	Sludge	Varnish	Vis. incr. /Oxid.	Rust/ corros.	Ring	Wear	Other	
ACEA tests																							
Mercedes M111FE	CEC L-054-96	MP	L4 (16v)		2.0	100/ 5500	95/ 0		4	3 times appr. 2 h <sup>(2)</sup>	13 Step cycle	750- 3070	0-49	20-75								Fuel economy	
Mercedes M111SL	CEC L-53-T-95	MP	L4 (16v)		2.0	100/ 5500	95/ 0		4.35	286 <sup>(1)</sup>	48-76-100 <sup>(1)</sup>	750- 6000	0-100	15-130	X	X					RS	Cam	
Mercedes M271 SL	CEC L-107-16	DI	L4 (16v)		1.8	150/ 5500	95/ 0		6.50	tbd	tbd	1000- 5500	0-150	30-125		X					RS		
Mercedes OM 364LA	CEC L-42-X3-97	DI	L4	TCIC	4.0	103/ 2400		0.3	5.8	300	50	1000- 2400	30-98	114-126	X	X			X		Liner, BP	OC	
Mercedes OM 441LA	CEC L-52-T-97	DI	V6	TCIC	11.0	243/ 2100		0.05	18	400	50	1140- 2100	0/- 240	120	X	X					X	General	BP/OC
Mercedes OM 501LA	CEC L-101-08	DI	V6	TCIC	11.9	360/ 1800	<0.0003, 4-5	19.1 kg	300	50	1080- 1800	18-360	106- 126.5	X	X						BP	OC	
Mercedes OM 602A	CEC L-51-A-98	IDI	L5	TC	2.5	90/ 4600		0.3	7.6	200	1	1000- 5000	0-90	50-142	X	X		X			Cam, liner, BP	OC	
Mercedes OM 6II DE 22 LA	MB DL, 300h	DI	L4 (16v)	TC	2.2	105/ 4200		0.005		300					X	X		X	X	X	BP	OC	
Mercedes OM646 BIO	CEC L-104-16	DI	L4 (16v)	TCIC	2.2	110/ 4200	B15	0.15	6.50	120	120	1000- 4200	0-90	47-133	X	X		X			RS		
Mercedes OM 646LA		DI	L4 (16v)	TCIC	2.2	110/ 4200	<0.0003, 4-5	5 kg	300	50	750- 4200	0-110	45-135								Cam		
PSA DV4 TD	CEC L-93-04	DI	L4	TC	1.4	51/ 4000		0.03	4.7	120	0.5	1100 4000	0-40	120	X			X				Oil soot	
PSA DV6 CTED	CEC L-106-16	DI	L4	TC	1.6	82/ 3600		0.00, 4.5	3.7	120	0.77; 0.14; 0.08	3600; 1750; 1000	0-82	120	X			X				Oil soot	
PSA EP6 CDT	CEC L-111-16	DI	L4 (16v)	TCIC	1.6	115/ 5800	E10, 100/0	0/0	4.7	174	29	750- 6500	0-115	50-125	X							turbo	
PSA TU-3MS	CEC L-038-94	SP	L4 (16v)		1.4	53/ 5500	95/ 0		3	100	40-60	1500 3000	1.6-11	40-100							Cam	Follower Scuffing	
PSA TU-SJP-L4	CEC L-088-02	MP	L4 (16v)		1.6	80/ 5800	95/ 0		3.2	72	6*2 phases (6*12h)	5600	62	150			X	X		RS		OC	
Volvo D12D	PK320	DI	L6	TC	12.1	338		0.0003	17.8	400	0.1 0.2	600- 1800	0-338	110-125	X						Ring Riding	BP	OC
Volvo D12DFE		DI	L6	TC	12.1	338		0.0003		24	3* 8h.	600- 1700	0-338	105-110								Fuel economy	
VW TDI	CEC L-078-99	DI	L4	TCIC	1.9	81/ 4150		0.3	4.5	54	2.5 0.5	4150- Idle	81-Idle	145-40	X			X	X				

## Engine test conditions

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Tests	Engine characteristics						Test conditions								Performance ratings						
	Procedure reference	Inject. type	Engine type	Aspiration	Engine displ., l	Max. output, kW/rpm	Fuel type: RON/Pb, g/l	Fuel type: % S, FAME %	Oil fill volume, l	Total test duration, h	Duration of each phase, h	Engine speed, rpm	Load, kW	Oil temp., °C	Deposit/ Piston cleanliness	Sludge	Varnish	Vis. incr. /Oxid.	Rust/ corros.	Ring	Wear
JASO tests																					
Mitsubishi Fuso 4D34T4	JASO M 354:05	DI	L4	TCIC	3.9	121.4/ 3200		0.05 max, 0.001 max	7.0	160	-	3200	121.4	105						Cam	
Nissan Diesel TD25	JASO M 336:98	IDI	L4	-	2.5	55.0/ 4300		0.05 max, 0.001 max	4.8	200	-	4300	55.0	120	X					RS	
Hino N04C	JASO M 354:15 JASO M 336:14	DI	L4	TCIC	4.0	120/ 2800		0.001 max	8.0	200	-	2800	120	113	-					Tappet	-
Nissan VG20E	JASO M 331:91	PFI	V6		2.0	91.9/ 6000	89-93 0		2	200 or 300	1h ( 24+24+12 )	800 1800 3500	1.6 18.5 34.1	50 96 117	WTD	X					
Nissan KA24E	JASO M 328:95	PFI	L4		2.4	103/ 5600	89 min. 0		3	100	1h ( 50+10 )	800 1500	1.2 2.3	50 60.5						Cam	
Toyota 1GFE	JASO M 333:93	PFI	L6		2.0	99/ 5600	89 min. 0		2.5	48 or 96		4800	29.6	149				X			

**Notes:**

(1) Depending on fuel batch severity.  
(2) Ref.-cand.-ref.

MP = Multi point  
SP = Single point  
DI = Direct Injection

TCIC = Turboch. intercooler  
TC = Turbocharged  
IDI = Indirect Diesel Injection  
PFI = Port fuel injection

L4 = In Line 4 cylinders  
V6 = 6 cylinders in V  
L6 = In Line 6 cylinders  
L5 = In Line 5 cylinders

RS = Ring Sticking  
OC = Oil consumption  
BP = Bore polishing

## Engine test conditions

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Tests	Engine characteristics							Test conditions							Performance ratings							
	Procedure reference	Inject. type	Engine type	Aspiration	Engine dispil.	Max. output, kW/rpm	Fuel type: RON/Pb, g/l	Fuel type: % S, FAME %	Oil fill volume, l	Total test duration, h	Duration of each phase, h	Engine speed, rpm	Load, kW	Oil temp., °C	Deposit/ Piston cleanliness	Sludge	Varnish	Vis. incr. /Oxid.	Rust/ corros.	Ring	Wear	Other
API / ILSAC tests																						
BRT	ASTM D6557		Bench test to replace Seq IID engine test						0.1	18										rust		
CAT 1M-PC (for CF)	ASTM D6618	IDI	1Y73 Single cyl.	TC	2.2	31.3/ 1800		0.40 min.	6.8	120		1800	31	Bearing 96	WTD TGF		WTD		RSC RS		Liner scuffing	
Caterpillar 1K	ASTM D6750	DI	1Y540 Single cyl.	TC	2.4	52/ 2100		0.40	6.0	252		2100	52	Bearing 107	WDK TGF TLHC		WDK		RS			
Caterpillar 1N	ASTM D6750	DI	1Y540 Single cyl.	TC	2.4	52/ 2100		0.05	6.0	252		2100	52	Bearing 107	WDN TGF TLHC		WDN		RS	Liner scuffing	OC	
Caterpillar 1P	ASTM D6681	DI	1Y3700 Single cyl.	TC	2.43	55/ 1800		0.05	6.8	360		1800	55	130+/- 3	WDP TLC TGC		WDP					OC
Caterpillar 1R	ASTM D6923	DI	1Y3700 Single cyl.	TC	2.43	68/ 1800		0.05	6.8	504		1800	68	120	WD TLC TGC		WDR		RS	Liner scuffing	OC	
Caterpillar C13	ASTM D7549	DI	C13	TC	12.5	391/ 1800		0.0015	38	500		1800	1760	Gallery 98	WTD TGF TLHC TGF TLC		WTD		RSC RS, weight loss			OC
Cummins ISB	ASTM D7484	DI	L6	TC	5.9	224/ 2600		0.0015	14.5	350	100/250	1600/ Cyclic		110							Valve train	
Cummins ISM	ASTM D7468	DI	L6	TC	10.82	332/ 1900		0.05	24.8	200	50	1600 +/-2 1800 +/-5	300	115	Rocker cover and oil pan						Valve train	Filter plugging
Cummins M11	ASTM D6838	DI	370E	TC	11.0	275/ 1800		0.05	29	200	50	1600 +/-2 1800 +/-5	275	130 maxi.	Filter plugging						Valve train	
Cummins M11-EGR	ASTM D6975	DI	L6	TC	11.0	275/ 1800		0.05		300	50	1600 +/-2 1800 +/-5			Filter plugging						Valve train	
Cummins NTC-400		DI		TCIC	14	298/ 2100		0.4		200		2100	298	250	X					Cam follower pin	OC	
DD6V92TA	ASTM D5862	DI	V6.2 Cycle	TCIC	9.0	370/ 2300		0.1-0.4	22	100		1200 2300	130 364 379	102-111					Face distress	Liner scuffing Port plugging		

## Engine test conditions

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Tests	Engine characteristics						Test conditions								Performance ratings							
	Procedure reference	Inject. type	Engine type	Aspiration	Engine displ., l	Max. output, kW/rpm	Fuel type: RON/Pb, g/l	Fuel type: % S, FAME %	Oil fill volume, l	Total test duration, h	Duration of each phase, h	Engine speed, rpm	Load, kW	Oil temp., °C	Deposit/ Piston cleanliness	Sludge	Varnish	Vis. incr./Oxid.	Rust/corros.	Ring	Wear	Other
API / ILSAC tests																						
EOAT Navistar	ASTM D6894	DI	V8	TC	7.3	160/ 3000		0.05	16	20		3000	153	121 max								Deaeration
COAT	ASTM D8047	DI	L6	TC	12.5	320/ 1800		0.0015	38	50		1800	0	90								Deaeration
Mack T-9	ASTM D6483	DI	E7-350	TC	12.0	261/ 1800		0.05	45.4	500	75/425	1800/ 1250	0/261	99/107					X	Weight loss	Liner + BC	TR
Mack T-8	ASTM D5967	DI	E.7	TC	12.0	258/ 1800		0.05	45.4	250		1800	258	100-107		Filter plugging		X				OC
Mack T-8A	ASTM D5967	DI	E.7	TC	12.0	258/ 1800		0.05	45.4	150		1800	258	100-107		Filter plugging		X				
Mack T-8E	ASTM D5967	DI	E.7	TC	12.0	258/ 1800		0.05	45.4	300		1800	258	100-107				X				OC
Mack T-10	ASTM D6987	DI	L6	TC	12.0	343/ 1800		0.05	35.9	300	75/225	1800/ 1200	245/ 325	88/ 112					Weight loss	Liner	BC	OC
Mack T-11	ASTM D7156	DI	L6	TC	12.0	343/ 1800		0.05	30.9	252		1800	240	88				X				
Mack T-12	ASTM D7422	DI	L6	TC	12.0	343/ 1800		0.0015	35.9	300	100/200	1800/ 1200	245/ 325	88/ 116					Weight loss	Liner	BC	OC
Mack T-13	ASTM D8048	DI	L6	TC	13	371/ 1500	PC-10 Test Fuel	-13ppm S, 0% FAME	25.8 kg for break-in, 22.8 kg test charge	360	360 h	1500	-340-370 kW. Load is controlled to a fuel flow rate of 68 kg/hr	130				X		Liner wear / bearings	OC	
RFWT	ASTM D5966	IDI	V6	-	6.5	155/ 3500		0.05		50		1000	30-34	120								Roller follower
SEQ IIIE	ASTM D5533		V6		3.8		Leaded gasoline			64		3000	50.6	149				X		RS	Cam + lobe	OC
SEQ IIIF	ASTM D6984		V6		3.8		Unl. gasoline			80		3600	73.6	155	X		X		RS	Cam + lifter		
SEQ IIIG	ASTM D7320		V6		3.8	125 bhp/ 3600	Unl. gasoline			100	Steady state	3600		150	X			X		Hot stuck	X	OC
SEQ IIIH	ASTM D8111	PFI	Chrysler V6		3.6	224 / 6350	Unl. Gasoline			90	Steady state	3900	102	151	X		X		RS			
SEQ IV-A	ASTM D6891	PFI	L4		2.4	103 / 5600	89 min.		3	100	1h ( 50+10 )	800 1500	1.2 2.3	50 60.5							Cam	

# Engine test conditions

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Tests	Engine characteristics							Test conditions							Performance ratings								
	Procedure reference	Inject. type	Engine type	Aspiration	Engine displ., l	Max. output, kW/rpm	Fuel type: RON/Pb, g/l	Fuel type: % S, FAME %	Oil fill volume, l	Total test duration, h	Duration of each phase, h	Engine speed, rpm	Load, kW	Oil temp., °C	Deposit/ Piston cleanliness	Sludge	Varnish	Vis. incr. /Oxid.	Rust/ coros.	Ring	Wear	Other	
API / ILSAC tests																							
SEQ IV-B	ASTM Dxxxx	PFI	L4		1.5		0			200	7 / 8 seconds	800 / 4300		54							Cam + lifter		
SEQ VE	ASTM D5302	PFI	Ford OCH-4		2.3		Unl. Gasoline		3.67	288	120 <sup>(1)</sup> x 72 75 <sup>(1)</sup> x 72 45 <sup>(1)</sup> x 72	2500 2500 750	25 25 0.75	68 99 46			X	X			RS	Cam	
SEQ VG	ASTM D6593	PFI	Ford V8		4.6		Unl. Philips « J »		3	216	2 115 0.45	1200 2900 700		68 100 45			X	X			RS		
SEQ VH	ASTM Dxxxx	PFI	Ford V8		4.6		Unl. Gasoline			216	2 115 0.45	1200 2900 700		68 100 45			X	X			RS		
SEQ VI-B	ASTM D6837	MP	Ford V-8 ('93)		4.6		Unl. Gasoline		6	133	I aging = 16 II aging = 80 FEI 17.5 FE II 7.5	800 1500	2.18 15.39	45 105								Fuel economy	
SEQ VI-D	ASTM D7589	MP	GM V6		3.6		Unl. Gasoline		5.4	155	I aging = 16 II aging = 109 FEI 17.5 FE II 7.5	695-2000	1.5-22	35-115									Fuel econ./ FE retention
SEQ VI-E	ASTM D8114	DI	GM V6		3.6	226 / 6800	Unl. Gasoline		5.4	196	I aging = 16 II aging = 109 FEI 17.5 FE II 7.5	695-2000	1.5-22	35-115									Fuel econ./ FE retention
SEQ VI-F	ASTM Dxxxx	DI	GM V6		3.6	226 / 6800	Unl. Gasoline		5.4	196	I aging = 16 II aging = 109 FEI 17.5 FE II 7.5	695-2000	1.5-22	35-115									Fuel econ./ FE retention
SEQ VIII	ASTM D6709		CLR mono		0.7	3.7 / 3150	Unl. Gasoline		1.8	40		3150	- 3.7	143						BWL			Shear stability
SEQ IX	ASTM Dxxxx	DI	Ford Ecoboost L4	TC	2.0	269 / 1750	Unl. Gasoline			16		1750	49	95									Pre-ignition events
SEQ X	ASTM Dxxxx	PFI	Ford V8		4.6		Unl. Gasoline			216	2 125 0.45	1200 2900 700		68 100 45			X	X			RS		

<sup>(1)</sup> Depending on fuel batch severity  
<sup>(2)</sup> Ref.-cand.-ref

IC = Intercooler

IDI = Indirect Diesel injection

DI = Direct injection

PFI = Port fuel injection

SC = Supercharged

TC = Turbocharged

MP = Multi point

TCIC = Turboch. intercooler

L4 = In Line 4 cylinders

V6 = 6 cylinders in V

L6 = In Line 6 cylinders

V8 = 8 cylinders in V

RS = Ring sticking

OC = Oil consumption

RSC = Ring side clearance

BP = Bore Polishing

BC = Bearing corrosion

BWL = Bearing Weight Loss

WDK = Total weighted demerit for Cat 1K

TGC = Top groove carbon

TGF = Top groove filling

TLC = Top land carbon

TLHC = Top land heavy carbon

# Elastomer compatibility testing



# Elastomer compatibility operating conditions and limits

- 1 -



Specifications	ACEA 2008 / 2010 / 2012						
	Seq. A/B, C	Seq. E	Seq. A/B, C, E	Seq. A/B, C	Seq. E	Seq. A/B, C, E	
Related specifications							
Elastomer material	RE1 (FPM, Fluorocarbon)		RE2-99 (ACM, Acryl Acrylate Copolymers)		RE3-04 (VMQ, Silicon)	RE4 (NBR, Nitrile Butyl Rubber)	DBL-AEM (Vamac, Ethylene Acrylic Elastomer)
<b>Operating conditions</b>			CEC L-39-96			CEC L-39-96	CEC L-39-96
Test piece			S 2			S 2	S 2
Duration, h			168			168	168
Pre-aging of the oil			No			No	No
Oil weight, g			270			270	270
Temperature, °C			150			100	150
<b>Change after test</b>							
Hardness, pts	-1 / +5	-1 / +5	-5 / +8	-22 / +1	-25 / +1	-5 / +5	-5 / +10
Tensile strength, %	-40 / +10	-50 / +10	-15 / +18	-30 / +10	-45 / +10	-20 / +10	-35 / -
Elongation at break, %	-50 / +10	-60 / +10	-35 / +10	-20 / +10	-20 / +10	-50 / +10	-50 / -
Volume, %	-1 / +5	-1 / +5	-7 / +5	-1 / +22	-1 / +30	-5 / +5	-5 / +15

Specifications	ACEA 2016				
	Sequence A/B, C, E				
Related specifications					
CEC L-112-16	RE6	RE7	RE8	RE9	
Elastomer material	(FKM, Fluorocarbon)	(ACM, Acryl Acrylate Copolymers)	(HNBR, Hydrogenated Nitrile Butyl Rubber)	(AEM, Ethylene Acrylic Elastomer)	
<b>Operating conditions</b>		CEC L-112-16			
Test piece	S 2	S2	S 2	S 2	S 2
Duration, h	168	168	168	168	168
Pre-aging of the oil	No	No	No	No	No
Oil weight, g	270	270	270	270	270
Temperature, °C	150	120	150	150	150
<b>Change after test</b>					
Tensile strength, %	Report	Report	Report	Report	Report
Elongation at break, %	-70 / +20	-65 / +15	-51 / +9	-65 / +19	-65 / +19
Volume, %	-5.5 / +2.1	-1.8 / +8.9	0.0 / +12.0	-2.5 / +16.0	-2.5 / +16.0

## Elastomer compatibility operating conditions and limits

- 2 -



Specifications	JASO DH-1 / DH-2 / DL-1					
	DH-1, DL-1	DH-2	DH-1, DH-2, DL-1	DH-1, DH-2, DL-1	DH-1, DH-2, DL-1	
Related specifications						
Elastomer material	RE1 (FPM, Fluoro)		RE2-99 (ACM, Acrylic)	RE3-04 (VMQ, Silicon)	RE4 (NBR, Nitrile)	DBL-AEM (Vamac, Ethylene Acrylic)
<b>Operating conditions</b>			CEC L-39-96		CEC L-39-96	CEC L-39-96
Test piece			S 2		S 2	S 2
Duration, h			168		168	168
Pre-aging of the oil			No		No	No
Oil weight, g			270		270	270
Temperature, °C			150		100	150
<b>Change after test</b>						
Hardness change, pts	-1 / +5	-1 / +5	-5 / +8	-25 / +1	-5 / +5	-35 / -
Tensile strength change, %	-40 / +10	-50 / +10	-15 / +18	-45 / +10	-20 / +10	-50 / -
Elongation at break change, %	-50 / +10	-60 / +10	-35 / +10	-20 / +10	-50 / +10	-5 / +15
Volume change, %	-1 / +5	-1 / +5	-7 / +5	-1 / +30	-5 / +10	-

## Elastomer compatibility operating conditions and limits

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Specifications	API CI-4 / CI-4 PLUS API CJ-4 / CK-4 / FA-4				
	Nitrile (NBR)	Silicone (VMQ)	Polyacrylate (ACM)	Fluoroelastomer (FKM)	Vamac G
Elastomer material					
<b>Operating conditions</b>	ASTM D7216				
Duration, h			336		
Pre-aging of the oil			No		
Temperature, °C	100	150	150	150	150
<b>Change after test<sup>(1)(2)</sup></b>					
Volume change, %	+5 / -3	+TMC 1006 / -3	+5 / -3	+5 / -2	+TMC 1006 / -3
Hardness change, pts	+7 / -5	+5 / -TMC 1006	+8 / -5	+7 / -5	+5 / -TMC 1006
Tensile strength change, %	+10 / -TMC 1006	+10 / -45	+18 / -15	+10 / -TMC 1006	+10 / -TMC 1006
Elongation at break change, %	+10 / -TMC 1006	+20 / -30	+10 / -35	+10 / -TMC 1006	+10 / -TMC 1006
Compression set <sup>(3)</sup>	Report	Report	Report	Report	Report

**Notes:**

(1) These are unadjusted specification limits for elastomer compatibility. Candidate oils shall, however, conform the adjusted specification limits, the calculation of which is described in ASTM D4485 annex A4.

(2) Ref Oil is TMC 1006 (original blend or subsequent approved re-blends of TMC 1006).

(3) Only required for DFS 93K214, per ASTM D395.

## Elastomer compatibility operating conditions and limits

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Specifications	API SN / SN Resource Conserving / ILSAC GF-5				
	Hydrogenated Nitrile (HNBR-1)	Silicone (VMQ-1)	Polyacrylate (ACM-1)	Fluorocarbon (FKM-1)	Ethylene Acrylic (AEM-1)
Elastomer material					
<b>Operating conditions</b>	ASTM D7216 Annex A2				
Duration, h		336			
Pre-aging of the oil		No			
Temperature, °C	100	150	150	150	150
<b>Variations after test <sup>(1)</sup></b>					
Volume change, %	-5 / 10	-5 / 40	-5 / 9	-2 / 3	-5 / 30
Hardness change, pts	-10 / 5	-30 / 10	-10 / 10	-6 / 6	-20 / 10
Tensile strength change, %	-20 / 15	-50 / 5	-40 / 40	-65 / 10	-30 / 30

**Notes:**

(1) Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643.  
Candidate oil testing shall be performed according to ASTM D7216 Annex A2.

The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed herein.

# Elastomer compatibility operating conditions and limits

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Specifications		GLOBAL DHD-1				
Elastomer material		RE1 (FPM, Fluorocarbon)	RE2 (ACM, Acryl Acrylate Copolymers)	RE3 (VMQ, Silicon)	RE4 (NBR, Nitrile Butyl Rubber)	
<b>Operating conditions</b>		CEC L-39-96				
Test piece			S 2		S 2	
Duration, h			168		168	
Pre-aging of the oil			No		No	
Oil weight, g			270		270	
Temperature, °C			150		100	
<b>Variations after test in</b>						
Hardness change, pts		-1 / +5	-5 / +5	-25 / +1	-5 / +5	
Tensile strength change, %		-50 / +10	-15 / +10	-45 / +10	-20 / +10	
Elongation at break change, %		-60 / +10	-35 / +10	-20 / +10	-50 / +10	
Volume change, %		-1 / +5	-5 / +5	-1 / +30	-5 / +5	

## Elastomer compatibility operating conditions and limits

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Specifications	GM dexos1 / 2						
	RE1 (FPM)	RE4 (NBR)	DBL-AEM (Vamac)	Nitrile (NBR-1)	Silicone (VMQ-1)	Fluorocarbon (FKM-2)	Polyacrylate (ACM-1) <sup>(1)</sup>
<b>Operating conditions</b>	CEC L-39-96	VDA 675301	ASTM D7216 Annex A2				
Test piece	S 2	S 2					
Duration, h	168	168					
Pre-aging of the oil	No	No					
Oil weight, g or specimen : oil ratio	270	1: 80					
Temperature, °C	150	150					
<b>Change after test</b>							
Hardness change, pts.	-1 / +5	-5 / +5	-5 / +10	-5 / +5	-30 / +10	-30 / +10 (Dexos 1) -10 / +10 (Dexos 2)	-10 / +10
Tensile strength change, %.	-40 / +10	-20 / +10	-35 / -	-20 / +10	-45 / 0	-80 / +50	-30 / +30
Elongation at break change, %.	-50 / +10	-50 / +10	-50 / -	-35 / 0	-40 / 0	-90 / +55	-45 / +5
Volume change, %.	-1 / +5	-5 / +5	-5 / +15	-5 / +5	-5 / +40	-5 / +5	-5 / +5
Tensile stress at 50% elongation change, %	-	-	-	-10 / +35	-50 / +10	-50 / +55	-20 / +65

**Notes:**

(1) Use ACM-1 until ACM-2 is available.

## Elastomer compatibility operating conditions and limits

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Specifications	VOLKSWAGEN Factory Fill specifications							
	RE-AK6/1 <sup>(1)</sup>	RE-ACM1 <sup>(2)</sup>	RE-AEM2 <sup>(3)</sup>	RE-AEM1 <sup>(4)</sup>				
Elastomer material								
VW TL 521 67	X	X	X	X	X	X	X	X
VW TL 521 95	X	X	X	X	X	X	X	X
VW TL 525 77	X	X	X	X	X	X	X	X
Operating conditions								
Procedure			PV 3344, PV 3323, DIN 53504					
Test Piece			S3A					
Pre aging			Yes					
Specimen: oil ratio			1: 80					
Temperature, °C			150					
Duration, h	168	282 (3 x 94)	500	168	500	168	500	168
Change after test								
Tensile strength, N/mm <sup>2</sup> , min.	7	8	-	-	-	-	-	-
Tensile strength change, % max.	60	-	40	30	40	35	40	30
Elongation at break, %, min.	160	160	-	-	-	-	-	-
Elongation at break change, %, max.	50	50	40	30	40	30	40	30
Hardness change, pts.	-	-	-4 / +10	-5 / +6	-4 / +10	-10 / +10	-4 / +10	-8 / +8
Weight change, %	-	-	-2 / +6	-2 / +4	-3 / +10	-3 / +15	-3 / +10	-3 / +15
Cracks	None	None	-	-	-	-	-	-

Notes:

(1) Old name: FPM AK6

(2) Old name: ACM

(3) Old name: Varmac

(4) RE-AEM1 scheduled to disappear, AEM2 is replacement

# Elastomer compatibility operating conditions and limits

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Specifications		VOLKSWAGEN Service Fill specifications					
Elastomer material		RE-AK6/1 <sup>(1)</sup>	RE-ACM1 <sup>(2)</sup>	RE-AEM2 <sup>(3)</sup>	RE-AEM1 <sup>(4)</sup>		
VW 504 00 / 507 00	X		X	X	X		
VW 508 00 / 509 00	X		X	X	X		
VW 502 00 / 505 01		X		X	X		X
VW 502 00 / 505 00		X		X	X		X
VW 501 01 / 505 00		X		X	X		X
<b>Operating conditions</b>							
Procedure	PV 3344, PV 3323, DIN 53504						
Test piece	S3A						
Pre aging	Yes						
Ratio specimen: oil	1: 80						
Temperature, °C	150						
Duration, h	168	282 (3 x 94)	500	168	500	168	500
<b>Change after test</b>							
Tensile strength, N/mm <sup>2</sup> , min.	7	8	-	-	-	-	-
Tensile strength change at break, % max.	60	50	40	30	40	35	40
Elongation at break, %, min.	160	160	-	-	-	-	-
Elongation at break change, %, max.	50	50	40	30	40	40	40
Hardness change, pts.	-	-	-4 / +10	-5 / +6	-4 / +10	-10 / +10	-4 / +10
Weight change, %	-	-	-2 / +6	-2 / +4	-3 / +10	-3 / +15	-3 / +10
Cracks	None	None	-	-	-	-	-

**Notes:**

(1) Old name: FPM AK6

(2) Old name: ACM

(3) Old name: Varmac

(4) RE-AEM1 scheduled to disappear, AEM2 is replacement

## Elastomer compatibility operating conditions and limits

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Specifications	FORD WSS-M2C948-B
Elastomer material	RE1, RE2-99, RE3-04, RE4, DBL-AEM
	Ford HNBR (Hydrogenated Nitrile Butyl Rubber)
<b>Operating conditions</b>	CEC L-039-96
Test piece	S 2
Duration, h	168
Pre-aging of the oil	No
Oil weight, g	270
Temperature, °C	150
<b>Change after test</b>	
Hardness change, pts	-5 / +6
Tensile strength change, %	-30 / +20
Elongation at break change, %	-35
Volume change, %	-5 / +5

## Elastomer compatibility operating conditions and limits

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Specifications	MB 226.5, 229.1, .3	MB 226.51	MB 228.0, .1, .2, .3	MB 228.31	MB 228.5	MB 228.51	MB 228.61	MB 229.31, .51, .52	229.5	MB 229.6
Requirements	ACEA A3/B3	ACEA C4	ACEA E7	ACEA E9 API CJ-4	ACEA E4	ACEA E6	ACEA F8 API FA-4	ACEA C3	ACEA A3/B4	ACEA A5/B5

Specifications	MAN M 3271-1, 3 / 3275-1, -2 / 3277 / 3377 / 3477 / 3575 / 3677		MTU MTL 5044 Oil Cat. 1 / 2 / 2.1 / 3 / 3.1	
Elastomer material	NBR (SRE-NBR 28)	FPM (AK 6)	NBR (SRE-NBR 28)	FPM (AK6)
<b>Operating conditions</b>	VDA 675 301	VDA 675 301 and M 3273 <sup>(1)</sup>	DIN 53521	DIN 53521
Test piece	S 2	S 2	S 2	S 2
Duration, h	168	168	168	168
Pre-aging of the oil	No	No	No	No
Oil weight, specimen / oil ratio	1: 80	1: 80	1: 80	1: 80
Temperature, °C	100	150	100	150
<b>Change after test</b>				
Hardness change, pts	max. -10	-5 / +5	-10 / 0	-5 / +5
Tensile strength change, % min.	max. -20	max. -30	max. -20	max. -50
Elongation at break change, %, min.	max. -30	max. -40	max. -35	max. -55
Volume change, %	0 / +10	-2 / +5	0 / +10	0 / +5

**Notes:**

(1) Procedure with addition of 0.6 % vol. of hydrochloric acid to the candidate oil to test.

## Elastomer compatibility operating conditions and limits

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Specifications	CES 20078	CES 20081 / 20086 / 20087 DFS 93K214 / 93K218 / 93K222 / 93K223 VDS-3 / 4 / 4.5
Requirements	API CI-4, CI-4 PLUS	API CJ-4, CK-4, FA-4

## Elastomer compatibility operating conditions and limits

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PSA B71 2290 & PSA B71 2297								
Elastomer material	AEM2	AEM2	FKM4	FKM4	FKM1	FKM1	HNBR1	HNBR1
	Freudenberg AEM 8540 blue	Freudenberg AEM 8540 blue	Freudenberg 80FKM260519 noir	Freudenberg 80FKM260519 noir	Freudenberg 75FKM595 brun	Freudenberg 75FKM595 brun	Freudenberg 70HNBR248231 noir	Freudenberg 70HNBR248231 noir
<b>Operating conditions</b>								
Duration, h	168	1000	168	1000	168	1000	168	1000
Temperature, °C	150	150	150	150	150	150	135	135
<b>Change after test</b>								
Volume variation, %	-5 / 5	-5 / 5	-3 / 3	-3 / 3	-3 / 3	-3 / 3	-5 / 5	-5 / 5
IRDH (Hardness) variation, points	-5 / +5	0 / +10	-5 / +5	-5 / +5	-5 / +5	-5 / +5	-5 / +5	-5 / +5
Module 100 variation, %, max.	+50	+70	+50	+70	N/A	N/A	+50	+70
Tensile strength variation, %, min.	-20	-20	-30	-40	-80	-80	-20	-20
Elongation at break variation, %, min.	-30	-40	-30	-60	-60	-70	-30	-30
Elongation at break, % min.	150	150	150	100	100	100	150	150
Compression set, %, max.	30	50	50	50	70	90	60	70

# Requirements for approvals and performance recognition



## Approvals and performance recognition

- 1 -



Specifications	Oil Company actions				OEM actions			Fees						
	Official letter	Forms	Sample	IR	Official letter	Validity period	Qualified prod. list	Original	Reblend	Rebrand	Formulation change	Annual field sample	Annual renewal fee	Small changes, documentation fees
API Licensing	No	Yes	No	No	Yes	1 year	Yes <sup>(2)</sup>	(3)	(3)	(3)	No	0	0	0
ACEA	No	Yes	No	No	No	(1)	No	No	0	0	0	0	0	0
BMW	Yes	Yes	Yes	No	Yes	2 years <sup>(7)</sup>	Yes	5000 €	3000 €	2000 €	4000 €	No	500 €	No
CUMMINS CES 20074, 20076, 20077, 20078, 20081, 20086, 20087	No	No	No	No	Yes	1 year	Cummins internal		15000 US \$	15000 US \$		No	Yes for customers	
Detroit Diesel 93K214, 93K215, 93K216, 93K218	Yes	Yes <sup>(4)</sup>	Yes	No	Yes	1 year	DDC Website	1050 US \$	1050 US \$	1050 US \$		No	Yes <sup>(5)</sup>	100-200 US \$
JASO DH-1, DH-2, DL-1	Yes	Yes	No	Yes	Yes	1 year <sup>(7)</sup>	Yes	40000 ¥	40000 ¥	40000 ¥	No, without change of product name	No	Yes <sup>(7)</sup>	No
Mack EO-M Plus	No	Yes <sup>(4)</sup>	Yes	No	Yes	(1)	Mack Website	1080 US \$	1080 US \$	1080 US \$		No	No	100-200 US \$
Volvo VDS-4 / Mack EO-O Premium Plus	No	Yes <sup>(4)</sup>	Yes	No	Yes	2 years	Mack Website	1080 US \$	1080 US \$	1080 US \$		Yes <sup>(6)</sup>	No	100-200 US \$
Volvo VDS-4.5 / Mack EOS-4.5	No	Yes <sup>(4)</sup>	Yes	No	Yes	2 years	Mack Website	0	0	0				
MAN M3277, MAN M3477, MAN M3677	Yes	Yes <sup>(6)</sup>	2 L	No	Yes	2 years	Yes	5000 €	2500 €	2500 €	5000 €			
MERCEDES-BENZ	Yes	Yes <sup>(8)</sup>	100 ml	No	Yes	5 year max. <sup>(9)</sup>	Yes	2500 €	2500 €	2500 €	1250 €			
MTU	Single grade	Yes	Yes <sup>(13)</sup>	Yes <sup>(13)</sup>	Yes <sup>(13)</sup>	-	Yes	1250 €	1000 €	1000 €	625 €			
	Multi-grade	Yes	Yes <sup>(13)</sup>	Yes <sup>(13)</sup>	Yes	-	Yes	1750 €	1250 €	1250 €				
Dexos	No <sup>(19)</sup>	Yes	1 gal	No	No	(14)	Yes	1000 €	3150 €	3150 €	1000 €	Yes	Yes <sup>(15)</sup>	
PORSCHE	Yes	Yes	2 L	Yes	Yes	3 years	Yes	3250 €	3250 €	3250 €	3250 €	No	No	No
PSA	Yes	Yes	No	Yes	Yes	1 year <sup>(20)</sup>	Yes	20000 €	20000 €	20000 €	20000 €	No	20000 €	No
RENAULT (passenger cars)	Yes	Yes	2 L	No	Yes	4 years	Yes	5800 €	5800 €	5800 €	5800 €	No	No	Yes
VOLVO VDS-3	Yes	No	No	No	Yes	(1)	No	No	No	No	No			

## Approvals and performance recognition

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Specifications		Oil Company actions				OEM actions			Fees						
		Official letter	Forms	Sample	IR	Official letter	Validity period	Qualified prod. list	Original	Reblend	Rebrand	Formulation change	Annual field sample	Annual renewal fee	Small changes, documentation fees
Deutz	DQC II	Yes	Yes	Yes	No	Yes	3 years	No	1000 €	750 €	750 €	-	No	No	No
	DQC III & DQC IV								2500 €	2000 €	1500 €				
VW 500 00, VW 501 01, VW 502 00, VW 503 00, VW 505 01 <sup>(1)</sup> , VW 503 01, VW 505 00, VW 506 00, VW 506 01		No <sup>(19)</sup>	Yes	No	Yes	Yes	<sup>(18)</sup>	No <sup>(12)</sup>	0	2000 €	1340 €	0 €	No	No	No

### Notes:

- (1) Valid until specification change or modification in lubricant formulation.
- (2) API publication 1520.
- (3) Fees are calculated according to a yearly volume of production of lubricants to be licensed: minimum is US \$ 1250 for API members and US \$ 1500 for non-members. In addition, an annual fee of US \$ 0.0020 per gallon of licensed motor oil after the 1<sup>st</sup> million gallons of product is assessed.
- (4) Forms submitted to Test Engineering Inc. of San Antonio, Texas.
- (5) Annual renewal fee is US \$500/product.
- (6) Mack field sample US \$1000 each.
- (7) To maintain on-file registration, it's required to pay an on-file maintenance fee: minimum charge is 30 000 € per year up to 1 000 kl of sales of each registered oil. For sales quantity of 1 000 kl or more, fees are calculated in increments of 30 € per kl.
- (8) Electronic application via DC BEAM system.
- (9) Validity as long as original approval. Yearly renewal required.
- (10) Combinations with VW 505.0: Rebrand, reblend and renewal are possible but no new approval.
- (11) AG福斯油品公司。
- (12) Application must include Appendix F and IR run in a approved laboratory which will send a 100 ml sample to MTU upon applicant request.
- (13) First generation dexos<sup>TM</sup> licences will expire on August 31, 2016. Second generation dexos<sup>TM</sup> formulations will be accepted for review at the March 2015 dexos Approval Committee Meeting. Dexos2<sup>TM</sup> to be determined.
- (14) A blender is charged 3150 US \$ for the initial qualification fee and each formulation that a blender has registered is also charged a License Release Fee of 1000 US \$ per calendar year.
- (15) Customer to do the reblend and send bench test results.
- (16) Technical approval is valid for 6 years. A commercial renewal involving a 500 € fee is required every 2 years.
- (17) Original approvals (for additive companies) are valid 5 years after the oldest engine test. Reblend and rebrand approvals are valid 3 years from the day of the demand.
- (18) Email only.
- (19) Technical validity is for 3 years from the date of release of the active PSA specification. Commercial approval has to be renewed every year with payment of the appropriate fees.

**OEM  
requirements  
for  
natural gas  
engine oils**



# Requirements for gas engine oils for busses and trucks

- 1 -



Specifications	Cummins		Mercedes-Benz 228.31 / 228.51	Detroit 93K216	Iveco	MAN M3271-1 / -3	Volvo	Scania
	CES 20074	CES 20085						
ACEA / API / OEM performance level	-	-	ACEA E9, API CJ-4 / ACEA E6	-	ACEA E6 (+2 TBN), ACEA B5 (light-duty only)	ACEA E6 + M 3477	ACEA E6 + VDS-3	Scania Low Ash
Viscosity grades (SAE J300)	10W-30, xW-40	10W-30, xW-40	Acc. ACEA	15W-40	Acc. ACEA	30, 40, 5W-x, 10W-x, 15W-x / 5W-x, 10W-x	xW-30, xW-40	10W-40
<b>Laboratory Tests</b>								
<b>HTHS viscosity</b> (CEC L-36-90, ASTM D4683), mPa.s, min.	3.5	3.5	3.5	4.2	Acc. ACEA	3.5	Report	3.5
<b>Shear stability</b> (CEC L-14-93, ASTM D6278, D7109)	-	-	Stay in grade	12.5	Stay in grade	xW-30: 9; xW-40: 12	xW-30: 9.3; xW-40: 12.5	Stay in grade
Viscosity at 100°C after 90 cycles shear (ASTM D445), mm <sup>2</sup> /s, min.	-	-	-	3.9	-	-	xW-30: 3.4; xW-40: 3.7	-
<b>HTHS viscosity</b> after 90 cycles shear (ASTM D4683), mPa.s, min.	-	-	-	-	-	-	-	-
<b>Evaporative loss</b> (Noack) (ASTM D5800), % loss, max.	13	13	13 / 12	15	13	13	13	13
<b>Sulfated ash</b> (ASTM D874), % m/m, max.	0.4 - 0.6	0.7 - 0.9	1.0	0.8	Acc. ACEA	1.0	1.0	1.0
<b>Zinc</b> (ASTM D5185), % m/m, min.	0.06 - 0.90	0.08 - 0.10	Rate & report	-	-	0.08 / Report	-	-
<b>Phosphorus</b> (ASTM D5185), % m/m, max.	0.06 - 0.085	0.07 - 0.09	0.12	-	Acc. ACEA	Report / 0.08	0.08	0.12
<b>Calcium</b> (ASTM D5185), % m/m	0.09 - 0.15	0.18 - 0.23	Rate & report	-	-	Report	-	-
<b>Sulfur</b> , % m/m, max.	0.4	0.4	0.4 / 0.3	-	-	-	0.3	0.4
<b>Infrared spectrum</b> (CES 6005)	Rate & report	Rate & report	Rate & report	-	-	-	-	-
<b>TBN</b> (ASTM D2896, D4739), mg KOH/g, min.	5.0	5.5	-	-	HD: 9, LD: 8	7	9	-
<b>TAN</b> (ASTM D664), mg KOH/g	0.5 - 1.5	0.5 - 1.5	-	-	-	-	-	-
<b>Pour point</b> (ASTM D97), °C, max.	-	-	-27	-25	-	5W-x: -40, 40: -15	Report	-

## Requirements for gas engine oils for busses and trucks

- 2 -



Specifications	Cummins		Mercedes-Benz 228.31 / 228.51	Detroit 93K216	Iveco	MAN M3271-1 / -3	Volvo	Scania
	CES 20074	CES 20085						
Foaming tendency (ASTM D892) (No option A) Sequence I, II, III, ml, max.	-	-	10/0, 50/0, 10/0	10/0, 20/0, 10/0	10/0, 50/0, 10/0	10/0, 50/0, 10/0	10/0, 20/0, 10/0	10/0, 50/0, 10/0
Corrosion tendency (CBT / HTCBT) (ASTM D5968 / D6594)	D5968	D5968	mod. D6594	D6594	D6594	D6594	D6594	D6594
Copper increase - without / with 10% m/m B100, ppm, max.	20 / -	20 / -	20 / 200	20 / -	Report	Report	20	Report
Lead increase, ppm, max.	120	120	100	120	Report	Report	120	Report
Tin increase, ppm, max.	50	50	-	50	Report	Report	-	Report
Copper strip rating - with / without 10% m/m B100 (ASTM D130), max.	3 / -	3 / -	3 / 4a	3 / -	-	-	3	
Thin Film Oxygen Uptake Test (TFOOUT) (ASTM D4742), min, min.	-		-	X-(0.22(X+5)) <sup>(1)</sup>	-	-	-	-
<b>Engine Tests</b>								
Dynamometer tests	Currently Cummins is working on qualification testing for this specification. Once testing is determined these test(s) will be added to this specification.		See document Mercedes-Benz specifications for service fill engine oils V2016.1	1000 h standard lab. test in a DDC Series 50G Model MK engine	Acc. ACEA	Acc. ACEA	Acc. ACEA E6 + VDS-3	Acc. ACEA E6, E9, API CJ-4
Field tests	Minimum of 5 of each ISL-G and ISX-12G series engines. Minimum duration 1 year.		-	6 engines for 1 year or 60.000 miles	-	M 3271-3: Field test monitored by EMRA department	-	Scania Low Ash

**Notes:**

(1) Where X = Engine Tested Oil TFOOUT

## Unit conversion



## Unit conversion tables

### Temperature conversion



To °F	From °T	To °C	To °F	From °T"	To °C	To °F	From °T	To °C	To °F	From °T	To °C	To °F	From °T	To °C
-144.4	-98	-72.2	96.8	36	2.22	249.8	121	49.44	402.8	206	96.67	683.6	362	183.33
-140.8	-96	-71.1	98.6	37	2.78	251.6	122	50.00	404.6	207	97.22	687.2	364	184.44
-137.2	-94	-70.0	100.4	38	3.33	253.4	123	50.56	406.4	208	97.78	690.8	366	185.56
-133.6	-92	-68.9	102.2	39	3.89	255.2	124	51.11	408.2	209	98.33	694.4	368	186.67
-130.0	-90	-67.8	104.0	40	4.44	257.0	125	51.57	410.0	210	98.89	698.0	370	187.78
-126.4	-88	-66.7	105.8	41	5.00	258.8	126	52.22	411.8	211	99.44	701.6	372	188.89
-122.8	-86	-65.6	107.6	42	5.56	260.6	127	52.78	413.6	212	100.00	705.2	374	190.00
-119.2	-84	-64.4	109.4	43	6.11	262.4	128	53.33	415.4	213	100.56	708.8	376	191.11
-115.6	-82	-63.3	111.2	44	6.67	264.2	129	53.89	417.2	214	101.11	712.4	378	192.22
-112.0	-80	-62.2	113.0	45	7.22	266.0	130	54.44	419.0	215	101.67	716.0	380	193.33
-108.4	-78	-61.1	114.8	46	7.78	267.8	131	55.00	420.8	216	102.22	719.6	382	194.44
-104.8	-76	-60.0	116.6	47	8.33	269.6	132	55.56	422.6	217	102.78	723.2	384	195.56
-101.2	-74	-58.9	118.4	48	8.89	271.4	133	56.11	424.4	218	103.33	726.8	386	196.67
-97.6	-72	-57.8	120.2	49	9.44	273.2	134	56.67	426.2	219	103.89	730.4	388	197.78
-94.0	-70	-56.7	122.0	50	10.00	275.0	135	57.22	428.0	220	104.44	734.0	390	198.89
-90.4	-68	-55.6	123.8	51	10.56	276.8	136	57.78	431.6	222	105.56	737.6	392	200.00
-86.8	-66	-54.4	125.6	52	11.11	278.6	137	58.33	435.2	224	106.67	741.2	394	201.11
-83.2	-64	-53.3	127.4	53	11.67	280.4	138	58.89	438.8	226	107.78	744.8	396	202.22
-79.6	-62	-52.2	129.2	54	12.22	282.2	139	59.44	442.4	228	108.89	748.4	398	203.33
-76.0	-60	-51.1	131.0	55	12.78	284.0	140	60.00	446.0	230	110.00	752.0	400	204.44
-72.4	-58	-50.0	132.8	56	13.33	285.8	141	60.56	449.6	232	111.11	755.6	402	205.56
-68.8	-56	-48.9	134.6	57	13.89	287.6	142	61.11	453.2	234	112.22	759.2	404	206.67
-65.2	-54	-47.8	136.4	58	14.44	289.4	143	61.67	456.8	236	113.33	762.8	406	207.78
-61.6	-52	-46.7	138.2	59	15.00	291.2	144	62.22	460.4	238	114.44	766.4	408	208.89
-58.0	-50	-45.6	140.0	60	15.56	293.0	145	62.78	464.0	240	115.56	770.0	410	210.00
-54.4	-48	-44.4	141.8	61	16.11	294.8	146	63.33	467.6	242	116.67	773.6	412	211.11
-50.8	-46	-43.3	143.6	62	16.67	296.6	147	63.89	471.2	244	117.78	777.2	414	212.22
-47.2	-44	-42.2	145.4	63	17.22	298.4	148	64.44	474.8	246	118.89	780.8	416	213.33
-43.6	-42	-41.1	147.2	64	17.78	300.2	149	65.00	478.4	248	120.00	784.4	418	214.44
-40.0	-40	-40.0	149.0	65	18.33	302.0	150	65.56	482.0	250	121.11	788.0	420	215.56
-36.4	-38	-38.9	150.8	66	18.89	303.8	151	66.11	485.6	252	122.22	791.6	422	216.67

## Unit conversion tables

### Temperature conversion



**Oronite**

To °F	From °T	To °C												
-32.8	-36	-37.8	152.6	67	19.44	305.6	152	66.67	489.2	254	123.33	795.2	424	217.78
-29.2	-34	-36.7	154.4	68	20.00	307.4	153	67.22	492.8	256	124.44	798.8	426	218.89
-25.6	-32	-35.6	156.2	69	20.56	309.2	154	67.78	496.4	258	125.56	802.4	428	220.00
-22.0	-30	-34.4	158.0	70	21.11	311.0	155	68.33	500.0	260	126.67	806.0	430	221.11
-18.4	-28	-33.3	159.8	71	21.67	312.8	156	68.89	503.6	262	127.78	809.6	432	222.22
-14.8	-26	-32.2	161.6	72	22.22	314.6	157	69.44	507.2	264	128.89	813.2	434	223.33
-11.2	-24	-31.1	163.4	73	22.78	316.4	158	70.00	510.8	266	130.00	816.8	436	224.44
-7.6	-22	-30.0	165.2	74	23.33	318.2	159	70.56	514.4	268	131.11	820.4	438	225.56
-4.0	-20	-28.9	167.0	75	23.89	320.0	160	71.11	518.0	270	132.22	824.0	440	226.67
-0.4	-18	-27.78	168.8	76	24.44	321.8	161	71.67	521.6	272	133.33	827.6	442	227.78
3.2	-16	-26.67	170.6	77	25.00	323.6	162	72.22	525.2	274	134.44	831.2	444	228.89
6.8	-14	-25.56	172.4	78	25.56	325.4	163	72.78	528.8	276	135.56	834.8	446	230.00
10.4	-12	-24.44	174.2	79	26.11	327.2	164	73.33	532.4	278	136.67	838.4	448	231.11
14.0	-10	-23.33	176.0	80	26.67	329.0	165	73.89	536.0	280	137.78	842.0	450	232.22
17.6	-8	-22.22	177.8	81	27.22	330.8	166	74.44	539.6	282	138.89	845.6	452	233.33
21.2	-6	-21.11	179.6	82	27.78	332.6	167	75.00	543.2	284	140.00	849.2	454	234.44
24.8	-4	-20.00	181.4	83	28.33	334.4	168	75.56	546.8	286	141.11	852.8	456	235.56
28.4	-2	-18.89	183.2	84	28.89	336.2	169	76.11	550.4	288	142.22	856.4	458	236.67
32.0	0	-17.78	185.0	85	29.44	338.0	170	76.67	554.0	290	143.33	860.0	460	237.78
33.8	1	-17.22	186.8	86	30.00	339.8	171	77.22	557.6	292	144.44	863.6	462	238.89
35.6	2	-16.67	188.6	87	30.56	341.6	172	77.78	561.2	294	145.56	867.2	464	240.00
37.4	3	-16.11	190.4	88	31.11	343.4	173	78.33	564.8	296	146.67	870.8	466	241.11
39.2	4	-15.56	192.2	89	31.67	345.2	174	78.89	568.4	298	147.78	874.4	468	242.22
41.0	5	-15.00	194.0	90	32.22	347.0	175	79.44	572.0	300	148.89	878.0	470	243.33
42.8	6	-14.44	195.8	91	32.78	348.8	176	80.00	575.6	302	150.00	881.6	472	244.44
44.6	7	-13.89	197.6	92	33.33	350.6	177	80.56	579.2	304	151.11	885.2	474	245.56
46.4	8	-13.33	199.4	93	33.89	352.4	178	81.11	582.8	306	152.22	888.8	476	246.67
48.2	9	-12.78	201.2	94	34.44	354.2	179	81.67	586.4	308	153.33	892.4	478	247.78
50.0	10	-12.22	203.0	95	35.00	356.0	180	82.22	590.0	310	154.44	896.0	480	248.89
51.8	11	-11.67	204.8	96	35.56	357.8	181	82.78	593.6	312	155.56	899.6	482	250.00
53.6	12	-11.11	206.6	97	36.11	359.6	182	83.33	597.2	314	156.67	903.2	484	251.11

## Unit conversion tables

### Temperature conversion



To °F	From °T	To °C	To °F	From °T"	To °C	To °F	From °T	To °C	To °F	From °T	To °C	To °F	From °T	To °C
56.4	13	-10.58	208.4	98	36.67	361.4	183	83.89	600.8	316	157.78	906.8	486	252.22
57.2	14	-10.00	210.2	99	37.22	363.2	184	84.44	604.4	318	158.89	910.4	488	253.33
59.0	15	-9.44	212.0	100	37.78	365.0	185	85.00	608.0	320	160.00	914.0	490	254.44
60.8	16	-8.89	213.8	101	38.33	366.8	186	85.56	611.6	322	161.11	917.6	492	255.56
62.6	17	-8.33	215.6	102	38.89	368.6	187	86.11	615.2	324	162.22	921.2	494	256.67
64.4	18	-7.78	217.4	103	39.44	370.4	188	86.67	618.8	326	163.33	924.8	496	257.78
66.2	19	-7.22	219.2	104	40.00	372.2	189	87.22	622.4	328	164.44	928.4	498	258.89
68.0	20	-6.67	221.0	105	40.56	374.0	190	87.78	626.0	330	165.56	932.0	500	260.00
69.8	21	-6.11	222.8	106	41.11	375.8	191	88.33	629.6	332	166.67			
71.6	22	-5.56	224.6	107	41.67	377.6	192	88.89	633.2	334	167.78			
73.4	23	-5.00	226.4	108	42.22	379.4	193	89.44	636.8	336	168.89			
75.2	24	-4.44	228.2	109	42.78	381.2	194	90.00	640.4	338	170.00			
77.0	25	-3.89	230.0	110	43.33	383.0	195	90.56	644.0	340	171.11			Interpolation
78.8	26	-3.33	231.8	111	43.89	384.8	196	91.11	647.6	342	172.22	1.8	1	0.56
80.6	27	-2.78	233.6	112	44.44	386.3	197	91.67	651.2	344	173.33			
82.4	28	-2.22	235.4	113	45.00	388.4	198	92.22	654.8	346	174.44			
84.2	29	-1.67	237.2	114	45.56	390.2	199	92.78	658.4	348	175.56			°T Figures are readings in either °F or °C.
86.0	30	-1.11	239.0	115	46.11	392.0	200	93.33	662.0	350	176.67			
87.8	31	-0.50	240.8	116	46.67	393.8	201	93.89	665.6	352	177.78			
89.6	32	0.00	242.6	117	47.22	395.6	202	94.44	669.2	354	178.89			Equivalent to 273.15 K (kelvin)
91.4	33	0.56	244.4	118	47.78	397.4	203	95.00	672.8	356	180.00			
93.2	34	1.11	246.2	119	48.33	399.2	204	95.56	676.4	358	181.11			
95.0	35	1.67	248.0	120	48.89	401.0	205	96.11	680.0	360	182.22			

## Unit conversion tables

### Measurement conversion from US to SI units - 1 -



Customary Unit	x Factor =	SI Unit	Customary Unit	x Factor =	SI Unit
<b>Area</b>			<b>Flow</b>		<b>meter<sup>3</sup> or kilogram</b>
square foot, ft <sup>2</sup>	9.2903	square meter, m <sup>2</sup>	foot <sup>3</sup> /minute, ft <sup>3</sup> /min	0.47195	second, m <sup>3</sup> or kg/s
square inch, in <sup>2</sup>	6.4516	square decimeter, dm <sup>2</sup>	decimeter <sup>3</sup> /second, dm <sup>3</sup> /s		decimeter <sup>3</sup> /second, dm <sup>3</sup> /s
square US statute mile, mi <sup>2</sup>	2.59	square centimeter, cm <sup>2</sup>	centimeter <sup>3</sup> /second, cm <sup>3</sup> /s		centimeter <sup>3</sup> /second, cm <sup>3</sup> /s
square yard, yd <sup>2</sup>	0.83613	square meter, m <sup>2</sup>	pound-mass/minute, lbm/min	7.5599	centimeter <sup>3</sup> /second, cm <sup>3</sup> /s
			short ton/hour, st/h	0.252	gram/second, g/s
<b>Density</b>		<b>kilogram/meter<sup>3</sup>, kg/m<sup>3</sup></b>			kilogram/second, kg/s
gram/centimeter <sup>3</sup> , g/cm <sup>3</sup>	1000	kilogram/meter <sup>3</sup> , kg/m <sup>3</sup>			
ounce-mass/inch <sup>3</sup> ozm/in <sup>3</sup>	1.73	megagram/meter <sup>3</sup> , Mg/m <sup>3</sup>			
pound-mass/foot <sup>3</sup> , lbm/ft <sup>3</sup>	16.018	kilogram/meter <sup>3</sup> , kg/m <sup>3</sup>	<b>Force</b>		<b>newton, N (kg•m/s<sup>2</sup>)</b>
pound-mass/Imp gallon, lbm/gal	99.776	kilogram/meter <sup>3</sup> , kg/m <sup>3</sup>	dyne	10	micronewton, μN
pound-mass/US gallon, lbm/gal	119.83	kilogram/meter <sup>3</sup> , kg/m <sup>3</sup>	kilogram-force, kgf	9.80665	newton, N
long ton/yard <sup>3</sup> , lHyd <sup>3</sup>	1.3289	megagram/meter <sup>3</sup> , Mg/m <sup>3</sup>	avdp pound-force, lbf	4.44822	newton, N
			poundal, pdl	0.13826	newton, N
<b>Energy or Work</b>		<b>joule, J (N•m, kg•m /s<sup>2</sup>)</b>	<b>Length</b>		<b>meter, m</b>
British thermal unit, Btu (Int. Table)	1.05506	kilojoule, kJ	angstrom, Å	100	picometer, pm
calorie, cal (Int. Table)	4.1868	joule, J	foot, ft	0.3048	meter, m
foot-pound-force, ft•lbf	1.35582	joule, J	inch, in	25.4	millimeter, mm
horsepower-hour, hp•h	2.6856	megajoule, MJ	micron, μ	1	micrometer, μm
meter kilogram-force, m•kgf	9.80665	joule, J	Int. nautical mile, naut mi (6076.1 ft)	1.852	kilometer, km
watt-hour, W•h	3.6	kilojoule, kJ	US statute mile, mi (5280 ft)	1.6093	kilometer, km
			yard, yd	0.9144	meter, m

## Unit conversion tables

### Measurement conversion from US to SI units - 2 -



Customary Unit	x Factor =	SI Unit	Customary Unit	x Factor =	SI Unit
<b>Mass</b>			<b>Viscosity dynamic</b>		
avdp ounce-mass, ozm	28.3495	kilogram, kg	kinematic		
avdp pound-mass, lbm	0.45359	gram, g	centipoises, cP	1.0	meter <sup>2</sup> /second, m <sup>2</sup> /s
long ton, lt (2240 lbm)	1.01605	kilogram, kg	centistokes, cSt	1.0	millipascal-second, mPa•s
metric ton (tonne), mt (2204.6 lbm)	1000.0	megagram, Mg			millimeter <sup>2</sup> /second, mm <sup>2</sup> /s
short ton, st (2000 lbm)	907.2	kilogram, kg	<b>Volume</b>		
		watt, W (J/s, kg.m <sup>2</sup> /s)	barrel (oil), bbl (42 US gal, 35 Imp gal)	0.15899	cubic meter, m <sup>3</sup>
<b>Power</b>		watt, W	cubic foot, ft <sup>3</sup> (1728 in <sup>3</sup> )	28.317	cubic meter, m <sup>3</sup>
Btu (Int. Table)/hour, Btu/h	0.29307	watt, W	Imp gallon, gal (160 Imp oz, 0.16054 ft <sup>3</sup> )	4.5461	cubic decimeter, dm <sup>3</sup>
kilo calorie(Int. Table)/hour, kcal/h	1.1639	watt, W	US gallon, gal (128 US oz, 0.13368 ft <sup>3</sup> )	3.7854	liter, l
foot-pound-force/second, ft•lbf/s	1.35582	watt, W	cubic inch, in <sup>3</sup>	16.387	liter, l
horsepower, hp (550ft•lbf/s)	745.7	watt, W	liter, L	1.0	cubic centimeter, cm <sup>3</sup>
metric horsepower, mhp, PS or CV	735.5	watt, W	US fluid ounce, fl oz	29.574	cubic decimeter, dm <sup>3</sup>
		pascal, Pa (N/m <sup>2</sup> , kg/m.s <sup>2</sup> )	US liquid pint, liq pt (16 fl oz)	0.47318	cubic centimeter, cm <sup>3</sup>
<b>Pressure or Stress</b>		kilopascal, kPa	US liquid quart, liq qt (32 fl oz)	0.94635	liter, l
normal atmosphere, atm (760 torr)	101.325	kilopascal, kPa	cubic yard, yd <sup>3</sup>	0.76455	liter, l
bar, b	100.0000	kilopascal, kPa			cubic meter, m <sup>3</sup>
dyne/centimeter <sup>2</sup> , dyne/cm <sup>2</sup>	0.1	pascal, Pa			
inch of water @ 39.2°F (4°C)	249.08	pascal, Pa			
kilogram-force/centimeter <sup>2</sup> , kgf/cm <sup>2</sup>	98.0665	kilopascal, kPa			
millimeter of Hg @ 0°C (32°F), torr	133.322	pascal, Pa			
pound-force/inch <sup>2</sup> , psi	6.89476	kilopascal, kPa			
long ton/inch <sup>2</sup> , lt/in <sup>2</sup>	15.4443	megapascal, MPa			

## Unit conversion tables

### Decimal inches to millimeters

in	mm	in	mm	in	mm
.01	.254	.36	9.144	.71	18.034
.02	.508	.37	9.398	.72	18.288
.03	.762	.38	9.652	.73	18.542
.04	1.016	.39	9.906	.74	18.796
.05	1.270	.40	10.160	.75	19.050
.06	1.524	.41	10.414	.76	19.304
.07	1.778	.42	10.668	.77	19.558
.08	2.032	.43	10.922	.78	19.812
.09	2.286	.44	11.176	.79	20.066
.10	2.540	.45	11.430	.80	20.320
.11	2.794	.46	11.684	.81	20.574
.12	3.048	.47	11.938	.82	20.828
.13	3.302	.48	12.192	.83	21.082
.14	3.556	.49	12.446	.84	21.336
.15	3.810	.50	12.700	.85	21.590
.16	4.064	.51	12.954	.86	21.844
.17	4.318	.52	13.208	.87	22.098
.18	4.572	.53	13.462	.88	22.352
.19	4.826	.54	13.716	.89	22.606
.20	5.080	.55	13.970	.90	22.860
.21	5.334	.56	14.224	.91	23.114
.22	5.588	.57	14.478	.92	23.368
.23	5.842	.58	14.732	.93	23.622
.24	6.096	.59	14.986	.94	23.876
.25	6.350	.60	15.240	.95	24.130
.26	6.604	.61	15.494	.96	24.384
.27	6.858	.62	15.748	.97	24.638
.28	7.112	.63	16.002	.98	24.892
.29	7.366	.64	16.256	.99	25.146
.30	7.620	.65	16.510	1.00	25.400
.31	7.874	.66	16.764		
.32	8.128	.67	17.018		
.33	8.382	.68	17.272		
.34	8.638	.69	17.526		
.35	8.890	.70	17.780		

### Millimeters to inches

mm	in	mm	in	mm	in
1	0.0394	36	1.4173	71	2.7953
2	0.0787	37	1.4567	72	2.8346
3	0.1181	38	1.4961	73	2.8740
4	0.1575	39	1.5354	74	2.9134
5	0.1968	40	1.5748	75	2.9528
6	0.2362	41	1.6142	76	2.9921
7	0.2756	42	1.6535	77	3.0315
8	0.3150	43	1.6929	78	3.0709
9	0.3543	44	1.7323	79	3.1102
10	0.3937	45	1.7716	80	3.1496
11	0.4331	46	1.8110	81	3.1890
12	0.4724	47	1.8504	82	3.2283
13	0.5118	48	1.8898	83	3.2677
14	0.5512	49	1.9291	84	3.3071
15	0.5906	50	1.9685	85	3.3465
16	0.6299	51	2.0079	86	3.3858
17	0.6693	52	2.0472	87	3.4252
18	0.7087	53	2.0866	88	3.4646
19	0.7480	54	2.1260	89	3.5039
20	0.7874	55	2.1654	90	3.5433
21	0.8268	56	2.2047	91	3.5827
22	0.8661	57	2.2441	92	3.6220
23	0.9055	58	2.2835	93	3.6614
24	0.9449	59	2.3228	94	3.7008
25	0.9842	60	2.3622	95	3.7402
26	1.0236	61	2.4016	96	3.7795
27	1.0630	62	2.4409	97	3.8189
28	1.1024	63	2.4803	98	3.8583
29	1.1417	64	2.5197	99	3.8976
30	1.1811	65	2.5591	100	3.9370
31	1.2205	66	2.5984		
32	1.2596	67	2.6378		
33	1.2992	68	2.6772		
34	1.3386	69	2.7165		
35	1.3780	70	2.7559		



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## Acronym table



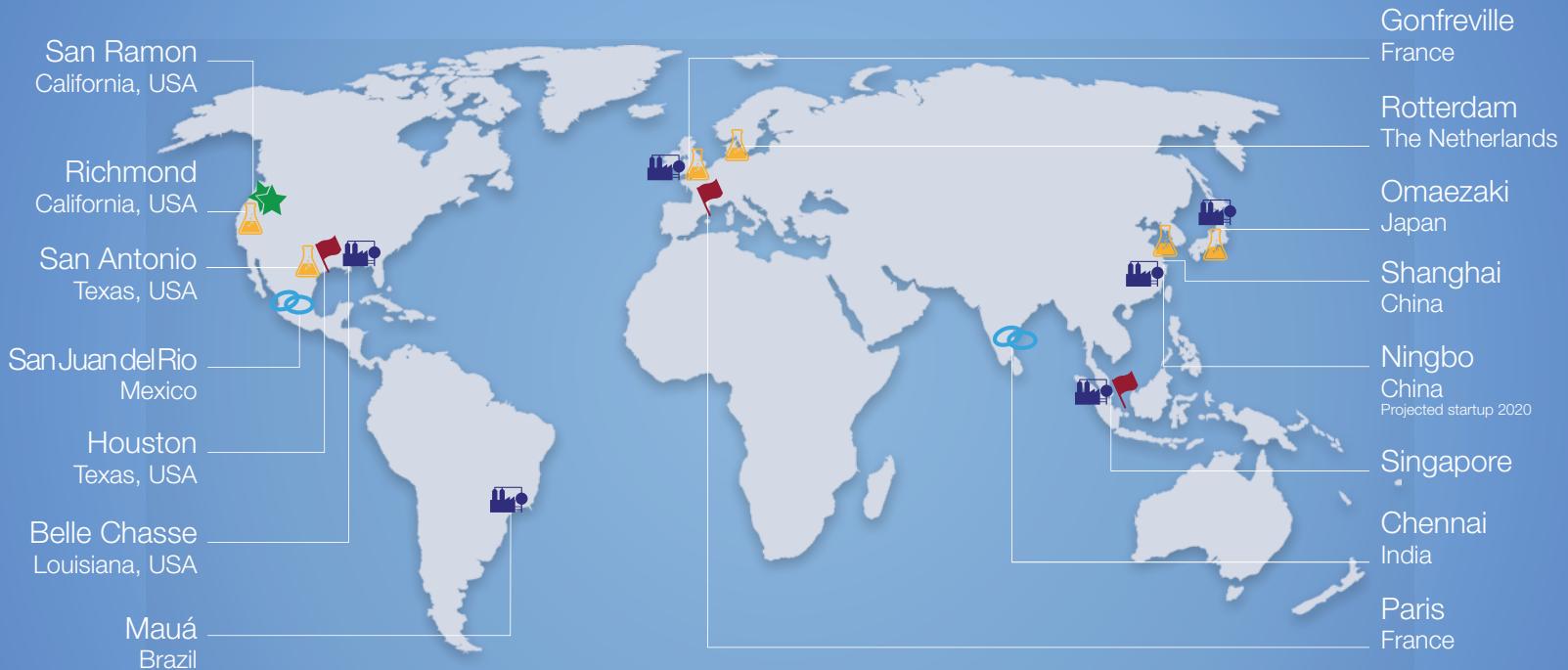
AAM	Alliance of Automobile Manufacturers	ECTC	Engine Coolant Technical Committee of CEC
ACC	American Chemistry Council	ECU	Electronic Control Unit (Gasoline + Diesel)
ACEA	Association des Constructeurs Européens d'Automobiles	EDC	Electronic Diesel Control
ACM	Acrylic Copolymer Material (Seal - Monomer is Ethylene Acrylate)	EELQMS	European Engine Lubricant Quality Management System
AFNOR	Association Française de Normalisation	EFTC	Engine Fuel Technical Committee of CEC
API	American Petroleum Institute	EGR	Exhaust Gas Recirculation
ASTM	American Society for Testing Materials, USA	ELTC	Engine Lubricant Technical Committee of CEC
ATC	Technical Committee of Petroleum Additive Manufacturers in Europe (Additives Technical Committee)	EMA	Engine Manufacturers Association, USA
ATEL	Association Technique de l'Industrie Européenne des Lubrifiants	EOAT	Engine Oil Aeration Test
BN	Base Number (TBN : Total Base Number)	EOLCS	Engine Oil Licensing and Certification System
BOI	Base Oil Interchangeability	EPA	Environmental Protection Agency
BTC	CEC British National Organisation (British Technical Committee)	EUDC	Extra Urban Driving Cycle
CCFA	Comité des Constructeurs Français d'Automobiles (France)	EUROPIA	European Petroleum Industry Association
CEC	Conseil Européen de Coordination	FAP	Filtre à Particules, Particulate Filter (= DPF)
CEN	Comité Européen de Normalisation	FSI	Fuel Stratified Injection
CCMC	Comité des Constructeurs d'Automobiles du Marché Commun	GDI	Gasoline Direct Injection
CEFIC	Conseil Européen des Fédérations de l'Industrie Chimique	GFC	CEC French National Organisation (Groupeement Français de Coordination)
CIMAC	Congrès International des Machines à Combustion	GRPE	Group of Reporters on Pollution and Energy
CMA	Chemical Manufacturers Association, USA	HC	HydroCarbon
CONCAWE	Conservation of Clean Air and Water in Europe	HDI	High pressure Direct Injection (Diesel)
CoP	Code of Practice	HEUI	Hydraulically actuated and Electronically controlled Unit Injector
CRC	Coordination Research Council, USA	HPI	High Pressure Injection (Diesel)
CRT	Continuously Regenerating Trap	HTCBT	High Temperature Corrosion Bench Test (Cummins)
CUNA	CEC Italian National Organisation (Commissione tecnica di Unificazione neell' Autoveicolo)	HTHS	High Temperature High Shear (Viscosity)
DHD	Diesel Heavy Duty (Global DHD-1 specification)	IDI	Indirect Diesel Injection
DI	Direct Injection	ILMA	Independent Lubricant Manufacturer Association (USA)
DIN	Deutsches Institut für Normung	ILSAC	International Lubricant Standardization & Approval Committee
DKA	CEC German National Organisation (Deutscher Koordinierung Ausschuss)	IP	Institute of Petroleum, UK
DPF	Diesel Particulate Filter	ISO	International Organisation for Standardization
EAM	Ethylene Acrylic copolymer Material (Seal)	JAMA	Japan Automobile Manufacturers Association, Inc.
EAME	Europe Africa Middle-East	JASO	Japan Automobile Standards Organisation
		JIS	Japan Industry Standard
		JPI	Japan Petroleum Institute

## Acronym table



JSAE	Society of Automotive Engineers, Japan	PDSC	Pressure Differential Scanning Calorimeter
LDF	Long Drain Field test (Scania)	RNT	Radio Nucleide (wear) Test
LEDL	Low Emission Diesel Lubricant	RWFT	Roller Follower Wear Test
LRI	Lubricant Review Institute, USA	SAAC	Statistical Application Advisory Committee of CEC
MTAC	Multiple Test Acceptance Criteria	SAE	Society of Automobile Engineers, USA
MVEG	Motor Vehicle Emission Group	SAPS	Sulfated Ash, Phosphorus and Sulfur
NBR	Nitrile Butadiene Rubber (seal)	TDI	Turbocharged Direct Injection
OEM	Original Equipment Manufacturers	TLTC	Transmission Lubricant Technical Committee of CEC
OHC	OverHead Camshaft	TRWL	Top Ring Weight Loss
OICA	Organisation Internationale des Constructeurs Automobiles (EU)	VDA	Verband der Automobilindustrie, Germany
OMEM	Other Major Engine Manufacturers	VDS	Volvo Drain Specification
PAJ	Petroleum Association of Japan	VTW	Valve Train Wear

# ORONITE ADDS UP AROUND THE WORLD



- Global headquarters
- Technology center
- Regional headquarters
- Shareholder interest Manufacturing & Supply
- Manufacturing and Supply



# Oronite

## WORLDWIDE HEADQUARTERS

Chevron Oronite Company LLC  
6001 Bollinger Canyon Road  
San Ramon, CA 94583-2324  
USA  
Phone: (1) 713-432-2500

## REGIONAL HEADQUARTERS

**American Region**  
Chevron Oronite Company LLC  
3901 Briarpark Dr.  
Houston, TX 77042  
USA  
Phone: 713-954-6060

**Asia-Pacific Region**  
Chevron Oronite Pte. Ltd.  
21 Sakra Road  
Singapore, 627890  
SINGAPORE  
Phone: (65) 6867 6557

**Europe, Africa, Middle East Region**  
Chevron Oronite SAS\*  
1, rue Eugène et Armand Peugeot  
CSA 10022 - 92508 Rueil-Malmaison Cedex  
FRANCE  
Phone: (33) 1 46 39 36 00

\*Registered office: Share capital € 18.407.665 - Nanterre Trade Register n° 562 061 630

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